FRACTUREVISION: Proppant-delivered Fracture Evaluation Services

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Proppant-Delivered Technology Platforms

Ceramics

Production Assurance
GUARD Technology

Flow Enhancement
RPM

Fracture Evaluation Services
FRACTUREVISION
CARBONRT Technology

- Chemically inert tracer technology used to identify proppant downhole

FRACTUREVISION Services

- Interpretation and evaluation of NRT technology provides multiple deliverables and technology integration
Problem: Where Did My Proppant Go?

• Traditional methods used:
  – Radioactive tracer (measure proppant)
    – Safety and toxicity issues
    – Illegal in some countries and states
  – Microseismic (infer where proppant is)
    – Measurement of rock failure
    – Large errors
Solution

• FRACTUREVISION
  – Non-radioactive tagged/traced proppant (CARBONRT technology) that can be detected downhole using a standard pulsed neutron log
  – Measures propped fracture height
  – Identifies propped stage intervals and perforations in vertical and horizontal wells
  – Measures near wellbore connectivity
How is CARBONRT Proppant Made?

CARBONRT is made like any other CARBO ceramic proppant.

- Tracer is added during the grind process of proppant production.
- Integral part of the proppant matrix.
- Not a coating or fluid additive.

Grind Process
How does CARBONRT Technology Work?

• Tracer absorbs neutrons at very high rate

• Emits small amount of Gamma rays compared to formation

• Alters response of neutron log to locate proppant
What is the Process in the Field?

- **Pulsed neutron log** is run before stimulation in sigma mode or spectral mode.
- **Well is stimulated.**
- **Pulsed neutron log** is run after stimulation in sigma mode or spectral mode.
- **Before and after logs** are compared to locate tracer, measure propped fracture height and stimulated intervals.

**Before stimulation neutron Log**

**After stimulation neutron Log**
Advantages of Using CARBONRT Technology

• Measuring Proppant

• Longevity and Repeatability

• High Resolution

• Environmentally Inert

• Field Proven Technology

➢ CARBONRT is not a fluid additive or a coating. It is an integral part of the grain matrix.

RELATIONSHIPS OF VARIOUS FRACTURE LENGTHS

FIG. 1
Advantages of Using CARBONRT Technology

- Measuring Proppant
- Longevity and Repeatability
- High Resolution
- Environmentally Inert
- Field Proven Technology
Advantages of Using CARBONRT Technology

• Measuring Proppant

• Longevity and Repeatability

• High Resolution

• Environmentally Inert

• Field Proven Technology

Microseismic resolution 25 – 500 ft
CARBONRT Tech Resolution 1-2 ft
Advantages of Using CARBONRT Technology

- Measuring Proppant
- Longevity and Repeatability
- High Resolution
- Environmentally Inert
- Field Proven Technology

- Uses CARBONRT, an inert proppant
- There are no special handling requirements
- Can be handled like any other proppant
Advantages of Using CARBONRT Technology

• Measuring Proppant
• Longevity and Repeatability
• High Resolution
• Environmentally inert

Field Proven Technology

Academic achievements: SPE 146744 (Field Trials), SPE 149102 (Middle East), SPE 151696 (Field Results), SPE 152169 (Rockies), SPE 152251 (Colombia), IPTC 14369 (China), IPTC 16581
Two Different Products

• CARBONRT
  – 100% Ceramic proppant

• CARBONRT ULTRA
  – Ceramic mixed with sand
FRACTUREVISION Interpretation

- Formation Sigma
- Formation Gamma Ray Counts Near Detector
- Formation Gamma Ray Counts Far Detector
- Gadolinium Yield
- Perforation Flag
- Propped Fracture Height Measurement
What Information does FRACTUREVISION Provide?

- **Propped Fracture Height**
  - Measure fracture height in vertical wells

- **Propped Zones**
  - Measure if perforation clusters and stages have been adequately stimulated and propped

- **Near Wellbore Connectivity**
  - Estimate the amount of proppant close to the wellbore
What is the Value of this Information?

