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SPECIAL COLLECTION: NEW ADVANCES IN SUBDUCTION ZONE MAGMA GENESIS

Origin and petrogenetic implications of anomalous olivine from a Cascade forearc basalt

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Abstract

Erupted absarokitic-shoshonitic volcanics in subduction zones make up a relatively small proportion of the total erupted volcanic material. However, they are a critical component for quantifying subduction metasomatism and mantle source heterogeneity. This study examines the geochemistry of anomalous olivine within a forearc absarokite lava and associated tephra, a compositional end-member of the Cascadia subduction zone magmatism, to infer mantle heterogeneity and magma petrogenesis. Ni concentrations from the young (42 ka) Quartzville absarokitic basalt lava flow and tephra in the Cascade forearc are up to ~6400 ppm Ni with correspondingly low Ca, averaging ~850 ppm Ca in Fo_{91} olivine cores. Decreasing Ni and Ca toward olivine rims cannot be accounted for by simple fractional crystallization and instead necessitates magma mixing ± diffusive re-equilibration between the high-Ni, low-Ca olivine cores and low-Ni, high-Ca rims. $\delta^{18}O$ of olivine phenocrysts (5.64‰) are elevated compared to other Cascade compositional components and outside of the range typically associated with peridotitic olivine or olivine crystallizing from peridotite-derived basaltic magmas. Trace element contents of whole rock, melt inclusions, and scoria glass have high Sr, high Dy/Yb, and low Y, characteristic of adakitic slab melts; however, major element compositions are of an alkali-rich basalt. In addition, similar trace element compositions between all analyzed glasses indicate a related petrogenesis between all components. We propose that a slab partial melt has reacted with depleted harzburgite in the mantle wedge, underlying the older Western Cascades (~40–10 Ma). Reaction of the siliceous slab-derived melt with depleted harzburgite could produce a metasomatized, zoned pyroxenite-harzburgite mantle source. High-Ni, low-Ca olivine crystallizes from melts of the subarc mantle reaction-pyroxenite. Later melting of the metasomatized harzburgite produces the absarokitic bulk composition, with olivine compositions recording diffusive re-equilibration following incorporation of pyroxenite-derived olivine in a peridotitic magma. Importantly, then, the observed olivine chemistry reflects mineralogical variations in the subarc mantle while melt trace element variations record melts/fluids derived from the subducting plate. High-Fo olivine rims (up to ~Fo_{94}) appear to be the result of late-stage oxidation in the lava flow resulting from SO_2 degassing and are unrelated to the otherwise complex magma petrogenesis.

Keywords: Reaction pyroxenite, shoshonite, subduction, trace element, diffusion, mixing