Differences in the Texture of Chalk as observed by NMR

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Differences in the Texture of Chalk as observed by NMR

Konstantina Katika, Mouadh Adassi, M. Monzurul Alam and Ida Lykke Fabricius

In this study, three cases under investigation illustrate how changes in the surface-to-volume ratio of chalk affect the low-field Nuclear Magnetic Resonance signal:

1. Outcrop chalk saturated with high salinity brine showed that saturation with divalent ions can cause major shifts in the T2 curve.

2. Fluid samples where precipitation reactions caused shifts in the T2 curve due to the creation of crystals within the fluid.

3. Two types of chalk with different surface-to-volume ratio, saturated with the same brines produced different NMR signals.

- NMR signal decay time (known as relaxation time) is affected by the solid phase:
  - Long distance from the pore walls means long decay times.
  - In smaller distances, NMR relaxation is affected by the solid.
  - Transverse relaxation rate, 1/T2:
    \[
    \frac{1}{T_2} = \frac{S}{\rho V}
    \]
    - S: surface relaxivity
    - \(\rho\): surface-to-volume ratio

- Differences in the rock texture:
  - Precipitants within the pore space
  - Variations in the bound water thickness

- May affect the transverse relaxation time by altering the surface relaxivity or the surface-to-volume ratio in the following equation:

\[
\frac{1}{T_2} = \frac{S}{\rho V}
\]

- As observed from the following results:

- Brines that contain precipitants after contact with chalk:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Concentration (g/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnesium chloride solution</td>
<td>58.1</td>
</tr>
<tr>
<td>Calcium chloride solution</td>
<td>67.7</td>
</tr>
</tbody>
</table>

- Outcrop chalk with high surface-to-volume ratio saturated with divalent ions:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>MA-Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Porosity (%)</td>
<td>~42</td>
</tr>
<tr>
<td>Grain density (g/cm³)</td>
<td>~2.71</td>
</tr>
<tr>
<td>Permeability (mD)</td>
<td>~6</td>
</tr>
<tr>
<td>Carbonate content (%)</td>
<td>~99</td>
</tr>
<tr>
<td>Specific surface (m²/g)</td>
<td>~1.7</td>
</tr>
<tr>
<td>Specific surface of the IR (m²/g)</td>
<td>~50</td>
</tr>
<tr>
<td>Surface relaxivity (μm/s)</td>
<td>~0.9</td>
</tr>
</tbody>
</table>

- Brines with precipitants Concentration (g/L)

- T2 Distribution of chalk with high vs. low surface-to-volume ratio

- NMR Relaxation in the homogenous system of brine saturated chalk:

- Low field NMR was successfully used to identify changes in the surface-to-volume ratio.

- Samples with high surface-to-volume ratio result in smaller relaxation times. Samples saturated with Mg-rich brines, brines containing precipitants, and chalk with different texture illustrate this.

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CERE
Center for Energy Resources Engineering

* Katika et al., Nuclear magnetic resonance and sound velocity measurements of chalk saturated with magnesium rich brine, Poromechanics V, 967-968, (2013).
* Katika et al., Nuclear magnetic resonance and sound velocity measurements of chalk saturated with magnesium rich brine, Poromechanics V, 967-968, (2013).