

Hydromagmatic PGE telluride-rich Ni-Fe-Cu sulfide mineralization related to melt-rock reaction processes in presence of carbonated hydrous fluids: examples from sulfide-rich ultramafic intrusions of the Ivrea-Verbano Zone

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Keywords: Ni-Cu-PGE ore, magmatic fluids, carbonates.

The Ivrea-Verbano Complex hosts several ultramafic intrusions which are enriched in volatiles including carbon, like the sulfide-rich Valmaggia pipe and the Campello Monti intrusion. The Valmaggia pipe displays widespread intergrowths between peculiar, coarse nodular Ni-Cu-PGE sulfide mineralization, carbonates and the magmatic silicate-oxide assemblage. The latter bears evidence of melt-rock reaction process between a peridotitic protolith and a volatile-rich, percolating adakite melt (Sessa et al., 2017). The pipe displays progressive reaction fronts where augite, olivine, enstatite and Cr spinel were replaced by pargasite amphibole oikocrysts, enstatite II, phlogopite and Al spinel by reacting with plagioclase-rich hydrous metasomatizing melt at 5–8 kbar and 700–900°C. Both PGE-bearing sulfide mineralization and carbonates are strictly related to the metasomatic assemblage. Dolomite blebs are interstitial to silicates, but most carbonates occur as intergrowths with the sulfide nodules and their peculiar aureoles of sulfide-silicate symplectites. Carbonates often make up bubble-like meniscus aggregates along embayments of the sulfide nodules and vary in composition (Fe-calcite, dolomite, siderite) according to the nearby phase (silicates, sulfide). Ni-Fe-Cu sulfide nodules are often concentrically zoned, with FeS cores and Fe-Ni-Cu sulfide-rich rims. Pt-Pd tellurides only occurs along the nodule rims as well as in the Fe-Ni sulfide blebs of the nearby sulfide-silicate symplectite haloes, especially where sulfides are intimately intergrown with carbonates and hydrous silicates. Textural relationships suggest metal-rich sulfide (\pm telluride) melt segregation ensuing from sulfur saturation during melt-rock reaction and coexisting with immiscible C-bearing vapour. In this context Pt- and Pd telluride deposition appears to be favoured as a late crystallization product of the fluid-drenched sulfide melt blobs in hydromagmatic conditions. The Valmaggia carbonates do not show carbonatite-like trace element composition, but they display C and O isotope mantle-like signatures, as is the case for the carbonates from the pyrossenitic intrusion of, considered for comparison. The Campello Monti intrusion is highly mineralized in Fe-Ni sulfides, but it is low in hydrous silicates. Like at Valmaggia, carbonates are intergrown with sulfides and silicates (including amphibole) and also enclosed in olivine, although the abundant Fe-Ni sulfides are PGE-poor. This further supports the coupling of carbon and hydrous magmatic fluids (Boudreau, 2019) as a key factor for PGE mineralization.

Sessa G., Moroni M., Tumiati S., Caruso S., Fiorentini M. (2017) - Ni-Fe-Cu-PGE ore deposition driven by metasomatic fluids and melt-rock reactions into the deep crust: the ultramafic pipe of Valmaggia, Ivrea-Verbano, Italy. *Ore Geology Review*, 90, 485-509.

Boudreau A. (2019) - *Hydromagmatic processes and Platinum-Group Element deposits in layered intrusions*. Cambridge University Press.