$K_i(p, T, p_K)$

?

p_b = Lab value 2620 psig

y_i

$x_i = z_i$ ✓ @ T

Bubblepoint Calc: $\sum y_i = 1$

$$y_i = K_i \cdot x_i = K_i z_i$$

$$\rightarrow \quad h_{BP}(p_b) = 0 = 1 - \sum y_i = 1 - \sum z_i K_i(T, p_K, p_b)$$

p_K — know

Dew point: $\sum x_i = 1$

$$x_i = z_i / K_i$$

x_i

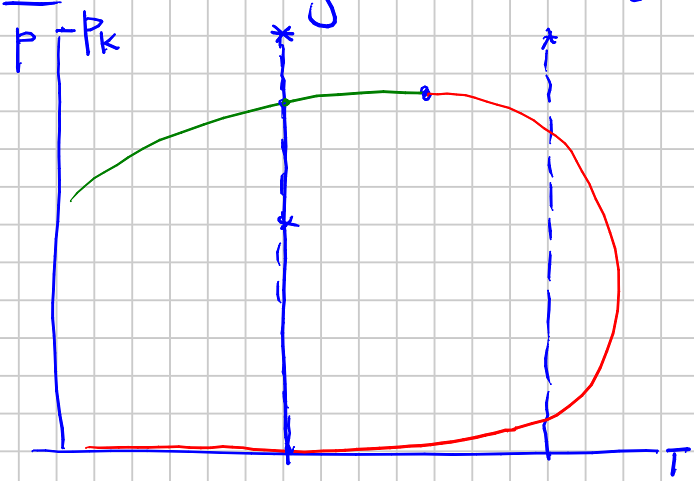
$$h_{DP} = 0 = 1 - \sum x_i = 1 - \sum z_i / K_i(T, p_K, p_d)$$

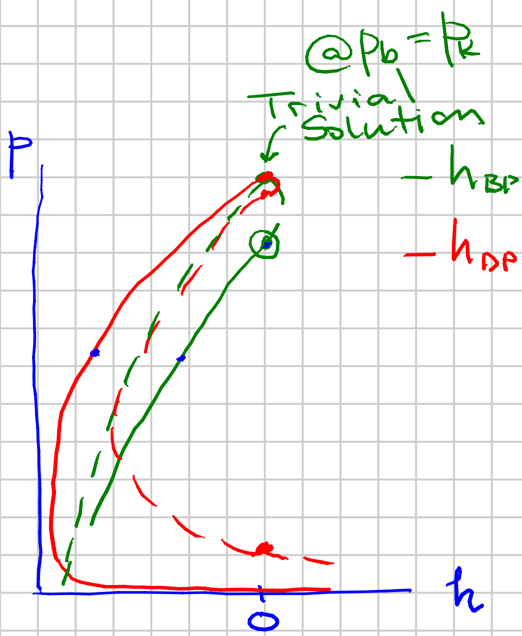
Know p_K, solve $p_b(T)$ or $p_d(T)$

$p_b(T)$: Upper Sat.

$p_d(T)$: Upper Sat, Lower Sat

Saturation Pressure Calculations (without knowing BP or DP):





Solve $h_{sp} = h_{BP}(p_s) \times h_{DP}(p_s) = 0$

Once found p_s, see if h_{BP} or h_{DP} that drove the $h_{sp} \to 0$

Black-Oil PVT Formulation (Ch. 7)

Review: Gas Phase : r_s – solution OGR $\sim y_i$

B_{gd} – gas FVF $\sim \rho_g$; expansion

Oil Phase : R_s – solution GOR $\sim x_i$

B_o – oil FVF $\sim \rho_o$; shrink

BO PVT are specific to a particular surface process $\underline{P}$

May be a strong dependence of BO PVT on the $\underline{P}$ used:

GOR $\gtrsim$ 200 Sm^3/Sm^3 measureable → large effect

< 100 little effect

$\boxed{\underline{P}}$ Worst — Best Recovery of i in $\bar{o}$

Single Stage Flash → ambient conditions

Multi-Stage Flash + GP

Applications of Black-Oil PVT:

