

Explore Minnesota: COPPER, NICKEL, PGEs

Several known copper-nickel±PGE deposits are associated with the 1.1 billion-year-old Midcontinent Rift, a failed, horseshoe-shaped, intracontinental rift system (Figure 1). In Minnesota, copper-nickel±PGE mineralization is associated with the Duluth Complex (Fig. 2), and the Tamarack Intrusive Complex, located one hundred kilometers west of the City of Duluth. The Duluth Complex is the major intrusive component of the Midcontinent Rift, and one of the great mafic igneous complexes of the world. The 18km-long Tamarack Intrusive Complex hosts a high-grade magmatic nickel-copper±PGE deposit within a geologic setting similar to the Eagle Mine's high-grade copper-nickel-PGE deposits in northern Michigan (Fig. 1).

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 three crudely layered intrusions, the South Kawishiwi, Partridge River, and Bathtub.

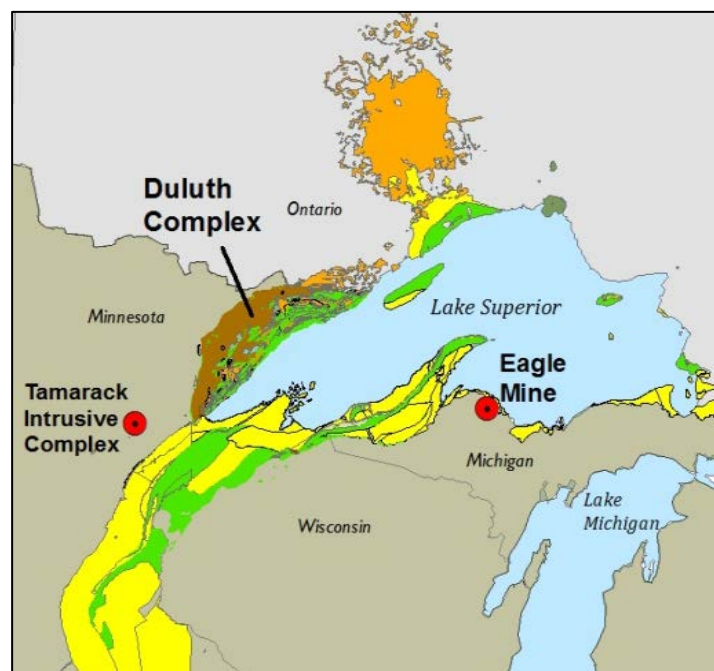


Figure 1: Relative Positions of the Duluth Complex, Tamarack Intrusive Complex, and Eagle Mine within the 1.1Ga Midcontinent Rift

