Topics for Today

• Geology of Resource Plays
• Development History
• Activity
• Hydraulic Fracturing
• Future Prospects
Topics for Today

- Geology of Resource Plays
- Development History
- Activity
- Hydraulic Fracturing
- Future Prospects
Resource Plays

• 1) **Large area** of organic-rich source rock.
• 2) **Heat, pressure, and time to mature** source rock.
• 3) **Expulsion** of hydrocarbons from source rocks into adjacent rocks.
• 4) **Trapping** of hydrocarbons in overlying and underlying reservoirs that are porous, but low permeability.
• 5) **Technology to extract** hydrocarbons using natural or artificial fractures to get economic amounts of petroleum production.
1) Regional Extent
Tyler and Bakken

Carboniferous

Tyler Absent

Bakken Absent
1) Organic Richness: Bakken

- Average Total Organic Carbon:
  11.5 weight %
  30-40 % by volume
1) Tyler Formation: TOC content

Average TOC = 1.39% by weight (1/8 Bakken)

Area containing:
- Excellent TOC = 2.02 million acres
- Good TOC = 8.87 million acres (1/80 Bakken)
2) Bakken $T_{\text{max}}$: Maturation Index
2) Tyler $T_{\text{max}}$ Maturation Index
3) Expulsion of Petroleum from Source Beds into Low Perm Bounding Beds
4) Trapping $\Rightarrow$ abnormally High Formation Pressure

Formation Pressures in the Antelope Field.

- Lithostatic Gradient = 0.94 psi/ft
- Kibbey Lime
- Mission Canyon
- Lodgepole
- Bakken/Sanish
- Silurian
- Hydrostatic Gradient = 0.465 psi/ft

Modified from Meissner (1978)
5) Technology = horizontal well / multi stage hydraulic fractured

Three Forks
Bakken
Producing Interval 1000's of feet

Horizontal Shale
This illustration is available for license
Topics for Today

- Geology of Resource Plays
- Development History
- Activity
- Hydraulic Fracturing
- Future Prospects
• Development History
  – 2001 through 2003 MT Elm Coulee Activity
  – 2004 through 2006 operators tried many spacing-drilling-fracing combinations (vertical frac length and pool defined)
  – 2006 through 2009 operators focused on 640 & 1,280 acre spaced wells with single stage fracturing
  – Q4 of 2009 stage fracturing of +20 - ceramic proppant - 1,280 acre - 10,000 foot lateral combination identified
  – Q1 of 2010 Industrial Commission organized 15,000 square miles into North-South 1,280 acre spacing and drilling units
Bakken Development Plan

- Original dual-zone development plan
  - 8 wells per 1,280 acres – 4 MB, 4TF
  - 603,000 Boe EUR per well (avg. 24.5 stages/completion)
  - ECO-Pad® design: 2 wells south, 2 wells north

- Additional Three Forks potential

<table>
<thead>
<tr>
<th>County</th>
<th>Bakken OOIP per County</th>
<th>Bakken EUR per County</th>
<th>Three Forks OOIP per County</th>
<th>Three Forks EUR per County</th>
<th>Total OOIP per County</th>
<th>Total EUR per County</th>
</tr>
</thead>
<tbody>
<tr>
<td>Billings</td>
<td>3,141,271,156</td>
<td>115,858,434</td>
<td>1,717,909,400</td>
<td>154,611,846</td>
<td>4,859,180,556</td>
<td>270,470,280</td>
</tr>
<tr>
<td>Bottineau</td>
<td>1,642,257,140</td>
<td>147,803,143</td>
<td>1,042,257,140</td>
<td>147,803,143</td>
<td>2,684,514,283</td>
<td>295,606,283</td>
</tr>
<tr>
<td>Burke</td>
<td>14,891,719,317</td>
<td>187,975,278</td>
<td>2,084,609,970</td>
<td>187,614,897</td>
<td>16,976,329,287</td>
<td>375,590,175</td>
</tr>
<tr>
<td>Divide</td>
<td>16,836,857,774</td>
<td>123,315,660</td>
<td>253,513,980</td>
<td>76,995,258</td>
<td>17,692,371,754</td>
<td>200,311,919</td>
</tr>
<tr>
<td>Dunn</td>
<td>18,059,716,691</td>
<td>294,169,921</td>
<td>2,008,459,540</td>
<td>180,761,359</td>
<td>20,068,176,231</td>
<td>474,931,279</td>
</tr>
<tr>
<td>Golden Valley</td>
<td>66,147,411</td>
<td>25,519,700</td>
<td>2,296,773</td>
<td>91,667,111</td>
<td>2,296,773</td>
<td>91,667,111</td>
</tr>
<tr>
<td>Grant</td>
<td>62,508,094</td>
<td>62,508,094</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mercer</td>
<td>118,427,220</td>
<td>10,658,450</td>
<td>118,427,220</td>
<td>10,658,450</td>
<td>2,376,848</td>
<td>23,315,898</td>
</tr>
<tr>
<td>Morton</td>
<td>84,144,950</td>
<td>84,144,950</td>
<td>84,144,950</td>
<td>84,144,950</td>
<td>1,689,900</td>
<td>1,689,900</td>
</tr>
<tr>
<td>Mountrail</td>
<td>27,242,765,837</td>
<td>424,826,873</td>
<td>1,676,048,980</td>
<td>150,844,408</td>
<td>28,918,844,817</td>
<td>575,671,281</td>
</tr>
<tr>
<td>Oliver</td>
<td>9,002,880</td>
<td>810,259</td>
<td>9,002,880</td>
<td>810,259</td>
<td>17,005,769</td>
<td>17,005,769</td>
</tr>
<tr>
<td>Renville</td>
<td>183,377,880</td>
<td>16,504,009</td>
<td>183,377,880</td>
<td>16,504,009</td>
<td>249,881,869</td>
<td>249,881,869</td>
</tr>
<tr>
<td>Slope</td>
<td>10,586,089</td>
<td>10,586,089</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stark</td>
<td>2,349,351,546</td>
<td>85,371,150</td>
<td>1,604,239,450</td>
<td>144,381,551</td>
<td>3,953,590,996</td>
<td>230,752,701</td>
</tr>
<tr>
<td>Ward</td>
<td>4,540,670,907</td>
<td>446,420,030</td>
<td>40,177,803</td>
<td>4,987,090,937</td>
<td>40,177,803</td>
<td>40,177,803</td>
</tr>
<tr>
<td>Total</td>
<td>149,157,766,614</td>
<td>2,089,563,745</td>
<td>19,955,384,990</td>
<td>1,872,556,554</td>
<td>169,113,151,604</td>
<td>3,962,120,299</td>
</tr>
</tbody>
</table>
Six Wells on a Single Pad

