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Additional U-series constraints on timescales of magma transfer and magma chamber residence time beneath the Southern Volcanic Zone of Chile

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Estimates of elemental fluxes through subduction zones depend to a large degree on the mechanism of melt transport through the mantle wedge Melt could be transported slowly by percolation at mineral-grain interfaces or rapidly by channeled flow. Slow melt percolation is likely to cause the melt to react with surrounding mantle minerals leading to modification of its chemical composition. In contrast, fast transport of melt through fractures may well bring to surface magma that still retains compositional record of the magma source. Radioactive disequilibria between nuclides of the U-series can give constraints on the rate of melt transfer if the mechanism of fractionation between the nuclides can be assessed.

Historic lavas from a few volcanoes in the SVZ of Chile show correlation of (^{226}Ra/^{230}Th) with (^{238}U/^{230}Th) and ^{10}Be/Be. These covariations strongly suggest that the excesses of ^{226}Ra and over ^{230}Th are slab-derived, since the cosmogenic ^{10}Be is inherited from the subducting slab. Similar correlations between ^{226}Ra- and ^{238}U-excesses relative to ^{230}Th have been observed in island-arc lavas elsewhere and also are likely to be caused slab-derived fluid-flux melting of the mantle wedge.

Equilibrium between ^{226}Ra and ^{230}Th will be reached after approximately 5 times the half-life of Ra, or in 8000 years, but the significant Ra-excesses observed in arc volcanics suggest shorter timescales. The vertical distance from the subducted crust to the volcanic front is on average not far from 100 km, which gives magma transfer rates faster than 10 meters per year. Such rapid magma transfer is better explained by channelized flow rather than by much slower mineral-grain percolation. If any interaction with the mantle or the crust occurs, such as in a melting-assimilation-storage-homogenization (MASH) process, it must be very rapid and have a limited dilution effect on the signature of the subducted component.

The fact that (^{226}Ra/^{230}Th) in the historic lavas from the SVZ correlates with other geochemical variables strongly indicates that magma chamber residence times are likely to be of the same order of magnitude beneath the large composite volcanoes of the SVZ. The residence time of the magma chambers can then be estimated by analyzing ^{226}Ra-^{230}Th disequilibria in basalts that are erupted from the smaller volcanic cones rather than through the large Andean stratovolcanoes. Indeed, the 1971 basalt from the strombolian cone of Mirador yields significantly higher (^{226}Ra/^{230}Th) than indicated by the correlations with (^{238}U/^{230}Th) and ^{10}Be/Be in the lavas from the stratovolcanoes. The difference in (^{226}Ra/^{230}Th) between the measured value for Mirador and these correlations suggest a magma chamber residence time on the order of 2000 years beneath the large stratovolcanoes. The maximum melt transfer time through the mantle wedge towards the magma chambers beneath the SVZ is therefore reduced to approximately 6000 years.