Petrogenesis of the Ferrogabbroic Intrusions and Associated Fe-Ti-V Mineralization Within the McFaulds Greenstone Belt, Superior Province, Ontario, Canada

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The McFaulds Lake area (also known as the Ring of Fire) has been the site of considerable exploration within northern Ontario. The McFaulds greenstone belt is located within the western portion of the 2.83 to 2.71 Ga Oxford Stull Domain within the North Caribou terrane. The area represents a recently discovered Archean greenstone belt, which is host to world-class chromite deposits, a major magmatic Ni-Cu-PGE deposit, and significant Cu-Zn VMS and Fe-Ti-V occurrences. The Thunderbird and Butler intrusions of the McFaulds belt are variably well layered gabbroanorthosite intrusions with abundant Fe-Ti oxides, termed the ferrogabbro. The layers are characterized by partial to complete cycles which are composed of basal massive oxides (magnetite-ilmenite) which grade into semimassive oxide units, followed by oxide-rich pyroxenite/melagabbro/gabbro, oxide-poor melagabbro/gabbro/leucogabbro, and topped with oxide-free leucogabbro/anorthosite. The cycles range from centimeters to meters in thickness and typically exhibit sharp upper and lower contacts with gradational internal contacts and define the well-layered portion of the intrusions. The intrusions contain broad intervals of disseminated magnetite-ilmenite (2–5%) hosted in melagabbro/gabbro/leucogabbro/anorthosite, which range in thickness from meters to tens of meters. The layering observed within the ferrogabbros is thought to be the result of intermittent convection currents with periods of quiescence, which resulted in the observed textures and cumulate phases.

The ferrogabbro intrusions are characterized by gently sloping LREE and flat HREE patterns, and generally positive ε_{Nd} values. This geochemical signature is most similar to that of E-MORB and is interpreted to represent the interaction of a mantle plume with MORB-like mantle material under the McFaulds Lake greenstone belt. The plume-related magmas likely differentiated into a primitive ultramafic portion and an evolved mafic portion, similar to the model proposed for the Emeishan plume in SW China. The petrogenesis of the evolved mafic melt is thought to have undergone a two-stage process. The first stage is characterized by a system that was closed to oxygen, anhydrous, and reduced, and underwent crystallization of Fe-poor mineral phases (e.g., olivine, plagioclase), which resulted in an Fe-rich residuum. The second stage is characterized by shallow emplacement above the garnet stability field within a system partially open to oxygen, which allowed the magma to initiate the crystallization of Fe-Ti oxides. The onset of magnetite-ilmenite crystallization would reverse the evolution from Fe-Ti enrichment to a system that would follow an anorthositic-granitic evolutionary trend. It is possible that the same mantle plume which differentiated the ferrogabbroic intrusions also produced the voluminous Cr-Ni-PGE–mineralized ultramafic intrusion (e.g., Eagle's Nest, Black Thor) and resulted in a thinned lithosphere which facilitated the coequal Cu-Zn VMS occurrences at circa 2735 Ma.