U-SERIES ISOTOPE CONSTRAINTS ON MELTING PROCESSES AND DEGASSING TIME SCALES AT ISLAND ARC VOLCANOES

Simon Turner[1], *Marcel Regelous*[2], *Stuart Black*[3], *Rhiannon George*[1] *and Chris Hawkesworth*[2]
1 *Macquarie University, Australia*
2 *University of Bristol, UK*
3 *University of Reading, UK*

We have undertaken measurements of ^{231}Pa and ^{210}Pb in young island arc lavas, that had previously been analysed for ^{238}U-^{230}Th-^{226}Ra, from the Lesser Antilles, Tonga, Vanuatu, Philippines, Marianas, Sunda, Kamchatka and the Aleutians. Pa is highly incompatible during mantle melting, and is thought to be highly insoluble in aqueous fluids, compared to U. However, previously published data show that most arc lavas have excesses of ^{231}Pa over ^{235}U, despite also having excesses of ^{238}U over ^{230}Th. The new data confirm and expand this results with the analysed lavas having (^{231}Pa/^{235}U) ratios which range from 0.82 to 2.42. For the dataset as a whole, there is a broad positive correlation of (^{231}Pa/^{235}U) with (^{230}Th /^{238}U), and samples with higher (^{231}Pa/^{235}U) also tend to have lower ratios of Ba/Th and U/Nb (smaller slab fluid input). There is no simple relationship between ^{231}Pa excess and subduction rate, subducting plate depth or sediment flux. Although U/Nb ratios indicate that up to 98% of the U in these lavas is derived from the subducting plate, all but one of the samples have (^{231}Pa/^{235}U) >1.0, and several have >100% ^{231}Pa excess. This could indicate that a period of several half-lives of ^{231}Pa elapsed between the timing of fluid addition from the slab and the final melting event. On the other hand, most samples have ^{226}Ra excess, indicating that the last episode of Ra addition to the melting zone occurred less than 8000 years ago. The large Pa excesses imply that significant fractionation of U and Pa occurs during separation of melt from the mantle. As both U and Pa are highly incompatible in mantle minerals, melting must occur at low porosity over a period of time that is significant relative to the half life of ^{231}Pa to allow ^{231}Pa in-growth in the melting region, either by dynamic melting in the mantle wedge at low melting rate, or during melting of continuously-fluxed mantle. In contrast, ^{210}Pb is formed by decay of ^{226}Ra via the gaseous intermediate ^{222}Rn and so provides the potential to investigate the time scales of shallow-level degassing of the magmas. Lavas erupted between 1953 and 1999 show extreme variation in ^{210}Pb -^{226}Ra disequilibria with age corrected (^{210}Pb /^{226}Ra) activity ratios ranging from 0.36 to 3.14. The majority (25) have ^{210}Pb deficits which are most readily interpreted in terms of protracted magma degassing and suggest that the typical duration of degassing is on the order of 10-50 years. There is no simple model for explaining the ^{210}Pb excesses in the remaining 14 samples and since plagioclase accumulation cannot account for the observed excesses, we suggest that inefficient gas release and/or sublimation of ^{210}Pb from ^{222}Rn during gaseous transport through the magma may be responsible.