Physics – Dielectric Permittivity

Permittivity is:

- a **physical quantity** that describes how an **electric field** affects, and is affected by a **dielectric** medium,

  and is determined by the ability of a material to **polarize** in response to the field,

  and thereby reduce the total electric field inside the material. Thus, permittivity relates to a material's ability to transmit (or "permit") an electric field.
Dielectric Polarization

- Mechanism
  - Water
  - Oil, Rock

> Medium

<table>
<thead>
<tr>
<th>Mechanism</th>
<th>Medium</th>
<th>Characteristic</th>
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<tbody>
<tr>
<td>Water</td>
<td>$\varepsilon_r \sim 50 - 80$</td>
<td></td>
</tr>
<tr>
<td>Oil, Rock</td>
<td>$\varepsilon_r \sim 2, 5 - 9$</td>
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Hence, we can discriminate water from hydrocarbons, whatever its salinity.

- Textural Effect

Dielectric as function of frequency
- Pore fluid analysis
- Formation matrix analysis

Principle of Dielectric Measurement

- We convert a collection of amplitude and phase measurements into $\varepsilon$ and $\sigma$

Amplitude $A$ | Phase $\phi$ | $\varepsilon$ Permittivity | $\sigma$ Conductivity

- Dielectric Constant, is complex with two components one real and one imaginary

$$\varepsilon^* = \varepsilon_r + i \frac{\sigma}{\omega\varepsilon_0}$$
Defining fresh formation water

This is an *environmentally friendly* oil field waste product

Variable Formation Water Salinity

**Standard logs**

Moved Oil?
High deep resistivity and high porosity
Invasion from shallow resistivity

Heavy oil

Water zone
Variable Formation Water Salinity

Dielectric-Scanner real time answer

Fresh Water
Dielectric water filled porosity overlays with total porosity

Heavy oil

Water zone

Thin Beds Analysis

Dielectric-Scanner real time answers

Dielectric shows thin beds and a lot more oil than Induction

Interpretation is confirmed by FMI images and with vertical and horizontal resistivities from Rt-Scanner

Thin Bed Analysis

- Thinly bedded sands, conductive clay beds
- High viscosity oil

Objectives
- Hydrocarbon volume
- Reservoir quality

Dielectric Scanner high resolution water-filled porosity
- Correct hydrocarbon volume (uninvaded zone)
- Sand count & net pay
- Identify potential high sand quality

Comparison of 3 Laminated Sand Analysis methods

Permian Basin Dielectric Scanner Example

West Texas High Water Cut Carbonate
- The goal is to identify higher oil saturations and improve economics.
- The result in this case using the Dielectric Scanner was identification of lower water saturations and higher oil cut than standard Elan.
- The oil cut was up to 15%, out-performing the offsets
- Another result was better water resistivity calculation in the shallow portion of the well.
Main Zone of interest

Perfs 840 bbl/day 10-15% oil cut

Zone with low salinity

Salinity (constant green curve)

RW used in Elan

ADT RW xo
Variable M & Rwa

Conventional processing of data shows a productive zone at the bottom of the well. This is incorrect as shown by the Elan/Dielectric and is verified PL results.

- The cost to drill and stimulate these unproductive zones is approximately $750K/well. With 60+ wells drilled to date, the client has spent in excess of $45M drilling and completing zones that have contributed nothing but excess water.
- Lost opportunity costs associated with the 7-10 days it takes to drill through the lower 2 zones coupled with $750k savings on all future wells has changed the client’s outlook on SLB logs.
- Savings by using SLB is about 20-25% of well cost and versus only 2% added well cost to use SLB for logging the ADT.

Delaware Basin Wolfbone
“Using ADT to reduce water-cut and decrease Drilling & Completion Costs”
Questions?