

Fluid Saturation Modeling

Credit to Mr. Ahmed Alher

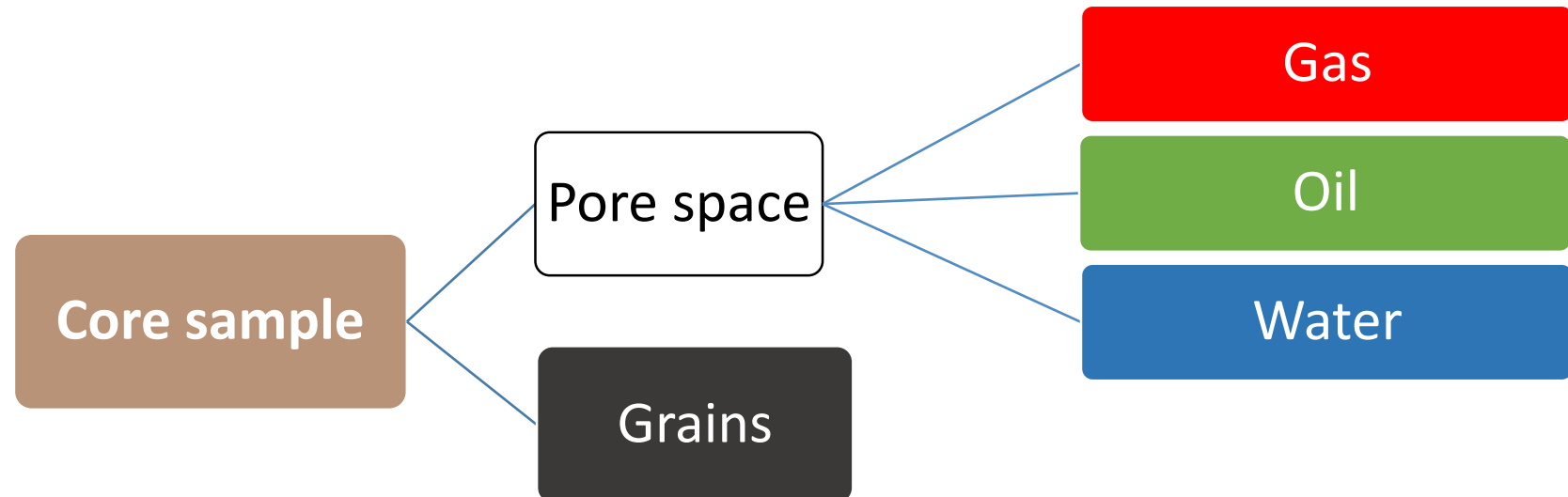
Introduction

- Saturation is defined as that fraction, or percent, of the pore volume occupied by a particular fluid (oil, gas, or water).

$$S_o = \frac{\text{volume of oil}}{\text{pore volume}}$$

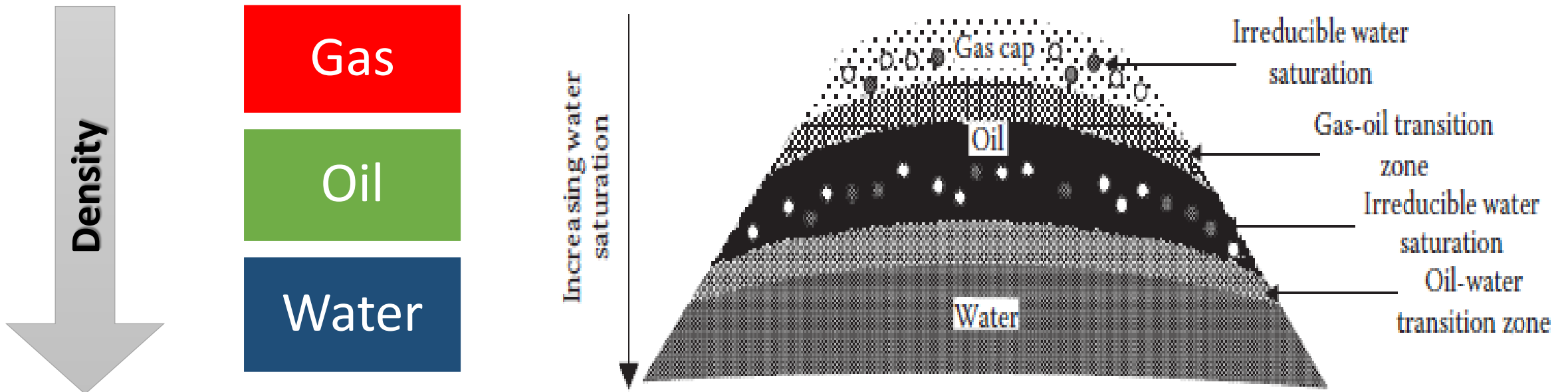
$$S_g = \frac{\text{volume of gas}}{\text{pore volume}}$$

