What drives arc magma diversity?

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Arc magmas are more silicic and diverse than magmas from other geotectonic settings. While this diversity is clearly causally related to the subduction setting, there is no consensus whether silicic arc magmas are primary melts from a mantle modified by slab additions, or whether silicic melts form in the crust by differentiation of basaltic mantle melts. In order to distinguish among these models, we conducted a comprehensive geochemical study on basaltic to dacitic magmas in the central Mexican Volcanic Belt that erupted from monogenetic centers and two composite volcanoes (Popocatepetl, Nevado de Tolua).

The systematic variation of melt SiO_2 with Sr-Nd-Hf-Pb-O isotope ratios precludes fractional crystallization to drive melt silica increase, and points to the integration of silicic crustal components. However, as olivines phenocrysts from basaltic to andesitic magmas combine high $\delta^{18}O$ = +5.3-6.6‰ (corresponding to $\delta^{18}O$ = +6.3-8.5‰ of host melt) with high $^{3}He/^{4}He$ = 7-8 R_a, this crustal component must be derived from slab, and not from the crustal basement. The high Ni (up to 5400 ppm Ni) and compositional diversity of the olivines point to arc magmas formation through mixing of primary basaltic to dacitic mantle melts from olivine-free silica-deficient and silica-excess secondary pyroxenite lithologies that formed by infiltration of silicic components from slab. Sr-Nd-Pb-Hf isotope ratios and trace elements systematics of arc output and subduction input show that the mantle is infiltrated by slab diapirs of eroded granodioritic fore-arc crust (dominant), supplemented by AOC-derived fluids, rare slab melts, and a minor enriched component, possibly made of recycled intraplate seamounts. While the primary arc magmas inherit the trace element diversity of these components, their high silica content can be linked to the strong silicic flux of the granodioritic slab diapirs to the mantle sources. Overall, there is no need for significant melt differentiation in the 45 km thick continental basement.