Explore Minnesota: COPPER, NICKEL, PGEs

Geology

Minnesota's known copper-nickel±platinum group elements deposits that have received the most attention, including the several deposits now being considered for possible near-term development, are located within the 1.1 billion-year-old Duluth Complex, (Fig. 1) one of the great mafic igneous complexes of the world. The Duluth Complex is the major intrusive component of the Midcontinent Rift, a failed, horseshoe-shaped, intracontinental rift system that is exposed in the Lake Superior Region.

The Duluth Complex is not a single layered igneous intrusion, e.g., the Bushveld of South Africa; rather, it is a composite mass of smaller intrusions all closely related in space and time that were emplaced into the basal section of comagmatic volcanic rocks of the rift. The currently known deposits occur in two crudely layered intrusions, the South Kawishiwi and the Partridge River. With the exception of the South Filson Creek deposit, major deposit areas (currently eight) occur in these intrusions within 500 meters of their basal contact with Paleoproterozoic sedimentary rocks and Archean granites (Fig.1). The South Filson Creek deposit appears to be a later stage mineralizing event and is generally above the basal zone.

Other Potential Targets

In addition to targets within the Partridge River and the South Kawishiwi intrusions, there are many unexplored targets in the other intrusions that compose the Duluth Complex (Fig.1). Several of these are better layered and might host Skaergaard-type PGE reef mineralization, while others may host basal contact-type mineralization. There may also be as yet undiscovered outlying intrusions related to the Midcontinent Rift, i.e., the Eagle intrusion hosting the Eagle and East Eagle massive copper-nickel-PGE deposits in northern Michigan and the Tamarack Ni-Cu-PGE deposit on the Aitkin/Carlton county line SW of Duluth, MN, both discovered by Rio Tinto's Kennecott Minerals.

The potential for Cu-Ni±PGE deposits in mafic intrusions outside of the rift system is not well known. The Minnesota Geological Survey has completed a four-year study of outcrop, drill core, and geophysical data to inventory the occurrences of mafic and ultramafic intrusions outside the Duluth Complex (Fig. 2). Using geochemical and lithologic data, these intrusions have been evaluated as to their mineralization potential.

The known Duluth Complex deposits have been estimated to contain 4 billion tons of copper-nickel ores with co-product PGE, Au, and Co.

