GOLD, IRON, COPPER, ZINC, AND SAND; WHAT’S DRIVING THE NEW INTEREST IN MINING AND MINERAL RESOURCES IN WISCONSIN

Bruce A. Brown

WISCONSIN GEOLOGICAL AND NATURAL HISTORY SURVEY
MADISON, WI
Map of the U.S. Lead Mines, 1829
WHAT’S HAPPENING AROUND THE STATE?

• A new iron mine has been proposed in the western Gogebic Range, raising economic hopes and environmental and regulatory concerns.
• Mining companies are showing interest in new exploration of Cu-Zn massive sulfide deposits.
• One company began drilling on a gold prospect in eastern Marathon Co.
• Western Wisconsin is in the middle of a “Gold Rush” to develop sand mines to supply the hydrofrac sand for natural gas production
IRON RESOURCES OF WISCONSIN

Locations in Wisconsin where iron reserves have been mined or are known to exist

R.W. Marsden estimated the western Gogebic range contained up to 3.7 billion tons of ore
WHAT DOES TACONITE IRON ORE LOOK LIKE?

Banded iron formation originated as sedimentary rock.

**Red bands:**
iron-rich silica (chert or jasper)

**Gray bands:**
iron oxides (hematite or magnetite)
MINOR RANGES SOUTH OF GOGEIBC

ASHLAND COUNTY

• Agenda Exploration
  – 160M tons crude ore, 45M tons 65% Fe conc. Total probably includes Ford-Lucas, Broom handle, Whiteside etc.

• Butternut Exploration
  – 48M tons crude ore, 13.6M tons 66% Fe conc.

IRON COUNTY

• Pine Lake Exploration
  – 184 M tons crude ore, 49.5M tons 63% Fe conc.

• Mercer Exploration
  – Exploration for precious metals associated with sub-economic iron
HOW IS TACONITE MINING DIFFERENT FROM THE NATURAL ORE MINES OF THE PAST?

• Mining costs dictate that taconite is mined by open pit method, leading to a larger environmental footprint and higher reclamation costs.

• Taconite concentration requires a mill and pelletizing plant, and produces fines or tailings which require management as a waste product.

• Ore processing uses significant amounts of water and produces waste water.

• Taconite has never been mined on the Gogebic, but Wisconsin has experience regulating and reclaiming similar mines, the best example being the Jackson County Mine.
MAIN AREA OF CURRENT IRON MINING INTEREST, UPSON TO SOUTHWEST OF MELLEN IN ASHLAND COUNTY
R.W. MARSDEN’S 1978 PIT DESIGN
57degree pit slope, 300-foot pit floor width
MAP SHOWING LOCATION OF MASSIVE SULFIDE (COPPER – ZINC) AND THE REEF GOLD PROSPECT

From DeMatties, Econ. Geol.
HYDROFRACKING A WELL

Fluid pressure fractures the rock, sand grains keep the fractures open.
WHERE THE GAS IS
WHERE THE BEST FRAC SAND IS (RED)
THE BEST FRAC SAND IS WELL ROUNDED AND NEARLY PURE QUARTZ

Many younger sands are too angular or contain other minerals or rock fragments
# COMPARISON OF FRACSAND CHARACTERISTICS

## Woodbury, Minnesota Materials Specification

<table>
<thead>
<tr>
<th>Recommended Sand Size</th>
<th>20x40 US MESH</th>
<th>30x50 US MESH</th>
<th>40x70 US MESH</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>&lt;0.1%</td>
<td>20 &lt;0.1%</td>
<td>30 &lt;0.1%</td>
</tr>
<tr>
<td>20</td>
<td>30</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>&gt;90% retained</td>
<td>35 &gt;90% retained</td>
<td>50 &gt;90% retained</td>
</tr>
<tr>
<td>30</td>
<td>40</td>
<td>60 &gt;90% retained</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>50</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>70</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Pan</td>
<td>&lt;1%</td>
<td>Pan &lt;1%</td>
<td>Pan &lt;1%</td>
</tr>
</tbody>
</table>

- **Crush Resistance**: ISO 7K, ISO 9K, ISO 12K
- **Roundness Sphericity**: Greater than 0.6
- **Turbidity**: Less than 250 ntu
- **Acid Solubility 12:3 HCl/HF**: <2%, <2%, <2%, <3%, <3%