Vern Whitten Photography
Topics for Today

• Geology of Resource Plays
• Development History
• Activity
• Hydraulic Fracturing
• Future Prospects
190 Rigs
Western North Dakota

- 1,800 to 3,000 wells/year = 2,000 expected
  - 150-250 rigs = 12,000 – 30,000 jobs
  - Another 10,000-15,000 jobs building infrastructure
  - 200 rigs can drill the wells needed to secure leases in 1 year
  - 200 rigs can drill the wells needed to develop spacing units in 18 years
  - 35,000-40,000 more new wells
A typical 2012 North Dakota Bakken well will produce for 45 years

If economic, enhanced oil recovery efforts can extend the life of the well

In those 45 years the average Bakken well:

- Produces approximately 615,000 barrels of oil
- Generates about $20 million net profit
- Pays approximately $4,325,000 in taxes
  - $2,100,000 gross production taxes
  - $1,800,000 extraction tax
  - $425,000 sales tax
- Pays royalties of $7,300,000 to mineral owners
- Pays salaries and wages of $2,125,000
- Pays operating expenses of $2,300,000
- Cost $9,000,000 to drill and complete
4,224  Bakken and Three Forks wells drilled and completed
35,000-40,000  more new wells possible in thermal mature area
Proven=7.5 BBO  Probable=11 BBO  Possible=15.5 BBO (billion barrels of oil)
$4 billion - New study shows this needs to double
Expected Case

North Dakota Oil Industry Jobs

- Prod jobs
- Gathering jobs
- Fracing jobs
- Drilling jobs

Year:
- 2005
- 2010
- 2015
- 2020
- 2025
- 2030
- 2035
- 2040
- 2045
- 2050

Jobs:
- 0
- 10,000
- 20,000
- 30,000
- 40,000
- 50,000
- 60,000
- 70,000
Topics for Today

- Geology of Resource Plays
- Development History
- Activity
- Hydraulic Fracturing
- Future Prospects
Hydraulic Fracturing
Lifeline to Domestic Energy

Hydraulic Fracturing

• Why
  • Easy oil and gas that flow without fracturing are already developed
  • Unconventional Reserves
    reservoirs are tight (look at sample)
    uneconomic to produce without fracking
    must create a path for oil to flow

• How
• Regulations
Performing hydraulic fracture stimulation south of Tioga
- all Bakken wells must be hydraulically fractured to produce
- 2-4 million gallons of water
- 3-5 million pounds of sand and ceramic
- cost $2-5 million
Potable Waters

- 4.5” liner
- 30-40 swell packers
- sliding sleeves
- 4.5” frac string
- 5 layers of protection

Packer

4.5” Frac String

Cement

4.5” liner

Upper Bakken Shale

Middle Bakken

Lower Bakken Shale
Thousands of fractures are created
• pumping water at 6,000-9,000 psi
• millions of pounds of sand and ceramic beads are pumped with the water to hold the fractures open.