To convert reservoir (p, T_R) Volumes
or @ any (p, T) Tubing, Flowlines etc.
to "surface" (sellable) gas ($\bar{g}$) and oil ($\bar{o}$)

$$b_{gd} = \frac{V_{\bar{g}}}{V_g(p,T)} \sim 50 \text{ to } 250 \ \frac{Sm^3}{m^3 @ (p,T)} \quad \text{Expansion}$$

$B_{gd} \sim 0.02 - 0.004 \ m^3 @ (p,T) / Sm^3$

$$b_o = \frac{V_{\bar{o}}}{V_o(p,T)} \sim 0.9 \rightarrow 0.3 \quad \text{Shrinkage}$$

$$B_o \sim \underbrace{1.1 \rightarrow 3}_{\text{loss of mass into gas phase}} \quad m^3 @ (p,T) / Sm^3$$

RB / STB

bbl / STB

$V_g \propto \frac{1}{p}$

B_{gd}

condense (loose mass) into a liquid : 1-15% change in final surface gas volume

$$R_s : \frac{V_{\bar{g}o}}{V_{\bar{o}o}}$$

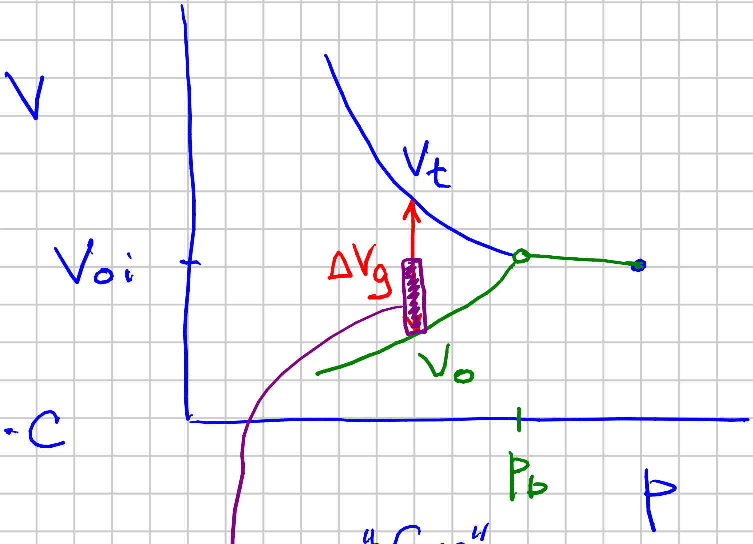
keep track of the (component surface) $\bar{g}o$ gas that is (still) in solution in the oil phase

$$\overbrace{[R_{si} - R_s(p)]}^{\Delta R_s} = \text{Liberated (Surface) Gas}$$

$300 \ Sm^3/Sm^3 - 200 \ Sm^3/Sm^3$

$$\underset{(p,T)}{\Delta V_g} = \left[\Delta R_s \times B_g(p,T)\right]$$

$$\frac{m^3}{Sm^3\ \bar{o}} \qquad \frac{\cancel{Sm^3}}{Sm^3\ \bar{o}} \qquad \frac{m^3}{\cancel{Sm^3}}$$



Solution OGR $r_s \propto \frac{y_{5+}}{(1-y_{5+})} \cdot C$

$r_s \propto y_{C_{5+}}(p,T)$ mol-%

if you produce alotta "free" reservoir gas

$$\left(\frac{\$}{mol\text{-}\%}\right)_{\bar{o} = C_{5+}} >> \left(\frac{\$}{mol\text{-}\%}\right)_{\bar{g}}$$

$\$115/bbl$

$\$3/Mscf$

$$\underset{Sm^3\ \bar{o}}{\Delta V_{\bar{o}}} = \underbrace{0.6(\Delta V_g) \times \frac{1}{B_{gd}}}_{\cancel{Sm^3\ \bar{g}}} \times r_s \qquad \frac{Sm^3\ \bar{o}}{\cancel{Sm^3\ \bar{g}}}$$

$$\Delta V_{\bar{o}g} = 0.6 \cdot \Delta R_s \cdot r_s$$