Geology, Petrology, and Controls on PGE Mineralization of the Southern Roby and Twilight Zones, Lac des Iles Mine, Canada

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Abstract

The Lac des Iles Pd mine, with reserves of 86 million metric tons (Mt) containing 1.51 g/t Pd, is hosted by the 2.69 Ga Lac des Iles intrusive complex in the southern Wabigoon subprovince of the Superior province of Canada. The known economic concentration of Pd occurs in the Mine Block intrusion, the central body of the intrusive complex, where gabbroic rocks range from leucogabbro to pyroxenite and show complicated textures, such as breccias, magma mingling, and pods and veins of pegmatite. The ore is characterized by low concentrations of sulfide (typically less than 3 vol %) and exceptionally high Pd contents (Pd/Pt ~10, Pd/Au ~13). Detailed mapping of the southern Roby and Twilight zones shows that early leucocratic rocks are barren and that the bulk of Pd was introduced by late melanocratic magmas. The average concentration of Pd in the melanocratic rocks, excluding the High-Grade zone, is estimated to be ~4 ppm. The concentrations of sulfur correlate positively with those of base metals, platinum group elements (PGE), and Au. Furthermore, sulfide grains commonly show exsolution textures. The evidence suggests a magmatic origin of the PGE mineralization where the PGE were concentrated in an immiscible sulfide melt in the parental magma.

Bulk chemical compositions suggest that all mafic igneous rocks in the mineralized zones, except for late clinopyroxenite, are cogenetic. The hypothetical parental magmas have high MgO and low (~15× chondrite), unfractionated rare earth elements (REE) with (Ce/Yb)chondrite <3, suggesting that the magmas formed through high degrees of partial melting in a moderately depleted mantle. Fractional crystallization of olivine, chromite, and high-temperature platinum group minerals (PGM) resulted in high concentrations of Pt, Pd, and Rh relative to Ir, Os, and Ru in the parental magmas. Extreme enrichment of Pd in the late melanocratic magmas is interpreted to have been attained through the incorporation of earlier formed sulfide melt. This interpretation is supported by high Cu/Pd in early barren leucocratic rocks and low Cu/Pd in fertile melanocratic rocks. Rocks in the volumetrically minor but economically important High-Grade zone (>35% of Pd in the deposit) on the eastern margin of the Roby zone have much higher concentrations of Pd than any other rocks and do not show correlations between sulfur and precious and base metals. Furthermore, the rocks are intensely and pervasively altered to actinolite, talc, anthophyllite, hornblende, chlorite, sericite, calcite, and quartz. These observations suggest subsolidus enrichment of Pd and mobility of S. The lack of apparent fluid pathways within the High-Grade zone and the distribution of the zone are consistent with the enrichment of Pd at high temperatures by fluids that originated from the mafic magmas.

The textures of the Lac des Iles deposit are similar to those of contact-type PGE deposits, but there are fundamental differences between the two. The Lac des Iles deposit is not localized near the contact between the host intrusion and the country rocks and evidence of the assimilation of the host rocks is lacking. Instead, the mineralization at Lac des Iles has many features in common with layered intrusion-hosted deposits, in which pulses of primitive magma introduced the PGE. Unlike the quiescent magma chambers of most layered deposits, the magmas at Lac des Iles were intruded energetically, forming breccias and magma-mingling textures.

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