Ball and Sleeve
• up to 40 stages
• ball opens the liner sleeve
Stage Fracturing
• up to 40 stages
Purposes of frac fluid
• crack the reservoir
• gel strength to carry sand

Frac fluid is produced back as flowback and produced water
Each hydraulic fracturing stage creates hundreds of fractures extending several hundred feet from wellbore.
Microseismic events are imaged via PSET, a migration based imaging algorithm.
- 24-Stage Frac / IP: 2,558 BOE/D
- Excellent “frac saturation” evidenced by minimal gaps of unfraced rock along the wellbore with some stages impacting the same rock volume.
- Minimal gaps along NE trending natural fractures where the frac follows large regionally extensive fractures. These areas already have good naturally occurring fractures.
- Lateral frac wings that average 750’ on either side of the wellbore. This is consistent with our other fracs and planned spacing pattern for full field development.
States have been regulating the full life cycle of hydraulic fracturing for decades

- Geology of each sedimentary basin is different
- Water Appropriation Regulation
- Oil & Gas Regulation
- Health and Environmental Regulation
North Dakota has been regulating the full life cycle of hydraulic fracturing for decades

• Water Commission
  • water supply
• Industrial Commission
  • well construction
  • disposal of flow back water
• Health Department
  • spill cleanup
Water Commission Regulation

- Regulate water appropriations
- Guard against withdrawals exceeding recharge
Thirsty Horizontal Wells

• 2,000 - 3,000 wells / year
• 15 - 25 years duration
• 20 - 30 million gallons water / day
Glacial Drift Aquifers
FRAC WATER NEEDS

• Lake Sakakawea (Missouri River) is the best water resource
• one inch contains 10 billion gal water
• enough to fracture 2,500-5,000 wells
• 30 million gallons flows through Bismarck every 3 minutes
Industrial Commission Regulation

- Well construction for Hydraulic fracturing
  - Two casing strings required
  - Both strings must be cemented
  - Pressure tests required
  - Frac is > 1.5 mile below potable water
Industrial Commission Regulation

- Water flow back after frac
  - Storage in open pits prohibited
  - Disposal wells permitted through Underground Injection Program
- Disposal zone is 1/2 mile below potable waters with impermeable shale between and >2 miles above earthquake zone with many layers including salt between
Significant Salt Intervals of Northwestern North Dakota

- Precambrian Basement
- Red River Formation
- Madison Group
- Tyler Formation
- Spearfish Formation
- Dakota Group
- Fresh Water Zone
- Bakken-Three Forks
- Shallow Gas Zone
- Prairie Formation
- Opeche Formation
- Piper Formation
- Dunham Salt
- Spearfish Formation: Pine Salt
- Charles Formation: Salt A
- Opeche Formation: A Salt
- F Salt
- Charles Formation: D Salt
- Prairie Formation: Prairie Salt
- Eclipse Salt A
- Red River Formation
- Precambrian Basement
Health Department Regulation

- Cleanup of discharge to environment
- Coordinate with local Emergency Managers
- Emergency Planning and Community Right-to-know Act (EPCRA)
- Congress passed for storing and handling of chemicals
- Requires material safety data sheet (MSDS) for each chemical on location
• **Compound**  
  – **Purpose**  
    • **Common application**

• **Fresh Water** – 80.5%
• **Proppant** – 19.0%  
  – Allows the fractures to remain open so the oil and gas can escape  
    • Drinking water filtration, **play ground sand**
• **Acids** - 0.12%  
  – Help dissolve minerals and initiate fractures in rock (pre-fracture)  
    • **Swimming pool cleaner**
• **Petroleum distillates** – 0.088%  
  – Dissolve polymers and minimize friction  
    • **Make-up remover**, laxatives, and candy
• **Isopropanol** – 0.081%  
  – Increases the viscosity of the fracture fluid  
    • **Glass cleaner**, antiperspirant, and hair color
• **Potassium chloride** – 0.06%  
  – Creates a brine carrier fluid  
    • Low-sodium **table salt substitute**
• **Guar gum** – 0.056%  
  – Thickens the water to suspend the sand  
    • **Thickener used in cosmetics**, baked goods, ice cream, toothpaste, sauces, and salad dressing
• **Ethylene glycol** – 0.043%  
  – Prevents scale deposits in the pipe  
    • Automotive **antifreeze**, household cleansers, deicing, and caulk
- Sodium or potassium carbonate – 0.011%
  - Improves the effectiveness of other components, such as cross-linkers
    • Washing soda, detergents, soap, water softeners, glass and ceramics
- Sodium Chloride – 0.01%
  - Delays break down of the gel polymer chains
    • Table Salt
- Polyacrylamide – 0.009%
  - Minimizes friction between fluid and pipe
    • Water treatment, soil conditioner
- Ammonium bisulfite – 0.008%
  - Removes oxygen from the water to protect the pipe from corrosion
    • Cosmetics, food and beverage processing, water treatment
- Borate salts – 0.007%
  - Maintain fluid viscosity as temperature increases
    • Used in laundry detergents, hand soaps and cosmetics
- Citric Acid – 0.004%
  - Prevents precipitation of metal oxides
    • Food additive; food and beverages; lemon juice
- N, n-Dimethyl formamide – 0.002%
  - Prevents the corrosion of the pipe
    • Used in pharmaceuticals, acrylic fibers and plastics
- Glutaraldehyde – 0.001%
  - Eliminates bacteria in the water
    • Disinfectant; Sterilizer for medical and dental equipment
Hydraulic Fracturing Stimulation is Safe