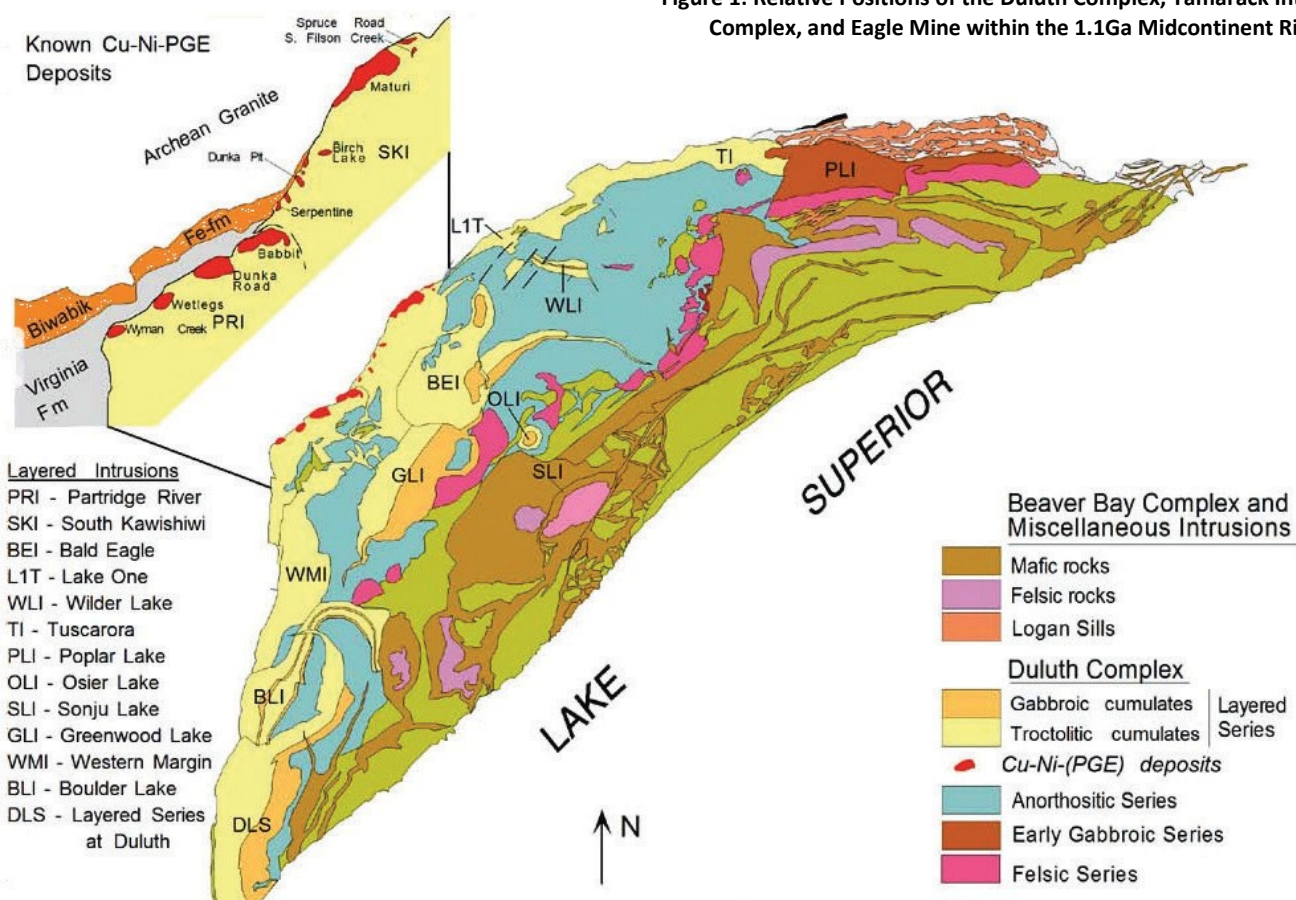


Figure 2. Generalized Duluth Complex geology with inset illustrating the known basal Cu-Ni±PGE deposits (from [Miller et al., 2002](#))

Unexplored or Underexplored Targets

In addition to Duluth Complex targets within the Partridge River, Bathtub, and South Kawishiwi intrusions, there are many unexplored targets in the associated intrusions (Fig.2). Several of these are better layered and might host Skaergaard-type PGE reef mineralization, while others may host contact-type mineralization. The possibility of undiscovered outlying intrusions related to the Midcontinent Rift, similar to the Tamarack Intrusive Complex and its high-grade Ni-Cu-PGE deposit also exists.

Historical mineral exploration programs have investigated the potential for Cu-Ni±PGE deposits in mafic intrusions outside of the rift system, particularly within the southern portions of the Archean Superior Province's Wawa and Wabigoon granite-greenstone terranes that extend across the international border from Northwestern Ontario into Northern Minnesota (Fig. 3). The Minnesota Geological Survey 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. Using geochemical and lithologic data, these intrusions have been evaluated as to their mineralization potential.

