CONSTANT VOLUME DEPLETION TEST

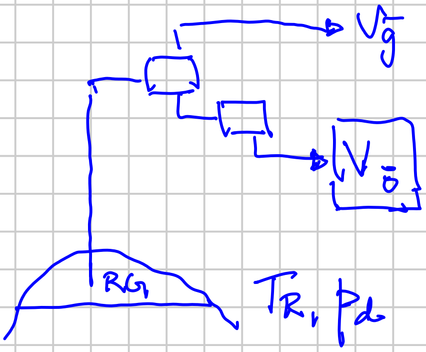
* Gas Condensates

(* Very Volatile / Near-Critical Oils) – high-GOR oils (>2500 scf/STB >500 Sm³/Sm³)

Key Data: $y_i \, (p < p_s) \Rightarrow RF_{\bar{o}} \leqq RF_{\bar{g}}$

$\underbrace{C_{7+} \, (C_{5+})}$: Surface Oil-forming components (Condensate) ⇒ Dominate the revenue for gas cond.

$$OGR \, (CGR) = \frac{V_{\bar{o}}}{V_{\bar{g}}}$$



$$r = \frac{V_{\bar{o}}}{V_{\bar{g}}}$$

r_p = producing OGR

r_s = solution OGR

r_{si} = initial in-situ solution OGR

Gas Condensate:

$\boxed{\text{IGIP}} = G$ = surface gas produced if you took entire RG volume to the surface

IOIP = N = $G \cdot r_{si}$ = surface oil (condensate) if you took entire RG volume to the surface

$$\underset{10^6\,USD}{V_g} = \underbrace{\underbrace{\underbrace{\underset{scf}{G} \cdot \frac{Mscf}{1000\,scf}}_{\cancel{Mscf}} \cdot \underbrace{\underset{\%}{RF} \cdot \frac{1}{100}}_{Frac} \cdot P_g \frac{USD}{\cancel{Mscf}}}_{USD} \cdot \frac{\text{"million USD"}}{10^6\,USD}}_{\text{"}10^6\,USD\text{"}}$$

IGIP Tcf = 10^{12} scf			
0.01	(= 10 Bscf = 10 · 10^9 scf)		Typical Shale USA Gas Well
1	(= 1000 Bscf)		Marginal N.S. Gas Field
10			Major (→ Giant) Gas Field
40			TROLL Gas Field (Norway)
>100			Super Giant Gas Field (few in world)
~300	+30-60 $\frac{STB}{MMscf}$ In-Situ OGR	same geologic field (Khuff formation)	South Pars (Iran)
~900			North Field (Qatar)