• Propped Fracture Height

• Perf Cluster and Stage Efficiency

• Near Wellbore Connectivity

• Integrated Solution

Calibrate fracture models in FRACPRO and optimize treatment of offset wells

Propped fracture length is calculated from mass balance
What is the Value of this Information?

- Propped Fracture Height
- Perf Cluster and Stage Efficiency
- Near Wellbore Connectivity
- Integrated Solution
What is the Value of this Information?

- Propped Fracture Height
- Perf Cluster & Stage Efficiency
- Near Wellbore Connectivity
- Integrated Solution

High connectivity maximizes production
Low connectivity reduces production
What is the Value of this Information?

- Propped fracture height
- Perf cluster & stage efficiency
- Near wellbore connectivity
- Integrated solution
Case Study #1 with Detection Technologies

SPE-168603
Case Study #2 Permian

• Project goals:
  – To evaluate propped fracture height using FRACTUREVISION
  – To evaluate the effects of overflushing on near wellbore connectivity and fracture height using pressure matching
Stage 1 Results

- Stage 1 has low overall perf near wellbore connectivity per perforation and short propped fracture height and 2 out of 6 perforations showing proppant with 2 distinct fractures.

- Consider avoiding over-flushing by any amount.

- Consider using viscous fluid systems (crosslinked or linear) for the entire treatments to ensure a uniform proppant distribution is achieved in near wellbore area.

- Consider decreasing the phase angle on perforations and shot density on stage 1.

### Stage 1 Heights

<table>
<thead>
<tr>
<th>Stage 1 Heights</th>
<th>NRT Height</th>
<th>Pressure Match Height</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>82</td>
<td>92</td>
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</table>

### Table

<table>
<thead>
<tr>
<th>Total Fluid</th>
<th>2,857 bbls</th>
<th>6 clusters, 39 shots</th>
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</thead>
<tbody>
<tr>
<td>Total Proppant</td>
<td>108,000 lb</td>
<td>31 bbl overflush + 24 bbl 15% HCL</td>
</tr>
<tr>
<td>Rate</td>
<td>65 bpm</td>
<td></td>
</tr>
</tbody>
</table>

Low near wellbore connectivity due to overflush
Stage 2 Results

- Stage 2 has high near wellbore connectivity per perforation but low perf efficiency with 1 out of 2 perforations showing proppant.
- A zone above the stage interval shows propped fracturing.
- Consider avoiding over-flushing by any amount
- Consider using viscous fluid systems (crosslinked or linear) for the entire treatments to ensure a uniform proppant distribution is achieved in near wellbore area.

Stage 1 Heights

<table>
<thead>
<tr>
<th>NRT Height</th>
<th>Pressure Match Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>110</td>
<td>230</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Stage</th>
<th>Total Fluid</th>
<th>Total Proppant</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>3,759 bbls</td>
<td>218,000 lb</td>
<td>51 bpm</td>
</tr>
<tr>
<td></td>
<td>2 clusters, 24 shots</td>
<td>9 bbl overflush + 12 bbl 15% HCL</td>
<td></td>
</tr>
</tbody>
</table>
Project Goal Effects of Overflushing

Avoiding overflush would lead to **30% increase** in near wellbore connectivity and **10% increase** in production.
Project Goals

• To evaluate propped fracture height using FRACTUREVISION

• To evaluate the effects of overflushing on near wellbore connectivity and fracture height using pressure matching
  – Over flushing has a negative impact on near wellbore connectivity and production
Cement Evaluation Published Field Test

Objective

- Determine final location of cement by logging through production tubing

Results

- Cement was detected to 680 feet through multiple casings
Summary

• CARBONRT is a traceable proppant that can be detected downhole with standard pulsed neutron log

• No shelf life and no safety or handling requirements

• Direct measurement of the proppant near the wellbore

• Using FRACTUREVISION you can measure propped fracture height, propped stages and zones, and near wellbore connectivity

• FRACTUREVISION enables a high resolution perf spacing and stage spacing analysis
Thank You!

Questions?