

Model Number A-21: Gabbro-Anorthosite-hosted Iron-Titanium-(Vanadium-Chromium-Phosphorus)

Synonym: Mafic-(ultramafic) intrusion-hosted Fe-Ti-(V-Cr-P).

Concise Description: Magmatic iron and titanium oxide mineralization within differentiated gabbro-anorthosite-norite intrusions.

Geological Environment

Host Rock Types: Massive, layered or zoned intrusive complexes of anorthosite, norite, and gabbro. Common associated rocks include diorite, diabase, and basal ultramafic intrusive rocks. The two general subtypes are: 1) ilmenite subtype of anorthosite-hosted Ti-Fe and 2) titaniferous-magnetite subtype of gabbro-anorthosite hosted Fe-Ti.

The Triangle Lake deposit in the La Ronge Domain is the only well-recognized significant example in the province. It is associated with the Bassett Lake Pluton, a layered complex of gabbro, olivine gabbro, magnetite-rich gabbro, peridotite and pyroxenite, including norite and anorthosite phases. Other prospective intrusive complexes include the Clearwater Anorthosite Complex in the Taltson Domain, and the Swan River and Porter Bay mafic complexes of the Peter Lake Domain.

Rock Textures: Characterized by primary magmatic textures, which may include cumulate, ophitic, subophitic, diabasic, equigranular, and rare pegmatitic textures. Cumulate layering is often present.

Ages of the Host Rocks and Mineralization: On a world scale, dominantly Precambrian, but may be of any age. The host rocks and mineralization are cogenetic. The Triangle Lake deposit is Paleoproterozoic. The prospective Clearwater Anorthosite Complex is <1.985 to >1.917 Ga, and in the Peter Lake Domain, the Swan River and Porter Bay complexes are *ca.* 2.56 Ga and 1.92 Ga, respectively.

Depositional Environment: As gabbro-anorthosite-norite complexes that were intrusive into metavolcano-sedimentary, granitic, and gneissic settings. The intrusions were emplaced at relatively deep crustal levels. Differentiation of residual fluids from the fractionating magmas resulted in late-stage intrusions that were enriched in Fe and Ti oxides and apatite. Layers formed from crystal settling and cumulate deposition in response to gravitational processes. Disseminated deposits formed *in situ*.

Tectonic Setting: General association with extensional and/or anorogenic tectonic settings. The large complexes are related to deep-seated, extensional tectonics and mantle plume magmatism. Many deposits may occur in elongate belts of intrusive complexes that were emplaced along deep-seated faults. Some Fe-Ti deposits are related to magmatism in continental margin arcs.

Associated Deposit Types: Mafic-ultramafic intrusion-hosted Ni-Cu-(PGE); PGE; and chromite; and Fe-Ti oxide placers.

Deposit Description

Mineralogy: Principal minerals include ilmenite, Fe-bearing ilmenite, Ti and V-bearing magnetite, magnetite, and titanhematite. Accessory minerals may include rutile, sphene, spinels, apatite, sulphides, and garnet.

Textures and Styles of Mineralization: Often stratabound to stratiform, conformable to primary layering. Deposits may occur as massive lenses, layers, pods, sills, dykes, and irregular intrusions; and as bodies of disseminated and interstitial oxide minerals. Exsolution intergrowths of ilmenite and magnetite are characteristic.

Alteration: None related to the mineralization.

Geological Ore Controls: 1) gabbro-anorthosite-norite intrusive complexes and stocks, generally of Precambrian age; 2) common associated deep-seated, extensional faults; 3) late-stage Fe and Ti oxide enrichment and primary cumulate magmatic processes to concentrate oxide minerals; 4) concordant and discordant styles of mineralization; 5) ilmenite deposits (subtype 1) are generally associated with the lower magnesian content phases of anorthositic intrusions; 6) titaniferous magnetite deposits (subtype 2) have a general association with the magnesian phases of anorthositic intrusions or gabbroic phases near the margins of the intrusion; and 7) in layered intrusions the titaniferous magnetite layers are commonly located in the upper levels, and in marginal zones of complex intrusive bodies.

Geochemical Signature: 1) elevated Fe, Ti, V \pm P in the host sequence and 2) Fe-Ti oxide-rich surficial material including placers.

Geophysical Signature: 1) airborne and ground magnetic surveys; magnetite concentrations are represented by strong magnetic highs, massive ilmenite bodies are often characterized by magnetic lows, and mafic intrusions are generally represented by broad magnetic highs and 2) massive oxide bodies would be represented by gravity highs.

Examples (with grades and tonnages)

World examples include the Bushveld Complex, South Africa; Lac Allard, Quebec; Sanford Lake, New York; and Ural Mountains, Russia.

The only well-defined example in Saskatchewan is the Triangle Lake deposit in the La Ronge Domain with an estimated historical resource of about 27 million tonnes grading <20% Fe and 2% Ti (Harper, 1983; SMDI 0819).

The Clearwater Anorthosite Complex in the Taltson Domain is prospective for this deposit type. At the Patzer Lake platinum showing (SMDI 2480) in the Complex, magnetite and/or ilmenite pods and bands are described. Disseminated magnetite is common in the Complex. The Clearwater River occurrence (SMDI 1094) is proximal to this Complex and contains about 10% disseminated magnetite over a large area in granitic to dioritic and charnockitic rocks. Some chip samples averaged 6.6% Fe and 0.9% Ti and Harper (1983) estimated in excess of 270 million tonnes of low-grade material.

The Swan River and Porter Bay complexes of the Peter Lake Domain contain large volumes of gabbroic rocks, including anorthositic gabbro, that comprise the mafic component of an Igneous Province. Although there are no known significant examples, these mafic complexes should be prospective for this deposit type.

Selected Bibliography

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