Th, Pb, Nd and Sr isotope variations in volcanic rocks from the Lesser Antilles

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Th, Pb, Nd and Sr isotope data on Recent volcanic rocks from the Lesser Antilles arc provide constraints on melting processes and the relative contributions of various source components. Although many of the samples are close to U-Th equilibrium, the total range in ($^{230}Th/^{232}Th$) is from 0.72 to 1.76 and ($^{238}U/^{232}Th$) from 0.66 to 1.59 thus the data extend to both sides of the Th-U equiline ($^{230}Th/^{238}U$) = 0.75-2.07), though Th excess predominates. There is no apparent correlation between the degree of disequilibrium, or U versus Th excess, and position from North (low-K tholeiitic) to South (calc-alkaline to shoshonitic) along the arc. However, ($^{230}Th/^{232}Th$) shows a broad negative correlation with $^{87}Sr/^{86}Sr$, $^{206}Pb/^{204}Pb$, $^{207}Pb/^{204}Pb$, $^{208}Pb/^{204}Pb$ and is positively correlated with $^{143}Nd/^{144}Nd$. The ($^{230}Th/^{232}Th$) - $^{87}Sr/^{86}Sr$ and ($^{230}Th/^{232}Th$) - $^{143}Nd/^{144}Nd$ arrays lie above that of MORB and OIB. Those rocks with excess Th have low $^{87}Sr/^{86}Sr$ and high ($^{230}Th/^{232}Th$) whereas those with excess U tend towards high $^{87}Sr/^{86}Sr$ and low ($^{230}Th/^{232}Th$). The degree of departure from equilibrium tends to be greatest in samples with low Th concentrations as noted in general for arc rocks (McDermott and Hawkesworth, 1991).

Likely source components include variably depleted or metasomatised mantle wedge, the subducting slab and the sediments carried upon it. The extension of the Lesser Antilles $^{87}Sr/^{86}Sr$-$^{143}Nd/^{144}Nd$ data array into the MORB field confirms the presence of depleted mantle in at

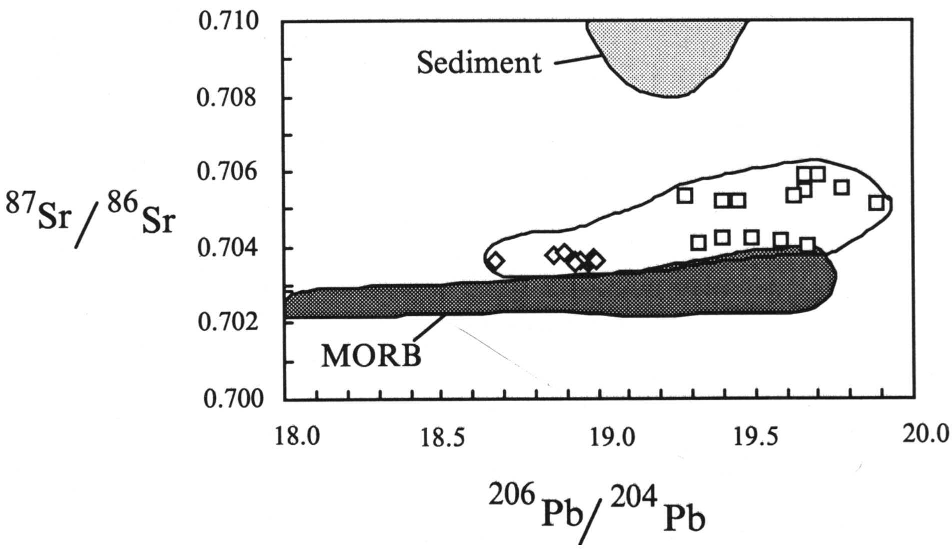

FIG. 1 $^{206}Pb/^{204}Pb$ vs $^{87}Sr/^{86}Sr$ for Lesser Antilles volcanic rocks (diamonds are samples from the northern part of the arc, squares are from the more southerly islands). Fields for MORB and sediment from White and Duprè (1986).

least some segments of the wedge. The origin of the elevated $^{87}Sr/^{86}Sr$ and $^{206}Pb/^{204}Pb$ and low $^{143}Nd/^{144}Nd$ is more problematic however, and may reflect the contribution of subducted sediment (e.g. White and Duprè, 1986). Alternatively, high level crustal contamination has also been proposed as the source of elevated $^{87}Sr/^{86}Sr$ in some of the Lesser Antilles magmas (e.g. Davidson, 1986). The low $^{87}Sr/^{86}Sr$ and high ($^{230}Th/^{232}Th$) rocks have excess Th, which could be explained by small degrees of melting in a relatively unmetasomatised (depleted) mantle wedge, enriching Th relative to U in the melt. In contrast, high $^{87}Sr/^{86}Sr$ and low ($^{230}Th/^{232}Th$), possibly coupled with excess U, is most likely to result from addition of Sr (and U?) in fluids derived from subducted pelagic sediment in the slab (e.g. Gill and Williams, 1990). Thus the elevated $^{87}Sr/^{86}Sr$ and $^{206}Pb/^{204}Pb$ (Fig. 1) and low $^{143}Nd/^{144}Nd$ is infered to have been derived from subducted sediment rather than high level crustal contamination.

The tendency of the data to approach ^{238}U-^{230}Th equilibrium, yet extend to both excess U and excess Th sides of the equiline may reflect the opposing effects of contributions from high U/Th fluids from the slab and low U/Th in melts within the mantle wedge. Alternatively, disequilibrium melting of metasomatised mantle, with variable contributions from U-rich fluids and Th-rich melts of depleted peridotite may be invoked (e.g. Condomines and Sigmarsson, 1993). If the later is correct, the fluids responsible for metasomatism of the mantle wedge must differ from those that caused excess U by having low $^{87}Sr/^{86}Sr$, $^{206}Pb/^{204}Pb$ and quite variable $^{230}Th/^{232}Th$.

References

Condomines, M. and Sigmarsson, O. (1993)*Geochim. Cosmochim. Acta*, **57**, 4491–7.

Davidson, J.P. (1986) *J. Geophys. Res.*, **91**, 5943–62.

Gill, J.B. and Williams, R.W. (1990) *Geochim. Cosmochim. Acta*, **54**, 1427–42.

McDermott, F. and Hawkesworth, C. (1991) *Earth Planet. Sci. Lett.*, **104**, 1–15.

White, W. and Duprè, B. (1986) *J. Geophys. Res.*, **91**, 5927–41.