- IOGCC survey—no contamination
- EPA survey – no contamination
- GWPC study verifies State’s regs
- GWPC National Registry f/chemicals
  - FracFocus
## Find a Well

### Back To Search

<table>
<thead>
<tr>
<th>API No.</th>
<th>Job Date</th>
<th>State</th>
<th>County</th>
<th>Operator</th>
<th>WellName</th>
<th>Well Type</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Datum</th>
</tr>
</thead>
<tbody>
<tr>
<td>33-025-01132</td>
<td>4/13/2011</td>
<td>North Dakota</td>
<td>Dunn</td>
<td>XTO Energy/ExxonMobil</td>
<td>Alwin Federal 12X-19</td>
<td>Oil</td>
<td>47.627564</td>
<td>-102.967017</td>
<td>NAD83</td>
</tr>
<tr>
<td>33-105-01913</td>
<td>4/18/2011</td>
<td>North Dakota</td>
<td>Williams</td>
<td>XTO Energy/ExxonMobil</td>
<td>Lonnie 31X-3</td>
<td>Oil</td>
<td>48.196639</td>
<td>-102.880264</td>
<td>NAD83</td>
</tr>
<tr>
<td>33-105-01824</td>
<td>5/14/2011</td>
<td>North Dakota</td>
<td>Williams</td>
<td>XTO Energy/ExxonMobil</td>
<td>Allen 21X-17</td>
<td>Oil</td>
<td>48.254792</td>
<td>-103.058819</td>
<td>NAD83</td>
</tr>
<tr>
<td>33-105-01825</td>
<td>4/28/2011</td>
<td>North Dakota</td>
<td>Williams</td>
<td>XTO Energy/ExxonMobil</td>
<td>Woodrow 34X-32</td>
<td>Oil</td>
<td>48.198603</td>
<td>-103.053617</td>
<td>NAD83</td>
</tr>
<tr>
<td>33-105-01948</td>
<td>2/26/2011</td>
<td>North Dakota</td>
<td>Williams</td>
<td>XTO Energy/ExxonMobil</td>
<td>Normark 24X-31</td>
<td>Oil</td>
<td>48.460233</td>
<td>-103.008811</td>
<td>NAD83</td>
</tr>
<tr>
<td>33-105-01899</td>
<td>2/17/2011</td>
<td>North Dakota</td>
<td>Williams</td>
<td>XTO Energy/ExxonMobil</td>
<td>Michael State 31X-16</td>
<td>Oil</td>
<td>48.167464</td>
<td>-103.031950</td>
<td>NAD83</td>
</tr>
<tr>
<td>33-025-01165</td>
<td>5/9/2011</td>
<td>North Dakota</td>
<td>Dunn</td>
<td>Marathon Oil</td>
<td>Lucky Fleckenstien #34-20H</td>
<td>Oil</td>
<td>47.264306</td>
<td>-102.330608</td>
<td>NAD83</td>
</tr>
<tr>
<td>33-025-01173</td>
<td>5/3/2011</td>
<td>North Dakota</td>
<td>Dunn</td>
<td>Marathon Oil</td>
<td>Wardner #24-35H</td>
<td>Oil</td>
<td>47.245872</td>
<td>-102.445641</td>
<td>NAD83</td>
</tr>
</tbody>
</table>
SHALLOW GAS PROJECT

The Geological Survey recently completed phase I of a study of shallow natural gas in North Dakota. We investigated 9,400 ND State Water Commission monitoring well sites, tested 4,325 wells, and detected methane in 905 wells. Approximately 20% of the wells contained detectable gas.

During the second phase of the project, thirty groundwater samples, primarily from eastern North Dakota, will be analyzed for dissolved gas composition, isotopes, and general chemistry. This will enable us to determine the source of the gas and identify chemical groundwater signatures that might assist the oil and gas industry in natural gas exploration.


Methane bubbling to the surface in a two-inch NDSWC monitoring well.

Monitoring wells that contained methane are indicated with red dots. Black dots are wells that contained no detectable methane. The red dots are sized to reflect the concentration of methane -- the higher the concentration, the larger the dot.
PLUG AND ABANDON
Well was plugged in 07/1998
Reclamation work in 09/1998
Seeded in Spring of 1999

BTA Oil Producers. JV-P#1. Near Rider Field
NDIC File No. 14857. SE SE 15-140-103.
Panoramic Reclamation photo taken looking 070
wards middle of location. May 1, 2001. dwn.

