1. Introduction

- The pore throat size and its distribution is important in many fluid transport processes in porous media (like reservoir rock) [1]. The pore throat size affects the fluid saturation distribution, porosity, permeability and, to some extent, wettability.
- Capillary pressure curves acquired using an MRI-based technique called GIT-CAP can be used to determine pore throat size distributions by calculating the saturation change at each pressure and converting the pressure into a pore throat size.
- Relative permeability is the ratio of the permeability of one fluid with a second fluid present compared to having no second fluid present.
- Relative permeability can be modeled from capillary pressure curves.

5.1 Relative Permeability from Pc

- Relative permeability can be calculated from capillary pressure using a number of existing techniques including the Burdine model [6].
- The wetting $k_w$ and non-wetting, $k_{nw}$, relative permeability are:

$$k_w = \left(\frac{\lambda_w}{\lambda_{nw}}\right)^2 \int_0^{\frac{\phi \Delta P_c}{\rho_g}} \frac{dS}{P_c}$$

$$k_{nw} = \left(\frac{\lambda_{nw}}{\lambda_w}\right)^2 \int_0^{\frac{\phi \Delta P_c}{\rho_g}} \frac{dS}{P_c}$$

- Applying the Purcell model directly to the Brooks-Corey capillary pressure model:

$$k_w = (1-S_w)^{n}$$

$$k_{nw} = (1-S_{nw})^{n}$$

5.2 Relative Permeability from Pc

- The capillary pressure data can be modeled and the conversion to relative permeability can be applied directly using the modeled constants.
- Below is a Brooks-Corey capillary pressure model equation.

$$P_c = P_e + \left(\frac{S_r - S_{wr}}{S_r - S_w}\right)^{n}$$

- Applying the Purcell model directly to the Brooks-Corey Pc model yields:

$$k_w = (1-S_w)^{n}$$

$$k_{nw} = (1-S_{nw})^{n}$$

6. Imbibition and Drainage Pc

- Oil/Brine imbibition and drainage ([1] and [2]) can be acquired using the MRI-based technique [4].
- A unique quality of MRI-based Pc is that both positive and negative pressures can be measured by moving the oil/brine contact to the middle of the rock.

7. Results (Relative Permeability from Pc)

- The relative permeability model can be directly applied to the Pc data.
- The difficulty lies in selecting the correct irreducible or residual saturation value, $S_r$.

8. Pore Size/Throat Comparisons

- The graph below shows an overlay of the pore size distribution from the T2 NMR data; mercury injection pore throat size; and the pore throat size derived from the MRI-based Pc.
- The T2 NMR data was scaled using a relaxivity value of 6.24 um/s (additional results are shown in the table in Section 11).

9. Capillary Pressure Comparisons

- Once the relaxivity value is known, the T2 NMR pore size distribution can be used to model a Pc curve (similar to mercury injection).
- Below is a comparison of the MRI-based Pc measurement; a Brooks-Corey fit of the MRI-based data; and the T2 NMR derived Pc curve.

10. Conclusions

- The pore throat size acquired from GIT-CAP is non-destructive and uses reservoir fluids so there is no impact on the clays, pore matrix or wettability.
- Determination of the NMR relaxivity value allows for the T2 pore size distribution to be quantified and capillary pressure can be modeled.
- Relative permeability can be modeled directly from the Pc data or from the model applied to the Pc data.
- Standard T2 cut-off values are not valid in tight rocks.

11. References

3. US patent 7,352,179, “Methods and apparatus for measuring capillary pressure in a sample”
5. Alshubhaia, UAE. 2008

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