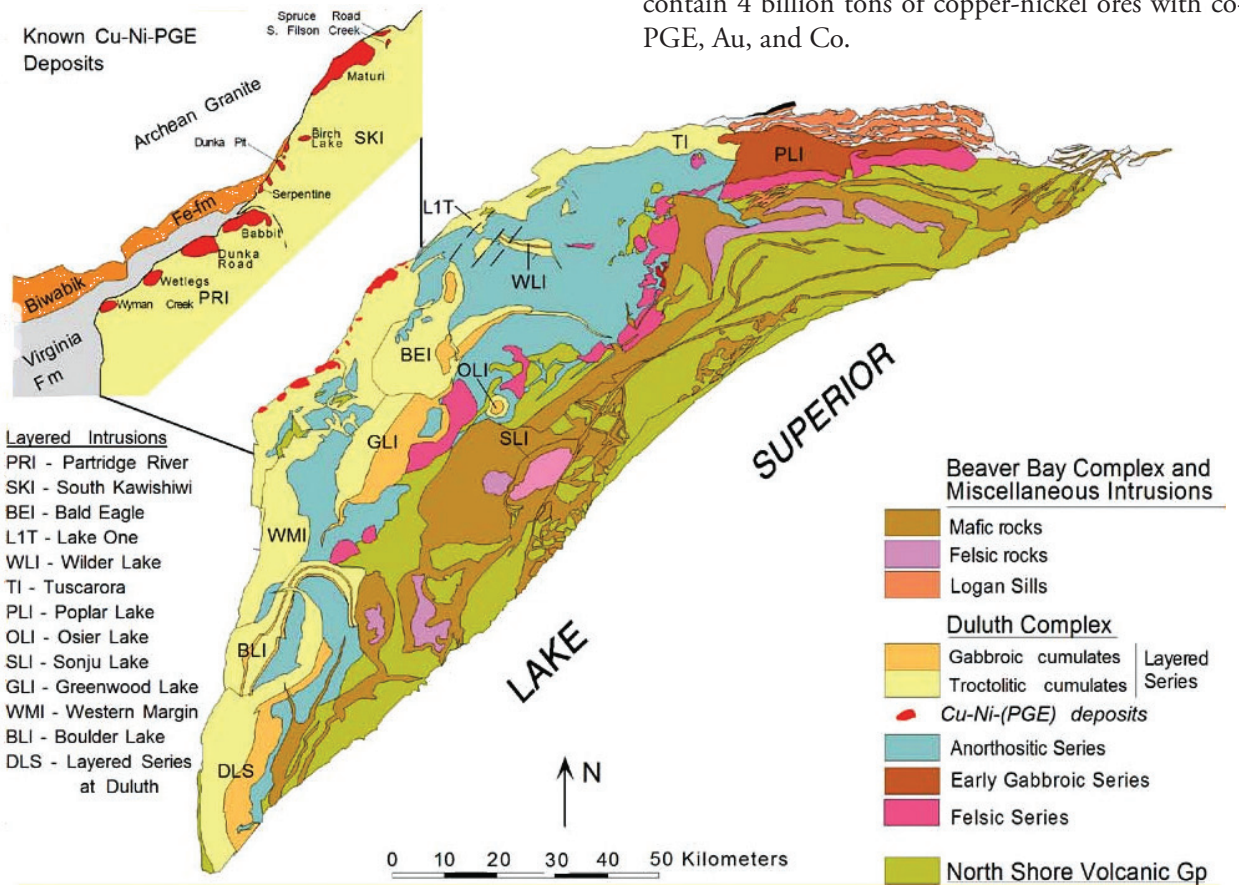

Figure 1. Generalized Duluth Complex geology with inset illustrating the known basal Cu-Ni plus or minus PGE deposits

History of Exploration

Though occurrences of copper had been noted in earlier years, serious exploration of Minnesota's copper-nickel resources did not begin until about 1950 following the discovery of mineralization during the blasting of a road cut in the Duluth Complex rocks along the Spruce Road (Fig. 1 inset & Fig. 3). During the ensuing 25 years, considerable exploration was carried out by a number of major mining companies along the basal contact of the Complex. Over 2,000 core holes were drilled by various explorers, generally close to the basal contact. Most of the deposits known today were identified at that time and considerable work was done to try to develop them.

In 1974, the state instituted a moratorium on further leasing, and a generic environmental impact statement on copper-nickel mining and processing. This moratorium lasted until 1980. After removal of the moratorium, some renewed work was carried on, mainly by AMAX. However, declining copper prices and the failure of conventional flotation processes, i.e., to be able to produce a suitably high-grade bulk concentrate or satisfactorily clean separate copper and nickel concentrates prevented the production of an economically acceptable product for conventional smelting. During all of this period, the generally low-grade PGE values were ignored because analytical techniques were difficult and only reported total PGE values.

