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Sr and Y in clinopyroxene as indicators for magma-mush interactions in the ultramafic-mafic Tulameen Alaskan-type intrusion, North American Cordillera

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Clinopyroxene in the Tulameen Alaskan-type ultramafic-mafic intrusion is a powerful petrogenetic indicator for magmatic processes and preserves a record of mingling between discrete magmas in a subduction zone setting. The Tulameen intrusion is the largest Alaskan-type intrusion (>60 km^2) in the Canadian Cordillera and contains a diverse range of clinopyroxene-bearing rock types including dunite, wehrlite, olivine clinopyroxenite, hornblende clinopyroxenite/hornblendite, and monzonite/monzodiorite. Outcrop relationships between these rock types show evidence for melt-mush interactions in a mid-crustal magma reservoir, including dike-like and amoeboid bodies of dunite and wehrlite that crosscut olivine clinopyroxenite, hornblendite laminations in clinopyroxenite, and intermingled hornblendite and monzonite/monzodiorite. Trace element concentrations (LA-ICP-MS) of diopsidic clinopyroxene vary by up to three orders of magnitude when normalized to primitive mantle, highlighting the efficiency of primitive magma differentiation in arc systems. Trace elements Sr (highly incompatible) and Y (moderately incompatible) provide insights into the complex interactions indicated by field relationships. In olivine clinopyroxenite, a decrease in Sr/Y with decreasing Mg# is consistent with a differentiation history dominated by magma mixing. In the dike-like and amoeboid dunite-wehrlite bodies, Sr/Y ranges from 85 to values as low as 10, approaching those characteristic of monzonite/monzodiorite. The parent melts to these evolved rock types may have reacted with semi-consolidated olivine clinopyroxenite to produce these unusual magmatic structures. In hornblende clinopyroxenite and hornblendite, differences in clinopyroxene trace element concentrations define two distinct signatures: one characterized by low Sr (50-100 ppm) and variable Y (5-90 ppm) and the other marked by exceptionally high Sr (200-450 ppm). Primitive clinopyroxene cores in high-Sr hornblendites and monzodiorites suggest interaction between primitive crystal mushes and more highly evolved magmas. Petrographic evidence for late-stage replacement of clinopyroxene by hornblende reflects the transit of evolved residual liquids through a porous crystal mush. Distinct Sr and Y characteristics of clinopyroxene in hornblende-bearing rocks indicate that replacement processes may also exert a significant control on clinopyroxene chemistry. Clinopyroxene in the Tulameen Alaskan-type intrusion is an effective petrochemical tool for investigating the evolutionary pathways that primitive subduction zone magmas take as they transit from the mantle to the Earth's surface.