geoconvention
Virtual Event
September 13 - 15
2021

The Fundamental Role of Electrostatic Forces Within Pore Systems and Their Effects on Resource Evaluation and Reservoir Performance

Bob Lee, P.Geol

Advisors - Per Pedersen PhD, Tom Moslow PhD, Roberto Aguilera PhD

Centre for Applied Basin Studies, Dept. of GeoScience, University of Calgary

Part 2a: Capillary Forces Theory: a model for understanding the electrostatic forces and their effects within pore systems.

Water saturated reservoir

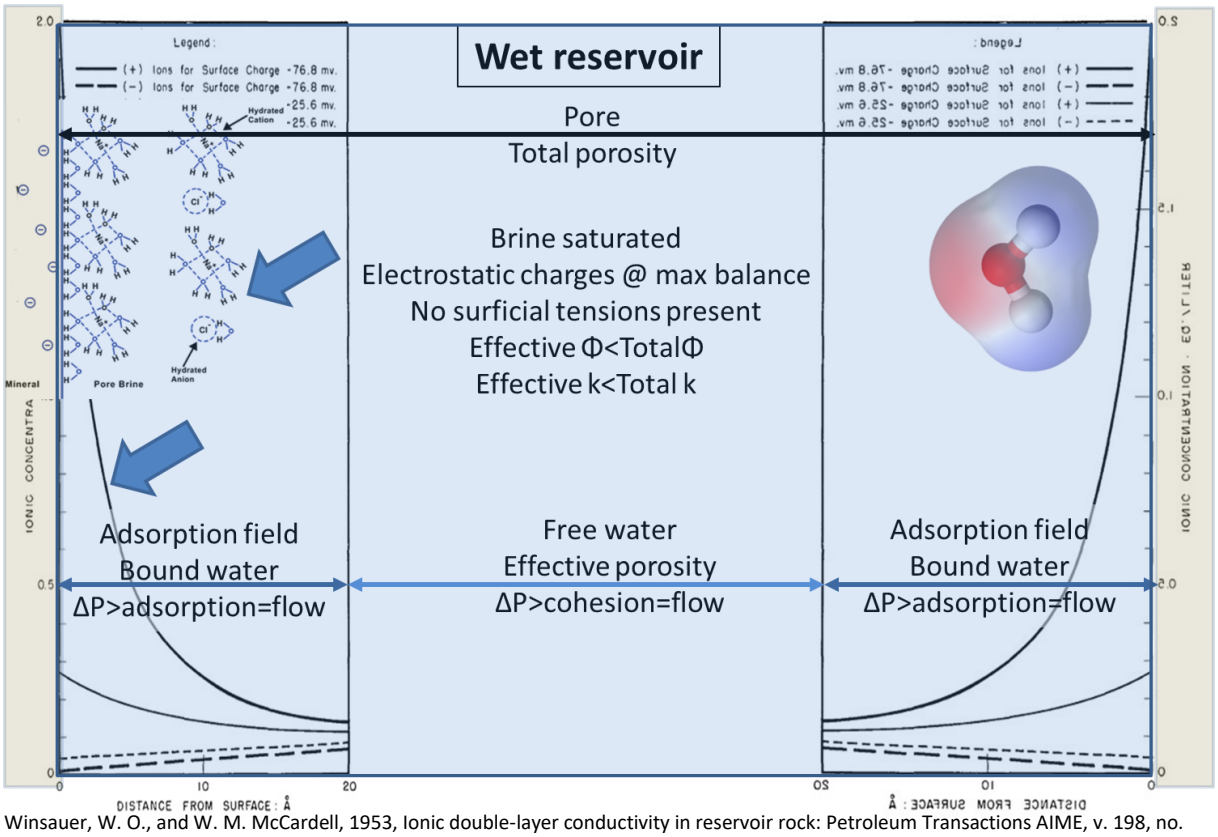
The overall study arose from unpublished work by the author over the past 30+ years to understand large volumes of bypassed oil resource in reservoirs across western Canada, primarily the shaly sandstone reservoirs of the Mannville Group. The fundamental issue with these resources is that, despite having conventional properties (1-1000mD) the low effective permeability to the oil phase means they, historically, tested tight in conventional wells. Research for this study revealed that intrinsic, permanent electrostatic forces within all pore systems control fluid saturation distributions and influence every technology typically used for resource evaluation. The model that has emerged is termed the Capillary Forces Theory (CFT).

The primary forces of CFT are adsorption (solid/liquid contact surfaces), cohesion (internal strength), surface tension (gas/liquid contact surfaces), and interfacial tension (liquid/liquid contact surfaces). The secondary forces of CFT are diffusion/osmosis (liquid/liquid miscibility) [2–7]. These are weak forces on an absolute scale but are powerful on the pore scale.

The term capillarity is defined as the intrinsic tendency of a reservoir to retain water because of the electrostatic forces within pore systems. It is used to describe relative differences in total electrostatic effects between reservoirs. It is directly related to capillary pressure and inversely related to reservoir quality. Any factors that increase the surface area per unit volume of a pore system increases the capillarity. Capillarity rises exponentially where the distances between surfaces decrease to the level where adsorption fields encroach or overlap.

The term capillary film is used to denote the adsorbed water. The capillary film in water saturated reservoirs reduces storage capacity and effective permeability. The behaviour of capillary film water in reservoirs with partial saturations is complex.

A key question the theory helps answer is whether a reservoir is wet or not. The theme under which CFT can be used for data interpretation is paraphrased from Archie (1942): The behavior of a water saturated reservoir must be understood before the behavior of partial saturations in the reservoir can be understood. A schematic of a water saturated reservoir are shown below [3,8].



Winsauer, W. O., and W. M. McCardell, 1953, Ionic double-layer conductivity in reservoir rock: Petroleum Transactions AIME, v. 198, no. 55, p. 129–134.

Thomas, E. C., 2018, What is It About Shaly Sands? Shaly Sand Tutorial 1 of 3: Petrophysics, v. 59, no. 1, p. 7–14.

References

1. Worden, R. H. & Burley, S. D. *Sandstone Diagenesis: The Evolution of Sand to Stone*. *Sandstone Diagenesis* (2009). doi:10.1002/9781444304459.ch.

2. Bardon, C. & Pied, B. Formation water saturation in shaly sands. *SPWLA 10th Annu. Logging Symp. 1969* (1969).

3. Thomas, E. C. What is It About Shaly Sands? Shaly Sand Tutorial 1 of 3. *Petrophysics* **59**, 7–14 (2018).

4. N. C. Wardlaw; R. P. Taylor. Mercury capillary pressure curves and the interpretation of pore structure and capillary behaviour in reservoir rocks. *Bull. Can. Pet. Geol.* **24**, 225–262 (1976).

5. Evans, C. E. & Guerrero, E. T. Theory and application of capillary pressure. *SPWLA 20th Annu. Logging Symp. 1979* (1979).

6. Uzun, O. & Kazemi, H. Assessment of improved oil recovery by osmotic pressure in unconventional reservoirs: Application to niobrara chalk and codell sandstone. *SPE/AAPG/SEG Unconv. Resour. Technol. Conf. 2020, URTeC 2020* (2020) doi:10.15530/urtec-2019-302.

7. Morrow, N. R. & Mason, G. Recovery of oil by spontaneous imbibition. *Curr. Opin. Colloid Interface Sci.* **6**, 321–337 (2001).

8. Winsauer, W. O. & McCardell, W. M. Ionic double-layer conductivity in reservoir rock. *Pet. Trans. AIME* **198**, 129–134 (1953).