U-Pb zircon and Sm-Nd isotopic constraints for the timing and origin of magmatic Ni-Cu-PGE deposits in northern Fennoscandia

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At present, U-Pb zircon age determinations are available for more than 100 mafic intrusions from Northern Finland alone. While this data yield almost continuous spectrum of ages between 1.8 Ga and 2.6 Ga, six distinct magmatic episodes stand out at 2.0 Ga, 2.05 Ga, 2.12 Ga, 2.15 Ga, 2.21, and 2.44 Ga. One in particular, seems to have been the most favorable for saturation of magmatic sulfides and formation of economic Ni-Cu-PGE deposits. The 2.05 Ga ultramafic complexes were emplaced soon after the deposition of the Savukoski volcanosedimentary sequence, containing komatiites and carbonaceous phyllites, onto rifting Archean basement.

The Kevitsa Complex which hosts a large, disseminated, Ni-Cu-PGE resource (M+I at 0.1% Ni cut-off: 237 Mt @ 0.29 Ni, 0.41 Cu, 0.60 g/t ∑PGE+Au) that is currently being mined by FQML belongs to the 2.05 Ga age group. The intrusion consists of co-tectic olivine-clinopyroxene-orthopyroxene-(chromite) cumulates and mineralization occurs as distinct ore types. Olivine-pyroxenite rocks yield a U-Pb zircon age of 2058 ± 4 Ma; confirmed by a Sm-Nd whole rock-mineral isochron age of 2049 ± 26 Ma (εNd = -3.4, n = 23). Samples from “Ni-PGE ore” yield much lower initial εNd values: whole-mineral isochron age is 2069 ± 31 Ma (εNd = -6.4). Sm-Nd analyses on adjacent schists and hornfels provide εNd(2.05 Ga) values from -3.7 to 6.8 thus ranging between the Kevitsa main suite and the Ni-PGE ore.

Current work in progress imply that 2.05 Ga event is more widespread within the Central Lapland nickel province than previously assumed. New age determinations from Moskuvaaara, Satovaara, and Puijärvi intrusion all yield ages close to 2.05 Ma. The Kevitsa Sm-Nd range is unique (εNd = from -3.4 to -6.4) compared to the un-mineralized intrusions which give initial εNd values close to zero. Age data are not available from the host rocks of Sakatti Ni-Cu-PGE deposit, but apparent similarities with Kevitsa suggest that it may well belong to the same age group. The Sm-Nd range (εNd (2 Ga) from -3.4 to -6.4) is remarkably similar to Kevitsa implying a significantly enriched component in the magma.

The 2.05 Ga event seems to represent a major metallogenic episode. In the Northern Fennoscandia Shield, crustal contamination was critical for magmas to reach sulfide saturation and produce magmatic Ni-Cu-PGE sulfides. Uncontaminated intrusions remain barren. Decoupling of the Sm-Nd and sulfur isotope systems imply that the contaminant was not local sulfidic black shales, but instead was Archean basement providing LREE and silica, but no external sulfur. Increasing evidence suggest that the 2.05 Ga event is a significant global magmatic metallogenic event. Other c. 2.05 igneous complexes hosting major Ni-Cu-PGE resources include Bushveld, Molopo Farms, and Utikcomst in South Africa, as well as Voronezh in Russia and the Booth River Complex in Canada.