Note Title 4/21/2016

Fetkovich Paper "Pot" Aquifer

HCPV reduction < Pore ↓, Water ↑

$$\frac{\bar{p}_R}{z_R}\left[1 - \bar{c}_e\,(p_{Ri} - \bar{p}_R)\right] = 1 - \left(\frac{G_p}{G}\right)$$

$\bar{c}_e$ ↑ Cumulative Effective Compressibility

$$\bar{c}_e(p) = \frac{\bar{c}_f(p) + \bar{c}_w(p) S_{wi} + M\left(\bar{c}_f(p) + \bar{c}_w(p)\right)}{1 - S_{wi}}$$

↑ max effect at lower pressures.

S_{wi} = initial water sat. in the gas-filled (Net) pores

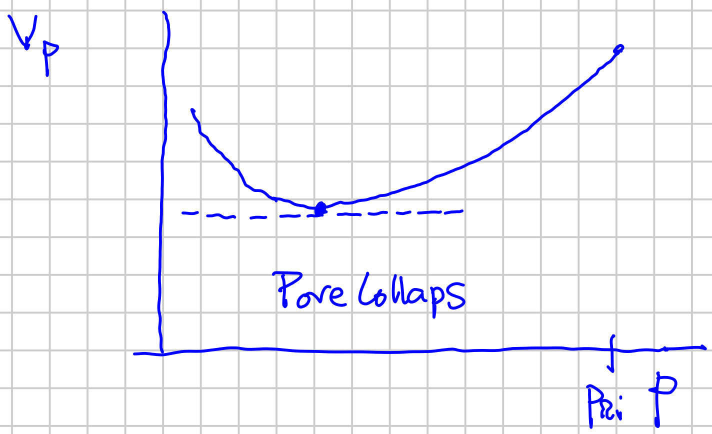
$$M \equiv \frac{V_{AQ} + V_{NNP}}{V_{pR}}$$

V_{pR} ↑

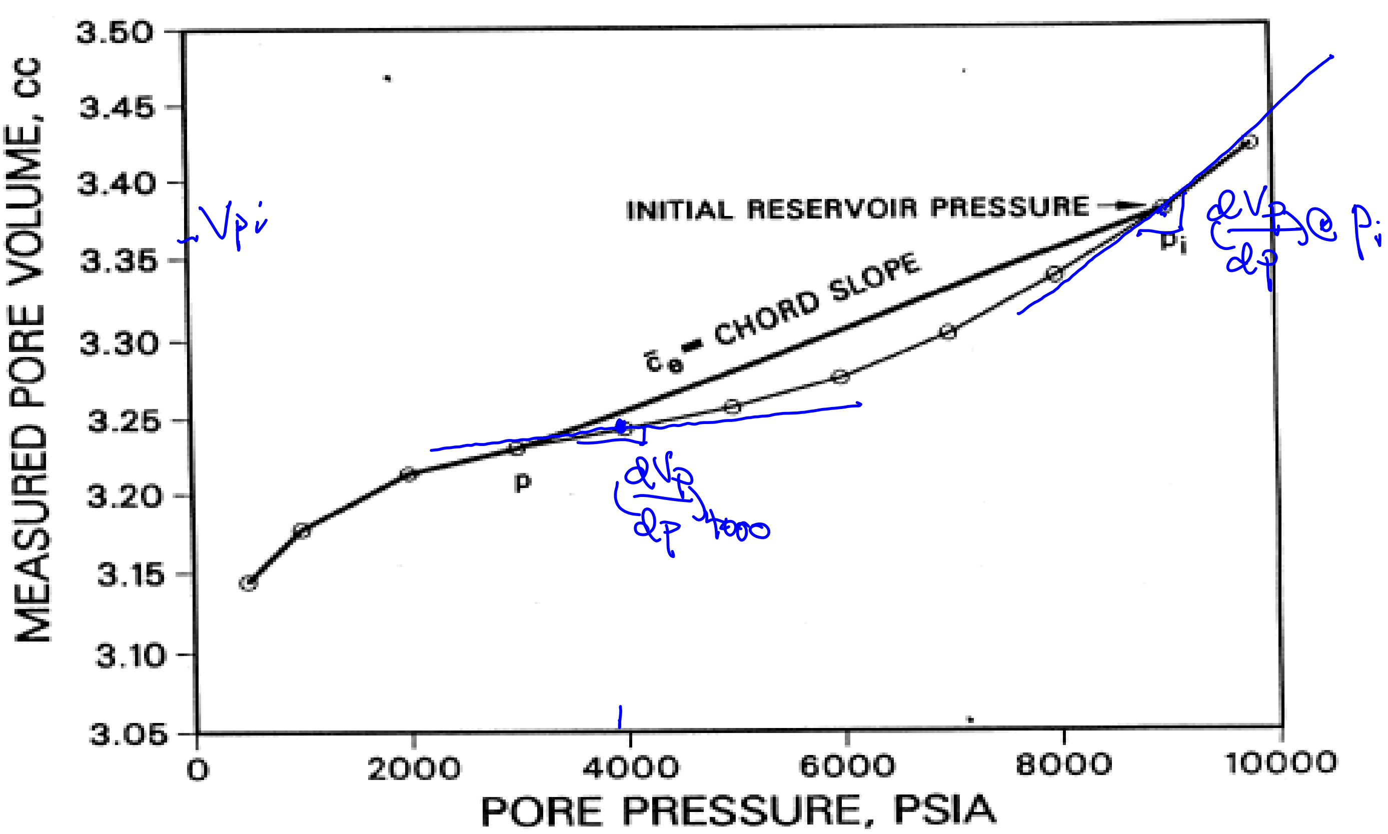
$\left(\frac{HCPV}{1 - S_{wi}}\right)$ = pore volume of the (net) reservoir with gas-filled pores