Panoramic photo looking east. Photo taken from butte to west on 7/2/2002.
BTA Oil Producers. JV-P#1. Near Rider and Knutson Fields.
NDIC File No. 14857. SE SE 15-140-103.
Panoramic photo looking east from butte west of location.
Photo taken on May 7th, 2003. dwn.
Topics for Today

• Geology of Resource Plays
• Development History
• Activity
• Hydraulic Fracturing
• Future Prospects
Three-Dimensional Geologic Model of Northwestern North Dakota

Uranium/Coal
Shallow Gas
Frac Propant
Geothermal

Salt-Water Disposal
Oil & Gas

Oil & Gas
Potash

Deep Oil & Gas

Fresh Water Zone
Shallow Gas Zone
Dakota Group
Spearfish Formation
Tyler Formation
Madison Group
Bakken-Three Forks
Prairie Formation
Red River Formation
Precambrian Basement

North Dakota Department of Mineral Resources

North Dakota Geological Survey
Shallow Gas Prospects

- Pierre Fm.
- Niobrara Fm.
- Carlile Fm.
- Greenhorn Fm.
<table>
<thead>
<tr>
<th>County</th>
<th>Year</th>
<th>Wells Investigated</th>
<th>Wells with a Positive FID Response (0-90)</th>
<th>Wells with no FID Response (90-)</th>
<th>Low ppm C1 (H)</th>
<th>High ppm C1 (H)</th>
<th>Average ppm C1 (H)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grand Forks</td>
<td>2010</td>
<td>344</td>
<td>102</td>
<td>16</td>
<td>165</td>
<td>555.0</td>
<td>57</td>
</tr>
<tr>
<td>Walsh</td>
<td>2010</td>
<td>146</td>
<td>29</td>
<td>12</td>
<td>0.4</td>
<td>419</td>
<td>6</td>
</tr>
<tr>
<td>Pembina</td>
<td>2010</td>
<td>160</td>
<td>70</td>
<td>19</td>
<td>62</td>
<td>979.9</td>
<td>57</td>
</tr>
<tr>
<td>Dickey</td>
<td>2010</td>
<td>708</td>
<td>257</td>
<td>17</td>
<td>240</td>
<td>3,051</td>
<td>189</td>
</tr>
<tr>
<td>2010-Total</td>
<td></td>
<td>1,356</td>
<td>618</td>
<td>69</td>
<td>480</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traill</td>
<td>2009</td>
<td>30</td>
<td>11</td>
<td>1</td>
<td>10</td>
<td>1,075</td>
<td>1,075</td>
</tr>
<tr>
<td>Griggs</td>
<td>2009</td>
<td>110</td>
<td>54</td>
<td>20</td>
<td>74</td>
<td>2,063</td>
<td>165</td>
</tr>
<tr>
<td>Ransom</td>
<td>2009</td>
<td>362</td>
<td>179</td>
<td>30</td>
<td>149</td>
<td>196</td>
<td>17</td>
</tr>
<tr>
<td>Rolette</td>
<td>2009</td>
<td>317</td>
<td>147</td>
<td>28</td>
<td>119</td>
<td>28,123</td>
<td>1,068</td>
</tr>
<tr>
<td>Oliver</td>
<td>2009</td>
<td>36</td>
<td>7</td>
<td>3</td>
<td>1.6</td>
<td>28</td>
<td>17</td>
</tr>
<tr>
<td>Mercer</td>
<td>2009</td>
<td>115</td>
<td>36</td>
<td>24</td>
<td>14</td>
<td>103</td>
<td>11</td>
</tr>
<tr>
<td>Dunn</td>
<td>2009</td>
<td>271</td>
<td>27</td>
<td>6</td>
<td>22</td>
<td>124.6</td>
<td>56.7</td>
</tr>
<tr>
<td>Bottineau</td>
<td>2009</td>
<td>121</td>
<td>14</td>
<td>1</td>
<td>13</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Golden Valley</td>
<td>2009</td>
<td>75</td>
<td>29</td>
<td>16</td>
<td>13</td>
<td>4,291</td>
<td>307</td>
</tr>
<tr>
<td>Stark</td>
<td>2009</td>
<td>168</td>
<td>36</td>
<td>7</td>
<td>28</td>
<td>5,598</td>
<td>269</td>
</tr>
<tr>
<td>Slope</td>
<td>2009</td>
<td>63</td>
<td>31</td>
<td>6</td>
<td>26</td>
<td>172.6</td>
<td>42</td>
</tr>
<tr>
<td>Bowman</td>
<td>2009</td>
<td>104</td>
<td>47</td>
<td>18</td>
<td>34</td>
<td>24,266</td>
<td>2,124</td>
</tr>
<tr>
<td>Morton</td>
<td>2009</td>
<td>111</td>
<td>36</td>
<td>19</td>
<td>15</td>
<td>516.5</td>
<td>51</td>
</tr>
<tr>
<td>McLean</td>
<td>2009</td>
<td>432</td>
<td>212</td>
<td>44</td>
<td>198</td>
<td>889.1</td>
<td>42</td>
</tr>
<tr>
<td>Grant</td>
<td>2009</td>
<td>50</td>
<td>18</td>
<td>4</td>
<td>14</td>
<td>4,238</td>
<td>1,171</td>
</tr>
<tr>
<td>Adams</td>
<td>2009</td>
<td>41</td>
<td>9</td>
<td>2</td>
<td>6</td>
<td>60.0</td>
<td>36.8</td>
</tr>
<tr>
<td>Hettinger</td>
<td>2009</td>
<td>43</td>
<td>16</td>
<td>6</td>
<td>7</td>
<td>30.7</td>
<td>17</td>
</tr>
<tr>
<td>McIntosh</td>
<td>2009</td>
<td>114</td>
<td>46</td>
<td>11</td>
