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# Compositional Variations of Olivine and Sulfur Isotopes in the Noril'sk and Talnakh Intrusions, Siberia: Implications for Ore-Forming Processes in Dynamic Magma Conduits

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## Abstract

Olivine from the Noril'sk I, Main and Northwestern Talnakh ore-bearing intrusions in the Noril'sk region occurs as inclusions, discrete grains, and poikilitic crystals. The original compositions of olivine inclusions have been well preserved by their host oikocrysts from reaction with interstitial silicate and sulfide liquids. In contrast, the compositions of discrete and poikilitic olivine crystals have been variably modified by reequilibration with trapped silicate and sulfide liquids. There are abrupt changes in the contents of nickel in olivine inclusions (500–1,500 ppm) between different rock units in all three intrusions, which indicates that the different rock units in these intrusions are not related to each other via in situ differentiation of a common parental magma but rather are consistent with separate pulses of magma with variable degrees of differentiation, possibly involving olivine crystallization and assimilation of siliceous crustal material in a staging chamber.

The $\delta^{34}S$ values of the samples with high sulfur contents (>800 ppm sulfur) from all three ore-bearing intrusions vary between 8 and 14 per mil. Two sulfur-poor samples (<600 ppm sulfur) from the Northwestern Talnakh intrusion yield $\delta^{34}S$ values of 1.5 and 3.6 per mil. These values are similar to the values of the sulfur-poor rocks from the ore-barren intrusions in the region and illustrate the fact that high sulfur contents couple with increasing $\delta^{34}S$ values. Such a relationship is consistent with the addition of crustally derived $^{34}S$-enriched sulfur to the magma of the ore-bearing intrusions.

In contrast to other models of sulfide segregation in closed systems, we propose that sulfide segregation occurred in an open system and the magma involved was undersaturated in sulfur and undepleted in chalcophile elements. We envision that the $^{34}S$-enriched sulfur was introduced via circulating fluids that transported sulfur from evaporite in the underlying sedimentary sequence to the magma in a dynamic magma conduit. The immiscible sulfide liquids that segregated during sulfur contamination settled down in the wider parts of the conduit as the magma continued to travel. Successive pulses of new magma entered the conduit, reacted with the early sulfide, and displaced much of the early magma in the conduit. The ore-bearing intrusions are thought to have crystallized within the wider parts of the conduits and their voluminous, sulfide-poor peripheral sills represent some (if not all) of the magma that flowed out of the conduits.

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