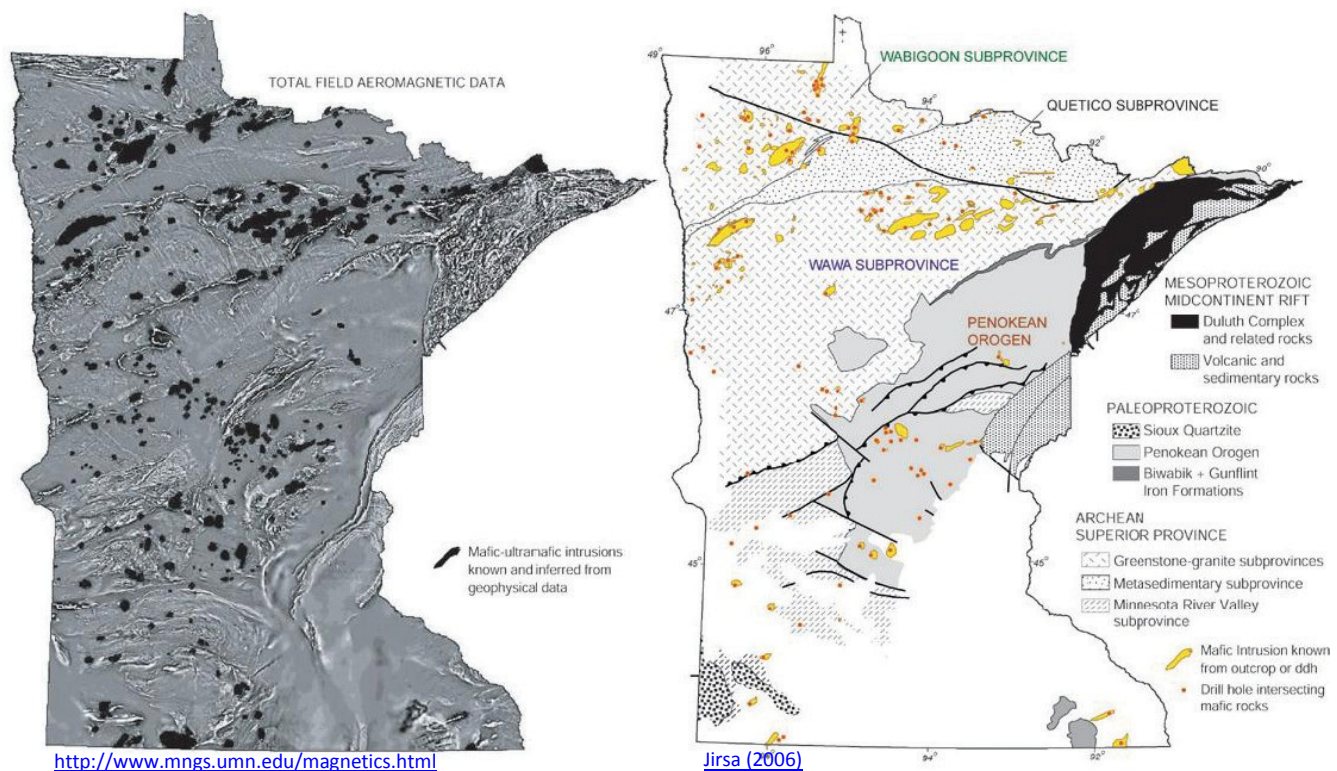
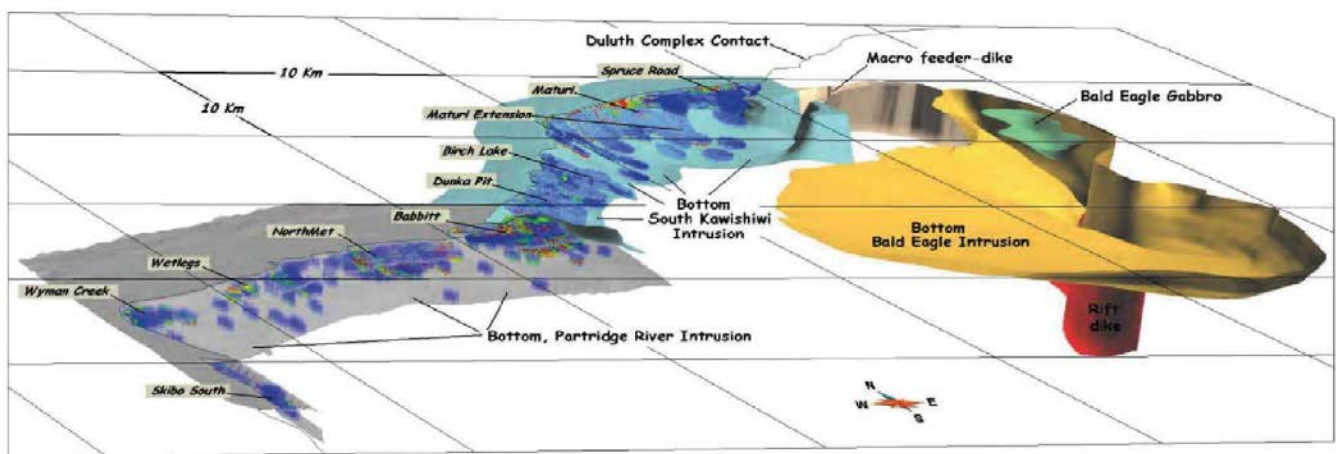


Fig. 3 Statewide aeromagnetic map showing basic intrusions and a generalized geological map (on right) also showing the basic intrusions.



