An experimental investigation of the effect of country rock assimilation on chromite crystallization in the Ring of Fire, James Bay lowlands, Ontario, Canada

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The Ring of Fire Intrusive Suite (ROFIS) in the James Bay lowlands, Ontario, is emplaced into the 2.734 Ga McFauld's Lake greenstone belt, and hosts the Black Thor, Big Daddy, Blackbird, Black Label, and Black Creek chromite deposits, together comprising ~201.3 million tonnes of measured and indicated chromite resources. The formation process of these and other chromitites worldwide is still debated, with models for their petrogenesis including gravitational settling of liquidus chromite to the base of an evolving magma chamber, mechanical sorting of chromite from an olivine-chromite cotectic assemblage during flow, transient increases in pressure, addition of water to the magma, increase in oxygen fugacity, magma mixing between primitive and evolved magma, and contamination of a primitive magma by surrounding country rock during ascent and emplacement. Although this latter process is likely to widely occur, with evidence for this in the ROFIS context, its effect on chromite crystallization has not been experimentally tested. We have addressed this shortcoming in a series of experiments involving mixtures of synthetic komatiite and country rocks to the ROFIS (Fe-bearing sediment and granodiorite) to measure phase equilibrium, chromite solubility, and chromite composition. Experiments involved equilibrating synthetic komatiite (~2100 ppm Cr) containing 0–10% Cr-free contaminants on Fe-presaturated Pt loops at 1200–1450°C and 0.1 MPa at the FMQ oxygen buffer in a vertical tube furnace. In all cases, the addition of the contaminant lowered the chromium content of the melt at chromite saturation (CCCS), with the addition of the iron-bearing compositions having the largest effect. Increased contaminant content also decreased the olivine liquidus, as evidenced by an increase in modal melt content. The Mg# of experimentally-produced chromite (0.54–0.89) is uniformly higher than the Mg# of natural ROFIS chromite (0.12–0.54), whereas the Cr# [Cr/(Cr+Al+Fe^{3+})] of experimentally-produced chromite (0.21–0.60) is lower than the Cr# of natural ROF chromite (0.51–0.66). These results, combined with mass balance, suggest that the Cr content of the komatiite in experiments may be too low compared to values for the ROFIS parental magma, although the shift in Mg# seems consistent with assimilation of a Fe-bearing contaminant. Experiments are now in progress using more Cr-rich compositions to test this hypothesis.

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