

# Palaeoproterozoic Ni–Cu–PGE mineralisation in the Shakespeare intrusion, Ontario, Canada: a new style of Nipissing gabbro-hosted mineralisation

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The 2217 Ma Shakespeare intrusion is part of the extensive 2.2 Ga Nipissing gabbro suite and is hosted within 2.45–2.2 Ga Huronian Supergroup metasediments in the Southern Province of the Canadian Shield, close to the border with the Superior Province. The Shakespeare intrusion is a complex differentiated sill approximately 14 km in strike length and approximately 300 to 430 m in thickness. It comprises two distinct magmatic packages: (a) a Lower Group composed of unmineralised pyroxenite and gabbro, and (b) an Upper Group composed of Ni–Cu–PGE mineralised melagabbro, quartz gabbro, and biotite quartz gabbro-diorite. The Shakespeare intrusion formed from a tholeiitic parental magma. All of the rocks in the intrusion are enriched in highly incompatible lithophile elements (HILE: Cs, Rb, U, Th, Nb, Ta, LREE) relative to moderately incompatible lithophile elements (MILE: Zr, Ti, HREE) and are strongly depleted in Nb and Ti relative to elements of similar incompatibility. These geochemical characteristics suggest that the Shakespeare magma underwent extensive degrees of upper crustal contamination before emplacement. Although other parts of the Nipissing gabbro suite exhibit similar geochemical characteristics, the Shakespeare intrusion is more enriched in HILE and more strongly depleted in Nb–Ti, and therefore appears to have undergone greater degrees of crustal contamination. Heavily disseminated to patchy net-textured (10–15%) Fe–Cu–Ni sulphides (pyrrhotite–chalcopyrite–pentlandite) occur in the upper portion of the melagabbro of the Upper Group, near and at the contact with the overlying quartz gabbro, and in melagabbro dykes. This is a new style of magmatic Ni–Cu–PGE mineralisation in the Nipissing gabbro suite. The mineralised zone contains abundant inclusions of quartzite, blue quartz eyes and rare diorite. The ores have compositions consistent with having been derived from the Shakespeare magma and to have equilibrated at moderate magma/sulphide ratios (R5500–1000). The Ni–Cu–PGE mineralisation in the Shakespeare deposit appears to have resulted from the following processes: (a) generation of Nipissing magmas via partial melting of mantle peridotite, (b) contamination of Nipissing magmas by continental crust during ascent, (c) introduction and crystallisation of contaminated but sulphide-undersaturated magmas into the Shakespeare intrusion, forming the Lower Group, (d) additional, apparently relatively local, crustal contamination and sulphide saturation resulting in the incorporation of abundant xenoliths of country rocks and the generation of moderate amounts of Ni–Cu–(PGE) sulphide melt, and, (e) introduction of the xenoliths and sulphide-bearing magma into the Shakespeare intrusion, forming the Upper Group, with heavier sulphides settling at the base of the new crystallisation floor, resulting in low-moderate R factor values.