Trends in Mining

Lake Superior Binational Forum
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Mark Severson
What is driving change in the mining industry?

Are there international factors that drive this change?

What is changing in the mining industry?

What types of mining are in the region?

Why are mines currently being explored in this region?

What are the consequences or impacts of these trends?
What is driving changes in the Mining Industry?

- **Supply & Demand**
  - This Dec ’05 article from the Canadian Globe & Mail highlights the dwindling amount of copper being supplied to the global economy.
  - You’ve probably heard of “Peak Oil”, how about “Peak Copper”?
What is driving changes in the Mining Industry?

Increase in metal prices
What is driving changes in the Mining Industry?

- **We are consumers**
- USA = only 5% of World Population but consume 33% of world’s total raw materials
- Compared to world average, Americans consume:
  - 7x plastic and petroleum products
  - 6x aluminum
  - 4x copper
  - 3x iron and steel
  - 1.5x cement
What is driving changes in the Mining Industry?

Every American Born Will Need . . .

- 31,266 lbs. Salt
- 22,388 lbs. Clays
- 849 lbs. Zinc
- 1.64 million lbs. Stone, Sand, & Gravel
- 82,634 gallons Petroleum
- 849 lbs. Lead
- +28,564 lbs. Other Minerals & Metals
- 572,052 lbs. Coal
- 6,176 lbs. Bauxite (Aluminum)
- 34,045 lbs. Iron Ore
- 5.59 million cu. ft. of Natural Gas
- 69,789 lbs. Cement

3.6 million pounds of minerals, metals, and fuels in their lifetime

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What is driving changes in the Mining Industry?

Every year—46,414 pounds of new minerals must be provided for every person in the United States to make the things we use, every day.

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>12,095 lbs. Stone</td>
<td>used to make roads; buildings; bridges; landscaping; numerous chemical and construction uses</td>
</tr>
<tr>
<td>9,134 lbs. Sand &amp; Gravel</td>
<td>used to make concrete; asphalt; roads; blocks &amp; bricks</td>
</tr>
<tr>
<td>904 lbs. Cement</td>
<td>used to make roads; sidewalks; bridges; buildings; schools; houses</td>
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<tr>
<td>441 lbs. Iron Ore</td>
<td>used to make steel—buildings; cars, trucks, planes, &amp; trains; other construction; containers</td>
</tr>
<tr>
<td>405 lbs. Salt</td>
<td>used in various chemicals; highway deicing; food &amp; agriculture</td>
</tr>
<tr>
<td>327 lbs. Phosphate rock</td>
<td>used to make fertilizers to grow food; animal feed supplements</td>
</tr>
<tr>
<td>290 lbs. Clays</td>
<td>used to make floor &amp; wall tile; dinnerware; kitty litter; bricks &amp; cement; paper</td>
</tr>
<tr>
<td>80 lbs. Aluminum (Bauxite)</td>
<td>used to make buildings; beverage containers; autos; airplanes</td>
</tr>
<tr>
<td>20 lbs. Copper</td>
<td>used in buildings; electrical &amp; electronic parts; plumbing; transportation</td>
</tr>
<tr>
<td>11 lbs. Lead</td>
<td>75% used for transportation—batteries; electrical; communications; TV screens</td>
</tr>
<tr>
<td>11 lbs. Zinc</td>
<td>used to make metals rust resistant; various metals &amp; alloys; paint; rubber; skin creams; health care; and nutrition</td>
</tr>
<tr>
<td>6 lbs. Manganese</td>
<td>used to make almost all steels for: construction; machinery; transportation</td>
</tr>
<tr>
<td>344 lbs. Other Nonmetals</td>
<td>numerous uses glass; chemicals; soaps; paper; computers; cellular phones; etc.</td>
</tr>
<tr>
<td>26 lbs. Other Metals</td>
<td>numerous uses same as nonmetals, but also electronics; TV &amp; video equipment; recreation equipment; etc.</td>
</tr>
</tbody>
</table>

Demand
What is driving changes in the Mining Industry?

