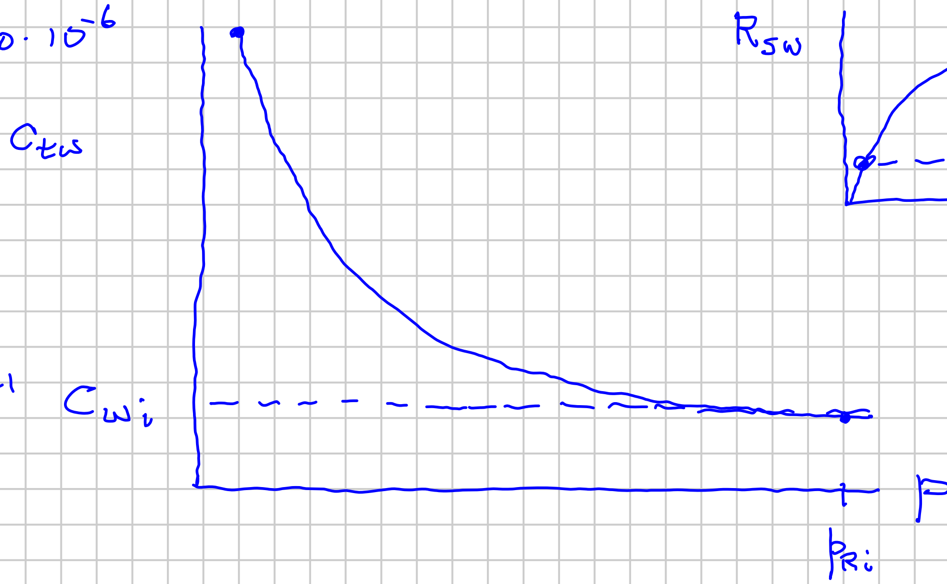
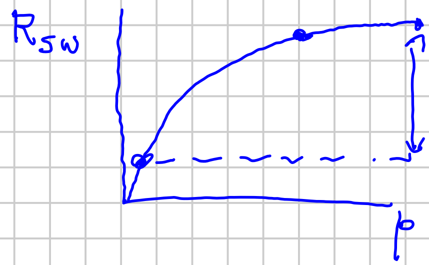
Note Title 9/5/2018

