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Geochemistry of the Dundonald Komatiite-Basalt Suite and Genesis of Dundeal Ni Deposit, Abitibi Subprovince, Canada

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Abstract

The genesis of komatiites, basalts, and associated Ni mineralization in the Dundonald township area, Ontario, is critical to understanding the metallogenic evolution of the Kidd-Munro assemblage, one of the most primitive volcanic assemblages in the world. The 2.5-km-thick stratigraphic succession has a basal calc-alkalic basalt-dacite-rhyolite sequence (2716.8 ± 2.1 Ma, U-Pb zircon) cut by the Dundonald peridotite-gabbro sill (2707^{-3}_{+5} Ma, U-Pb zircon), overlain by komatiitic and basaltic flows containing magmatic Ni sulfide mineralization, which are, in turn, overlain by chemically distinctive low Ti basalt flows. The Dundonald komatiites correlate with komatiites in the footwall of the giant Kidd Creek volcanic-associated massive sulfide deposit 40 km to the west, but are slightly older than the komatiites of Munro township which are 40 km to the east.

The Dundonald komatiites comprise a Munro-type, Al-undepleted komatiite suite, with liquid compositions having Al_2O_3/TiO_2 = 18 to 22 and MgO up to 30.3 wt percent (anhydrous, n = 24). Most samples in the komatiite suite have slightly depleted light REE contents, with La_N/Sm_N = 0.6 to 1.1 and La_N/Yb_N = 0.4 to 0.9 (n = 21), and negligible Ti/Ti* and Zr/Zr* anomalies. Their major and trace element geochemistry is consistent with a derivation by significant partial melting of a chemically primitive mantle with little or no influence of majorite garnet. Flows that are host to the Dundeal and Alexo Ni deposits have distinctively high Th_{PM}/Nb_{PM} ratios (>1.7, n = 3), suggesting crustal contamination, and peperite textures that are consistent with contamination from nearby graphitic argillite. The chemically distinctive low Ti basalts have 49 to 53 percent SiO_2, 4.5 to 9.5 percent MgO, 18.8 to 21.5 percent Al_2O_3, 0.30 to 0.37 percent TiO_2, moderately depleted light REE contents, with La_N/Sm_N = 0.9 to 1.2 and La_N/Yb_N = 0.4 to 0.6, high Ni, Cr, and Ba contents (570-6,800, 390-630, 90-320 ppm, respectively; n = 6). Their high Al_2O_3 contents place them in the calc-alkalic field on a Jensen cation plot, although their trace element ratios (Zr/Y, La/Yb) are more consistent with a tholeiitic affinity. They are compositionally identical to, and they correlate with, low Ti basalts in the Kidd Creek Volcanic Complex. Their geochemistry is consistent with a derivation by partial melting of a refractory harzburgitic mantle that has undergone a previous melt extraction, possibly influenced by a large ion lithophile-enriched hydrous phase.

The Empire flow is the thickest and most primitive komatiite flow and is host to the Dundeal Ni deposit (resource of ~0.4 Mt at 2.0% Ni). The Empire flow contains an elongate dunite-peridotite basal unit interpreted as the core of a flow that thermally eroded into footwall heterolithic breccias and pillowed andesites. The main Dundeal Ni horizon overlies part of the basal dunite-peridotite unit within the flow channel and extends over the cutbank wall. The Dundeal deposit and the nearby Dundonald South Ni deposit have low total sulfide contents and high Ni/S ratios (0.9 and 1.0, respectively) in comparison to most komatiite-hosted magmatic sulfide deposits. The high Ni tenor in sulfide is believed to be due to assimilation of reducing carbonaceous sediment which causes greater Ni partitioning into the magmatic sulfide phase.