Size Degradation of Granular Lost Circulation Materials

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Outline

- Initial tests
- Expanded tests
- Field results
- Conclusions
Shear Degradation of LCM – Why Do We Care?

- Wellbore Strengthening (WS) process uses 30-60 mesh granular LCM.

- WS Success: Granular LCM circulated with the mud at all times – about 30 ppb.

- Requires special 3-deck shaker to recycle the 30-60 mesh material.

- LCM must survive multiple circulations to maintain the high concentration.

- Non-WS applications also recycle LCMs.
Plan – Shear Test LCM’s in the Lab

- Choose most common granular LCMs used for WS
- Shear at different intensities and times in the lab
- Measure resulting PSD (particle size distribution) to understand survivability of LCM’s regarding shear
- How does it compare to field results?
**Products Tested**

- **Ground Marble (CaCO₃)**
  - Common, cheap

- **Resilient graphitic material**
  - Calcined petroleum coke - expensive

- **Nut Hulls**
  - Walnut (black walnut, English walnut)
  - Pecan
  - Cheap, low specific gravity
Test Procedure

- Wet Sieve LCM to 30-60 mesh, dry, weigh
- Add to simple, unweighted bentonite mud
- Shear in mixer for 5-15 minutes
  - Low-shear Hamilton Beach®-type Mixer
  - High-shear Silverson® Mixer
- Wet sieve through 60 mesh
  - Dry and weigh
  - “% Degradation”
- Beckman Coulter Laser Diffraction PSA
Hamilton Beach – Low Shear
Silverson – High Shear
## Results – 30-60 Mesh

### Percent Degradation

<table>
<thead>
<tr>
<th></th>
<th>Hamilton Beach</th>
<th></th>
<th></th>
<th>Silverson</th>
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<tbody>
<tr>
<td></td>
<td>5 min</td>
<td>10 min</td>
<td>15 min</td>
<td>5 min</td>
<td>10 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Black Walnut</td>
<td>1.5</td>
<td>2.0</td>
<td>2.0</td>
<td>9.0</td>
<td>9.3</td>
<td>9.9</td>
</tr>
<tr>
<td>English Walnut</td>
<td>3.3</td>
<td>3.3</td>
<td>4.3</td>
<td>7.7</td>
<td>9.5</td>
<td>9.9</td>
</tr>
<tr>
<td>Pecan</td>
<td>11.7</td>
<td>14.3</td>
<td>15.0</td>
<td>24.2</td>
<td>26.9</td>
<td>28.3</td>
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<tr>
<td>Graphite</td>
<td>0.5</td>
<td>0.5</td>
<td>1.5</td>
<td>7.6</td>
<td>15.9</td>
<td>16.9</td>
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<tr>
<td>Marble</td>
<td>5.2</td>
<td>9.6</td>
<td>12.1</td>
<td>99.5</td>
<td>99.5</td>
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</tbody>
</table>
Before and After Photos – 60 Mesh
Conclusions

- Degradation increases with time and intensity
- Use Nut Hulls or Graphite for circulating WS or lost circulation applications with 30-60 mesh LCM
- Do not use Ground Marble
- Ground Marble can be used for spotting pills for WS or lost circulation
We Were Curious

- We saw the good results and had further questions
- Do smaller granular LCM sizes degrade less?
- Do LCMs degrade more slowly in a weighted mud because all the barite solids would “protect” them from degradation?
Further Tests

- 100-140 Mesh (106-150 microns) LCMs
- 200-325 mesh (45-74 microns) LCMs
- 30-60 mesh in 14.0 ppg mud
## 100-140 Mesh LCM (106-150 microns)

### Percent Degradation

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<td>5 min</td>
<td>15 min</td>
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<tr>
<td>Black Walnut</td>
<td>10.0</td>
<td>6.4</td>
<td>4.0</td>
<td>12.4</td>
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<tr>
<td>Graphite</td>
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<td>9.6</td>
<td>3.8</td>
<td>12.0</td>
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<tr>
<td>Marble</td>
<td>3.9</td>
<td>3.8</td>
<td>20.7</td>
<td>42.1</td>
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<tr>
<td>Coarse Barite</td>
<td>2.2</td>
<td>6.8</td>
<td>43.0</td>
<td>80.5</td>
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100-140 Mesh Graphite
### 200-325 Mesh LCM (44-75 microns)

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<tr>
<td><strong>Marble</strong></td>
<td>11.9</td>
<td>12.0</td>
</tr>
<tr>
<td><strong>API Barite</strong></td>
<td>5.7</td>
<td>6.1</td>
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Ground Marble – Various Sizes

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<td>Marble - 250-600 microns</td>
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<tr>
<td>Marble - 106-150 microns</td>
<td>3.9</td>
<td>3.8</td>
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<td>42.1</td>
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<tr>
<td>Marble - 45-74 microns</td>
<td>11.9</td>
<td>12.0</td>
<td>13.2</td>
<td>18.2</td>
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These results have implications for Reservoir Drill-In Fluids!
### 30-60 Mesh in 14.0 ppg Mud

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<tr>
<td></td>
<td>5 min</td>
<td>15 min</td>
</tr>
<tr>
<td>Black Walnut (Unwtd)</td>
<td>1.5</td>
<td>2.0</td>
</tr>
<tr>
<td>Black Walnut (Wtd)</td>
<td>1.5</td>
<td>4.4</td>
</tr>
<tr>
<td>Marble (Unwtd)</td>
<td>5.2</td>
<td>12.1</td>
</tr>
<tr>
<td>Marble (Wtd)</td>
<td>0.0</td>
<td>0.0</td>
</tr>
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Field Results

- **Case 1: WS with Walnut Hulls**
  - 5 days of operations (circulating)
  - 40 ppb
  - Sieved on location twice a day – 60 mesh
  - Only 1.6 ppb maintenance required
  - Low degradation (only 4% per day)
Field Results

- **Case 2: WS with Graphite and Marble**
  - 8 days of operations with maintenance
  - Virtually no CaCO$_3$ left (95%+ degradation)
Conclusions

- Granular LCMs degrade with increasing shear intensity and time

- Ground Marble:
  - 30-60 Mesh degrades completely at high shear
  - Barite in weighted muds slightly protects marble, but still complete degradation
  - 30-60 Mesh marble degrades completely in the field
  - Marble - Not suitable for circulating application
  - Smaller marble suffers less degradation
  - Reservoir Drill-In Fluids requiring large marble sizes must be analyzed and treated often to maintain designed PSD
Conclusions (cont.)

- Walnut Hulls and Resilient Graphite survived very well in lab and field – preferred LCM for circulating applications
- Pecan Hulls suffered moderate degradation – not recommended
- Barite degrades worse than CaCO$_3$
- Lab results compare well to field results
Paul Scott – Initial idea and test plans
Eddie Evans – lab work and report writing
Zack Wade – lab work and data analysis
Krista Franks – PSD’s and Photos
ConocoPhillips and Drilling Specialties Co.