$c_{tw}(p)$: Biggest impact at lower pressures

$\times \bigcirc = 10-50 \cdot 10^{-6}$





$5 \cdot 10^{-6}$ psi^{-1}

$$c = -\frac{1}{V_t}\left(\frac{dV_t}{dp}\right)_{T,m}$$

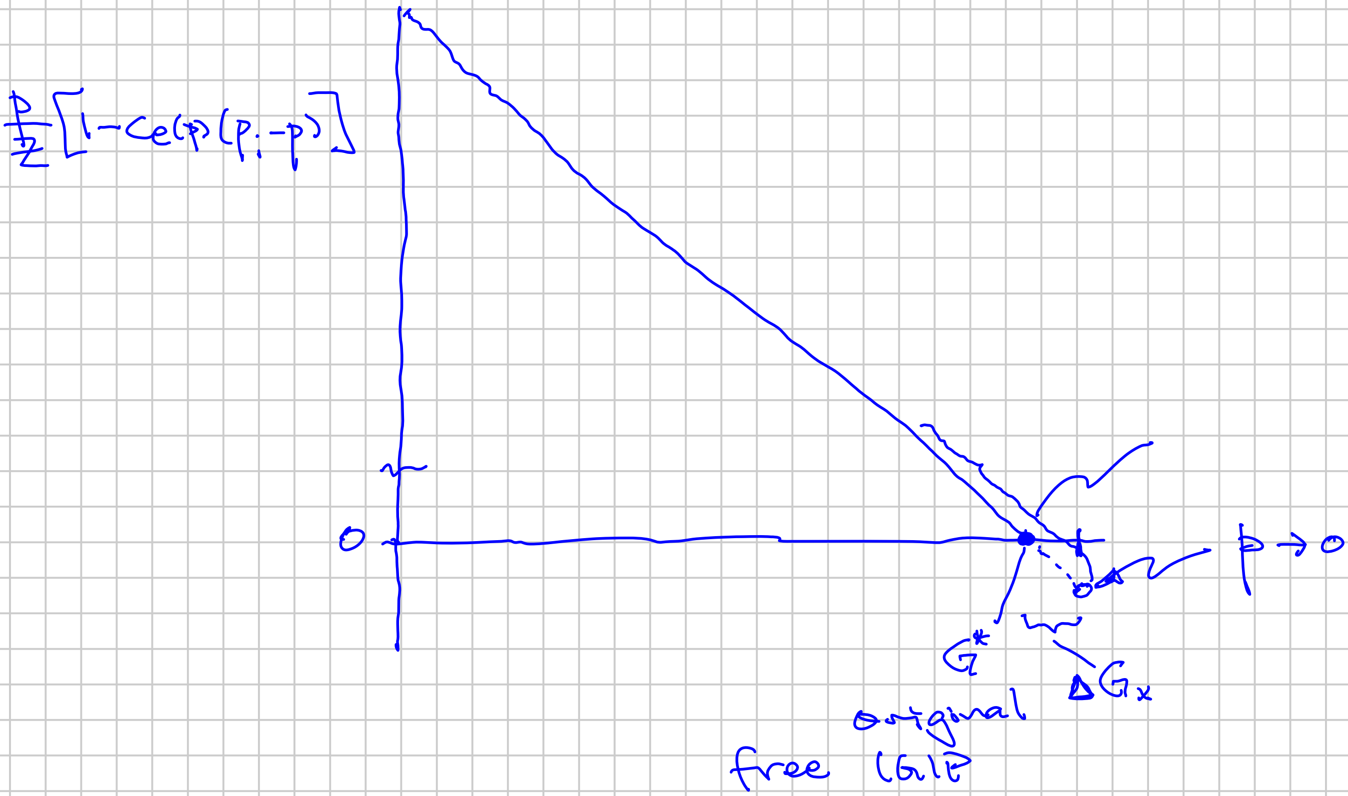
└── $p < p_{Ri}$ split into g+w

$$V_t = V_w + V_g(p)$$

~ const

$$V_g(p) = \underbrace{(R_{swi} - R_{sw}(p))\, B_g(p)}$$

$$\boxed{(R_{si} - R_s(p))\, B_g(p)}$$ Oil M.B.

