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

**Crush Resistance**
- ISO 4K
- ISO 6K
- ISO 6K
- ISO 6K

**Roundness Sphericity**
- Greater than 0.6

**Turbidity**
- Less than 250 ntu
<table>
<thead>
<tr>
<th></th>
<th>T1220F</th>
<th>T1630F</th>
<th>T2040F</th>
<th>T3050F</th>
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<tr>
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<td>30.4</td>
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<tr>
<td>Pan</td>
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<td>Crush K Value</td>
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<td>10,000</td>
<td>10,000</td>
<td>9000</td>
<td>12,000</td>
</tr>
</tbody>
</table>

### Chemical Analysis

- Silicon Dioxide (SiO₂): T-grade 99.20%, F-grade 99.76%
- Aluminum Oxide (Al₂O₃): 0.10%
- Calcium Oxide (CaO): 0.08%
- Iron Oxide (Fe₂O₃): 0.06%
- Potassium Oxide (K₂O): 0.05%
- Sodium Oxide (Na₂O): 0.003%
- Magnesium Oxide (MgO): 0.01%
- Titanium Oxide (TiO₂): <0.01%

### Physical Properties

- Specific Gravity: 2.65
- Particle Density: 22.11 [lb/gal]
- Absolute Volume: 0.38 [cm³/g] 0.0453 [gal/lb]

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.
Gravels associated with each lobe reflect the geology of the rocks the glacier eroded as that lobe advanced. Green Bay Lobe contains dolomite, Chippewa Lobe mostly igneous rock.
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.
Orange areas are Jordan Sandstone, Red is Wonewoc sandstone.

Both are mined for frac sand.
GEOLOGY AND SAND PRODUCTION SITES IN WEST-CENTRAL WISCONSIN
UNDERGROUND SAND MINING, PIERCE COUNTY
JORDAN SANDSTONE, WESTERN WISCONSIN

ANOMALOUS LOCAL SILICA CEMENTATION, CALCITE CEMENT ALSO OCCURS AS CONCRETIONS
EXTENT OF WONEWOC AND JORDAN RESOURCE IN DRIFTLESS AREA OF WESTERN WISCONSIN

Major roads in blue, rail shown in red

Wonewoc (red) is widely exposed, Jordan (gold) is on ridges
WONEWOC (GALESVILLE) EXPOSURES
BADGER TAYLOR MINE AND PLANT

Photos taken 20 years ago.
A large sand mine with a successful operating and reclamation record
Current production is based in the Utley (Markesan, Fairwater, Ripon) area of northeast, but much of southern Wis. has potential.
ST. PETER VARIABILITY, NORTHEASTERN WISCONSIN

OCCURS IN CHANNELS CUT IN UNDERLYING CARBONATES, MAY VARY FROM ZERO TO 300’+, UNDERLAIN BY RED SHALY READSTOWN MBR.
SAND PRODUCING AREAS IN WESTERN WISCONSIN

Major mines prior to “sand boom”

Now for some new sources!
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.
Areas shown in orange and yellow contain outwash sand and gravel.
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.
BADGER TAYLOR MINE AND PLANT

Photos taken 20 years ago.
A large sand mine with a successful operating and reclamation record