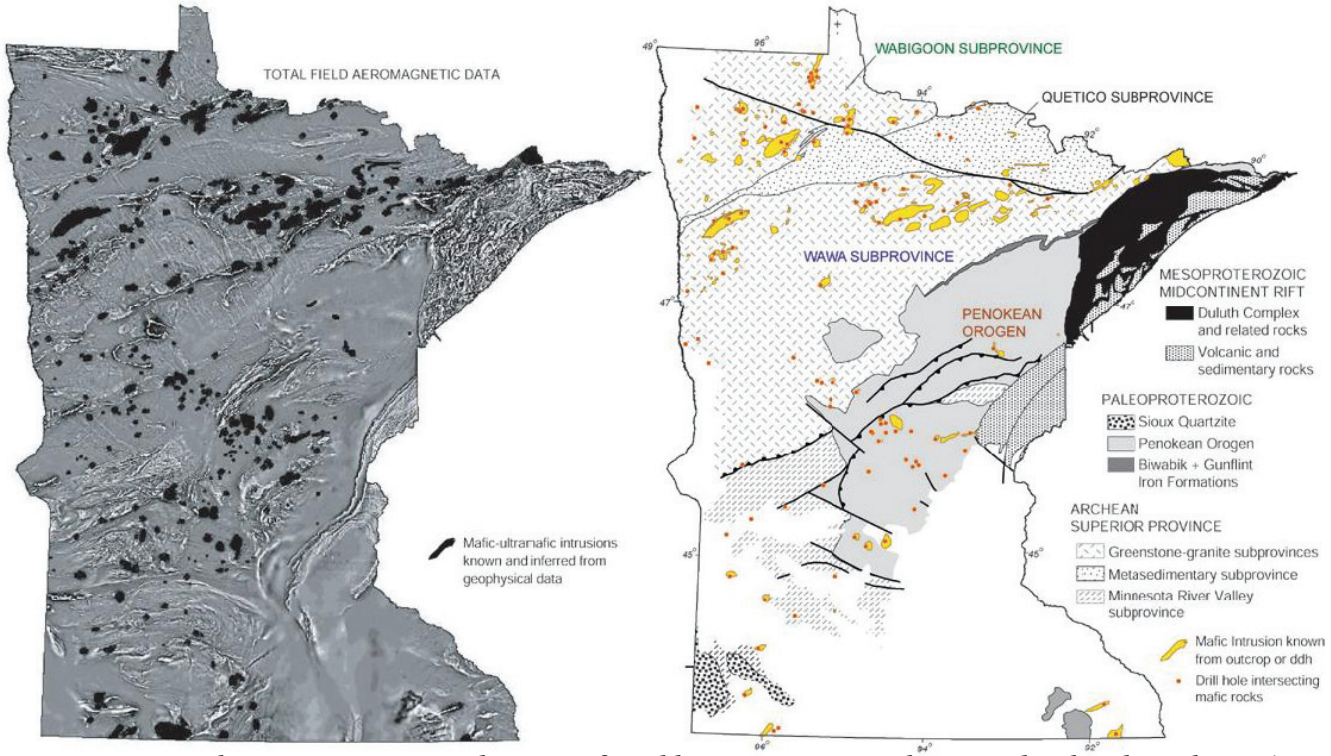

Fig. 2 Statewide aeromagnetic map showing inferred basic intrusions and a generalized geological map (on right) also showing the basic intrusions.