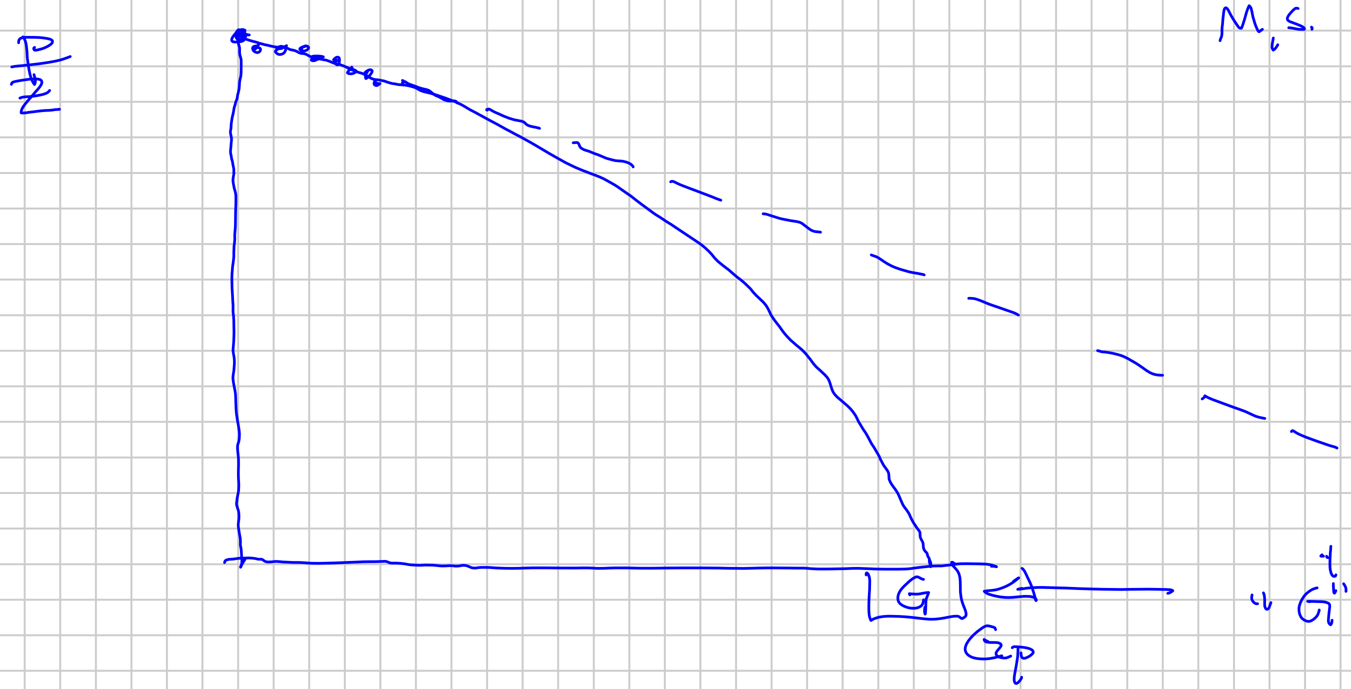


True $G = G^* + \Delta G_x$

$= R_{swi} \cdot IWIP$

↑

M.S.



"EOR"

v_D v_p

$v_D = 1$ m/d

$t_f \neq \frac{L_f}{v_D}$

$t_f = \frac{L_f}{v_p}$

Prove:

$$v_p = \frac{v_D}{\phi \, \Delta S}$$

(ΔS of the injected phase)

$S_{wc} = S_{wi} = 0.2$

S_w (Behind Front) In Swept Volume $= 1 - S_{orw} = 0.75$

0.25

$\Delta S_w = 0.55$

Modeling Methods

① Mat. Bal.

② Approx. Flow Eqs

- Pseudosteady State "Rate" Eqs

Oil: IPR (Inflow Performance Relationship)

Gas: BPE ("Reservoir" Backpressure Eq.)

$q_{\bar{g}}$, $q_{\bar{o}}$, $q_{\bar{w}}$ } $(\underline{\underline{p_R}} - \underline{\underline{p_{wf}}})$

Steady State: doesn't change with time

Pseudo SS: (a) Something does change with time — But very slowly

$p_R(t)$ slowly

(b) Now (at some time) the system behaves SS

③ Numerical Reservoir Simulation (>1980-90s)

<1980 ⇒ 60s — BOAST (2) COMP1 (2) (4) "INTERCOMP" (Coats et al) THERM } : NOLEN

>1980 — ECL100 ECL300 SENSOR VIP NEXUS INTERSECT ... -MORE

Review: See paper (optional) SPE Chapter 17 by Coats et al. (2009): Optional reading.

- Finite Difference
  - Conventional IMPES | Implicit | Adaptive Implicit
  - Streamline (key: EOR Volumetric Sweep) "Conformance"

- Grid Refinement
  - Each REU?
  - Numerical dispersion (fake mixing)
    ⇒ Very problem/process dependent
    ⇒ Requires attention, always
  - Wells: PSS Rate Eqs. $= N_w \cdot N_c$
    ⇒ Needs fully implicit treatment
    - Connects Wells to Grid Cells
  - May include Reservoir-to-Surface connection
    - VL Tables (Vertical Lift) — $P_{wf} \to P_t$
    - VL Eqs (VIP) — $\Delta p(q_g, q_o, q_w, P_{wf})$
  -

DEPLETION RECOVERY

① Volumetric Material Balance

Theoretical $p_R \to 0$

$$(\bar{p}_R)_{RFU} = f(Q_p ; p_{Ri}, Q_{pu})$$

$p_R(Q_p)$ ~ Est.

Ultimate Recovery ("EUR") @ $p_R \to$ Abandonment, 0

② PSS Rate Eq. $\bar{q}_o$

$$q = f(p_R, p_{wf} ; \underbrace{PI/J, C \& n ; A, B}_{\text{constants}})$$

$$q(p_{wf}, p_R) = \frac{dQ_p}{dt}$$

③ Couple MB & Rate Eq.

[Time dependence of $q(t)$ and $Q_p(t)$ for a given, specified $p_{wf}(t)$]

- Analytically for special MB / IPR Eqs
- Iterative (Explicit) ~ Solution Excel

$$\left\{ q_o = J(p_R - p_{wf}) \qquad p_R = p_{Ri}\left(1 - \frac{N_p}{N_{pu}}\right) \right\}$$

④ Compare with Empirical (Arp's) DCA Eq.