Three-dimensional depiction of Cu-Ni-PGE deposits within the Duluth Complex.

Active Cu-Ni±PGE Projects

PolyMet Mining

PolyMet Mining, Inc. (PolyMet) is proposing to develop a mine and associated processing facilities for the extraction of copper, nickel, and platinum group elements (PGE) from the NorthMet Deposit in northeastern Minnesota. The mine would be the first of its kind in the state.

The proposed NorthMet mine project would be located in the St. Louis River watershed on the eastern edge of the Mesabi Iron Range, about 6 miles south of Babbitt and about 1 mile south of the existing iron-ore Northshore Mine. Processing of the ore would take place at a former industrial site, the LTV taconite processing plant in Hoyt Lakes. The total project area would include the open pit mine, a processing plant, tailings basin, and an existing 7-mile-long railroad/utilities corridor for the transportation of ore between the proposed mine and existing processing facility.

The Final Environmental Impact Statement (FEIS) for the NorthMet project was released in November 2015. The FEIS generated more than 30,000 comment submissions during the public review period that ended in December 2015. The Minnesota Department of Natural Resources is considering the comments received as the agency works to develop a record of decision and make an adequacy determination on the FEIS. If the FEIS is determined to be adequate, the environmental review process would be complete and the project would be able to [transition](#) to the permitting phase.

Twin Metals Minnesota, LLC

Twin Metals Minnesota, LLC, a subsidiary of Antofagasta Plc, with offices in St. Paul, Ely and Babbitt, MN, is pursuing the development and operation of an underground copper, nickel, platinum, palladium, gold and silver mining project in northeast Minnesota. Twin Metals Minnesota's property interests include four mineral deposits with NI 43-101 reports: Nokomis, Maturi, Spruce Road and Birch Lake.

A NI 43-101 compliant Prefeasibility Study Technical Report (PFS) for the TMM project was published by Duluth Metals on October 9, 2014. In January 2015, Antofagasta completed a \$US85M friendly acquisition of Canadian exploration company Duluth Metals Ltd., its former joint venture partner in the Twin Metals Minnesota (TMM) project. Prior to this acquisition, Antofagasta had owned 10% of Duluth Metals stock, and a 40% stake in the TMM project.

Teck American

Teck American, a subsidiary of Teck Ltd., holds leases on the largest known deposit in the belt, the Mesaba deposit, which lies between the NorthMet and Birch Lake deposits. The deposit is historically reported (within a non- NI 43-101-compliant report) to contain about 800 million tonnes of 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. 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 collected a new bulk sample and did CESL testwork on floatation sulfide concentrates produced at NRRI's Coleraine Minerals Research Laboratory in Coleraine, MN.

