Mazina'igan Supplement

Published by the Great Lakes Indian Fish & Wildlife Commission Spring/Summer 2012

Iron mining in the Lake Superior region

A report by the GLIFWC Environmental Section

Introduction

The Great Lakes Indian Fish and Wildlife Commission's (GLIFWC) Board of Commissioners has indicated an interest in developing scoping level information about how taconite mining is conducted in Michigan and Minnesota, where active taconite mines are located.

This document's intent is to inform readers about the process and some of the impacts associated with taconite mining.

Topics include: removal of ore, ore processing, generation and storage of tailings, removal and storage of non-target waste rock, development of mine-related infrastructure, and reclamation.

Understanding more about the taconite mining process, its consequences in neighboring states and potential considerations in Wisconsin can support a more informed discussion about iron mining in the future.

Also, look for an upcoming publication, Sulfide Mining: The Process and the Price, which will be available in the fall of 2012 and feature in-depth discussion on sulfide mining.

Minntac iron mine, Minnesota.

What is Taconite Iron Ore and Where is it Found?

Taconite is a low-grade magnetic iron ore. When high-grade iron ore was plentiful, taconite was considered a waste rock and was not used. But as the supply of high-grade iron ore decreased, the mining industry began to view taconite as a resource.

Eventually a process was developed to create taconite pellets by concentrating the low grade ore into an economically viable resource.[1]

Taconite ore is attracted by magnets and is known as magnetite. Magnetite occurs extensively in the Minnesota Iron Range, the Michigan Iron Range near Marquette and Wisconsin's Penokee Range. In Wisconsin, the taconite iron deposits of the Penokee Range are concentrated in a band running from near Mellen in Ashland County east to near Upson in Iron County.

Removal of the Taconite Ore

Taconite mining in the region is now conducted exclusively by open-pit mining methods. The mining process begins by drilling into the ground to determine the quality and exact location of the ore deposit and the character of the surrounding rocks. For a large modern mine, hundreds of exploratory and characterization bore holes are drilled into these formations.

Once the ore body and overburden have been adequately characterized, the next step is removal of non-ore rock over and next to the deposit.

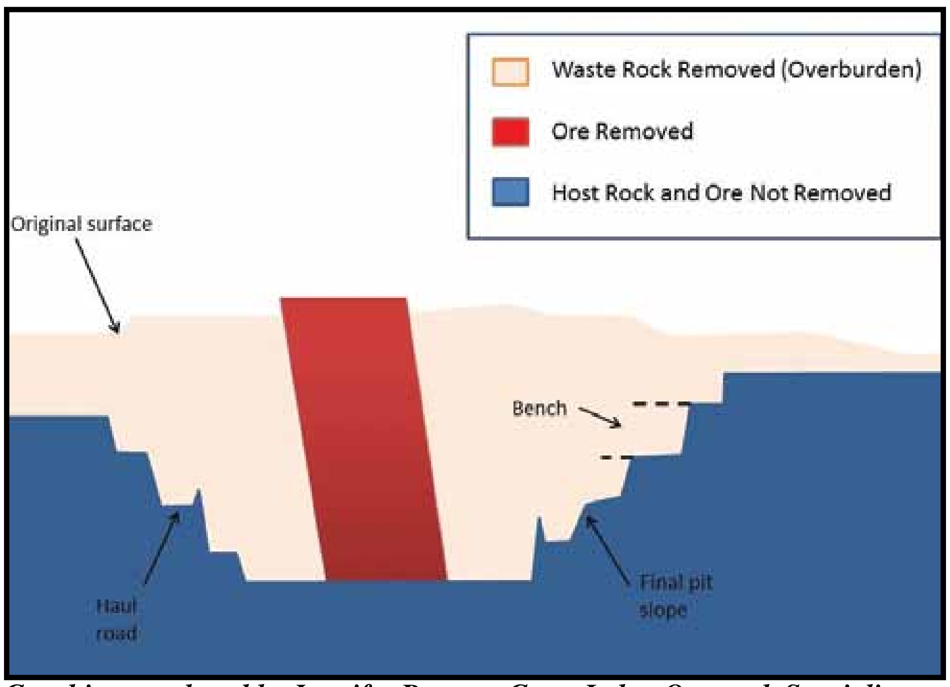
A "stripping ratio" (the ratio of ore to waste rock that must be removed to access the ore) of 1:1 or 2:1 is not uncommon.[2,3,4] If the ore deposit is oriented vertically in the ground the amount of overburden that must be removed to access the ore may be more than the volume of ore extracted. The rock surrounding the ore zone is hauled out of the mine pit and stored as waste rock.