$$S_w = \frac{\text{volume of water}}{\text{pore volume}}$$



Introduction

- The fluids in most reservoirs are believed to have reached a state of equilibrium and, therefore, will have become **separated according to their density**, i.e., oil overlain by gas and underlain by water.

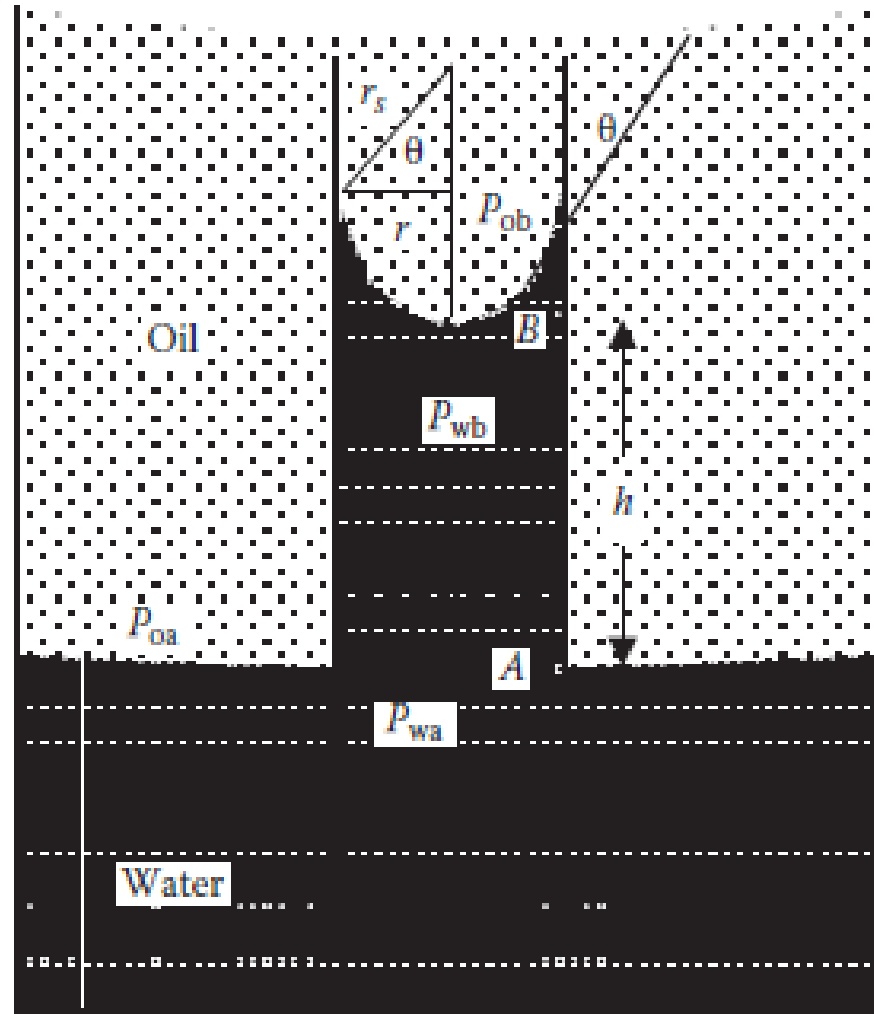


Fluid saturation modeling

- The distribution of fluid saturation depends on a number of factors that are related to the physical properties of both the **rock** and the **fluids**, as well as to **rock-fluid interactions**.
- The saturations conditions of the reservoir formation are affect the calculation of the **hydrocarbon in place** in addition to expected **producing performance** of the field.
- A number of techniques are available to ascertain the saturation conditions of a reservoir rock. Some of them are based on measurements performed either on **core samples** or in the **borehole environment (logs)**.

