Note Title 8/27/2018

"RESERVOIR"

① Geologic & Petrophysical

* Barriers
  - To Vertical Flow
    - k_v low → 0 "shaly" (& other types)
  - To Areal Flow
    - Faults ($T_F = 0$ → 0 > 0)
    - Stratigraphic (pinchouts)

} Defines RFUs
- Depl.
- EOR

* Spatial Variation of Rock (& Fluid) Properties

Mapping / Well bore logs / Petrel / Geostatisticians

- k_z k_x k_y — Anisotropy in all direction

  $f(x, y, z)$

- $\phi(x, y, z)$
- $S_w(x, y, z)$

$S_{HC}(x, y, z) = 1 - S_{wc}$ ← connate ("initial")

Core
- $k_h(\phi)$
- $k_v(\phi)$

└ Henning Omre, NTNU

② FLUID "SYSTEMS" & "PROPERTIES"

TPG4145

Fluid Systems

- Reservoir "Gas" (RG) $RF_g \propto (p_{R\,abandonment})$
  (Dry & Wet)
- Reservoir "Oil" (RO) $p_{Ri} \geq p_b$ } $p_b(x_{Ri}(Z, X, Y); T_R)$
- Aquifer (AQ)
  - Transition Zone ($Z < Z_{FWL}$

    S_w from 100% to

    $k_{rw} \sim 0$

    $p_w = p_o$

    Free Water Level "(OWC / GWC)"

    Shallowest Z where $S_w = 100\%$

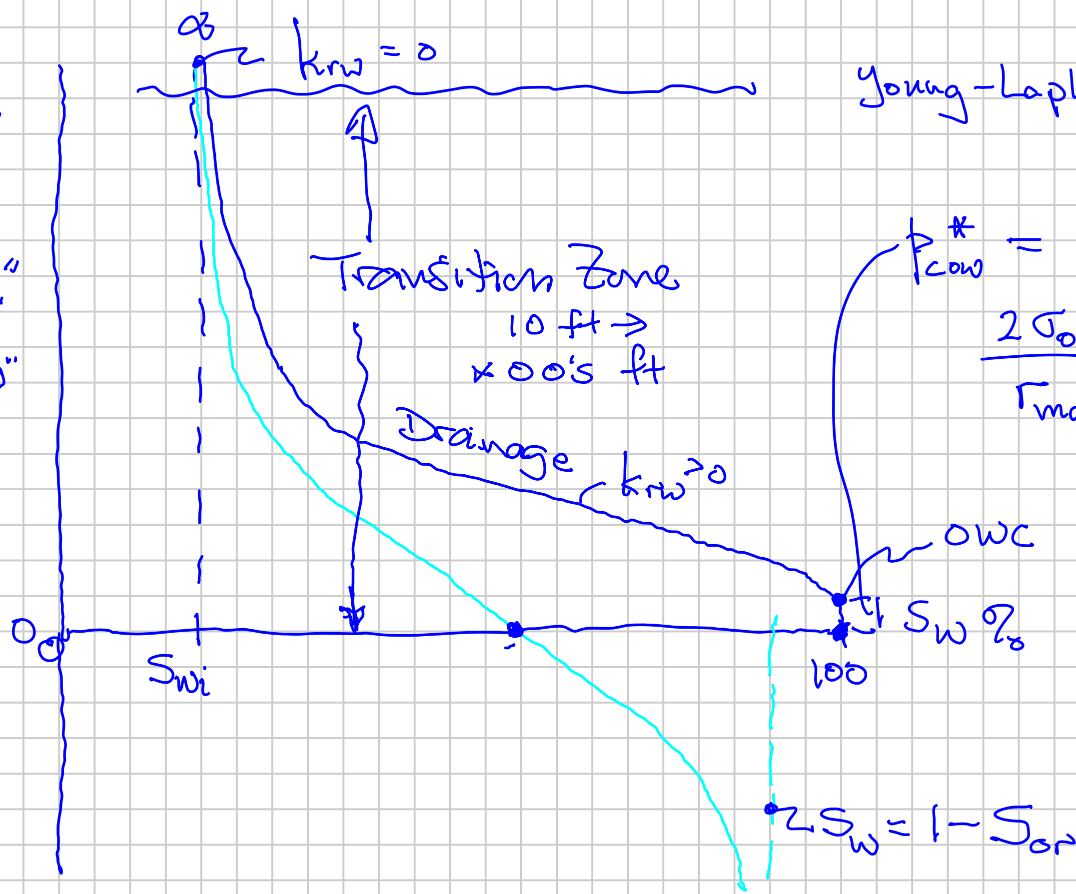
    "OWC, GWC"
  - Below FWC "Paleo" Zone

