The impact of subducted slab components on back-arc melting

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Back-arc lava compositions range from depleted in incompatible trace elements, similar to those observed in mid-ocean ridge basalts (MORB), to arc-like with distinct enrichments in fluid-mobile elements (e.g., high Ba/Nb, Ce/Pb ratios). Spreading centres formed oblique to an island arc afford an opportunity to appraise elemental exchange between the arc and back-arc. Well documented decreases in fluid signatures with increasing distance from the arc could reflect stepwise dehydration of the subducting slab, (sub)vertical fluid transport and subsequent melting of the mantle wedge. Alternatively, they could result from slab roll-back which leaves behind an arc signature in its wake. Re-melting of such mantle previously fluxed with subduction zone components could also explain the overall observations but does not result in the gradients observed in some back-arcs. Here, we use trace element data from the Valu Fa and Eastern Lau Spreading Centre and the Tonga-Kermadec arc to test between these competing models. The back-arc lavas range in Ba/Nb, and Zr/Nb ratios that are almost arc-like (~380 and ~80, respectively) at <80 km distance from the arc to MORB-like ratios (~5 and 6, respectively) at distances >140 km from the arc at ~200 km slab depth. We propose a model in which the decreasing fluid signature can be explained by overlap of the melting zones between the arc and back-arc at distances <120 km from the arc. Lateral transport of melt at shallow mantle depths from the arc into the upwelling zone beneath the back-arc is responsible for the observed chemical gradients. Our model can explain the depleted HFSE compositions and ($^{238}U/^{230}Th$) >1 in some back-arc lavas. It is also consistent with imaging in recent geophysical models [1] and indicates that the spatial variability of fluid and depletion-related signatures in back-arcs may not reflect dehydration of the subducting slab and vertical fluid transport but instead could result from shallow overlapping melting zones.

[1]Wei et al. 2015. Seismic evidence of effects of water on melt transport in the Lau back-arc mantle. *Nature*. Doi: 10.1038/nature14113