<td>37</td>
<td>79.7</td>
<td>16</td>
</tr>
<tr>
<td>McKenzie</td>
<td>2009</td>
<td>376</td>
<td>88</td>
<td>29</td>
<td>39</td>
<td>13,407</td>
<td>1,192</td>
</tr>
<tr>
<td>Williams</td>
<td>2009</td>
<td>324</td>
<td>157</td>
<td>66</td>
<td>101</td>
<td>14,296</td>
<td>364</td>
</tr>
<tr>
<td>Burke</td>
<td>2009</td>
<td>65</td>
<td>20</td>
<td>5</td>
<td>14</td>
<td>31,347</td>
<td>6,344</td>
</tr>
<tr>
<td>Divide</td>
<td>2009</td>
<td>196</td>
<td>88</td>
<td>38</td>
<td>60</td>
<td>16,156</td>
<td>761</td>
</tr>
<tr>
<td>Cass</td>
<td>2009</td>
<td>107</td>
<td>102</td>
<td>20</td>
<td>62</td>
<td>5,520</td>
<td>321</td>
</tr>
<tr>
<td>Stutsman</td>
<td>2009</td>
<td>501</td>
<td>209</td>
<td>40</td>
<td>249</td>
<td>933.0</td>
<td>51</td>
</tr>
<tr>
<td>Wells</td>
<td>2009</td>
<td>113</td>
<td>77</td>
<td>22</td>
<td>65</td>
<td>4,867</td>
<td>316</td>
</tr>
<tr>
<td>Daley</td>
<td>2009</td>
<td>173</td>
<td>64</td>
<td>7</td>
<td>67</td>
<td>311</td>
<td>39</td>
</tr>
<tr>
<td>Foster</td>
<td>2009</td>
<td>121</td>
<td>69</td>
<td>10</td>
<td>69</td>
<td>196</td>
<td>39</td>
</tr>
<tr>
<td>Nelson</td>
<td>2009</td>
<td>117</td>
<td>32</td>
<td>9</td>
<td>23</td>
<td>90</td>
<td>12</td>
</tr>
<tr>
<td>Ramsey</td>
<td>2009</td>
<td>260</td>
<td>68</td>
<td>14</td>
<td>64</td>
<td>294</td>
<td>62</td>
</tr>
<tr>
<td>Carville</td>
<td>2009</td>
<td>84</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>8,047</td>
<td>3,044</td>
</tr>
<tr>
<td>2009-Total</td>
<td></td>
<td>5,148</td>
<td>2,044</td>
<td>603</td>
<td>1,344</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Berdan</td>
<td>2009</td>
<td>71</td>
<td>7</td>
<td>2</td>
<td>5</td>
<td>520.2</td>
<td>287</td>
</tr>
<tr>
<td>Bismarck</td>
<td>2009</td>
<td>341</td>
<td>127</td>
<td>9</td>
<td>118</td>
<td>223.7</td>
<td>44</td>
</tr>
<tr>
<td>Logan</td>
<td>2009</td>
<td>127</td>
<td>76</td>
<td>12</td>
<td>63</td>
<td>415</td>
<td>16</td>
</tr>
<tr>
<td>2009-Total</td>
<td></td>
<td>523</td>
<td>208</td>
<td>23</td>
<td>198</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ward</td>
<td>2007</td>
<td>151</td>
<td>79</td>
<td>27</td>
<td>62</td>
<td>60,000</td>
<td>2,363</td>
</tr>
<tr>
<td>Barnes</td>
<td>2007</td>
<td>51</td>
<td>28</td>
<td>6</td>
<td>23</td>
<td>2,997</td>
<td>529</td>
</tr>
<tr>
<td>Morton</td>
<td>2007</td>
<td>48</td>
<td>29</td>
<td>12</td>
<td>17</td>
<td>1,247</td>
<td>271</td>
</tr>
<tr>
<td>LaMoure</td>
<td>2007</td>
<td>207</td>
<td>156</td>
<td>48</td>
<td>145</td>
<td>3,719</td>
<td>252</td>
</tr>
<tr>
<td>Burkeleigh</td>
<td>2007</td>
<td>143</td>
<td>64</td>
<td>18</td>
<td>48</td>
<td>1,209</td>
<td>211</td>
</tr>
<tr>
<td>McHenry</td>
<td>2007</td>
<td>433</td>
<td>380</td>
<td>68</td>
<td>206</td>
<td>2,320</td>
<td>131</td>
</tr>
<tr>
<td>Sweeley</td>
<td>2007</td>
<td>21</td>
<td>9</td>
<td>3</td>
<td>6</td>
<td>146.3</td>
<td>79</td>
</tr>
<tr>
<td>Pierce</td>
<td>2007</td>
<td>148</td>
<td>108</td>
<td>7</td>
<td>97</td>
<td>71.7</td>
<td>18</td>
</tr>
<tr>
<td>2007-Total</td>
<td></td>
<td>1,202</td>
<td>655</td>
<td>177</td>
<td>682</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Renville</td>
<td>2006</td>
<td>24</td>
<td>8</td>
<td>3</td>
<td>5</td>
<td>20.6</td>
<td>8</td>
</tr>
<tr>
<td>Batemnau</td>
<td>2006</td>
<td>110</td>
<td>33</td>
<td>11</td>
<td>22</td>
<td>30,382</td>
<td>3,103</td>
</tr>
<tr>
<td>Beulmans</td>
<td>2006</td>
<td>109</td>
<td>50</td>
<td>12</td>
<td>39</td>
<td>776</td>
<td>196</td>
</tr>
<tr>
<td>Kinder</td>
<td>2006</td>
<td>451</td>
<td>377</td>
<td>83</td>
<td>314</td>
<td>940.5</td>
<td>41.1</td>
</tr>
<tr>
<td>Stutsman</td>
<td>2006</td>
<td>170</td>
<td>107</td>
<td>21</td>
<td>96</td>
<td>162</td>
<td>27</td>
</tr>
<tr>
<td>Tower</td>
<td>2006</td>
<td>78</td>
<td>31</td>
<td>6</td>
<td>25</td>
<td>32.8</td>
<td>8</td>
</tr>
<tr>
<td>Rolette</td>
