INCOMPATIBLE ELEMENT VARIATIONS AT TOFUUA, KAO AND RAOUN, TONGA-KERMADEC ARC

T. J. Worthington, C. D. Garbe-Schönberg, P. Stoffers
Institut für Geowissenschaften, Universität Kiel (tw@gpi.uni-kiel.de)

Intra-oceanic arc volcanoes represent the simplest expression of subduction-related magmatism, yet stratigraphically controlled studies are few. We present new data from the Tonga-Kermadec arc focusing on the adjacent volcanic islands of Tofua and Kao (19.7°S), and contrast this with similar data from Raoul (29.3°S). The key variables being tested are sensitivity of magma genesis to a change in subduction rate from 18 cm/year beneath Tofua to 8 cm/year beneath Raoul, and the expected development of long-term compositional trends at individual centres. All three volcanoes have experienced cycles of cone-building followed by prolonged quiescence, with the most recent cycles commencing at ~10 ka. Low-K basaltic andesite with strong depletion in conservative incompatible elements (Nb, Ta, Zr, Hf) relative to MORB predominates in most cycles.

Lavas from Tofua and Kao are, on average, only marginally more depleted in conservative elements than those from Raoul (e.g., Nb/Yb = 0.11–0.22 vs. 0.13–0.33). Thus, the depleted character of these lavas does not simply correlate with subduction rate. Nor does it correlate with changes in the backarc environment from spreading and eruption of moderately depleted hybrid lavas (behind Tofua-Kao) to slow rifting and eruption of undepleted MORB (behind Raoul). No long-term trends in conservative element depletion relative to MORB are evident at these volcanoes, and only subtle medium-term trends in conservative and non-conservative element ratios are observed. This requires tight coupling between the rate of melt production, rate of induced mantle wedge convection, and the slab-derived flux. Nevertheless, each volcano has a distinct set of incompatible element ratios reflecting local variations in the slab- and mantle-derived components. Crustal assimilation is also an important process be-
neath Kao, yet negligible at nearby (<10 km) Tofua.

The full range of both conservative and non-conservative incompatible element ratios, and Sr-Nd-Pb isotope compositions, is significantly less for Tofua and Kao than for Raoul. Efficient pooling of fractional melts is promoted where a high magma flux enables long-lived magma chambers. Thus, we attribute the greater homogeneity of Tofua and Kao to a higher magma flux resulting from the faster subduction rate. An important corollary is that slower subduction rates lead to less efficient melt pooling beneath arc volcanoes and may provide greater preservation of individual melt batches.