To remove the ore, it is blasted, loaded into trucks and hauled out of the pit. The ore is transported to a processing plant where it is crushed by several types of crushers and mills.

The scale of the land alteration associated with taconite mining in Michigan and Minnesota is enormous, and is unlike what was known in the 1800s and the first half of the 1900s. U.S. Steel's Minntac mine project covers an area of approximately 20,000 acres.

The Hull-Rust-Mahoning taconite mine near Hibbing, Minn. has a larger footprint, with a pit approximately 3½ miles long, 1½ miles wide and 535 feet deep and an even larger tailings basin. That mine is known as one of the largest open-pit iron mines in the world.[1]

Hull-Rust-Mahoning taconite mine near Hibbing, Minnesota. (Photo by Daniel W. Lynch.)



Graphic reproduced by Jennifer Burnett, Great Lakes Outreach Specialist.

Ore grinding mills.[2]

Tilden Mine, Michigan. (Photo by Matt Peters)

Open pit taconite mines result in permanent changes to the landscape. In Michigan and Minnesota, taconite pits and waste storage sites are permanent features that cover hundreds of square miles. Without additional information, it is unclear what the footprint of a taconite mine project in the Penokee Range or elsewhere in Wisconsin would be, but it is clear that a portion of the landscape and the resources and habitats that it now supports would be permanently removed.

Taconite Ore Processing

Once the ore has been hauled out of the pit, it is taken to the processing facility, a series of large buildings many stories tall. The ore is crushed to approximately the size of a pea by rock crushers. It is then mixed with water and ground in rotating mills until it is as fine as powder.

The iron is separated from the other minerals using magnets. The remaining material is called tailings and is dumped into tailings basins. The powder containing the iron is called concentrate.[1]

Next, in the taconite pellet plant, the concentrate is mixed with limestone and baked into balls the size of marbles called taconite pellets. These grinding and baking processes use large amounts of energy and water, and liberate mercury. Air emissions from taconite plants are the largest source of mercury in the Lake Superior basin.[5]

Waste Disposal

Waste rock resulting from stripping away non-ore rock from over and around the ore is typically put in large piles next to the mine pits. The waste rock can be dumped back into the mine pit after mining is finished; however, this is expensive and is uncommon at regional iron mines.

Tailings, the non-iron material separated from the ore, consist of particles of crushed rock ranging from the size of coarse sand to fine powder. The character of the tailings depends on the chemical composition of the rock that was fed into the crushers and grinders. Tailings include non-target rock and minerals that are associated with the taconite ore, such as silica and pyritic shales.[6]

Tailings are usually mixed with water to create a slurry, which is carried through pipes and discharged into tailings basins. Dry disposal of tailings is possible but is expensive because of the cost of dewatering the tailings before stacking.[7]

Dry stacking is a relatively new approach that has been used for higher value ores such as those at copper and gold mines. Dry stacking may be proposed for use in future iron mines but dry stacking has not been previously used for low value ores such as taconite.

Regardless of the tailings disposal method, the volume of material can be large. A taconite mine that produces 8 million tons of taconite pellets per year could generate approximately the following amounts of material:

24 million tons of ore mined per year (3 tons of ore per 1 ton of taconite pellets)[8]

