

Controls on the Formation of Contact-Type Platinum-Group Element Mineralization in the East Bull Lake Intrusion

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Abstract

The East Bull Lake intrusion is the type example of a series of 2.48 to 2.49 Ga layered mafic intrusions that developed within the rifted southern margin of the Superior craton, central Ontario. The East Bull Lake intrusion contains contact-type PGE mineralization, e.g., strata-bound, PGE-rich, disseminated sulfide mineralization occurring within 200 to 300 m of the contact with footwall and sidewall units. Although the mineralization locally occurs in massive plagioclase cumulates (anorthosite zone), most of the sulfides are concentrated within an underlying, heterolithic, inclusion-rich unit (inclusion-bearing zone) that grades into an intrusive breccia. Disseminated sulfides also occur in fine-grained gabbroic veins within brecciated footwall rocks (border zone). Geochemical characteristics of the contact-type sulfide mineralization and its host rocks include: (1) high-average Pd abundances throughout the East Bull Lake intrusion, including an average of ca. 200 ppb in the Lower Series; (2) low-average S contents (typically <1%); (3) average Pd/Pt ~3 and Cu/Ni ~3; and (4) PGE concentrations and relative abundances similar to disseminated sulfide mineralization from the contact environment of other mafic-ultramafic intrusions.

Contact-type PGE mineralization in the East Bull Lake intrusion reflects flow-enhanced gravitational settling of a Cu-rich sulfide liquid followed by local fractionation of Ni-rich monosulfide solid solution to produce minor amounts of Cu- and Pt-rich, residual sulfide liquid. Most of the observed compositional variation in the sulfides can be modeled using variable silicate liquid/sulfide liquid mass ratios. Field and geochemical observations suggest that the parental magmas to the mineralized parts of the East Bull Lake intrusion were S saturated and PGE rich at the time of their emplacement. These fertile parent magmas most likely originated as buoyant, feldspathic residual magmas that escaped from a deeper, more primitive subchamber.

Although first described from the East Bull Lake intrusion, contact-type PGE mineralization is now recognized in all of the major East Bull Lake suite intrusions. Similar styles of magmatic sulfide mineralization are developed in the contact environments of the Bushveld Igneous Complex (Platreef deposits) and the Duluth Complex, Minnesota (e.g., Dunka Road deposit). These contact-type deposits are part of the family of "basal accumulation" magmatic sulfide deposits. The economics of low sulfide tenor, contact-type, PGE-Cu-Ni mineralization, such as that developed in the East Bull Lake intrusion will be most favorable in systems in which (1) the parent magmas possessed high initial PGE tenors and reached S saturation prior to emplacement; (2) the parent magmas experienced vigorous convection in the early stages of chamber development; and (3) segregated sulfide was not diluted by coprecipitating silicate minerals—a scenario that is most likely to occur in feldspathic magmas in which plagioclase is the principal high-temperature liquidus mineral.