Decline Curve Analysis

for p_{wf} = const.

$$q \simeq \frac{q_i}{[1 + bDt]^{1/b}} = q_i e^{-Dt}$$

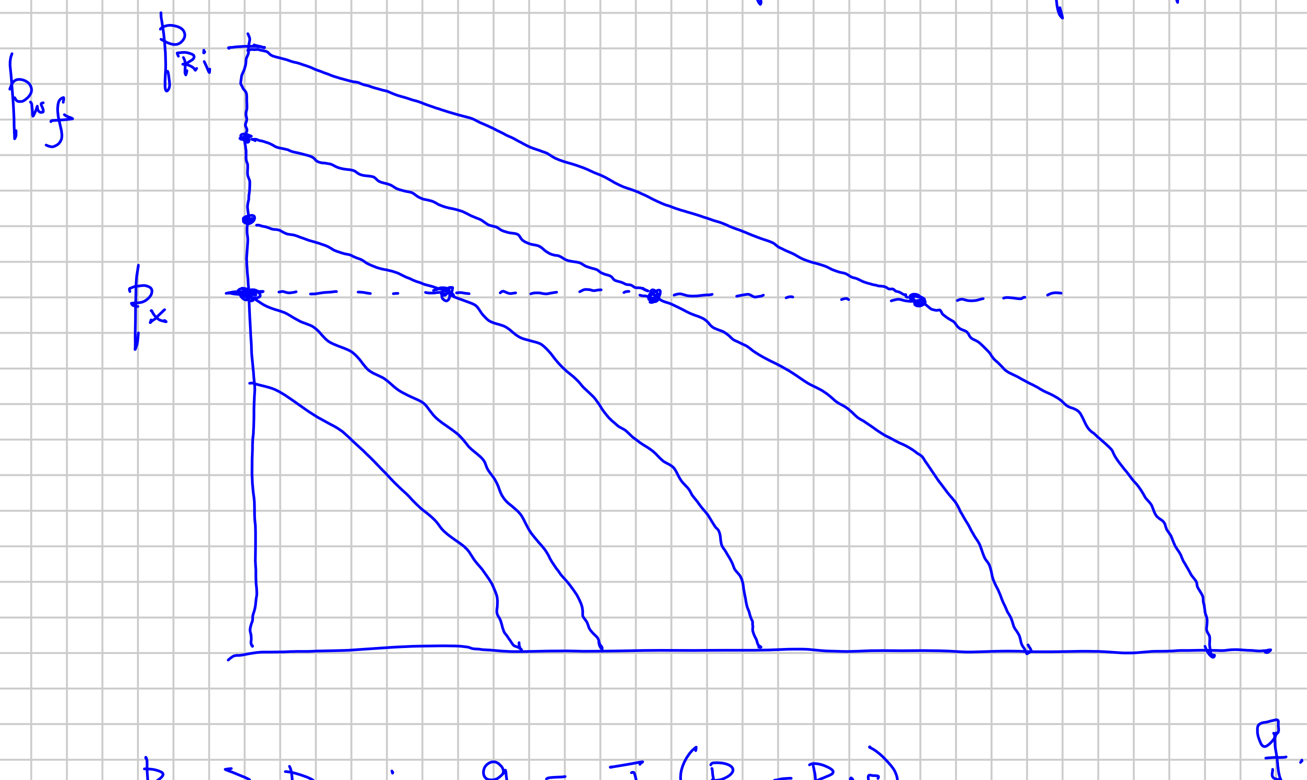
$b = 0$

$$\frac{dN_p}{dt} = q_o$$

Generalized Rate Eq. Gas & Oil

- Low $p_R < 200$ bar
- High p: $p_R > 200$ bar

- Undersat.: $p_R > p_b$
- Sat. (SGD): $p_R < p_b$



$p_{wf} > p_x$: $q = J\,(p_R - p_{wf})$

$p_{wf} < p_x$: $q = J'\,(p_R^2 - p_{wf}^2)$

OILS : q_o $\quad p_x = p_b$

GASES : q_g $\quad p_x \approx 200 \pm$ bar