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An experimental study of the effect of pressure on the formation of chromite deposits

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Despite extensive research on chromitites in the Bushveld Complex, the mechanism(s) that form such anomalous chromite segregations remains uncertain. Recent work applying the MELTS thermodynamic model proposed that reduction of pressure upon magma ascent shifts the silicate-in temperature to lower values, with the chromite-in temperature remaining unchanged, resulting in chromite-alone crystallization and formation of massive chromitites. We are evaluating this hypothesis through laboratory phase equilibrium experiments conducted at 0.1 MPa and 1 GPa, employing two bulk compositions. Composition 1 (C1) corresponds to a widely accepted parental magma of Bushveld chromitites, termed B1. Composition 2 (C2) is the same used in the MELTS modelling study, which contrasts with C1 most significantly in Al_2O_3 (17.4 wt% vs 11.8 wt% in C1), MgO (6.7 wt% vs 11.9 wt% in C1), and Cr (680 µg/g vs 970 µg/g in C1) contents. Thus far, experiments have been conducted at 0.1 MPa by mounting synthetic starting materials on Fe-Ir alloy wire loops and equilibrating them over the temperature interval of 1170-1340°C in a vertical-tube, gas-mixing furnace for 24-48 hours, at the FMQ buffer. Results indicate that the Cr# in C1 experimental chromite (0.65-0.75) is within the range of the most primitive chromitites (~0.65-0.76) found in the Lower Critical Zone of the Bushveld Complex. The Cr# of experimental chromite in C2 (0.6-0.62) is more consistent with chromitites in the Upper Critical Zone (~0.59-0.70). The C1 crystallization sequence agrees with that observed in the Lower Critical Zone with chromite + orthopyroxene on the liquidus at 1280°C. Composition C2 crystallizes chromite-alone at 1280°C, followed by plagioclase + chromite at 1200°C and plagioclase + chromite + orthopyroxene at 1170°C, which is more reflective of the dominantly noritic Upper Critical Zone. MELTS modelling reproduces the observed phase assemblages and crystallization temperatures to within 10-30°C, except that C2 chromite-alone crystallization begins at a higher temperature (1280°C) than predicted (1230°C). The Cr solubility modelled by MELTS is ~20-50% and ~70-85% higher at a given temperature than experimental values for C1 and C2 respectively. Experiments at 1 GPa using Fe-Ir capsules to buffer fO_2 are in progress to document the chromite-in shift with pressure.