EGU25-10943, updated on 28 Nov 2025
https://doi.org/10.5194/egusphere-egu25-10943
EGU General Assembly 2025

Exploration potential of the Paleoproterozoic komatiites in the northern Finland: computational simulations applied to the Mineral System Approach

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Several Cu-Ni(-PGE) sulfide deposits, including the economically important Kevitsa and Sakatti, are present in the northern Finland. These deposits are related to a ca. 2.05 Ga magmatic event, which is characterized by widespread komatiitic magmatism. Sulfide saturation was reached locally by sulfur assimilation from black shales or anhydrites, which are common in the sedimentary basin hosting the magmatic rocks. Following the Mineral System Approach, we characterized the mantle melting and crustal fractionation conditions for these komatiites to estimate their exploration potential on the regional scale. To do this, we compiled a comprehensive whole-rock and olivine chemistry database and used computational simulations to quantitatively assess their formation. Using a chilled margin of a komatiitic dyke and most primitive olivine populations ($Fo_{92–94}$) from Kevitsa and Sakatti, we calculated parental melt compositions (MgO = 20.6–25.7 wt.%) for the komatiites. REEBOX PRO simulations indicate that a chemically homogeneous but thermally stratified (mantle potential temperature = 1575–1700 °C) plume from a depleted mantle source can produce the parental melts when the degree of partial melting is 14–22 %. The degree of melting is sufficient to completely dissolve sulfur from the mantle source based on sulfide saturation modeling. Compared to most Archean komatiites, the degree of melting is relatively low, which means that the parental melts of these Paleoproterozoic komatiites were less diluted in sulfur and metals. Fractional crystallization simulations conducted with Magma Chamber Simulator show that the parental melt compositions are compatible with the data from the natural komatiites. The MgO vs. Ni systematics of the simulated olivine are well compatible with most of the data from Kevitsa and Sakatti and highlight subpopulations of Ni-depleted olivine. The Ni-depleted olivine most likely formed from sulfide saturated melt, hence the simulated compositions can be applied for geochemical exploration. Sulfide saturation modeling indicates that, depending on the minor differences in the degree of melting or sulfur content of the mantle source, the sulfur content of the parental melt is about 110–800 ppm below sulfide saturation. Either Ni-rich or Cu-rich sulfide melt (Ni/Cu = 0.2–1.8) can precipitate from the fractionating melt without assimilation, whereas formation of more Ni-rich sulfides, as locally present in Kevitsa and Sakatti,

requires either early sulfide saturation, likely driven by the assimilation of external sulfur. Our simulations indicate that the Paleoproterozoic komatiites in the northern Finland have high exploration potential because they inherited high sulfur and metal contents from the mantle source and because they were relatively close to sulfide saturation during fractionation.