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Olivine-hosted melt inclusions reveal deep magma storage and possible CRB-influenced mantle sources beneath Mount Rainier

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Mount Rainier represents a geochemically enriched endmember among continental arc volcanoes. We analyzed Cr-spinels and homogenized melt inclusions (MIs) in Fo_{87}-Fo_{90} host olivines separated from high-Mg# scoria and associated basaltic andesite lava from Rainier's north flank, which may represent parental melts to the main edifice. Crushed olivine from the lava released helium with $^{3}He/^{4}He$ of 8.81±0.49 R/Ra, precluding a crustal origin. Olivine-spinel thermometry and oxybarometry record average olivine crystallization conditions of 1153 °C (lava) and 1185 °C (scoria) at ΔQFM~+0.7. Olivine-melt hygrometry indicates ≥4 wt.% magmatic H_2O during crystallization.

Lava-hosted MI compositions are bimodal. The dominant type has trace element patterns that closely match those of the lava whole-rocks (WR). These inclusions contain up to ~8500 ppm CO_2, yielding saturation pressures of 550–900 MPa (20–33 km). The similarity of the WR and MI trace element patterns indicates that the high-Mg# basaltic andesite reflects a near-primary magma composition present at the Moho. A minor "OIB-like" group is characterized by lower large-ion lithophile element abundances and muted Nb–Ta anomalies (Th/Nb<0.2), though both groups exhibit positive Sr anomalies. The OIB-like MIs have lower CO_2 (350–5500 ppm), giving mid- to upper-crustal saturation pressures (200-600 MPa). *All scoria MIs are of the OIB-like type*.

Quantitative trace element modeling indicates that both magmas formed by low-degree melting of a garnet-bearing mantle source fluxed by slab melts. The OIB-like MIs are consistent with an enriched ambient mantle overprinted by melts of basaltic ocean crust. The "normal" arc lava MIs require larger slab melt contributions, with significant sediment melt.

The OIB-like MI compositions are strikingly similar to Imnaha group lavas of the Columbia River Basalt (CRB). The Imnaha compositions are interpreted to reflect the pristine CRB mantle source, but they do show evidence of slab-melt overprint, likely from interaction between an ascending plume and the Farallon slab. The OIB-like MIs of Rainier may record this Yellowstone hotspot plume-derived asthenosphere. We propose that after the arrival of the plume and eruption of the CRB, continued subduction drove corner-flow advection of plume material into the mantle wedge (Fig. 1), establishing a petrogenetic connection between CRB and modern Cascade magmatism.

Figure 1.