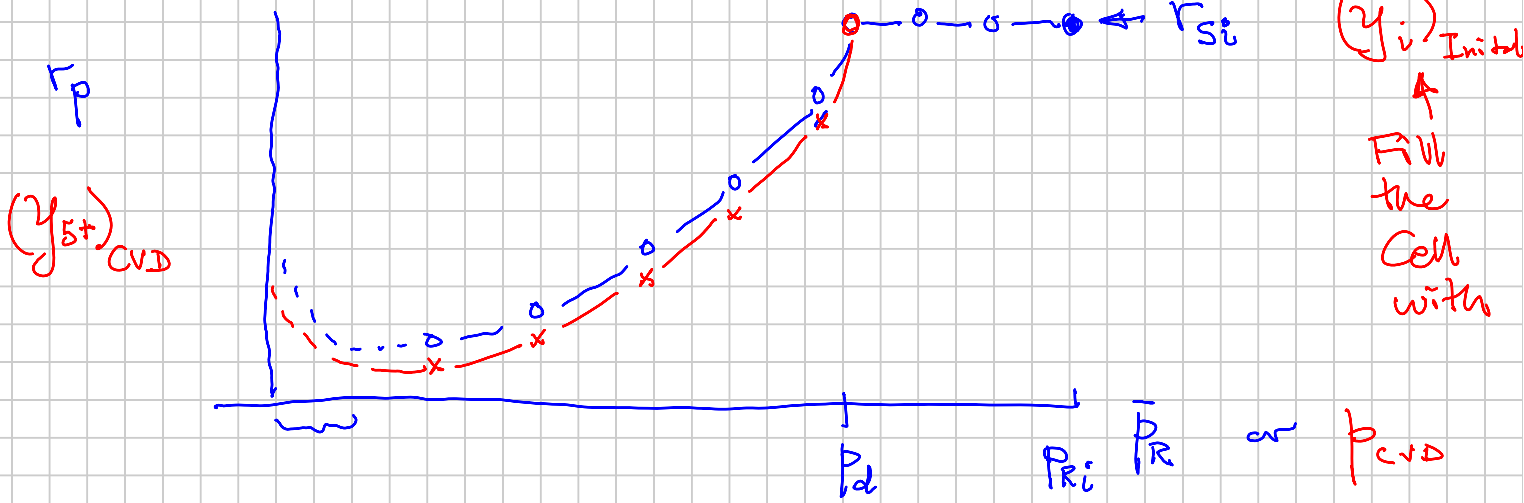
CVD Test

original: Reudelberger-Hinds (NCO example)

T_R (only) : Starts @ p_s : 5-8 depletion stages

For a gas condensate fluid, CVD test ≃

the expected depletion performance of any reservoir containing the G.C. mixture in the CVD test.



"Approximate"

Define our Surface Process as $\bar g = C_{4-}$ or C_{5-}

$\bar o = C_{5+}$ C_{6+}

More Efficient Process

Less —"—

Producing Wellstream Composition z_{wi}

@STC

$$\Rightarrow OGR = r_p \cong \frac{(z_{w5+})}{(1-z_{w5+})} \left\{ \frac{(M/\rho)_{5+}}{(RT_{sc}/p_{sc})} \right\}$$

~ constant during depletion

$$z_{wi}(p_R) \simeq (y_i)_{CVD}(p_{CVD})$$

$$z_{w5+}(p_R) \simeq \underline{(y_{5+})_{CVD}(p_R)}$$

$$\hookrightarrow r_p(p_R) \underset{(<)}{\approx} \underbrace{r_{sCVD}(p_R)}$$

Producing OGR) Solution oil-gas ratio

2-5% (Very reasonable approximation)

⇒ We want (need) accurate measurements of CVD gases removed in the test!

PVT Labs should (usually do) try to get $(y_i)_{CVD}$ accurate.

Curtis says that the reservoir retrograde condensate that drops out in the pores do not – effectively – flow to the wells, $\lambda_o \sim 0$.

Yes, all G.C. reservoirs, no matter how "rich" ($r_{si} \to 250$-300 STB/MMscf)

$$\left(\frac{V_o}{V_o+V_g}\right)_{CVD} = \left(\frac{V_o}{V_{si}}\right)_{CVD} = \underset{CVD}{V_{ro}} \text{ max} \sim 45\%$$

