Goldschmidt 2022 Abstract
https://doi.org/10.46427/gold2022.11305

Olivine in primitive arc magmas from the Polaris Alaskan-type intrusion in the North American Cordillera

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Olivine from the Early Jurassic Polaris Alaskan-type ultramafic-mafic intrusion in the North American Cordillera displays a wide range of textures and compositions produced in a dynamic crystallization environment within a transcrustal magmatic system. The Polaris intrusion is an elongate, sill-like body in the Quesnel terrane and was emplaced during regionally extensive magmatism in the Late Triassic-Early Jurassic. Field relationships among ultramafic cumulates record periodic magma recharge, mingling, and mixing in a long-lived magma reservoir. Olivine compositions in dunite, olivine wehrlite, and wehrlite, are Mg- and Ni-rich (Fo_{92-87}, <3100 ppm Ni), and imply crystallization from near-primary arc magmas that experienced little fractionation prior to emplacement in the crust. Fo-Ni systematics of olivine from rocks ranging from dunite to magnetite-rich olivine clinopyroxenite (Fo_{84-79}, 275-550 ppm Ni) are consistent with the evolution of a common parental magma through fractional crystallization in a closed system. In contrast, Ni-rich olivine in magnetite-poor olivine clinopyroxenite (Fo_{84-81}, 1300-2100 ppm Ni) reflects mixing of primitive and relatively differentiated magmas. Olivine from the Polaris intrusion is Ca-poor (<1000 ppm, and mostly <500 ppm) compared to olivine from volcanic rocks globally, including those from subduction zone environments, and may reflect the effects of hydrous parent melt compositions, co-crystallization of clinopyroxene with olivine, and pervasive diffusional loss of Ca from olivine to interstitial melt. The lack of Fo-Ni-Mn zonation indicates effective re-equilibration of quickly diffusing divalent cations at high temperatures. Trace elements in olivine determined by LA-ICP-MS show increasing Mn, Co, and Zn with decreasing forsterite content. In contrast, Li, Al, Sc, Ti, V, and Cr do not vary systematically with forsterite content and may record compositional differences in the magma or olivine growth zonation preserved by slow diffusion timescales. The diverse chemical history of olivine in the Polaris intrusion indicates that these ultramafic rocks are the product of multiple magma pulses and their interactions in an evolving magma reservoir. The upper crustal emplacement depth (<12 km) of the Polaris Alaskan-type intrusion and presence of high-Mg olivine (up to Fo_{92}) requires relatively rapid ascent of primitive, unfractionated magmas through the crust.