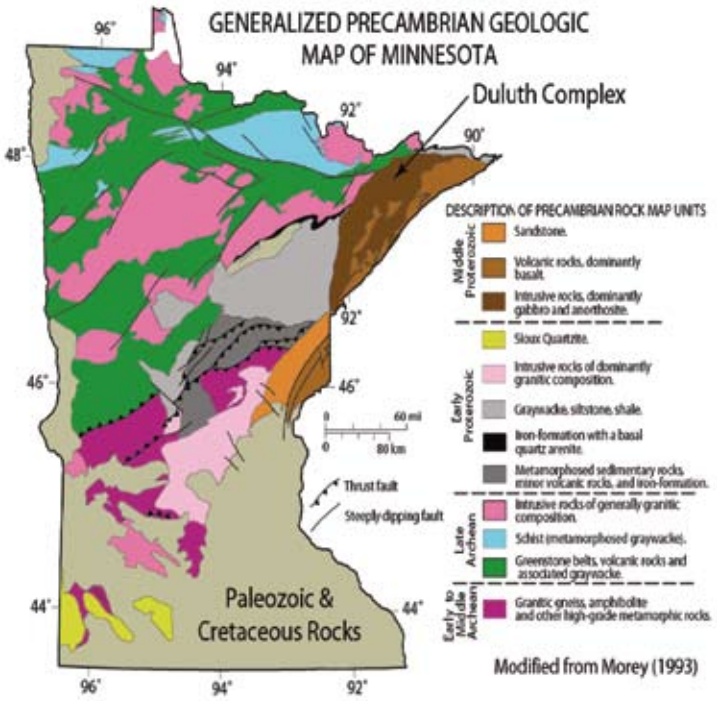
Explore Minnesota: TITANIUM

Titanium Uses

Northeastern Minnesota has potential ilmenite-rich deposits associated with the gabbroic intrusive Duluth Complex. Titanium oxide produced from the minerals ilmenite, rutile, leucoxene, and synthetic rutile is the predominant white pigment used in paints, paper, and plastics in a multi-billion dollar market in the United States. In addition, titanium is also essential to aerospace, military, and medical applications. In 2003, ilmenite accounted for 93 percent of world titanium mineral production (5.3 million tons), with most of the supply coming from Australia, South Africa, and Canada.



Titanium in Minnesota

Deposits of copper-nickel (± platinum group elements) have been recognized since the 1960s in the basal contact zone along the western margin of the Duluth Complex. Exploration of these deposits continues, and one deposit, the NorthMet deposit of PolyMet Mining Corporation, is currently in the permitting and mine-planning phase.

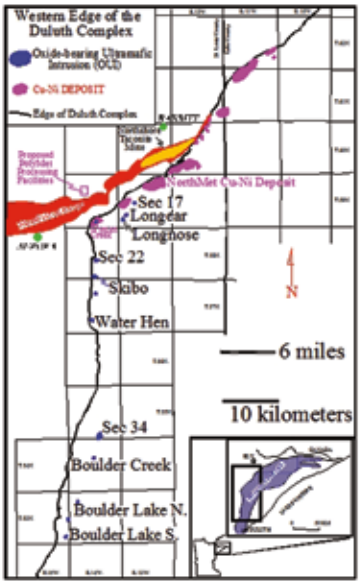
In addition to the copper-nickel deposits, several oxide-rich ultramafic plugs were also discovered along the western margin of the Complex in the 1960s; these plugs are late in that they intrude the Duluth Complex and are referred to as Oxidebearing Ultramafic Intrusions (OUI). At least 13 OUI bodies have been outlined by limited drilling. The titanium potential of the OUI was not recognized until the 1970s, and drilling to date is only sufficient to define TiO_2 resources for two of the bodies: Longnose (11 drill holes - 50 million tons averaging 21% TiO_2) and Water Hen (37 drill holes - 62 million tons averaging 14% TiO_2). Almost all of the OUI are close to the surface and would be easily amenable to open pit mining with minimal stripping of overburden. Some of the OUI have Cu-NI±PGE credits; however, others contain minimal amounts of sulfides. The OUI are extremely low in co-products (U, Th, Zr, REEs) that are typically associated with currently mined placer titanium deposits.