<td>2006</td>
<td>114</td>
<td>53</td>
<td>10</td>
<td>42</td>
<td>15.2</td>
<td>6</td>
</tr>
<tr>
<td>2006-Total</td>
<td></td>
<td>1,066</td>
<td>656</td>
<td>126</td>
<td>632</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project Totals</td>
<td></td>
<td>9,390</td>
<td>4,288</td>
<td>897</td>
<td>3,194</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Preliminary Data Subject to Review.*
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>113</td>
<td>77</td>
<td>22</td>
<td>55</td>
<td>0.1</td>
<td>4,567</td>
<td>316</td>
</tr>
<tr>
<td></td>
<td>173</td>
<td>64</td>
<td>7</td>
<td>57</td>
<td>0.1</td>
<td>211</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>121</td>
<td>69</td>
<td>10</td>
<td>59</td>
<td>0.1</td>
<td>186</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td>117</td>
<td>32</td>
<td>9</td>
<td>23</td>
<td>0.2</td>
<td>60</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>260</td>
<td>68</td>
<td>14</td>
<td>54</td>
<td>0.2</td>
<td>294</td>
<td>82</td>
</tr>
<tr>
<td></td>
<td>64</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>0.1</td>
<td>6,087</td>
<td>3,044</td>
</tr>
<tr>
<td>2009-Total</td>
<td>5,149</td>
<td>2,044</td>
<td>503</td>
<td>1,344</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>71</td>
<td>7</td>
<td>2</td>
<td>5</td>
<td>1</td>
<td></td>
<td>538.3</td>
</tr>
<tr>
<td></td>
<td>341</td>
<td>127</td>
<td>9</td>
<td>118</td>
<td>0.5</td>
<td></td>
<td>223.7</td>
</tr>
<tr>
<td></td>
<td>127</td>
<td>75</td>
<td>12</td>
<td>63</td>
<td>3.4</td>
<td></td>
<td>41.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2008-Total</td>
<td>539</td>
<td>209</td>
<td>23</td>
<td>186</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>151</td>
<td>79</td>
<td>27</td>
<td>62</td>
<td>0.2</td>
<td></td>
<td>60,000</td>
</tr>
<tr>
<td></td>
<td>51</td>
<td>28</td>
<td>5</td>
<td>23</td>
<td>0.3</td>
<td></td>
<td>2,897</td>
</tr>
<tr>
<td></td>
<td>48</td>
<td>29</td>
<td>12</td>
<td>17</td>
<td>1.1</td>
<td></td>
<td>2,347</td>
</tr>
<tr>
<td></td>
<td>287</td>
<td>195</td>
<td>49</td>
<td>146</td>
<td>0.4</td>
<td></td>
<td>3,712</td>
</tr>
<tr>
<td></td>
<td>143</td>
<td>64</td>
<td>18</td>
<td>46</td>
<td>1.1</td>
<td></td>
<td>1,208</td>
</tr>
<tr>
<td></td>
<td>433</td>
<td>350</td>
<td>55</td>
<td>295</td>
<td>0.2</td>
<td></td>
<td>2,329</td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>9</td>
<td>3</td>
<td>6</td>
<td>2</td>
<td></td>
<td>146.3</td>
</tr>
<tr>
<td></td>
<td>148</td>
<td>105</td>
<td>8</td>
<td>97</td>
<td>1.7</td>
<td></td>
<td>71.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2007-Total</td>
<td>1,292</td>
<td>859</td>
<td>177</td>
<td>682</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>34</td>
<td>8</td>
<td>3</td>
<td>5</td>
<td>20.6</td>
<td></td>
<td>28,000</td>
</tr>
<tr>
<td></td>
<td>110</td>
<td>33</td>
<td>11</td>
<td>22</td>
<td>2.4</td>
<td></td>
<td>30,362</td>
</tr>
<tr>
<td></td>
<td>109</td>
<td>50</td>
<td>12</td>
<td>38</td>
<td>1.6</td>
<td></td>
<td>775</td>
</tr>
<tr>
<td></td>
<td>451</td>
<td>377</td>
<td>63</td>
<td>314</td>
<td>0.2</td>
<td></td>
<td>840.5</td>
</tr>
<tr>
<td></td>
<td>170</td>
<td>107</td>
<td>21</td>
<td>86</td>
<td>0.4</td>
<td></td>
<td>182</td>
</tr>
<tr>
<td></td>
<td>78</td>
<td>31</td>
<td>6</td>
<td>25</td>
<td>0.2</td>
<td></td>
<td>32.8</td>
</tr>
<tr>
<td></td>
<td>114</td>
<td>52</td>
<td>10</td>
<td>42</td>
<td>0.6</td>
<td></td>
<td>15.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2006-Total</td>
<td>1,066</td>
<td>658</td>
<td>126</td>
<td>532</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Project Totals</td>
<td>9,390</td>
<td>4,288</td>
<td>897</td>
<td>3,194</td>
<td>*Preliminary Data Subject to Revision</td>
<td></td>
</tr>
</tbody>
</table>
SHALLOW GAS WELLS DRILLED IN NORTH DAKOTA EAST OF THE MISSOURI RIVER

