^{231}Pa excesses in subduction zone magmas: indicators of melting rates and processes in the mantle wedge

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Melting processes in subduction zones are still poorly understood reflecting the complicated processes of slab dehydration, recycling of sediment, and partial melting of the mantle wedge. U-series disequilibria in young arc lavas provide constraint on the processes and time scales of melting. ^{231}Pa excesses are unique among the disequilibria pairs in that these excesses probably do not reflect fractionation during fluid addition, but rather in-growth of ^{231}Pa during partial melting of the mantle wedge. Thus, ^{231}Pa excesses can uniquely constrain the melting rate of an arc magmatic system, which is difficult to constrain by other methods. Notably, average (^{231}Pa/^{235}U) in arcs globally appears to correlate negatively with subduction rate [1]. Our new ^{231}Pa data from Kick'em Jenny from the southern Lesser Antilles arc reinforce this observation with (^{231}Pa/^{235}U) > 2.0 in 10 out of 12 samples. Thus, the Lesser Antilles arc clearly has very high average (^{231}Pa/^{235}U) to go with its low subduction rate, while the fastest subducting Tonga arc has the lowest (^{231}Pa/^{235}U). Using the simple assumption that the water flux into the mantle wedge depends on the subduction rate, we present a physical model to explain the negative correlation between (^{231}Pa/^{235}U) and subduction rate. In the model, the solidus of overlying mantle is depressed by the amount of water released from the down-going slab by dehydration. The melting rate is directly proportional to the amount of water under a steady state as shown in [2]. Previous numerical models of "in-growth melting" (e.g., either dynamic melting [3] or equilibrium porous flow models [4]) have shown that (^{231}Pa/^{235}U) in magmas are sensitive to variation in melting rate. In the case of arcs, the melting rate mostly will reflect solidus lowering by the fluid flux, not the matrix flow rate. Thus, this model explains the relationship between ^{231}Pa excess and the subduction rate observed in arcs globally by controlling the melting rate of the overlying mantle wedge.

References

[1] Turner, S., Regelous, M., Hawkesworth, C. and Rostami, K. (2006) *GCA* **70**, 480-503.

[2] Davies, H. and Bickle, M.J. (1991) *Pilos. Trans. R. Soc. London (A)* **335**, 355-364.

[3] McKenzie, D. (1985) *EPSL* **74**, 81-91.

[4] Spiegelman, E. and Elliott, T. (1993) *EPSL* **118**, 1-20.