Mineralogy

Photomicrographs of titanium ore (from left to right): 1) subround ilmenite (reflectedlight); 2) plagioclase, olivine and titanium oxides (polarized light); and 3) magnetite with ilmenite lamellae and ilmenite (reflected light).

Titanium minerals in the OUI consist of intergrown coarse-grained ilmenite and titanomagnetite; in some groups of OUI ilmenite is dominant, whereas titanomagnetite is dominant in others. Oxide content in the OUI is variable and ranges from 15% to 100% in localized massive oxide zones. Thick massive oxide zones are common to the Longnose deposit, which has been described by BHP as being "The largest, highest grade deposit of near-pure ilmenite in North America."

Following is a listing of TiO_2 and Vanadium values in the known OUI. Note that the OUI have been historically undersampled and that in the table, the average TiO_2 listings are not calculated for ore zones and include an unknown proportion of lean ore and waste rock.



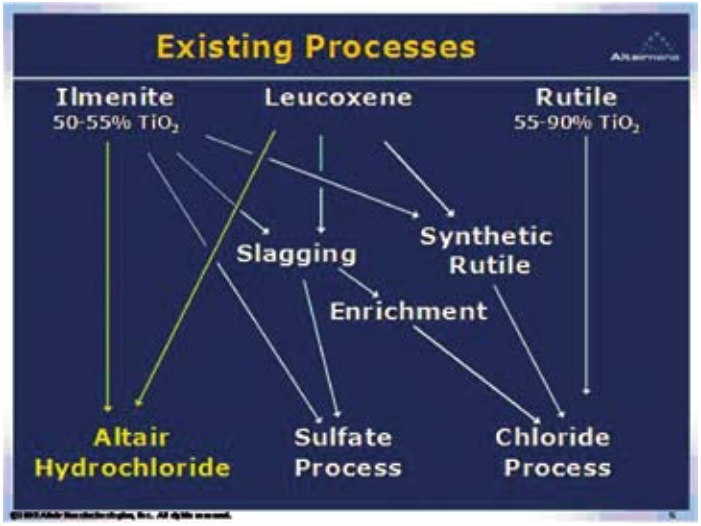
Location map of oxide-bearing ultramafic intrusions (OUIs) and copper-nickel±PGE deposits in the Duluth Complex.

Processing

Development attempts to date, mostly associated with the Longnose deposit, have failed due to the high content of MgO associated with the ilmenite (2-4% MgO) which makes the concentrate unsuitable for chloride processing. However, Altair Nanotechnologies Inc. (originally a branch of BHP) has recently developed a hydrochloride pigment process that can process ilmenite directly into a titanium product. This method can be used to treat high MgO ores, is competitive with existing sulfate and chloride processes, and recycles all waste streams (and thus would be more environmentally friendly and more easily permitted).

Infrastructure

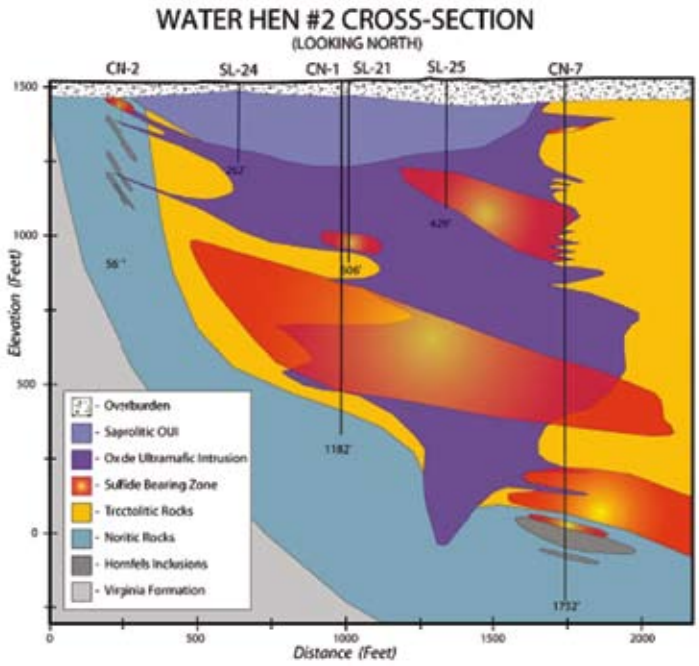
Minnesota has been a mining state for over 120 years; therefore, most of the infrastructure in the form of roads, railroads, power lines, and a mining workforce with support industries is already in place. Many of the OUI are located within 15 miles of the Mesabi Iron Range and a few miles from potential copper-nickel deposits. Grinding and processing facilities associated with taconite and copper-nickel deposits located at Northshore Mining and facilities for PolyMet Mining Inc., respectively, could possibly be used in processing titanium ores. In addition, Minnesota has an established mine permitting process that is currently ongoing for PolyMet's NorthMet Cu-Ni deposit.



