

Ni-Cu-(PGE) Mineralization in a Continental Back-Arc Setting: The Riwaka Complex, New Zealand

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Magmatic Ni-Cu-(PGE)-sulfide deposits rarely form in convergent tectonic environments; however, deposits in this type of setting are becoming increasingly recognized as an important economic resource. The ca. 364 Ma Riwaka Complex of northwest Nelson, New Zealand, is a SSW-striking, faulted, elongate intermediate-mafic-ultramafic intrusive body ca. 50 km long and ≤ 6 km wide. Nickel-Cu mineralization was discovered in 1967, initiating exploration by a succession of companies, lasting into the late 1970s. The mineralization is disseminated pyrrhotite-chalcopyrite-pentlandite-pyrite-PGE, with highest grade drill hole intersections of 2.20% Ni over 1.4 m, 1.42% Cu over 0.6 m, and 1.044 ppm total PGE over 0.6 m. Sulfide concentrations are greatest in hornblende-bearing gabbros, with locally up to 50% sulfide minerals, ranging from disseminated blebs to abundant, net-textured cumulate sulfides enclosing silicate minerals.

New geochemical and geochronological data constrain the nature of the mantle sources and magmatic processes responsible for the formation of the Ni-Cu-(PGE)-sulfide mineralization. Major and trace element trends, zircon Hf isotope data, and contemporaneous A-type magmatism reveal that the Riwaka Complex was emplaced in a post-orogenic extensional back-arc setting along the paleo-Pacific margin of Gondwana. Associated subduction assemblages have apparently been excised, but possible late Devonian correlatives occur along the paleo-Gondwana margin in Queensland. Because of the association with continental margin arc magmatism, this study contributes to the lesser studied, but economically important, class of Ni-Cu-(PGE) sulfide deposits formed in convergent margins.

Generation and emplacement of ultramafic magmas enriched in PGE, Ni, and Cu were possible due to this arc extensional setting where high heat flow facilitated production of high degree mantle melting. The complex consists of multiple vertically emplaced ultramafic-gabbroic and pyroxene-hornblende-biotite-bearing diorite-monzodiorite intrusions that can be subdivided on the basis of chemistry into two distinct geochemical groups. Crosscutting intrusive contacts indicate ultramafic peridotite and pyroxenite and associated sulfide mineralization in the narrow south of the complex (largely representing geochemical group 1) were emplaced first within the magma conduit system, followed by later and stratigraphically higher gabbroic and dioritic intrusions to the north (group 2).

Primary melts (group 1) were generated by partial melting of a heterogeneous mantle source (E-MORB, N-MORB and OIB) and a young mafic underplate. Initial primary magmas were tholeiitic, sulfur-undersaturated and enriched in Ni, Cu and PGE, and were vertically emplaced within a sheeted magma conduit system. Crystal fractionation, accumulation, magma mixing, and minor crustal contamination of primary magmas induced sulfur saturation of the melt, resulting in crystallization of Ni-Cu-PGE sulfides within hornblende-bearing clinopyroxenite and gabbro cumulates, followed by Cu-Fe-S (PGE-poor) mineralization. The more evolved gabbroic and dioritic rocks of group 2 are characterized by calc-alkaline to weakly shoshonitic chemistry, and are interpreted to have been emplaced within a higher-level magma chamber. The Riwaka Complex represents a small, sulfide-rich Ni-Cu-(PGE) mineralized system, similar to Alaska-type complexes, and may be an economically important reservoir of PGE mineralization.