    $k_{ro} \sim$ low $\rightarrow 0$

$P_{cow} = p_o - p_w$

or

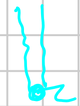
Depth "k" $= \frac{P_{cow}}{(\rho_w - \rho_o) g}$ "PS"



Young-Laplace

$$P^*_{cow} = \frac{2\sigma_{ow}}{r_{max}}$$

Transition Zone : $[k_{ro} > 0$ & $k_{rw} > 0]$


$k_{ro} = 0$

$k_{ro} \simeq 0$ to $k_{rw} \simeq 0$

– RG ("Gas Cap") & RO ("Oil Rim" / Zone)

- Saturated Fluid System

  Gas-Oil Contact transition $p_{R,GOC} = p_{d,GOC} = p_{b,GOC}$

  Most "common" situation assumption

  RG in Gas Cap Uniform $y_{Ri} \sim$ constant (X, Y, Z)

  RO in Oil Zone Uniform $x_{Ri} \sim$ —— " ——

  – May have a smaller gas-oil transition zone

$$\text{Depth} = \frac{P_{cgo}}{(\rho_o - \rho_g)g}$$

because usually $(\rho_o - \rho_g) > (\rho_w - \rho_o)$

$$P_{cgo}(S_o) < P_{cow}(S_o)$$

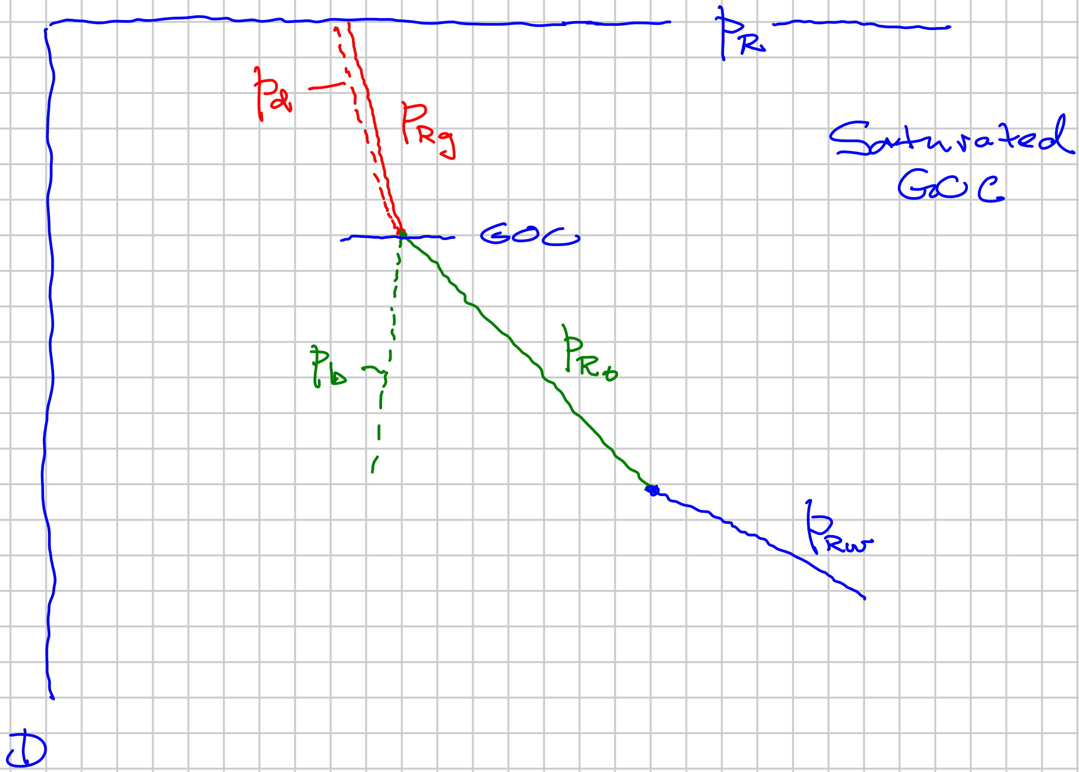
Lab $P_{c\,air-w}$ $\Rightarrow$ $(P_{cgo})_R = P_{ca-w} \cdot \dfrac{(\sigma_{go})_R}{(\sigma_{a-w})_L}$