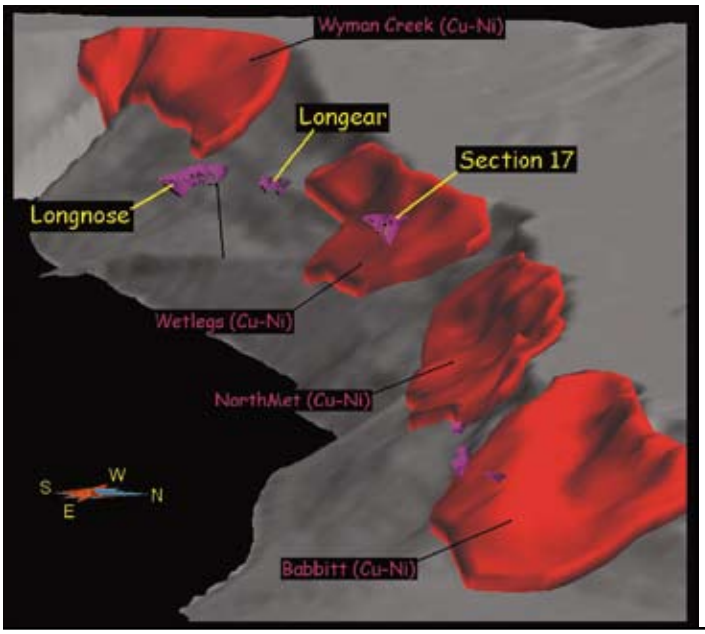
Deposit	Drill Holes	Avg. TiO_2 Wt. %	Max. TiO_2 Wt. %	Avg. V (ppm)	Max. V (ppm)	Resources in Mt
Longnose	11	12.49	30.37	1,325	4,400	50 Mt @ 21% TiO_2
Water Hen	37	11.15	29.30	1,065	2,285	62 Mt @ 14% TiO_2
Longear	3	18.06	50.50	580	3,590	?
Sec. 34	6	15.66	26.74	2,610	4,035	?
Sec. 17	6	33 analyses	14.66	790	950	?
Sec. 22	2	62 analyses	28.72	1,130	2,790	?
Skibo	9	18 analyses	25.28	165	220	?
Skibo South	1	3 analyses	12.60	1,100	1,346	?
Wyman Creek	4	10 analyses	28.65	?	540	?
Boulder Creek	2	8 analyses	19.09	4,630	8,125	?
Boulder Lake – North	3	6 analyses	35.20	4,045	6,835	?
Central Boulder Lake	1	no analyses	?	?	?	?
Boulder Lake – South	3	2 analyses	16.03	?	787	?

Resource Potential

Limited drilling to date has outlined at least 13 ilmenite-bearing OUI bodies along the western margin of the Duluth Complex. Resources for only two of the OUI have been defined. The remaining OUI are sorely in need of additional drilling and TiO_2 analyses before their resources can be calculated. The roots/feeder conduits of the various OUI have never been drilled and may contain significant PGE credits. In addition, it may also be possible that weathering during the Cretaceous may have produced titanium beach sands along the western shoreline of an inland sea (the shoreline could be located just west of the present-day Duluth Complex basal contact). The presence of a thick saprolite cap over the Water Hen OUI suggests that such a mechanism could have occurred during the Cretaceous.



Cross-section of the Water Hen OUI body showing saprolite cap and sulfide-bearing zones within the OUI and adjacent gabbroic (troctolitic) rocks. Note that the root zone of the OUI has not been drilled.



Spatial position of three OUI bodies (magenta) in relation to disseminated Cu-Ni deposits (red) at the basal contact (gray). Note that the roots of the OUI have yet to be drilled.

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The "Dig"Program provides up to 20 percent of the cost of an exploration drill hole. For more information, visit:
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