From the mantle source to crustal sink: petrogenesis and sulphide saturation of the Central Lapland Greenstone Belt komatiites, Finland

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In northern Finland, the Central Lapland Greenstone Belt (CLGB) hosts widespread komatiites that formed ca. 2.05 Ga. The CLGB komatiites erupted mostly underwater on a sedimentary basin containing abundant sulphur-rich rocks. The komatiites are spatiotemporally and possibly genetically linked with the Kevitsa and Sakatti Cu-Ni(-PGE) deposits, which formed as the magmas assimilated the sulphur-rich crustal rocks. To help identifying chemical signs of assimilation-induced sulphide saturation in the natural rock record, we conducted computational simulations to constrain the komatiite petrogenesis from the mantle source to crustal sink. We calculated the parental melt composition (major elements, Ni, Cu, and REE) by adding olivine ("reversed fractional crystallization") to a chilled margin of a komatiitic dyke until the melt was in equilibrium with Fo_{92} olivine. We used REEBOX PRO together with data from mantle melting experiments to show that 15–20 wt.% melting of a pyrolytic mantle source is sufficient to generate the parental melt. Using the parental melt composition and the pressure-temperature conditions in the mantle, we calculated maximum sulphur solubility and constrained initial sulphur content of the parental melt to 750–1172 ppm. The estimated range in sulphur content is compatible with chromite melt inclusion data from the CLGB komatiites.

We simulated closed-system fractionation of the komatiitic parental melt (MgO = 20.6 wt.%) at crustal conditions using Magma Chamber Simulator. To evaluate the simulation results, we compiled a whole-rock and olivine chemistry database from literature and supplemented it with new whole-rock data of komatiites from Sattasvaara area of the CLGB. The CLGB komatiite data is largely compatible with closed-system fractionation of a single parental melt composition. The natural rocks represent either melt compositions or mixtures between melt and accumulated olivine ± Cr-spinel. Our simulations reproduce the most Ni-rich olivine compositions from Kevitsa and Sakatti and the slight variation can be explained as variable amounts of orthopyroxene fractionation in lower crustal level. Some olivine grains from Kevitsa and Sakatti have lower Ni content than predicted by the simulation, which we interpret as a sign of crystallization from a melt that had reached sulphide saturation (sulphides scavenge Ni causing the observed depletion in olivine). Depending on the initial sulphur content, the komatiite can precipitate Ni-rich (Ni/Cu = 1.9) or Cu-rich (Ni/Cu = 0.4) sulphides upon closed-system fractionation. The simulation results can be used as a baseline to identify chemical signs of early sulphide saturation in the CLGB komatiites and related intrusive rocks.