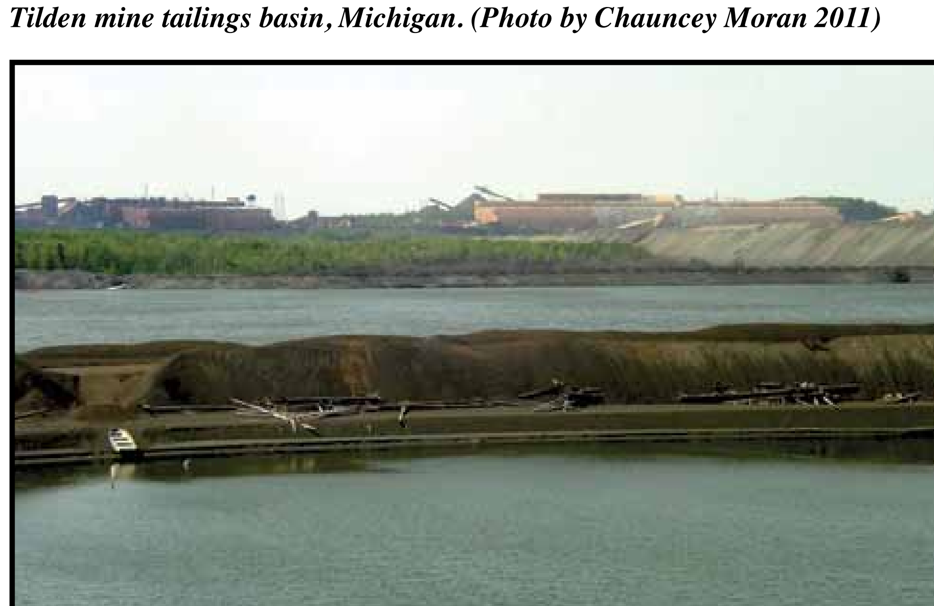
24 million tons of waste rock per year (with an assumed 1:1 stripping ratio)[2]

16 million tons of tailings per year,[8] and

8 million tons of taconite pellets per year.

An iron mine of this scale could generate approximately 560 million tons of tailings and 840 million tons of waste rock over a mine life of 35 years.

Tilden mine tailings basin, Michigan. (Photo by Chauncey Moran 2011)



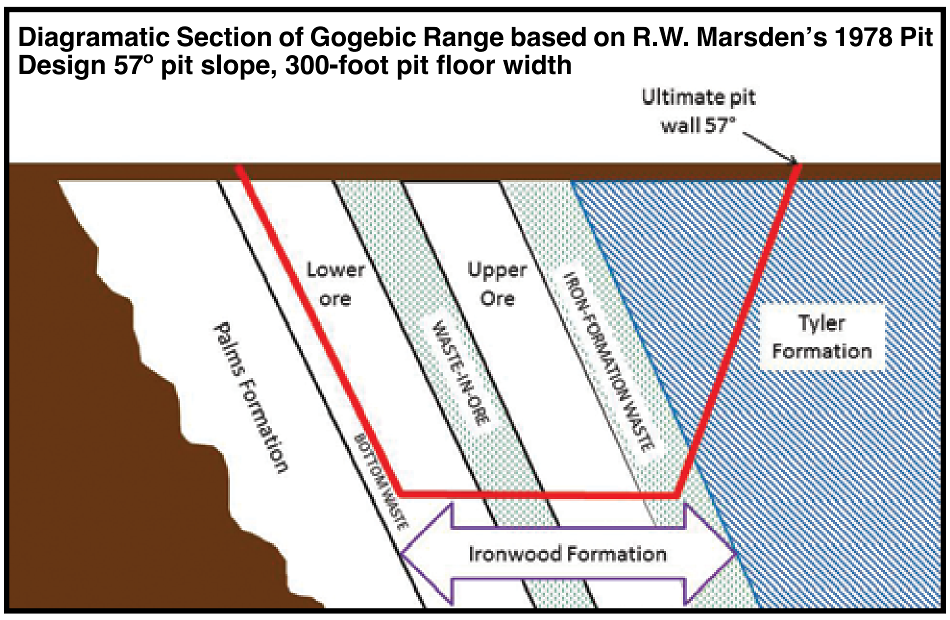
Tailings ponds and taconite processing facilities at Minntac, Minnesota.

Composition of Tailings and Waste Rock

Because iron ore always has bands of other minerals intermingled in the deposit and the ore itself is made up of iron and non-iron minerals, the composition of the tailings varies considerably between mines and even over time within the same mine.

In the Minnesota Iron Range, sulfur bearing rocks in the Virginia Formation and pyrite minerals within and adjacent to the ore zone contribute sulfur and soluble heavy metals to the tailings and waste rock.

Similarly, the Penokee Range iron deposit has documented[6] but unknown quantities of pyritic shale mixed with the ore zones (see the deposit labeled "iron-formation waste" and "waste in ore" in the figure below).[6,10]



Penokee Range iron ore deposit and potential pit design. (Graphic reproduced by Jennifer Burnett, Great Lakes outreach specialist.)[10]

Haul road at taconite mine in Minnesota.