American vehicle  European vehicle

Guess which society demands more Earth’s resources?
Uses of Palladium (Pd)

**Autocatalysts**
Ductile and resistant to oxidation and high temperature corrosion, palladium is useful in eliminating harmful emissions from gasoline engines - converts over 90% of hydrocarbons, carbon monoxide and NOx into carbon dioxide, nitrogen and water vapor.

**Electronics**
Chemical stability and electrical conductivity make it an alternative to gold for plating in electronic components.

**Dentistry**
Dental crowns and bridges. Used in a radioactive form for the treatment of cancer.

**Jewelry**

**Chemical**
Refining of nitric acid and uses in developing raw materials for synthetic rubber and nylon.

**Fuel Cells**

**Coinage**

**Oil Refining**

**Polyester**
Critical catalyst in the manufacture of polyester.

**Photography**
Superior to conventional silver in tonal quality and archival longevity.

**Water Treatment**
Studied for use in removing a number of toxic and carcinogenic substances from groundwater.

**Hydrogen Purification**
Effective material to filter hydrogen from other gasses resulting in an ultra pure hydrogen gas.
Researchers believe that scarce metals, such as platinum, risk depletion in this century because there is no suitable substitute for use in devices such as catalytic converters and hydrogen fuel cells. Platinum and palladium, are increasingly bought by Chinese for consumption in jewelry. In 2004, Chinese jewelers purchased some 31 tons of platinum and 22 tons of palladium, representing almost 12% of world platinum group metal demand.
What about the rest of the World?

- A new "materials" centric world is unfolding for BILLIONS of people who desire a better lifestyle and are demanding improvements in technology, education, globalization, and communication.

- China – strides to improve infrastructure
  - Transportation
  - Power stations and transmission lines
  - Telecommunications
Chinese and Asian demand for metals
India’s plan to rebuild their Infrastructure

- $2.24 billion to improve roads
- $4.95 billion in oil refining capacity
- $4.2 billion for rural infrastructure

In the implementation of these projects, India will have to consume huge quantities of base metals and industrial metals including steel, copper, aluminum, and so on.
Does the world have enough metals to satisfy future consumer demands?

- Even the full extraction of metals from the Earth’s crust, and extensive recycling programs, may not meet future demand if all nations begin to use the same services enjoyed by developed nations.
- All of the known copper ore, plus all of the copper currently in use, would be required to bring the world to the level of developed nations for power transmission, construction and other services and products that depend on copper.
- For the entire globe:
  - 26% of extractable Cu in Earth’s crust is now lost in non-recycled waste.
  - 19% of Zn is lost in non-recycled waste.

“Metal Stocks and Sustainability”
by
Robert Gordon and Thomas Graedel – Yale University
Marlen Bertram – Organization of European Aluminum Refiners
What is changing in the mining industry?

- Easy deposits have already been found – only the hidden/hard-to-find ones are left
- Hydrometallurgy vs Pyrometallurgy
- The loss of workers due to the Aids pandemic in Africa
- Political unrest is driving companies back to the western world
- Need better tools to find ore deposits (3D visualization)
3D Visualization

Cu-Ni deposits defined by lots of drill holes

Dunka Road/NorthMet deposit

Babbitt/Mesaba deposit

3D rendering by Dean Peterson
What types of mining are in the region? = Taconite

Six Producing Mines:
- Keetac
- Hibtac
- Minntac
- Utac
- ArcelorMittal Steel
- Northshore

40 million tons/yr
(75% of total US iron ore production)
Have to move 240 million tons of rock/yr
What types of mining are in the region?

Sand and Gravel

Other

Minneapolis
St. Paul
International Falls
Duluth
Rochester
Moorhead

Other Mine Sites and in Minnesota

Dimension Stone
Clay
Silica Sand
Why are mines currently being explored in this region?

- The rocks of northern Minnesota form a portion of the Canadian Shield, which are the old rocks that form the core of the continent.

