Geophysical Research Abstracts, Vol. 7, 03416, 2005
SRef-ID: 1607-7962/gra/EGU05-A-03416

From hydrous fluids- to slab melt-metasomatism in the New Hebrides arc? New insights from along-arc geochemical and isotopic variations.

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The New Hebrides (NH) arc has long been cited as the type-example of a subduction zone where magmas are produced by the melting of the peridotitic mantle wedge fluxed by hydrous fluids originating from the downgoing oceanic crust that is progressively deshydrating.

While in the main part of the arc, typical tholeiitic arc basalts (and crystal fractionation products) are produced, its southern tip is distinguished by the production of magnesian andesites. Many geochemical and isotopic characteristics of these intermediate magmas contrast strongly with the rest of the arc. Observation of along-arc variations shows, for instance, a sharp decrease of fluid mobile/immobile element ratios like Ba/La or Ba/Th, while La/Yb or Sr/Y ratios clearly increase. Sr and Nd isotopes ratios tend towards MORB-like values. While not entirely typical of adakites, those characteristics are close to those usually attributed to melts produced by the partial melting of a basaltic protolith at high pressure. U-Th disequilibria indicate that the fluid-induced U enrichment prevailing in most of the arc is almost absent in the magnesian andesites.

In the absence of any thick arc crust that could potentially induce garnet fractionation, the HREE fractionation of the magnesian andesites must originate in the deep source of the magma. The progressive disappearance of fluid-related geochemical imprints of the magma (such as high Ba/La ratios) indicates that fluid enrichment of the source prevailing in the bulk of the arc loses its influence at the southern tip. Yet, high concentrations of incompatible elements, such as LILE or LREE, necessitate some kind of enrichment contribution from the slab (since isotopes and HFSE contents fully discount any OIB-related mantle source).

We suggest, given the “adakite-like” geochemical characteristics of these andesites, that the metasomatizing agent is a slab melt. This hypothesis is strengthened by a reduction in the depth to the Benioff zone from 150 km in the central part of the arc to only 80 km at the southern tip, corresponding to the putative pressure window for slab melt generation.

As for why slab melting would occur in this area only, we propose that the high thermal regime supported by the tip of the slab entering the upwelling mantle of the Southern Fiji Basin is capable of triggering slab melting as suggested by other similar geodynamical situations worldwide.

Interestingly, the magnesian andesites at the southern tip of the NH arc display similar absolute concentrations in Nb (compared to the rest of the arc) but higher La/Nb ratios. This would suggest that there exists a HFSE-rich mineral phase in the refractory subducting slab and/or mantle, buffering Nb concentrations in erupted magmas, whatever the mechanism of slab devolatilization.