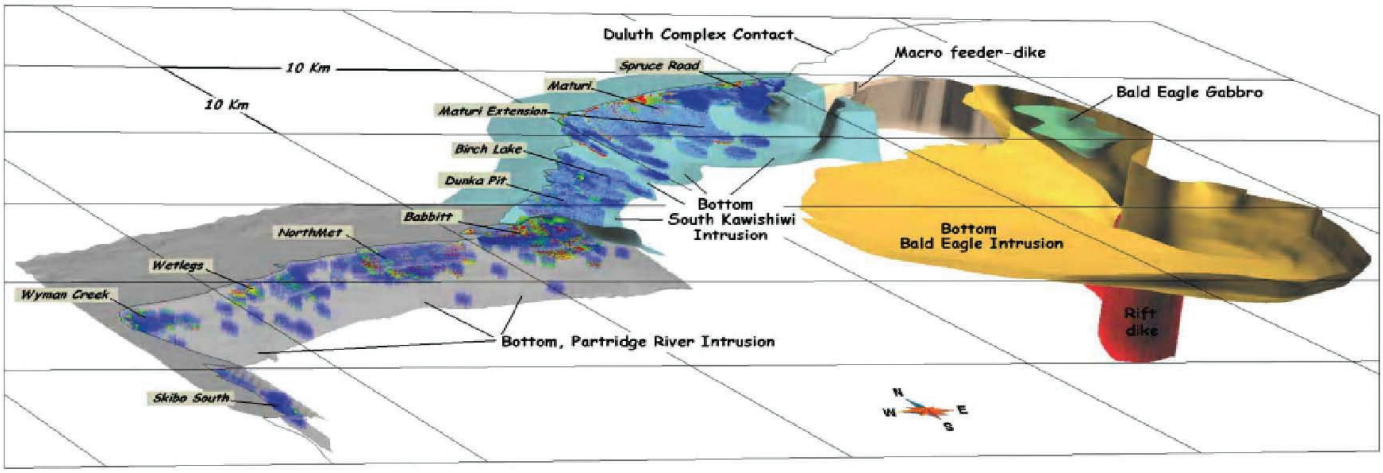

Fig. 3 Active Cu-Ni-PGE projects.

Discovering Significant PGEs

In 1985, the Minerals Division (now Lands and Minerals Division) of the state's Department of Natural Resources undertook a program of assaying old drill cores for vanadium, chromium, and PGEs. In the course of this sampling, a seven-foot zone of significant PGEs was discovered in one hole drilled by Duval in the 1970s. This announcement and rising interest in PGEs for catalytic converters triggered a short period of PGE exploration, but since the PGEs were associated with copper and nickel, the metallurgical puzzle remained. PGEs now added possible value not previously recognized to the deposits.

Solving the Metallurgical Puzzle

In the mid-1990s, solutions for the metallurgical puzzle began to appear on the horizon as hydrometallurgical processes advanced. Work by Teck Ltd. in Vancouver, B.C. resulted in the development of CESL, a proprietary pressure oxidation leach plus SXEW process that can extract the Cu, Ni, and Co from a bulk flotation concentrate. It was tested on the Mesaba (Babbitt) deposit ores and has been recently pilot plant tested in Brazil. A second proprietary process, PlatSol™, which extracts both the base and precious metals, has been developed in conjunction with PolyMet's exploration and development of the NorthMet (Dunka Road) deposit. It has been pilot plant tested on Minnesota's ore deposits, as has Teck's CESL process.

With the key metallurgical puzzle now apparently solved, the door is open to economic development.

Active Cu-Ni±PGE Projects

PolyMet Mining

PolyMet, (NYSE-AMEX: PLM) and Toronto Stock Exchange (TSX: POM), completed a feasibility study in 2006 and is working towards obtaining permits to develop the NorthMet deposit as a 32,000 tpd open pit with approximately a 1.4:1 life-of-mine stripping ratio. The NorthMet reserve is 274.6 million tons proven and probable at 0.30% Cu, 0.08% Ni, 73 ppm Co, and 0.37 ppm Pt + Pd + Au. Overall, the defined resource is 694 million tons measured and indicated at 0.27% Cu, 0.08% Ni, 71 ppm Co, and 0.34 ppm Pt + Pd + Au, plus 230 million tons inferred at 0.27% Cu, 0.08% Ni, 56 ppm Co, and 0.37 ppm Pt + Pd + Au. The company has ownership of the former LTV taconite processing plant, tailings ponds, and associated infrastructure. PolyMet plans a mix of hydrometallurgical processing and concentrate sales. An agreement is in place with Glencore to purchase product from the project. The Draft EIS is under review, with the Final EIS and permits to mine expected in 2010. Construction will begin in late 2010, and production is expected in late 2011 or early 2012.

Duluth Metals

Duluth Metals is a company focused on exploring and developing its Nokomis Cu-Ni-PGE property in northeastern Minnesota. Duluth Metals has conducted a significant drilling program, has completed three NI-43-101 compliant resource estimates, two scoping studies, multiple metallurgical tests, and its working toward a pre-feasibility study. Recently, a JV was formed with Antofagasta plc of Chile.

Franconia Minerals Corporation

At the Birch Lake deposit, Franconia Minerals Corporation, a TSX listed company, is evaluating the potential viability of an underground mine with a production rate on the order of 7 million metric tonnes per year. The orebody would be developed from vertical shafts and is expected to be mined by mechanized bulk mining methods. The NI-43-101 compliant indicated and inferred resources of Birch Lake are 131 m tonnes of 0.56% Cu, 0.20% Ni, 0.01% Co, and 0.99g/t Total PGEs and 37.5 m tonnes of 0.55% Cu, 0.17% Ni, 0.1% Co, and 0.84g/t Total PGEs, respectively.