Waste rock that is created from stripping the overburden from over and next to the ore zone also contains non-target minerals. In the Penokees, much of the waste would be from the Tyler Formation to the immediate north of the iron ore.[10]

The Tyler Formation is similar to Minnesota's Virginia Formation and may contain significant sulfur. The sulfur in the Tyler Formation and pyrite in shales in the ore zone, when exposed to air and water may generate acid and leach heavy metals.

The true character of the tailings and waste rock can only be known by careful and complete characterization of the waste materials within the ore zone and in the rocks that must be stripped away to access the ore.

However, mines in Michigan and Minnesota show that elevated levels of selenium (e.g. Tilden Mine, Mich.), sulfate (e.g. Minntac Mine, Minn.), manganese (e.g. Cliff Erie Mine, Minn.), and asbestos-like fibers (e.g. Reserve Mining, Minn.) can be a problem in water discharges.

The power plant in Ashland, Wisconsin has an output capacity of 76 megawats.[11]

Infrastructure

Iron mining is energy and transportation intensive. Estimates indicate that a mine in the Penokee Range would require at least 145 megawatts of electrical power[8], which is double the generating capacity of the power plant in Ashland.

Either new plants would need to be built in the Penokees or high tension lines built to supply power to the ore crushers/grinders. In addition, taconite pellets are usually dried with large quantities of natural gas, meaning that a new gas delivery line would need to be built.

There are few roads currently suitable for heavy trucks, no haul roads, and no rail lines along the Penokee Range. These would need to be constructed to serve a mine so that ore can be moved to crushers, concentrate moved to pellet plants, and taconite pellets moved to shipping facilities.

Mining in the headwater regions of the 76-mile long Bad River, like this area near Caroline Lake, would impact the high quality water currently flowing from the Penokee Range. Waste rock and tailings from large iron mining projects in the region affect water quality and quantity through seepage to groundwater and runoff to surface waters. (Photo by Charlie Otto Rasmussen)

