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Volatile-driven melting, ascent, and explosive eruption of picritic slurries in arc settings

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Convergent margin-related juvenile arc magmas contain elevated concentrations of volatile elements (i.e., C,O,H,S) relative to primitive magmas from divergent or intraplate tectonic settings. This implies that, relative to bulk of the Earth's mantle, volcanic arcs are underlain by mantle enriched in volatiles. The rarity of near-primary volcanic rocks in arc settings, coupled with the large decrease in volatile element solubility during the ascent of silicate melts through the crust, makes accurate estimates of the volatile budget of primary melts equilibrated with the sub-arc mantle challenging. The North American Cordillera of British Columbia hosts at least two occurrences of near-primary arc volcanic rocks of Mesozoic age [1,2]. Both occurrences belong to a global suite of crystal-rich picrites (MgO ~15-40 wt.%; ~25–60 wt.% accumulated olivine +Cr-spinel), formed by explosive eruption onto the surface of the Earth. The picrite eruption was driven by limited escape of H_2O and other volatiles and the resulting buoyant transit of ultramafic, crystal-rich slurries from the mantle. The genesis of ultramafic primary magmas in arc settings requires efficient slab dehydration that results in high water concentrations in the hottest portion of the sub-arc mantle wedge, where mantle-equilibrated magmas attain picritic compositions.

The highly variable Ca concentrations in olivine ($Fo_{89.6–93.5}$), measured by EPMA, suggest that ultramafic volcanic rocks of the Late Triassic Nicola Group in the North American Cordillera record initial crystallization of Ca-poor olivine (~400 ppm) from a water-rich (≥8wt.%) and oxidized near-primary magma containing ~19 wt.% MgO. Initial crystallization was followed by rapid degassing-driven ascent, during which Ca-rich olivine (>2000 ppm) crystallized. The concomitant changes in Mn content and Fe/Mn ratios of olivine and the increasing Fe^{3+} contents in coexisting Cr-spinel suggest that degassing also caused significant oxidation of the melt, possibly through SO_2 degassing.

References:

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