## Sanders, Arizona Materials Specification

<table>
<thead>
<tr>
<th>Recommended Sand Size</th>
<th>16x30 US MESH</th>
<th>20x40 US MESH</th>
<th>40x70 US MESH</th>
<th>30x50 US MESH</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>&lt;0.1%</td>
<td>16 &lt;0.1%</td>
<td>30 &lt;0.1%</td>
<td>20 &lt;0.1%</td>
</tr>
<tr>
<td>16</td>
<td>20</td>
<td>40</td>
<td>60 &gt;90% retained</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>&gt;90% retained</td>
<td>25 &gt;90% retained</td>
<td>50 &gt;90% retained</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>30</td>
<td>60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>40</td>
<td>70</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>50</td>
<td>80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pan</td>
<td>&lt;1%</td>
<td>Pan &lt;1%</td>
<td>Pan &lt;1%</td>
<td></td>
</tr>
</tbody>
</table>

- **Roundness Sphericity**: Greater than 0.6
- **Turbidity**: Less than 250 ntu
### Hydraulic Fracturing Sands

<table>
<thead>
<tr>
<th></th>
<th>T1220F</th>
<th>T1630F</th>
<th>T2040F</th>
<th>T3050F</th>
<th>T4070F</th>
<th>FW4070F</th>
<th>FW50140F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sieve % Retained</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.1</td>
</tr>
<tr>
<td>20</td>
<td>0.1</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>35</td>
<td>0.3</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>50</td>
<td>0.5</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
</tr>
<tr>
<td>70</td>
<td>0.7</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>Pan % Retained</td>
<td>0.2</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
</tr>
</tbody>
</table>

**Total % Retained**
- 96.7
- 97.4
- 93.8
- 93.8
- 93.8
- 93.8
- 99.1

<table>
<thead>
<tr>
<th>NTU</th>
<th>51</th>
<th>41</th>
<th>38</th>
<th>36</th>
<th>34</th>
<th>34</th>
<th>40</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acid Sol</td>
<td>0.3274</td>
<td>0.2362</td>
<td>Acid Sol</td>
<td>0.2898</td>
<td>Acid Sol</td>
<td>0.3030</td>
<td>Acid Sol</td>
</tr>
<tr>
<td>Crush K Value</td>
<td>4000</td>
<td>6000</td>
<td>7000</td>
<td>10,000</td>
<td>10,000</td>
<td>9000</td>
<td>12,000</td>
</tr>
</tbody>
</table>

### Chemical Analysis

<table>
<thead>
<tr>
<th>Chemical</th>
<th>T-grade</th>
<th>F-grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silicon Dioxide (SiO₂)</td>
<td>99.20%</td>
<td>99.70%</td>
</tr>
<tr>
<td>Aluminum Oxide (Al₂O₃)</td>
<td>0.10</td>
<td>0.19</td>
</tr>
<tr>
<td>Calcium Oxide (CaO)</td>
<td>0.08</td>
<td>0.21</td>
</tr>
<tr>
<td>Iron Oxide (Fe₂O₃)</td>
<td>0.06</td>
<td>0.03</td>
</tr>
<tr>
<td>Potassium Oxide (K₂O)</td>
<td>0.05</td>
<td>0.14</td>
</tr>
<tr>
<td>Sodium Oxide (Na₂O)</td>
<td>0.003</td>
<td>0.002</td>
</tr>
<tr>
<td>Magnesium Oxide (MgO)</td>
<td>0.01</td>
<td>0.02</td>
</tr>
<tr>
<td>Titanium Oxide (TiO₂)</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

### Physical Properties

<table>
<thead>
<tr>
<th>Physical Property</th>
<th>Specific Gravity</th>
<th>Particle Density</th>
<th>Absolute Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2.65</td>
<td>22.11</td>
<td>0.38</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Tests performed using X-Ray Fluorescence.*

All chemical and physical properties are typical. We give no warranty for our products, either expressed or implied. We recommend that you confirm all properties in the laboratory.
OUTCROP AREA OF THE CAMBRIAN SANDSTONES
WISCONSIN AND MINNESOTA
**BEDROCK SAND RESOURCES**

**Cambrian Wonewoc Fm.**
Important producer and potential resource in west, not exposed elsewhere.

**Cambrian Jordan Fm.**
Extensive potential in west, currently important source of fracsand from underground mines. Poor exposure in east.

