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SPECIAL COLLECTION: NEW ADVANCES IN SUBDUCTION ZONE MAGMA GENESIS

Using mineral geochemistry to decipher slab, mantle, and crustal input in the generation of high-Mg andesites and basaltic andesites from the northern Cascade Arc

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Abstract

To better understand the role of slab melt in the petrogenesis of North Cascades magmas, this study focuses on petrogenesis of high-Mg lavas from the two northernmost active volcanoes in Washington. High-Mg andesites (HMA) and basaltic andesites (HMBA) in the Cascade Arc have high Mg# [molar $Mg/(Mg+Fe^{2+})$] relative to their SiO_2 contents, elevated Nd/Yb, and are Ni- and Cr-enriched. The rock units examined here include the Tarn Plateau HMBA (51.8–54.0 wt% SiO_2, Mg# 68–70) and Glacier Creek HMA (58.3–58.7 wt% SiO_2, Mg# 63–64) from the Mount Baker Volcanic Field, and the Lightning Creek HMBA (54.8–54.6 SiO_2, Mg# 69–73) from Glacier Peak. This study combines major and trace element compositions of minerals and whole rocks to test several petrogenetic hypotheses and to determine which, if any, are applicable to North Cascades HMA and HMBA. In the Tarn Plateau HMBA, rare earth element (REE) equilibrium liquids calculated from clinopyroxene compositions have high Nd/Yb that positively correlates with Mg#. This correlation suggests an origin similar to that proposed for Aleutian adakites, where intermediate, high Nd/Yb slab-derived melts interact with the overlying mantle to become Mg-rich, and subsequently mix with low Nd/Yb, mantle-derived mafic magmas with lower Mg#. In the Glacier Creek HMA, elevated whole-rock MgO and SiO_2 contents resulted from accumulation of xenocrystic olivine and differentiation processes, respectively, but the cause of high Nd/Yb is less clear. However, high whole-rock Sr/P (fluid mobile/fluid immobile) values indicate a mantle source that was fluxed by an enriched, hydrous slab component, likely producing the observed high Nd/Yb REE signature. The Lightning Creek HMBA is a hybridized rock unit with at least three identifiable magmatic components, but only one of which has HMA characteristics. Cr and Mg contents in Cr-spinel and olivine pairs in this HMA component suggest that its source is a strongly depleted mantle, and high whole-rock Sr/P values indicate mantle melting that was induced through hydration, likely adding the component responsible for the observed high Nd/Yb REE pattern. The elevated SiO_2 contents (54.6 wt%) of the HMA component resulted from differentiation or high degrees of partial melting of ultramafic material through the addition of H_2O. Therefore the Lightning Creek HMBA is interpreted to have originated from a refractory mantle source that underwent melting through interaction with an enriched slab component. Our results indicate that in addition to slab-derived fluids, slab-derived melts also have an important role in the production of HMA and HMBA in the north Cascade Arc.

Keywords: High-Mg andesites, slab melt, clinopyroxene REE, Mount Baker, Glacier Peak