Investigating formation of Ni-Cu-PGE mineralizations by black shale partial melting experiments

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Assimilation of S and C-bearing wallrocks is one of the most important processes related to formation of magmatic Ni-Cu-PGE deposits. Excess S derived from the wallrock enhances sulfide saturation in the magma, but the details of this assimilation process are poorly understood. In the 1.1 Ga Duluth Complex, Minnesota, mafic magma assimilated black shales of the Paleoproterozoic Virgina Formation, creating one of the largest, Ni-Cu-PGE mineralizations in the world. The predominantly disseminated-type sulphide mineralization occur systematically adjacent to the wallrocks and are often associated with abundant Virginia Formation xenoliths. The extent to which sulfur was derived from the wallrock is yet to be constrained. In addition, both fluid and melt phases have been suggested as the transport medium for the wallrock derived sulfur, but the relative magnitudes of these possibly partly contemporaneous processes require more accurate estimations.

In order to characterize the interaction between the magma and wallrock, we conducted partial melting experiments at 2 kbar, 700–1100 °C on a natural Virginia Formation black shale sample collected outside of the thermally altered contact zone of the Duluth Complex. The experiment P-T conditions are in agreement with conditions estimated for contact metamorphism of the Virginia Formation. Partial (silicate) melting becomes important at about 900 °C and sulfide droplets that probably represent immiscible melts are observed in the silicate melt at 1000 °C. Ni and Cu partition into these droplets providing a mechanism of initial concentration and extraction of the chalcophiles during (partial) assimilation of the wallrock. Our results will provide better constraints on how the magma-wallrock interactions influence formation of Ni-Cu-PGE mineralization not only in the Duluth Complex but in other similar igneous complexes as well.