**Ordovician St. Peter Fm.**
Long production history and good potential in south and east. Channels can make prospecting a challenge in the northeast.
GEOLOGY AND SAND PRODUCTION SITES IN WEST-CENTRAL WISCONSIN
St. Peter Resource

Current production is based in the Utley (Markesan, Fairwater, Ripon) area of northeast, but much of southern Wis. has potential
SAND PRODUCING AREAS IN WESTERN WISCONSIN

Major mines prior to “sand boom”

Now for some new sources!
ALLUVIAL/BEDROCK-CRANSAND
ADVANTAGES OF SAND MINING

- Local jobs and economic growth.
- The demand for natural gas as a clean fuel will sustain the industry into the future.
- Wisconsin has a history of industrial sand mining that has recorded very few problems in 100+ years.
- When compared to other types of mining, sand mining has minimal environmental impact and sand mines can be reclaimed successfully.
POTENTIAL PROBLEMS AND ISSUES

• Groundwater usage and potential for contamination.
• Air quality; dust and the risks from crystalline silica.
• Truck traffic, safety and cost of road maintenance.
• Blasting and potential damage to structures.
• Noise levels and hours of operation.
• Reclamation and subsequent land use.
HOW SERIOUS ARE THE PROBLEMS AND HOW DO WE DEAL WITH THEM?

• **Groundwater use**- DNR regulates high capacity wells. Permits are based on extensive review.
• Mines and processing plants routinely recycle as much water as possible
• Impact to private wells can be minimized if mining companies agree to do a well survey and guarantee a water supply for close neighbors. This type of arrangement has worked successfully for the aggregate industry and protects the operator at a small cost compared to litigation.
• **Water quality**- Runoff and surface water impact is regulated by DNR. Sand mining has the same potential for groundwater impact as a limestone quarry or gravel pit.

• The issue of prime concern is potential contamination from flocculants used in settling ponds. There is currently little data available and no standards or regulations, but also no history of problems from older mines.
AIR QUALITY ISSUES

• Frac sand requires clean, round unbroken grains. Processing involves disaggregation and screening, usually done wet, rather than dry grinding.

• A frac sand plant will produce less angular crystalline silica dust than a quarry that crushes quartzite or a gravel pit that dry crushes coarse material.

• There are standard ways to minimize dust such as watering haul roads, paving roads, spraying conveyor belts, and wash baths for truck tires that have proven successful in other mining operations.

• MSHA and OSHA have strict workplace standards, and DNR and EPA air standards also apply.
OPERATING ISSUES

• Blasting is regulated by Dept of Commerce. blasting is only used to loosen material. If rock is too heavily cemented, it is not even useful for frac sand!

• Traffic, operating schedule, road maintenance etc. are best handled in a conditional use permit, but if no zoning, direct negotiation between Town government and the mining company can be productive as in Town of Howard in Chippewa Co.

• Reclamation is regulated under N.R.135, and a plan subject to public comment, along with financial assurance must be in place before mining begins.
SO WHAT CAN WE CONCLUDE?

• The sandstone formations of Wisconsin and Minnesota are the best available for frac sand.

• As long as fracking is the best available technology for producing previously unrecoverable natural gas, frac sand mining will continue to be big business in our region.

• Interest in Wisconsin sand has been growing, but the “sand boom” took us by surprise. Many counties were overwhelmed by mining applications, and the scale of mining has presented problems we haven’t dealt with before.
The good news is that Wisconsin has a 100 year history of sand mining with very few problems. Most environmental issues can be dealt with under existing regulations, by using existing technology, and applying standard industry practices.

Many new mines rely on truck transport. This means traffic and safety issues and potential road maintenance issues that need to be resolved.

Operational issues can usually be resolved by zoning conditions or negotiation.

As new mines come into production, the demand should be met and the pace of development should slow, allowing time to work out remaining issues.
SAND CONCLUSIONS

- Mother Nature didn’t give us oil or gas in Wisconsin, but we got the sand needed to produce it.
- Frac sand should continue as a strong industry as long as there is interest in tight shale oil and gas.
- The current “boom” should settle down as supply catches up with demand. Transportation costs will be an important factor.
- So far there has not been much interest in the St. Peter for frac sand, but it and the Jordan in eastern Wisconsin will continue to be an important source of foundry and filter sand.
GENERAL CONCLUSIONS

• Iron mining is creating lots of headlines, but I am not yet convinced of the economics.
• Interest in base metals (cu, Zn) will vary with the metal markets. The high price of gold will keep interest up since it is a byproduct.
• Reef gold prospect needs more work to prove extent of resource.
• Frac sand is going to be around for a while, so we need to develop innovative ways to deal with the issues.