Completion Deployed Scale Inhibitor Applications in Deep-Water, West Africa

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Presentation Content

• Introduction to inorganic scale

• Concept of the pre production squeeze

• Field results for treatments in stimulation fluids
  - Liquid scale inhibitor within acid wash/overflush and frac gel

• Conclusions

• Acknowledgment
Common Oilfield Scales

\[ \text{Ca(HCO}_3\text{)}_2 \rightleftharpoons \text{CaCO}_3 + \text{CO}_2 + \text{H}_2\text{O} \]

Calcium carbonate

\[ \text{Ba}^{2+} + \text{SO}_4^{2-} \rightarrow \text{BaSO}_4 \]

Barium sulphate
Pre-Production Scale Treatment

How is it deployed

- Scale inhibitor treatment applied during well completion
- Liquid scale inhibitor in the perforation cleaning acid and overflush and/or linear gel stages and/or cross linked gel
  - Compatible
  - Non-damaging
  - Good retention profile

Radial flow dominated brine inflow: best treatment option is radial matrix treatment

Linear flow dominated brine inflow: best treatment option is SI in linear frac gel
Why Consider this method of scale control?

- Uncertainties in water composition.
- Potential BaSO₄ and CaCO₃ risk.
- Risk of scale at low water cut and poor dispersion of continuous injection treatment.
- Chemical return data provides vital information for scale management program and future squeeze application, if needed.
Seawater (SW) Flood Schematic

Impact of a heterogeneous reservoir on BaSO$_4$ scale risk during SW flooding

SW

FW

AWS

IW = Seawater or Aquifer rich in SO$_4$

FW = rich in Ba, Sr, Ca
Pre Production Scale Inhibitor Application

• Liquid scale inhibitors within fluids “lost” to the formation such as stimulation fluids (acids, linear gel, cross linked gel)

• Solid scale inhibitors (within frac propant or pre pack screens)
Monitoring and Location

Monitoring
• Well Test frequency
• Multiple wells in single riser

Geographic Location
• Analysis capability
• Chemical supply chain
• Equipment limitation
• Expert support
## Nature of the WA Fields

### Inorganic Scale Challenges

<table>
<thead>
<tr>
<th>Ion in mg/l</th>
<th>Reservoir B</th>
<th>Reservoir B1</th>
<th>Reservoir T</th>
<th>Reservoir L</th>
<th>Reservoir LN</th>
<th>Seawater</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na</td>
<td>23200</td>
<td>21000</td>
<td>24960</td>
<td>25894</td>
<td>17800</td>
<td>11019</td>
</tr>
<tr>
<td>K</td>
<td>150</td>
<td>136</td>
<td>144</td>
<td>140</td>
<td>272</td>
<td>408</td>
</tr>
<tr>
<td>Ca</td>
<td>2500</td>
<td>1180</td>
<td>2660</td>
<td>1000</td>
<td>884</td>
<td>422</td>
</tr>
<tr>
<td>Mg</td>
<td>380</td>
<td>117</td>
<td>515</td>
<td>318</td>
<td>107</td>
<td>1322</td>
</tr>
<tr>
<td>Hba</td>
<td>19</td>
<td>15</td>
<td>44</td>
<td>230</td>
<td>150</td>
<td>0</td>
</tr>
<tr>
<td>Sr</td>
<td>62</td>
<td>52</td>
<td>113</td>
<td>185</td>
<td>55</td>
<td>7</td>
</tr>
<tr>
<td>Cl</td>
<td>37600</td>
<td>31900</td>
<td>426500</td>
<td>44814</td>
<td>29010</td>
<td>19805</td>
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<tr>
<td>SO4</td>
<td>45</td>
<td>170</td>
<td>14</td>
<td>5</td>
<td>74</td>
<td>2775</td>
</tr>
<tr>
<td>HCO3</td>
<td>400</td>
<td>500</td>
<td>500</td>
<td>636</td>
<td>-</td>
<td>145</td>
</tr>
<tr>
<td>pH</td>
<td>7.4</td>
<td>7.2</td>
<td>7.3</td>
<td>5.8</td>
<td>6.1</td>
<td>8.4</td>
</tr>
</tbody>
</table>
Deep Water WA Field Results