Core saturations

- Fluid saturations can be determined on core either by measuring the quantity of **fluid extracted** from a core sample, or by **means of capillary pressure**.
- Extraction of fluids from core samples is based on the **determination of water and hydrocarbon quantities** existing in a native state core sample, Later, **porosity** is measured on the clean sample and water saturation is calculated as the fraction (or percentage) of pore space filled with water.
- There is an inherent relationship between capillary pressure and water saturations, because water is retained in the pore spaces by capillary forces. Therefore, a **vertical distribution function** for water saturation may be obtained through the prior knowledge of the capillary pressure distribution within the reservoir.

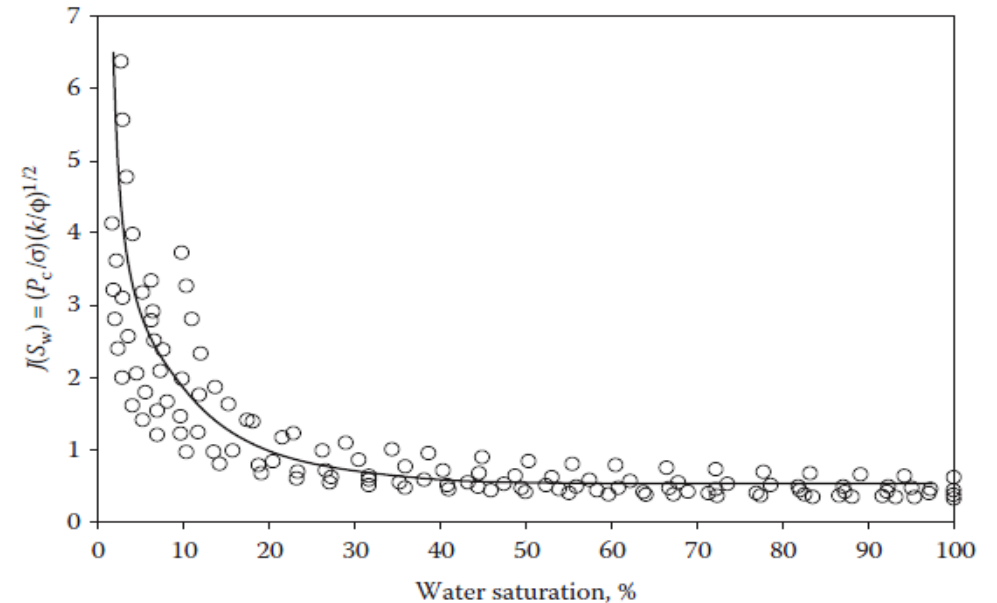


Capillary pressure data

Averaging

Since capillary pressure is affected by PSD, porosity, and permeability, these effects need to be corrected before comparing the capillary pressure data.

$$J(S_w) = \left(\frac{P_c(S_w)}{\sigma} \right) \left(\frac{k}{\phi} \right)^{1/2}$$