- Globally, such rocks host a majority of the world's mineral resources.
Why are mines currently being explored in this region?

- The rocks are right

Good Geophysical Coverage
Why are mines currently being explored in this region?

- Hydrometallurgical advances
- Smelters are no longer needed
Why are mines currently being explored in this region?

- Minnesota is a mining state
- The state actively promotes Minnesota to the minerals industry
- Excellent mineral potential
- Excellent transportation infrastructure
- Highly skilled workforce
- Political stability
What are the consequences or impacts of these trends?

- New Mines may be opened (Permitting Process)
- Existing mines will be expanded (Permitting Process)
- Local towns and cities will need to expand housing; health care; schools; recreational facilities; and all other services
- New Areas will be explored
  - Cu-Ni-PGE; Cu-Pb-Zn; Ti; Diamonds; Gold
Environmental Assessment Worksheet (EAW)
Environmental Impact Statement (EIS)
Permit to Mine - DNR
Water Appropriation Permit - DNR
Public Waters Work Permit - DNR
Dam Safety Permit - DNR
Part 70 Permit (Air Emissions) - MPCA
NPDES/SDS Wastewater Permits - MPCA
Section 404 Permit - ACE

Summary:
- A mandatory EIS is required for a metallic mine in Minnesota.
- The EAW/EIS process includes:
  - Scoping EAW
  - Draft EIS
  - Final EIS
- Permitting includes:
  - Permit to Mine
  - Water Appropriation Permit
  - Public Waters Work Permit
  - Dam Safety Permit
  - Part 70 Permit (Air Emissions)
  - NPDES/SDS Wastewater Permits
  - Section 404 Permit

Timeline:
- One Month
- One Year

Decision:
- Final decision dependent on adequacy of mandatory EAW/EIS.
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  Cu-Ni-PGE; Cu-Pb-Zn; Ti; Diamonds; Gold
Cu-Ni-PGE

GENERALIZED PRECAMBRIAN GEOLOGIC MAP OF MINNESOTA

Paleozoic & Cretaceous Rocks

DULUTH COMPLEX

MIDDLE PROTEROZOIC
(Keweenawan Supergroup)

Duluth Complex

Lake Superior

FGE Prospects & Occurrences

Cu-Ni Sulfides Deposits

Fe-Ti oxide Bodies

Granitic Intrusions

Grabbro & Troctolite

North Shore Volcanic Group

Flows & Clastic Strata
Large but Low-grade Copper-Nickel-PGE deposits (Low sulfide)
PolyMet’s Plan
One way of getting the Cu-Ni-Pt-Pd out

Instead of a Smelter!
Iron Ore Comparisons on World-wide basis

(What is driving the current trends?)
PARTIAL DATA of USGS “IRON ORE” WORLDWIDE OCCURRENCES -- **No Shortage** of Global Resource.

Brazil and Australia account for >67% of the world commerce in iron ore
World Steel Consumption Continues to Grow

- As the population increases and the developing countries improve their economic situations, steel usage grows.
- China and other Asian countries have been key factors in overall steel consumption – efforts to improve their infrastructure.
- India is making strides to improve their infrastructure.
- Steel usage is also increasing in the countries of the former Soviet Union.
- Indonesia?
China remains key driver in iron trade

- **Chinese iron ore is in the interior and of poor grade**
- **Chinese are partnering with ore suppliers (United Taconite – Laiwan)**
- **Chinese have large infrastructure building needs**
  - Highway construction
  - Airport construction
  - Manufacturing plants
  - City modernization – especially in preparation for showcasing China for 2008 Olympics
Steel Production in Key Countries

[Graph showing steel production in key countries from 1994 to 2004.]

