

# The East Bull Lake Intrusive Suite: Remnants of a ~2.48 Ga Large Igneous and Metallogenic Province in the Sudbury Area of the Canadian Shield

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## Abstract

The 2.49 to 2.475 Ga intrusions of the East Bull Lake intrusive suite occur in an east-northeast-trending discontinuous belt along the presently exposed boundary between the Archean Superior and the Proterozoic Southern provinces of the Canadian Shield near Sudbury, Ontario. The East Bull Lake intrusive suite is part of a regional Paleoproterozoic magmatic event, extending from 2.49 to 2.44 Ga, which also includes bimodal volcanic rocks, felsic plutons, and the regionally extensive Hearst and Matachewan dike swarms. This regional magmatic event is thought to be the result of a mantle plume-driven, intracontinental rifting event that led to the development of a major basin to the south that was subsequently filled by sedimentary rocks of the Huronian Supergroup. The East Bull Lake intrusive suite appears to have been emplaced along a major axial-rift fault related to this rifting event.

Compelling field and geochemical evidence summarized here indicates that the three largest East Bull Lake suite intrusions, the East Bull Lake, Agnew Lake, and River Valley intrusions, crystallized from similar, low Ti, high Al tholeiitic parent magmas that originated in deeper, more basic chambers. It is proposed that the primary magmas for the East Bull Lake suite intrusions were second-stage melts derived from a sublithospheric depleted mantle source that had been modified by Neoproterozoic subduction and accretion events.

Most of the petrological characteristics of the East Bull Lake suite intrusions reflect plagioclase-dominated fractional crystallization that generated a pronounced Fe enrichment trend in the residual magmas. Orthopyroxene is the high-temperature pyroxene and occurs as a cumulus phase through most of the stratigraphy of each intrusion of the suite. Local olivine-rich cumulates, present in all of the major East Bull Lake suite plutons, in some instances appear to be comagmatic with associated plagioclase-rich cumulates. A distinctive marginal facies, comprising brecciated and locally thermally recrystallized and/or partially melted footwall rocks, is a common feature of the East Bull Lake suite plutons and indicates that a high-energy flow regime existed during the initial stages of emplacement. This marginal unit typically grades into a heterolithic, inclusion-rich gabbro that contains erratically distributed mafic autoliths and footwall-derived xenoliths. Chemical contamination of the mineralized matrix of these inclusion-bearing rocks can be extreme at a local scale. The inclusion-rich zone is overlain by a thick interval of undifferentiated, plagioclase-rich cumulates that locally display spectacular glomerocrystic textures. Rhythmically and irregularly, modally layered leucogabbro and gabbro make up much of the middle parts of the stratigraphy. Massive to crudely layered ferrogabbro and ferrosyenite only occur in the uppermost part of the Agnew Lake intrusion. Varitextured gabbro and pegmatitic gabbro occur as irregular layers and local veins and pods throughout the stratigraphy.

The East Bull Lake suite is currently being explored for contact-type platinum-group element (PGE)-Cu-Ni mineralization that has a clear spatial association with orthopyroxene-rich cumulates which are otherwise poorly represented in these intrusions. Disseminated PGE- and Cu-rich sulfide mineralization is concentrated within the inclusion-bearing zones but extends upward into overlying plagioclase cumulates and appears to have collected along the lower margins of these intrusions through the combined action of vigorous convection of the resident magma and downward percolation of dense, mafic residual liquid. The resultant narrow zones of sulfide mineralization were thus derived from a much larger volume of parent magma. Feeder dikes to the mineralized parts of the intrusions appear to have been saturated in sulfide upon emplacement and had relatively high background PGE contents compared to those for other known magmatic PGE deposits; however, the economic potential of the contact-type mineralization hinges on the efficacy of the physical concentration process, which upgraded the metal content and size of the original sulfide particles inside the magma chambers. Based on the proposed basal accumulation model, the best prospective mineralization is most likely to occur in embayments along the sidewall and floor of the intrusions.

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