Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.19757

The sulfide-fluid connection, from magmas to ore deposits

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Research studies provide growing evidence for the presence of fluids within magmatic mineral systems of mafic-ultramafic composition, although these ore-forming magmas are generally considered volatile-poor. Magmatic interaction with sulfur-bearing sedimentary rocks, for instance, introduces sulfur into the magma facilitating sulfide saturation, and concurrently produces an abundant fluid phase coexisting with the magma. We present an experimental study at magmatic conditions that shed light on physical and chemical processes ensuing from the association between sulfide melt and fluid phase in mafic-ultramafic magmas. The proportion of fluid phase, more than its composition, seems to control the implications of this association. When the amount of fluid phase is limited, physical processes dominate: the sulfide-fluid association favors the accumulation of the sulfide liquid, by facilitating the coalescence of the sulfide droplets that are attached to the same fluid bubble. This enables sulfide droplets coalescence and deposition in flowing magma, which otherwise have been shown to be unlikely processes. When the proportion of fluid phase increases, sulfur degassing to the fluid phase also increases, therefore reducing sulfide melt stability. Consequently, the sulfide melt is consumed and its metal content augments, due to the preferential partitioning of metals into the sulfide melt. Experimental samples with increasing fluid contents present increasingly Ni and Cu-richer sulfide melts, illustrating how metal enrichment of the sulfide melt can be attained by sulfur degassing. Moreover, extensive sulfur degassing may completely consume the sulfide melt and form platinum group minerals, while Ni and Cu are partitioned between the silicate melt and the fluid phase. These experimental results illustrate how the occurrence of a fluid phase in a mafic-ultramafic magma may represent a significant boost for magmatic sulfide ore forming processes: sulfide melt accumulation, tenor increase, and crystallization of platinum group minerals are indeed key processes in the formation of magmatic Ni-Cu-Co-PGE ore deposits. We use the world-class Noril’sk-Talnakh ore deposits, in Polar Siberia as a case study. In these ore-bearing intrusions (i) sulfide-fluid associations preserved in the magmatic rocks and (ii) ore type distribution within the intrusion strongly suggest that the processes described above occurred during magma emplacement.