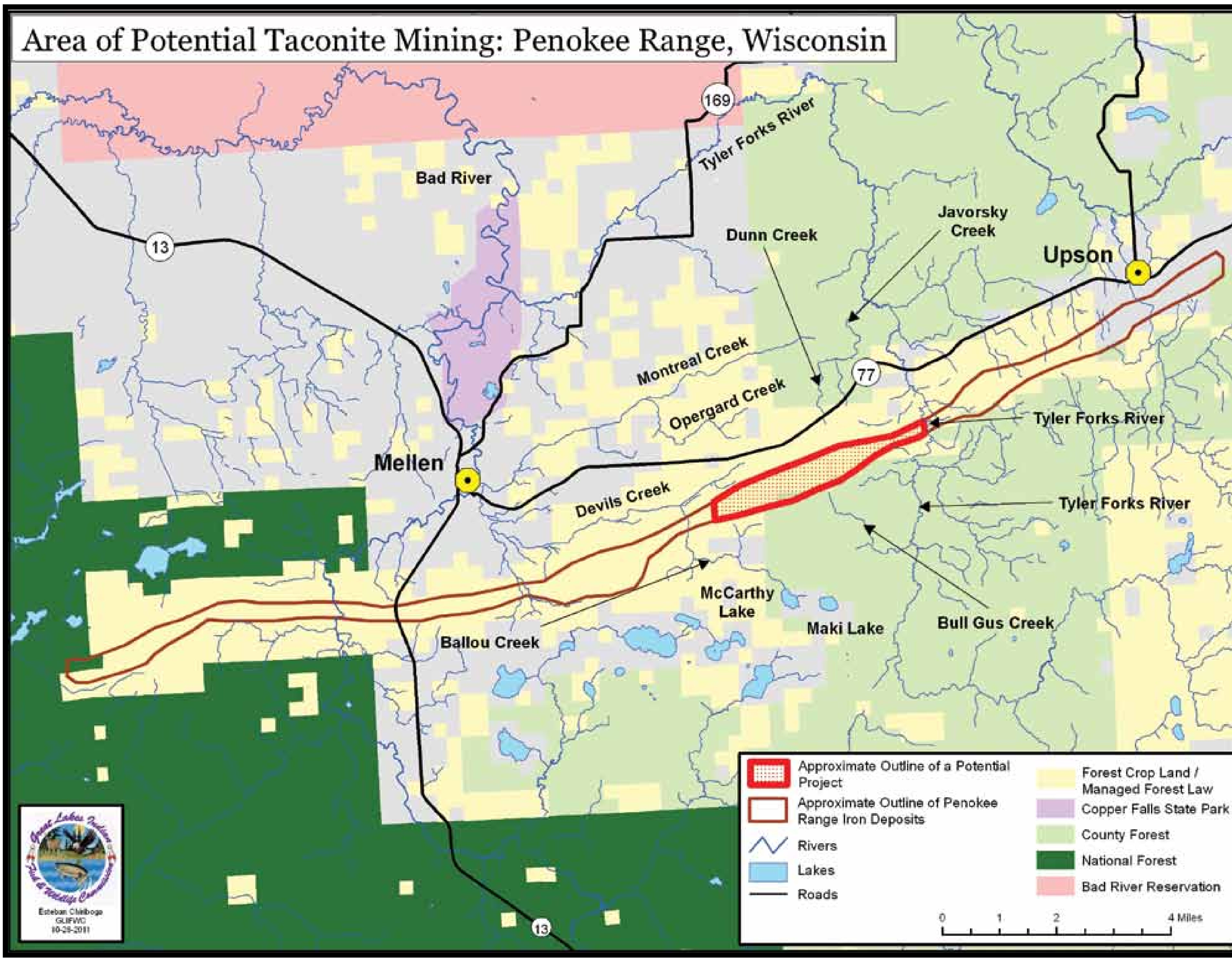
Reclamation

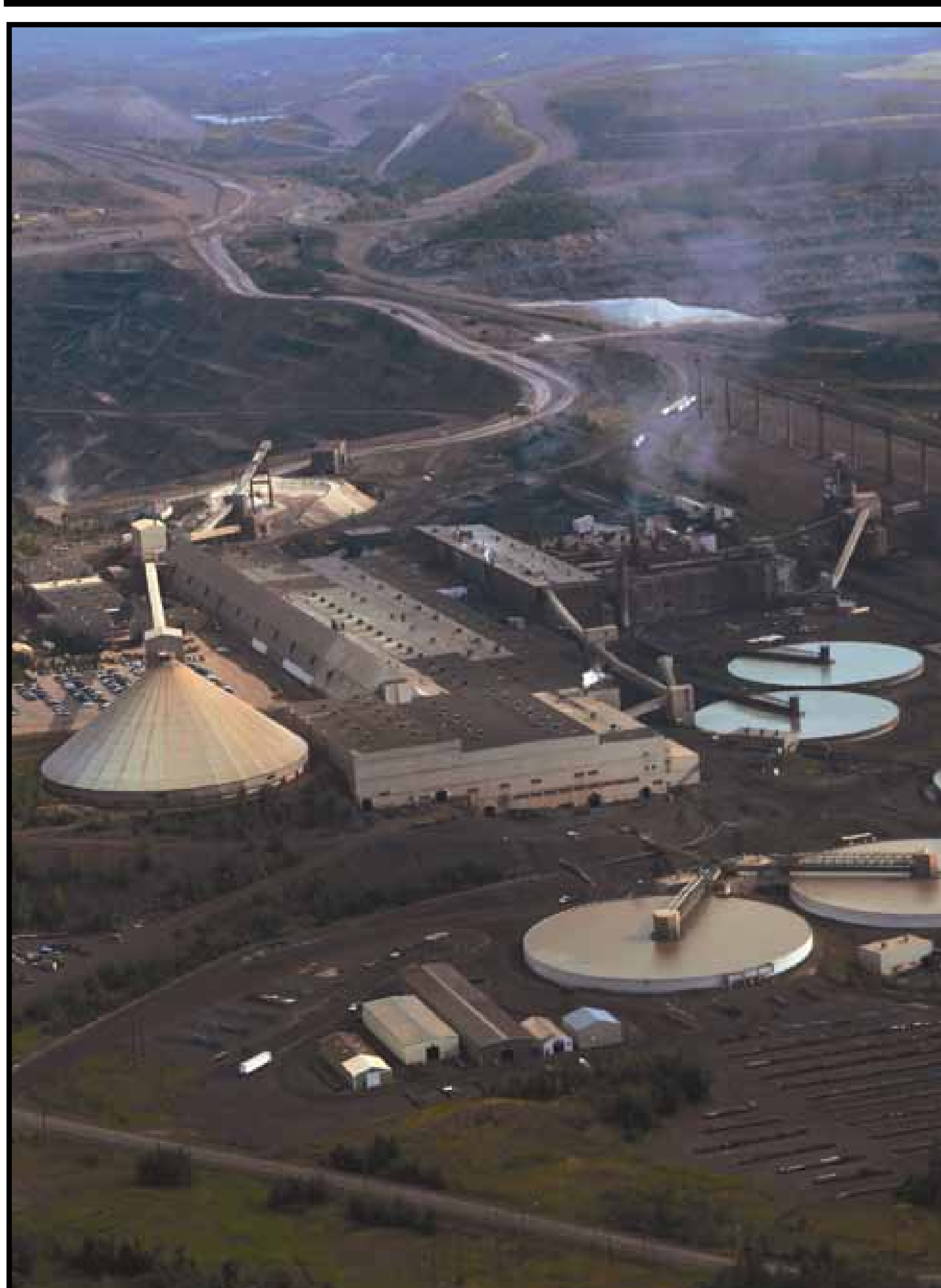
After mining is complete, the site must be reclaimed. Buildings and other structures are removed and the site is stabilized. A small scale example of taconite mine reclamation was performed at a Jackson County, Wisconsin site that is now a recreation area.

