Olivine composition as a fertility indicator of mafic intrusions: Examples from Voisey's Bay and Pants Lake, Labrador

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The distribution of Ni-Mg-Fe in olivine is conventionally used to assess if sulfide saturation and segregation of a potentially economic sulfide liquid have occurred in a mafic intrusion. Despite the limited geochemical resolution of this traditional application, olivine multi-trace element studies have never been adopted to expand the geochemical sensitivity of olivine as tracer of multiple ore-forming processes.

We present major and trace element data (Ca, Sc, Mg, Si, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Sr, Y, and Zr) that show informative geochemical variability in olivine from both barren and mineralized olivine-gabbro and troctolite lithologies in the Voisey's Bay (VBI) and Pants Lake intrusions (PLI). Both intrusions have broadly similar lithologies and petrographic characteristics and are approximately coeval (1.34 Ga and 1.32 Ga, respectively) members of the Mesoproterozoic Nain Plutonic Suite. However, the VBI hosts a producing economic Ni-Cu-Co sulfide deposit, whereas in the PLI, although it displays evidence of Ni-Cu sulfide mineralization, a viable ore deposit has not yet been discovered.

In general the olivine chemistry in the VBI varies systematically – more primitive (~Fo_{77} , ~1,600 ppm Ni) in barren intervals, more evolved (~Fo_{62} , ~800 ppm Ni) in mineralized sections – with a pronounced increase in especially Mn (+~7,000 ppm) and Zn (+~350 ppm) towards the mineralized base of the intrusion. These, locally abrupt, changes in composition (also in, for instance, Co, Sr, and Y) indicate: (1) that olivine crystallized from separate pulses of magma with variable degrees of differentiation, and (2) that the Fe-Mn-Zn-rich olivine in the mineralized basal intervals crystallized from an increasingly country rock- contaminated, sulfide-saturated mafic magma. The distinct element signature of this latter olivine population can be used to infer the relative vertical proximity to massive sulfides and potentially predict if economic mineralization is expected in the proximity of a drill hole terminus in the VBI.

The olivine composition from the PLI is, compared to the VBI, fairly homogeneous and more evolved (~Fo_{60}, ~340 ppm Ni, ~4,300 ppm Mn, ~460 ppm Zn) with higher concentrations of incompatible elements (e.g., Ca, Sc, Ti, and Y). It also commonly lacks the mutually Mn-Zn-rich signature of olivine from the mineralized intervals in the VBI that is characteristic of contamination of the parent magma by country rock gneiss, and there reflects a close proximity to massive sulfides. As a result, the distinct chemical variations in olivine from the economic VBI (bimodality, primitiveness) and the presently sub-economic PLI (homogeneous, evolved) provide potential as a regional- scale mineralogical indicator of fertility in mafic intrusions.

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