Crystal settling and in-situ differentation by interstitial melt and fluid migration in a 45m mafic sill

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The Neoproterozoic Franklin igneous event is preserved as lavas, dikes, and laterally extensive sills on Victoria Island, NWT, Canada. Cores from four drill holes through a single 43 to 46m thick sill were split lengthwise, and ~0.5 m sections were homogenized for bulk rock analysis. The sill has a classic S-shaped profile when Mg# is plotted relative to height, and shows little change in thickness or internal stratigraphy along strike. The lower ~8m of the sill is a picritic gabbro and the upper ~37m of the sill, is a dolerite. Bulk rock Mg# reaches a maximum of 80 at the top of the picrite zone and a minimum of 35 at a "sandwich zone" 9 m below the upper contact. The % olivine in the picrite zone increases upward from a few % at the lower contact to ~55% at the top of the zone. The sill was emplaced as a series of at least three magma injections based on small Mg# "recharge" spikes observed at approximately the same horizon in all four sections. The average initial magma was a tholeiite with ~8.3% MgO and 6.5% olivine phenocrysts. MELTS (Ghiorso) calculates liquidus olivine (Fo83) followed by augite (Wo42:En48:Fs10), and plag (An78). Least-squares-fit models based on average microprobe analyses of olivine (Fo85), augite (Wo40:En51:Fs9), and plag (An71) suggest differentiation in the sill resulted from the initial settling of olivine phenocrysts followed by in-situ crystallization of augite, plagioclase, and olivine. Pigeonite, an interstital phase in the dolerite, is a late phase in MELTS and does not fit in the fractionation models. Upward migrating interstital melt was concentrated in the sandwich horizon where excluded element abundances are ~2X sill averages. Olivine at the top of the picrite zone, with the highest olivine/"trapped liquid" shows the most reequilibration because it had the lowest olivine/"migrating interstital melt". Calculated sill profiles match the observed element distribution for Si, Ti, Al, Fe, Mg, Ca, Na, P, Sc, V, Cr, Co, Ni, Cu, Sr, Y, Zr, Nb, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Hf, Th, and U. The distributions of Mn, K, Ba, and Rb do not fit the model and suggest redistribution by a late fluid phase that deposited these components 3-5 m below the upper contact, where the sill is observed to be vesicular.