Franconia Minerals also controls the Maturi and Spruce Road Cu-Ni deposits. The Maturi deposit was extensively drilled and explored by INCO prior to 1974. INCO also sunk an exploration shaft with limited underground workings. The inferred resource of the Maturi underground mine is 119.9 m tonnes of 0.67% Cu, 0.25% Ni, 0.02% Co, and 0.39g /t Total PGEs.

Spruce Road was also extensively drilled by INCO before 1974. The Spruce Road open pit has a NI-43-101 compliant indicated resource of 128.7 m tonnes of 0.39% Cu and 0.14% Ni, and an inferred resource of 28.4 m tonnes of 0.23% Cu and 0.09% Ni. The inferred Spruce Road underground resource is 124 m tonnes of 0.59% Cu and 0.21% Ni.

Teck American

Teck American, a subsidiary of Teck Ltd., holds leases on the largest known deposit in the belt, the Mesaba (or Babbitt) deposit, which lies between the NorthMet and Birch Lake deposits. The CESL hydrometallurgical process was developed to treat ores that are not amenable to conventional concentration and pyrometallurgical processing such as those from the Duluth Complex. In 2008-09, the company has collected a new bulk sample and did CESL testwork on concentrates produced at Natural Resources Research Institute (NRRI) Coleraine Minerals Research Laboratory in Coleraine, MN. The deposit is reported to contain about 800 million tonnes open pit ore with 0.43% Cu and 0.11% Ni plus a small amount of Au and PGEs, and also about 400 million tonnes of underground ore with a grade of 0.84% Cu and 0.19% Ni.

Infrastructure

Minnesota is a mining state. It hosts about 75 percent of the U.S. domestic iron ore production, and iron has been mined here for well over 120 years. Its iron (taconite) mines annually move on the order of 240 million tons of material per year to produce about 40 million tons of high-grade iron pellets. As a result, there is skilled mining labor and the needed suppliers of mining goods and services. Minnesota has two deep-water ports on Lake Superior, providing access to world markets. Power lines, railways, and highways reach most areas. A high standard of education is accessible to employees.

Land and Mineral Ownership

The right to explore and mine a property is obtained by leasing the mineral rights for a parcel. Mineral ownership may be held by the state, the federal government, private individuals or corporations. The state is the largest owner of mineral rights, holding about 12 million acres or 20% of the total state land area. It has in place a system of leasing state minerals for exploration and mining. The federal government also holds a large acreage of surface and minerals, mainly in the northeast and north central part of the state. An exploration or mining company can obtain mineral leases directly or there are businesses that will provide the service to assist in obtaining mineral leases.

Taxation

The state of Minnesota levies two taxes specific to non-ferrous mineral production: an "Occupation Tax" that is essentially the same as the corporate income tax and has an effective rate of 2.45% of taxable income after depreciation and depletion. The second tax is a 2% "Net Proceeds Tax" that is levied on income before interest, depreciation, depletion, and royalties. It is in lieu of an *ad valorem* tax on ore reserves. Most mining equipment is exempt from the sales tax. The county and municipality levy an *ad valorem* tax on buildings, but there is no personal property tax on mining or processing equipment.

Regulation and Permitting

The two principal regulatory and permitting authorities are the state's Department of Natural Resources and the Pollution Control Agency. Exploration drilling requires notice to the MN Department of Health and an exploration plan to the MN Department of Natural Resources.

Rules for permitting non-ferrous mining operations have been in place for over 15 years. For commercial operations, the rules require a mandatory Environmental Impact Statement before the approval of any permits. The major issues will generally relate to water, sulfide-bearing mine wastes, and, in some cases, air emissions. A high level of environmental standards is desired by the state, and the history of the mining industry in Minnesota demonstrates that conditions can be satisfactorily met.

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