$(\sigma_{ow})_R \sim 40 - 20$ mN/m

$(P_{cow})_R = P_{ca-w} \cdot \dfrac{(\sigma_{ow})_R}{(\sigma_{a-w})_L}$

$(\sigma_{go})_R \sim 40 \rightarrow < 1$

70 mN/m



Undersaturated Gas-Oil Contact

Strong Compositional Variation with Deph $z_{Ri}(Z)$ substantial

Final Eq. is reached by molecules moving around to minimize total energy.

no force field

Chemical Energy μ_i

Molecular Diffusion $q_i = D_i \left(\frac{d\mu_i}{dZ} \right)$

Eq. reached $q_i \Rightarrow 0$

In force field $a = \text{const.}$

$$\phi_i = \mu_i + M_i \, a \, \Delta Z$$

$$q_i = D_i \left(\frac{d\phi_i}{dZ} \right) \Rightarrow q_i = 0$$

Muskat 1930s : $\mu_i \simeq$ simplified liquid model

Sage Lacey 1937 : $\mu_i \sim$ more rigorous model

⋮

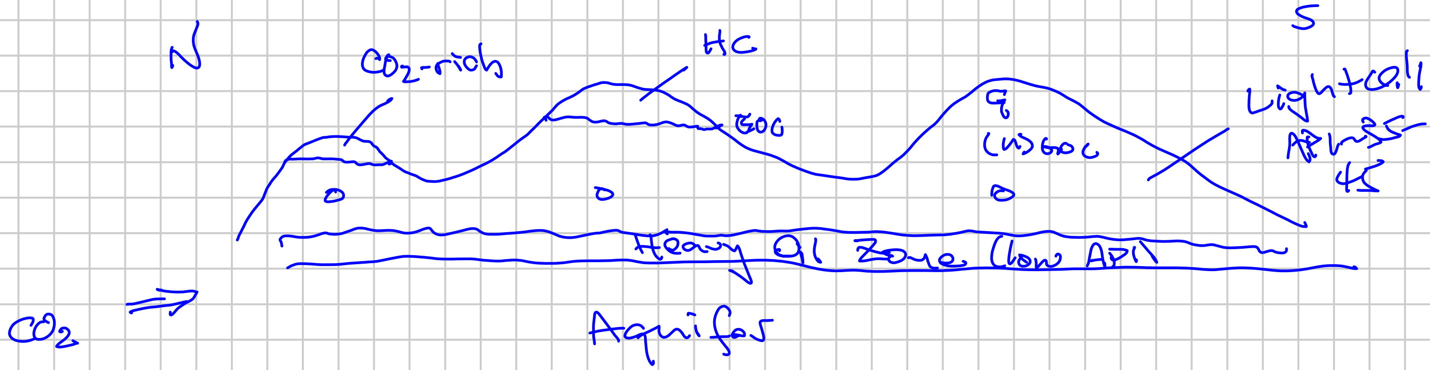
1980 : Tom Schulte (Shell)

$z_{Ri} \left(Z ; \mu_i^{\text{Cubic EOS}} \right)$

- Brent Field
- Birba Oman

- Non-Equilibrium Fluid Systems

Italy Val d'Agri


N
S
CO2-rich
HC
GOC
(w) GOC
Light oil
API
Heavy Oil Zone (low API)
Aquifer
CO2