$\mu_o \sim 0.2$

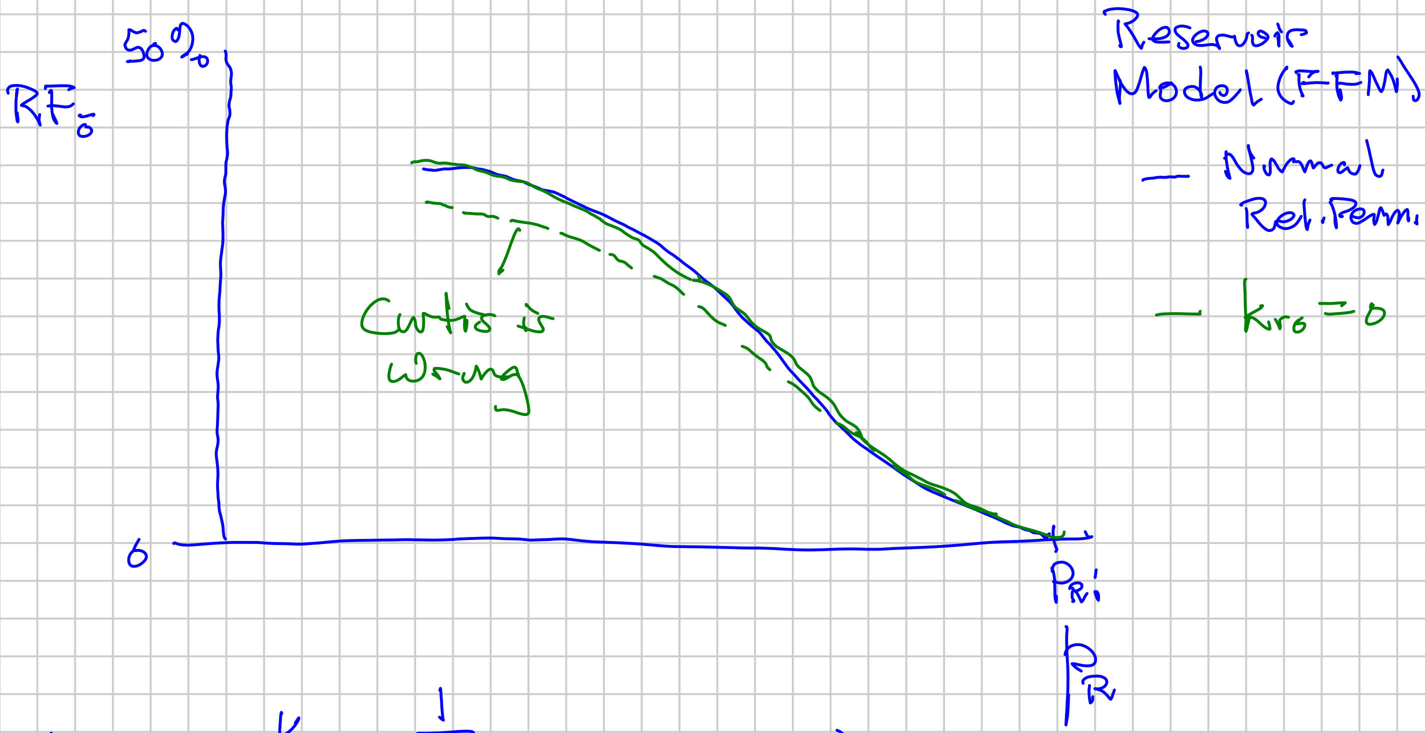
$k_{ro} \sim 10^{-2}$

$$S_o = \underset{CVD}{V_{ro}} \times \underset{0.2}{(1-S_w)} = 0.45(0.8) = 35\%$$

Sor (Soc) where $k_{ro} > 0$ ~ 20-30%

$$\lambda_g \approx \frac{k_{rg}}{\mu_g} = \frac{0.7}{0.02} \quad \text{vs} \quad \lambda_o = \frac{10^{-2}}{0.2}$$

$$[[\ \lambda_g >> \lambda_o\ ]]$$



At low p $K_i = \frac{1}{p}$ causes $r_s(p_{low})$ to increase

C_{5+}

$$\overset{\checkmark(G)}{z_{Si}} = f_{obm} \cdot \overset{\checkmark(E)}{x_{obmi}} + (1-f_{obm})\, \overset{\text{Decontaminated}\downarrow}{z_{RGi}}$$

$$f_{obm} = \frac{n_{obm}}{n_{obm} + n_{RG}} = \frac{n_{obm}}{n_S}$$

$$z_{RGi} = \frac{z_{Si} - f_{obm} \cdot x_{obmi}}{1 - f_{obm}}$$

$\boxed{f_{obm}}$ <u>Know</u>

$$m_{obm} = \overset{f_{obm}}{\underset{=}{n_{obm}}} \cdot \overset{\checkmark}{M_{obm}}$$

$$m_{RG} = \overset{1-f_{obm}}{\underset{=}{n_{RG}}} \cdot \overset{\checkmark}{M_{RG}}$$

$$m_{obm7+} = m_{obm} \cdot \overset{=1}{(w_{7+})_{obm}}$$

$$m_{RG7+} = (m_{RG}) \cdot (w_{7+})_{RG}$$

$$\boxed{f_{obm7+wt}} \searrow \text{Lab} \Rightarrow f_{obm}$$

$$\bar{M}_{RF} \quad \bar{M}_{obm}$$

$$(w_{7+})_{RF} \quad (w_{7+})_{obm} = 1$$

$$\underset{\times}{f_{obm}} \longleftrightarrow \underset{\checkmark}{f_{obm7+wt}}$$