• Frac packed wells
• Liquid scale inhibitor within stimulation stage and fracture gel stage
• Acid phosphonate inhibitor within acid perforation wash/overflush stages
• Neutral phosphonate inhibitor within cross linked gel stages
• Nine wells treated to date
• Three wells currently cutting water
Deep Water WA Field Results

<table>
<thead>
<tr>
<th>Formation</th>
<th>Well code</th>
<th>Life time of the inhibition treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>P1-ST1</td>
<td>15 months and still protected</td>
</tr>
<tr>
<td>B</td>
<td>P3-ST3</td>
<td>4 months and still protected</td>
</tr>
<tr>
<td>B1</td>
<td>P4</td>
<td>31 months and still protected</td>
</tr>
<tr>
<td>B1</td>
<td>P5-ST1</td>
<td>14 months and still protected</td>
</tr>
<tr>
<td>B1</td>
<td>P6</td>
<td>20 months and still protected</td>
</tr>
<tr>
<td>B1</td>
<td>P9</td>
<td>10 months and still protected</td>
</tr>
<tr>
<td>T</td>
<td>P1-ST3</td>
<td>13 months and still protected</td>
</tr>
<tr>
<td>L</td>
<td>P4-ST1</td>
<td>8 months and still protected</td>
</tr>
<tr>
<td>L</td>
<td>P2-ST1</td>
<td>11 months and still protected</td>
</tr>
</tbody>
</table>

- Observed duration of protection for the nine wells treated
## Deep Water WA Field Results

<table>
<thead>
<tr>
<th>Well code</th>
<th>Reservoir</th>
<th>Volume acid plus SI conc.</th>
<th>Volume overflush plus SI conc</th>
<th>Volume Frac Gel plus SI conc</th>
<th>Design protected water volume (bbls) for Acid/overflush</th>
<th>Observed or predicted protected water volume (bbls) for Acid/overflush</th>
<th>Observed or predicted protected water volume (bbls), Acid/overflush plus Frac Gel</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1-ST1</td>
<td>B</td>
<td>190 bbls (5.4%)</td>
<td>380 bbls (7.7%)</td>
<td>812 bbls (4.6%)</td>
<td>500,000</td>
<td>520,000</td>
<td>1,000,000</td>
</tr>
<tr>
<td>P4</td>
<td>B1</td>
<td>577 bbls (5%)</td>
<td>1154 bbls (7%)</td>
<td>1956 bbls (5%)</td>
<td>550,000</td>
<td>490,000</td>
<td>965,000</td>
</tr>
<tr>
<td>P5-ST1</td>
<td>B1</td>
<td>308 bbls (5%)</td>
<td>576 bbls (7.8%)</td>
<td>1725 bbls (4%)</td>
<td>375,000</td>
<td>320,000</td>
<td>860,000</td>
</tr>
</tbody>
</table>

- Fluid stages, inhibitor concentrations and produced water protected
Well P4 Projected Treatment Life

- If all deployed inhibitor is contacted by produced water potential squeeze life 960,000 bbls water protected
Well P1 ST1 Projected Treatment Life

- If all deployed inhibitor is contacted by produced water potential squeeze life 1,000,000 bbls water protected
Conclusions

Many factors influence the suitability of pre-production squeeze treatments for application while completing production wells these include:

- Scaling tendency of the produced water,
- The geographic remoteness of the asset,
- The challenge of monitoring scale control,
- The completion type itself controls the location and stage of the completion program where chemicals can be added,
- The cost of these types of application relative to stand alone classic squeeze treatments need to be considered.
Conclusions

• The presence of scale inhibitor in the initial produced water reduces the risk of a scaling event if the onset of injection water breakthrough is missed in deepwater, subsea wells with limited well test availability.
Acknowledgements

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Back Ground Publications

• NACE 2011, paper no.17984

