Formation of massive sulfides by magma-sediment interactions: The Noril'sk-Talnakh case-study

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We use thermodynamic calculations and experimental petrology to point out how high-temperature interactions between mafic and ultramafic magmas and volatile-rich sedimentary rocks (e.g. evaporitic or organic matter-bearing rocks) can (i) lead to a dramatic change in the redox state of the magma, (ii) increase its volatile content, and consequently (iii) impact ore forming processes associated to its emplacement in the crust.

Our modeling is based on gas-melt thermodynamic calculations that take into account S-H-O-C gaseous species at temperatures and pressures in equilibrium with mafic liquids [1]. The incorporation of sulfates into the magma increases its sulfur content, but also oxidizes it, making sulfide saturation unlikely. Extreme assimilations (> 5 wt% $CaSO_4$) can eventually lead to sulfate saturation in the magma. Conversely, the interaction with carbonaceous sediments induces a strong reduction of the magma, even for extremely low degree of assimilation (fO_2 decreases of 3 log units for 0.2 wt % organic matter assimilated).

We apply our modeling to the case of the Noril'sk-Talnakh district, where sulfate-rich evaporitic rocks and carbonaceous sediments represent the most common host rocks of the ore-bearing intrusions. In this case massive sulfide production is calculated as a consequence of S incorporation into the magma by assimilation of sulfates, followed by a substantial reduction of the magma due to assimilation of carbonaceous sediments.

We also illustrate this process by high temperature high pressure experiments simulating the interaction of picritic magma with coal or anhydrite. The experiments are conducted in internally heated pressure vessels using a picrite from Noril'sk 1 intrusion, coal and anhydrite from the Noril'sk area as starting materials.

We conclude that exceptional conditions favoring large assimilation of sediments are needed to form exceptional ore deposits like those of the Noril'sk-Talnakh district.

[1] Iacono-Marziano, Gaillard, Scaillet, Polozov, Marecal, Pirre, Arndt (2012b), *Earth and Planetary Science Letters* **357-358**, 319-326