Wells drilled prior to July 2003

Wells drilled after July 2003
1-10-51   DST #1 B912-221  Open 2 hours, shut in 15 minutes.  Res. 25' drilling fluid, 720 black sulfur water and 1/2 pt. 30° brown oil in test tool. Initial hydrostatic mud pressure 2631 psi, initial flow pressure 295 psi, final flow pressure 468 psi, shut in pressure 1965 psi, final hydrostatic mud pressure 2602 psi.
We have received a number of enquiries from the mineral industry in the past 18 months as the price increased for a variety of elements and minerals. Chief among these enquiries has been uranium and potash. Uranium was mined in North Dakota in the 1960s. It was heavily explored for in the 1970s, but has been of little interest for the last 30 years until the price for uranium oxide reached an all time high in June of 2007. Companies have also expressed interest in associated elements molybdenum and germanium. We are aware of three companies that are contemplating mining uranium in southwestern North Dakota.

Potash or potassium salts are primarily used in the production of fertilizer. Potash exploration took place in northwest North Dakota in the 1970s. Since 2006, the price of potash rose from $190 to $1,050 per ton then fell to $300 per ton and is rising again. Based on increasing demand in rice growing regions. There are two companies that we know are actively pursuing potash exploitation.

Estimate 20-50 billion tons of ND Mineable Reserves
$6 trillion -15 trillion

Potash core from a depth of 9,000 feet in Burke County.

Formation Resources drilling for uranium, molybdenum, and germanium under a subsurface mineral permit in Billings County during the fall of 2008.

Counties that contain uranium deposits are in yellow and those that contain the shallowest potash deposits are in blue.
PROPPANT PROJECT

Millions of tons of sand and ceramic proppants are used every year in the Williston Basin, part of a multi-billion dollar industry. The Geological Survey has collected 125 sand samples throughout the state in our search for deposits that could be utilized for oil and gas proppants in the well fracturing process. We are in the process of performing preliminary analysis on those samples to determine if any would fit the proppant criteria. We have also collected clay samples and will be testing those samples for their kaolin content to determine their suitability in the manufacturing of ceramic proppants.

Under the second phase of this project, the ten most promising sand samples will undergo full ISO analysis (including bulk density, specific gravity, crush resistance, etc), mineralogy (XRD), and stack conductivity analysis to determine which are the most suitable proppant candidates and we will continue to evaluate the clay beds.

Locations of sand samples (red dots) and clay samples (blue dots) collected during this study. The areas in yellow are known sand deposits and the areas in brown are kaolinitic claystones within the Golden Valley Formation.
The future looks promising for sustained Bakken/Three Forks development

Draft BLM Hydraulic Fracturing rule could double federal drilling permit approval time or worse.

Draft EPA guidance on diesel fuel in hydraulic fracturing could triple drilling permit approval time or worse.

Current administration budget contains tax changes that could reduce drilling capital 35-50%

World and U.S. economies continue to struggle. If China joins the downward spiral oil price could fall enough to make some areas uneconomic