Kennecott Exploration and Talon Metals

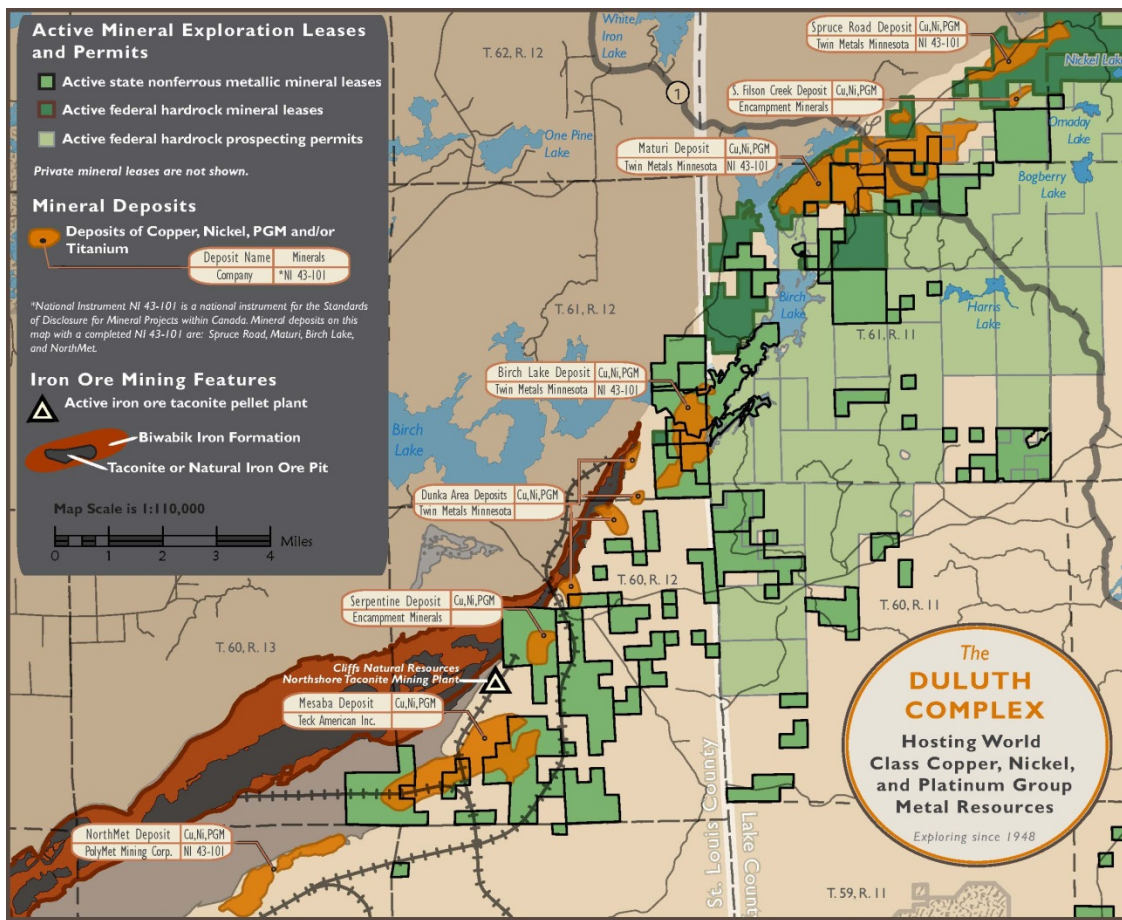
Kennecott Exploration Company first intersected disseminated nickel-copper mineralization within the Tamarack Intrusive Complex in 2002. Significant high grade nickel-copper mineralization was first intercepted in 2008. Kennecott's exploration program at Tamarack included a wide range of geophysical surveys and, up to the Summer of 2015, 199 exploratory boreholes totaling more than 76,000 meters.

In November 2015, Talon Metals Corp, through its subsidiary Talon Nickel (USA) LLC, announced that it had secured the required financing to complete its 2014 earn-in agreement with Kennecott Exploration Company (Kennecott) for a minority interest in the Tamarack Nickel-Copper-PGE Project.

A new zone of high grade Ni-Cu-PGM mineralization was recently discovered, through step-out drilling and downhole electromagnetic surveys during the 2015 Winter drilling campaign. The "221 Zone" is located approximately 2km north-east of the main ore body (as described in an October 2014 NI 43-101 compliant technical report). The new mineralized zone is being further tested during the current Winter 2016 drilling program of 10-20 drill holes, downhole EM surveys, and ground geophysics.



**Exploration Drilling at the
Tamarack Ni-Cu-Pt Project**



For more information:

Jess Richards, Director

Division of Lands and Minerals
Minnesota Department of Natural Resources
(651) 259-5379
jess.richards@state.mn.us
www.dnr.state.mn.us

Harvey Thorleifson, Director

Minnesota Geological Survey
(612) 626-2150
thorleif@umn.edu
www.mnngs.umn.edu

George Hudak

Director, Minerals-Metallurgy-Mining Program
Natural Resources Research Institute
(218) 788-2739
ghudak@d.umn.edu
www.nrri.umn.edu

Dan Jordan,

Mining & Reclamations Program Supervisor
Iron Range Resources and Rehabilitation Board
(218) 254-7007
dan.jordan@state.mn.us
www.mn.gov/irrrb

Laurence Reszetar

Director of Foreign Direct Investment
MN Dept. of Employment and Economic Development
651-259-7488
laurence.reszetar@state.mn.us

Bob Wagstrom

Engineering Specialist
MN Dept. of Revenue - Minerals Tax Office
(218) 744-7420
bob.wagstrom@state.mn.us

Eric Wirz, Forest Geologist

USDA Forest Services (218) 626-4382
ewirz@fs.fed.us
www.fs.fed.us