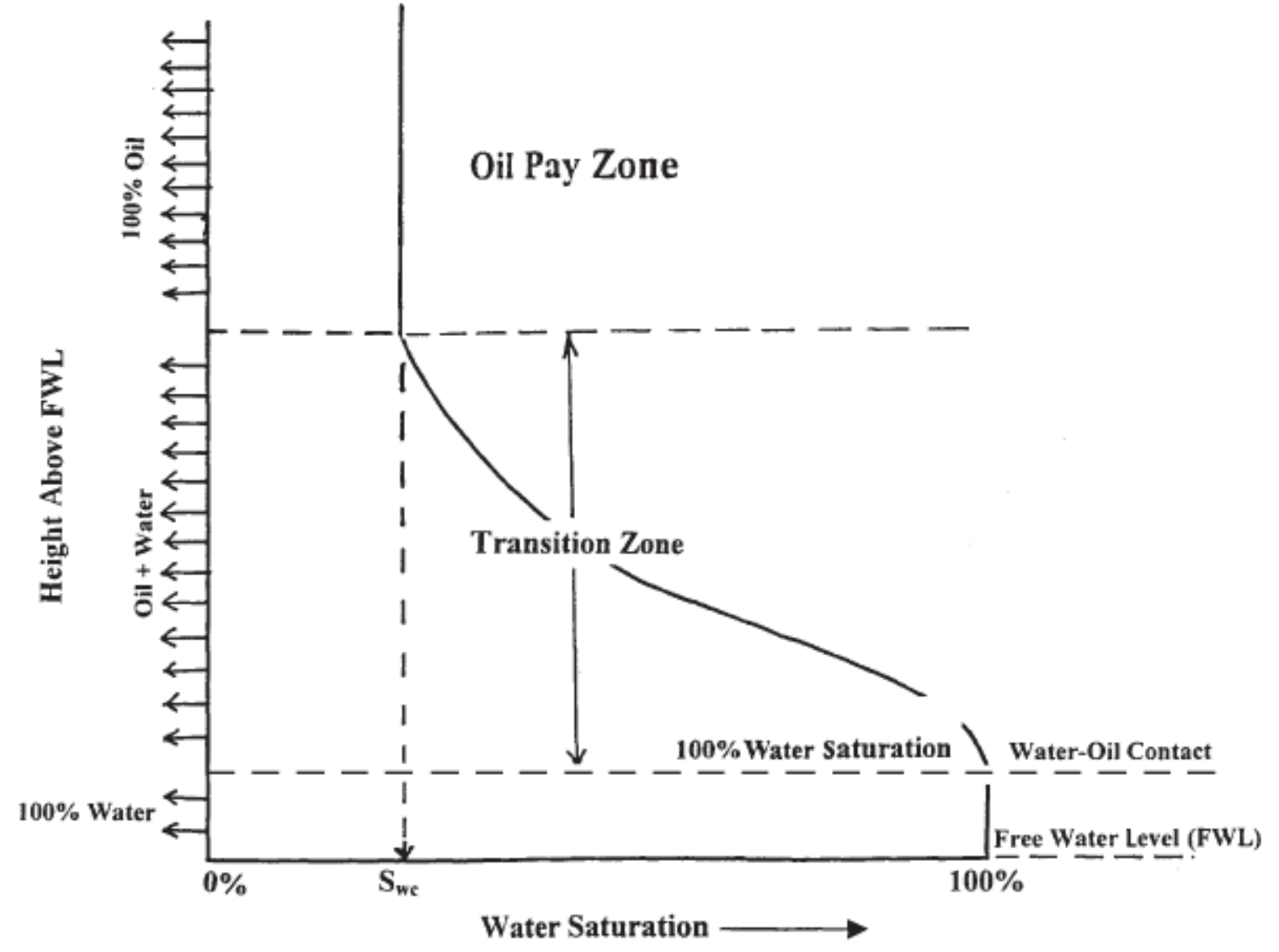
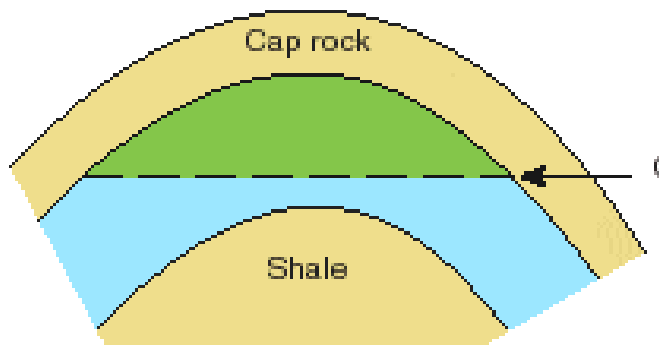
Converting

it becomes necessary to convert laboratory-measured capillary pressure data to reservoir condition capillary pressure data.

$$[P_{cow}]_R = \frac{\sigma_{ow}}{\sigma_{gw}} [P_{cgw}]_L \sqrt{\frac{\phi_R k_L}{\phi_L k_R}}$$

Log saturations

- Water saturation can be indirectly measured in the borehole environment by logging device. The common practice of evaluating water saturation for a reservoir is through the interpretation of log resistivity curves.
- The principle behind this methodology is that the electrical conductivity of formation is entirely due to the water presence.
- The equation that allows for the calculation of water saturation from resistivity measurements is the well known **Archie** equation.



Report Procedure

1- Calculate the J function for both well core data (Lab data) $J(S_w) = \left(\frac{P_c(S_w)}{\sigma} \right) \left(\frac{k}{\phi} \right)^{1/2}$

2- Estimate the average J function for both cores to

3- calculate PC at reservoir conditions (average K and average porosity for reservoir).

3-Calcualte the depth for each PC value from the following equation:

Field Units:
$P_c = \frac{h\rho_w}{144} \text{ or } P_c = \frac{h(\rho_w - \rho_o)}{144} \text{ psi (or lb/sqin)}$
$\rho_w, \rho_o = \text{lb/ft}^3$
$h = \text{ft}$

4-Plot the Depth Vs. SW (log data) for both wells. Add plot of lab SW VS. depth (calculated from Pc)

5- Manipulate the lab data until the lab (SW vs. depth) curve takes the same trend of log curves