- United States
- European Union
- Japan
- China
- India
- South Korea
- Former Soviet Union

Source: IISI World Steel Statistics
Closer to Home -
Aggregate Demand

Minnesota's Natural Gravel Pits

Gravel Pits:
- Active
- Commercial
- MnDOT
- Inactive

County Boundary

Data courtesy of Minnesota Department of Transportation.
Future shortage could be key opportunity

- **Impeding shortage of aggregate**
  - Two Aggregate Resources Task Force (1998, 2000) reports forecast impending shortage of aggregate in the 7 County Metro area

- **DOT officials in neighboring states already cite a shortage of high quality aggregate**
Coarse Taconite Tailing = Good Aggregate Material

- Material is equivalent to fine aggregate (\(-3/8”\))
- Roughly 1 ton of material produced for every ton of finished product shipped
  - 2002 processing produced roughly 33 million tons of this product
Local (Mn/DOT) Usage

2004 > 1,500,000 tons Used for Highway 53/169 North road construction; primarily for granular borrow and 15% of pavement mix.
Results

- Very consistent product
- Clean with engineered fines level
- Durable – meets hardness specifications
- Very low absorption (+/-1%)
- Equivalent of manufactured sand (100% fractured faces)
- High friction factor – superior skid resistance
Titanium potential - Minnesota

- What is Titanium used for?
**TiO₂ Pigment Uses**

- **Plastics**: 27%
- **Paper**: 16%
- **Paints & coatings**: 54%
- **Other**: 3%

**Other Uses**
- Ceramics
- Fabrics and textiles
- Floor coverings
- Printing ink
- Roofing granules
- Rubber
- Food additives
Specific gravity of Ti is 4.5.
About 50% of Ni or Cu, 60% of steel

High corrosive resistance

Bio Compatible Material

Low specific gravity

Non Magnetic Property

High specific strength

Specific strength of Ti is about as
3 times as Al, and higher than stainless steel.
In addition, Ti resists temperatures up to 400 °C

Ti has as high corrosive resistance to
sea water as platinum
In almost every corrosive environment,
Ti keeps excellent resistance to corrosion.

Magnetic permeability is 1.0001.
Nearly perfectly nonmagnetic.
Titanium Metal—Uses

Aerospace 65%

Other 35%

Other
- Consumer Goods
  (golf clubs, watches, jewelry)
- Chemical Process Industry
  (pressure vessels, heat exchangers, pipe)
- Oil and Gas
  (production risers)
- Medical
  (hips, screws, plates, dental implants)
- Military
  (M1A1, Bradley, M777)

Aerospace
- (blades, discs, skins, wheels, spacer rings, landing gear, rocket motor cases)
Summary

- Internal and international demand is the driving mechanism for expanding supply base
- Minnesota’s iron mining industry will continue (will supply aggregate?)
- Minnesota has the right rocks for other types of mining (Cu, Ni, PGE, Ti)
- The state actively promotes Minnesota to the minerals industry
Norilsk, Siberia, Russia
(the other way of getting the Cu-Ni-Pt-Pd out)

- Largest producer of Pd in the world (40% of worldwide market = 2,500,000 oz Pd)
  
  **BUT**

- Largest polluter in the world (6X emissions from ENTIRE US nonferrous metal industry)

2,800,000 ton/yr SO2
85,000,000 ton/yr waste water

Yellow snow from sulfur for 30 miles around smelters

Smoke plume from the Norilsk Smelters as seen from a Landsat 7 ETM+ image. Date: July 31, 2000. True color composite. This smoke plume that contains sulphur dioxide and heavy metals stretches up to a 175 km away from the smelters damaging larch stands, the water and soil in its way.
The Irony of it all!

“Clean air in the urban centers of North America is exchanged for a poisoned Siberian landscape [and air]”

Pyrometallurgy vs Hydrometallurgy
(smelter vs contained system)

We have to think GLOBALLY!
Thank you
Iron Ore Comparisons

- Compared to world players – we are small
- Some iron mines have similar stripping ratios – but Minnesota mines move more rock
- Our mill grades are generally much lower than that of competitive mines on world-wide basis
- The cost to produce our products is higher than many other areas due to ore grade and material movement requirements