Unfortunately, mine wastes often do not have characteristics favorable for plant growth. In Minnesota, where tailings basins and stockpiles are large, biosolids (i.e. solids from sewage treatment plants), are sometimes applied to increase soil fertility and promote plant growth. If not adequately revegetated, these areas are prone to wind and water erosion.[12]

Conclusion

- As evidenced by taconite mining in Minnesota and Michigan, there would be environmental impacts if a mine is constructed in the Penokee Range. At best, the landscape would be permanently altered. At worst, a variety of environmental damage and human health risks could result. Where a Penokee mine would fall along that spectrum is currently unknown.
- Taconite mining projects are complex and encompass large areas and many natural resources. Understanding the impacts of a specific project requires detailed project plans and a thorough description of the land, water and other resources that will be affected.
- When landscape changing projects are considered, they should be evaluated carefully and with full, objective discussion of benefits, costs and impacts.





Empire Mine, Palmer Michigan. Foreground: processing facilities; Midground: mine pits; Background: waste rock piles. (Photo Chauncey Moran, 2011).

References

1. http://www.dnr.state.mn.us/education/geology/digging/taconite.html
2. http://www.geo.msu.edu/geogmich/tilden.html
3. http://en.wikipedia.org/wiki/Stripping_ratio
4. Pages 383 and 463 of Kennedy, B.A. 1990. Surface mining, 2nd. Ed. Society for Mining, Metallurgy, and Exploration. 1197 p.
5. Lake Superior Lakewide Management Plan (LaMP) 2008, page 4B-5.
6. Cannon, W.F., LaBerge, G.L., Klasner, J.S., and Schulz, K.J. 2007, The Gogebic iron range—a sample of the northern margin of the Penokean fold and thrust belt: U.S. Geological Survey Professional Paper 1730, 44 p.
7. http://www.tailings.info/drystack.htm and www.infomine.com/publications/docs/Lupo2010.pdf
8. Gogebic Taconite response to Ashland County Mining Impact Committee. April 20, 2011.
9. Meineke, D. G., and Djerlev, H. 2009. Geology and Magnetic Taconite Resources of Western Gogebic Iron Range, Wisconsin. Institute of Lake Superior Geology Annual Meeting 2009.
10. Marsden, R.W., 1978, Iron ore reserves of Wisconsin—A Minerals Availability Systems Report: in Proceedings of the 51st Annual Meeting, Minnesota Section AIME and 39th Annual Minnesota Mining Symposium, p. 24-1—24-28.
11. http://www.ncstudents.net/environmentalcouncil/LEAP/Bayfront.html
12. Minnesota Department of Natural Resources, Division of Lands and Minerals, Biosolids for Reclaiming Minelands, April, 2004.

Supplement credits:

Photos: Photos not credited were taken by John Coleman, GLIFWC

Map: Esteban Chiriboga, GLIFWC

Mazina'igan *(Talking Paper) is a tri-annual publication of the Great Lakes Indian Fish & Wildlife Commission (GLIFWC), which represents eleven Ojibwe tribes in Michigan, Minnesota and Wisconsin.*

Additional copies of this supplement can be ordered at no charge from GLIFWC, P.O. Box 9, Odanah, WI 54861; phone (715) 685-2150; e-mail pio@glifwc.org or www.glifwc.org.