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Using the High Mobility of Palladium in Surface Media in Exploration for Platinum Group Element Deposits: Evidence from the Lac des Iles Region, Northwestern Ontario

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Abstract

Platinium group element (PGE) mineralization is commonly accompanied by large amounts of Ni-Fe sulfides, which are explored for using a variety of geophysical and geochemical methods. Appreciation of a new type of PGE mineralization is emerging, hosted by gabbroic rocks with low concentrations (<5 vol %) of disseminated sulfides. The host rocks commonly display textural complexity, such as brecciation, pods and veins of pegmatite, and magma mingling of different lithological units. Examples include the Lac des Iles deposit in northwestern Ontario, the East Bull Lake suite in eastern Ontario, and several intrusions in the Kola Peninsula, and northern Finland. Such mineralization does not result in prominent geophysical and geochemical anomalies, thus posing a challenge for exploration. We initiated a project to develop new geochemical exploration approaches for such PGE deposits with low sulfides and selected the Lac des Iles district, northern Ontario, Canada, which contains one producing mine and many Pd showings. Mineralization is hosted by gabbroic rocks with low concentrations (<5 vol %) of sulfides. Enriched elements include Pd, Pt, Au, Ni, Cu, and Co. In separate sulfide-rich mineralization, base metals can be abundant, up to 1 wt percent, but Pd is insignificant (<200 ppb). This reduces the relevance of Ni, Cu, and Co as possible pathfinders for sulfide-poor PGE mineralization, leaving Pd, Pt, and Au.

A detailed study in the Baker zone at the Lac des Iles mine and the Legris Lake property indicates the essentially immobile nature of Pt in these surface environments. By contrast, Pd is depleted in B horizon soil, suggesting its removal during the conversion of C to B horizon soils. The loss of Pd in B horizon soil reflects the transport of Pd as neutral and anionic complexes, probably with OH^- and possibly with organic ligands, which are not adsorbed by Fe oxyhydroxides in the soils. Instead, Pd migrates in solution to accumulate in humus in swamps and organic-rich lake sediments downslope from mineralization. The distribution of Pd in humus, therefore, provides a distal indicator of nearby mineralization.

Total digestion of humus using fire assay or aqua regia yielded up to 160 ppb Pd, whereas a variety of commercially available leaching methods extracted few ppb Pd. The results indicate that Pd is tightly held in organic matter. This behavior of Pd contrasts with many metallic elements, such as Cu and Ni, that are enriched in B horizon soil and may be extracted by a variety of leaching techniques.

Palladium arsenides, tellurides, antimonides, and sulfides are unstable in weathering environments and their dissolution releases Pd to surface waters. Therefore, Pd can be used to indicate other PGE mineralization as it is always abundant among PGE. Where PGE mineralization is associated with high concentrations of Fe sulfides, their oxidation produces acidic waters, which further promotes Pd dispersion. Thus, the findings of this study are applicable to exploration for both sulfide-rich and -poor PGE mineralization.

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