Instantaneous (Normal)

$$c \equiv -\frac{1}{V}\cdot\left(\frac{dV}{dp}\right)_T$$



Normal



$$\Delta V_p = \int_{p_i}^{p} C_p(p) \cdot V_p(p)\, dp$$

Numerical Reservoir Simulator needs $C_p(p)$

$$\Delta V_p = V_{pi}\, \bar{C}_p \,(p_i - p)$$

Based on chord slope

$$\bar{C}_p = \frac{1}{V_{pi}} \cdot \frac{V_{pi} - V_p}{p_i - p} \rightarrow \bar{C}_f$$

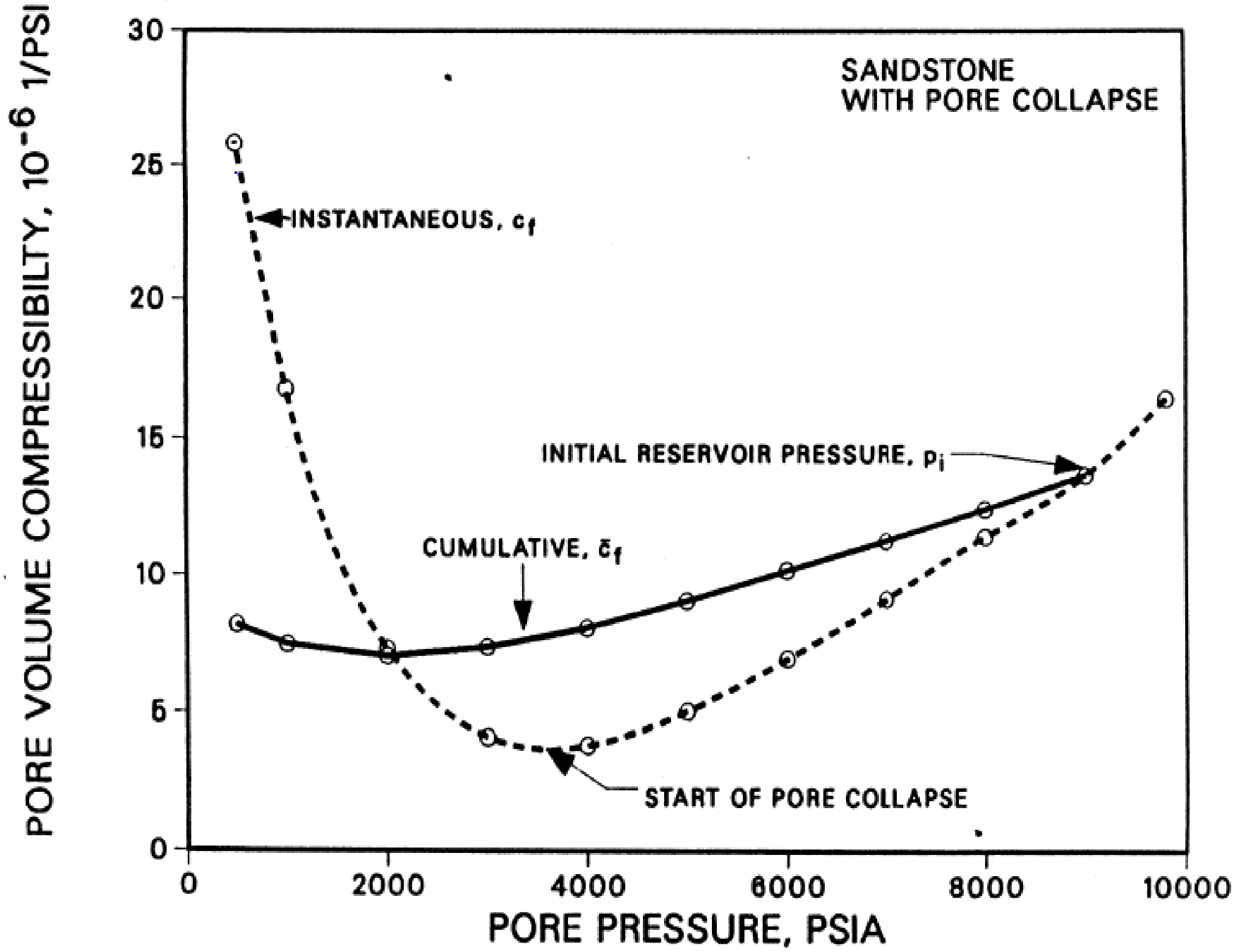
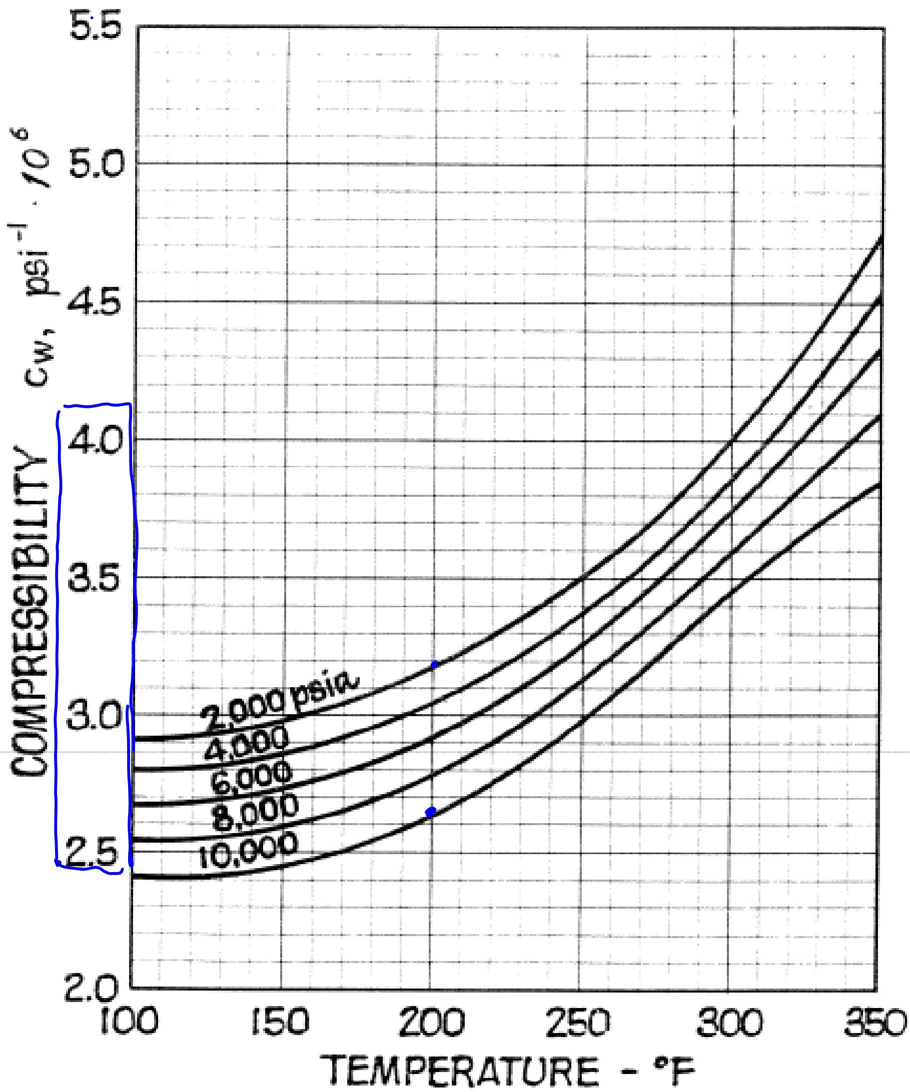


Fig. 3 Cumulative and Instantaneous c_f vs p for a Sandstone With Pore Collapse

$\boxed{\bar{c}_f(p_R)}$ For high-pressure reservoirs

$\bar{c}_f \sim$ const. for low-pressure reservoirs

$c_w(p)$

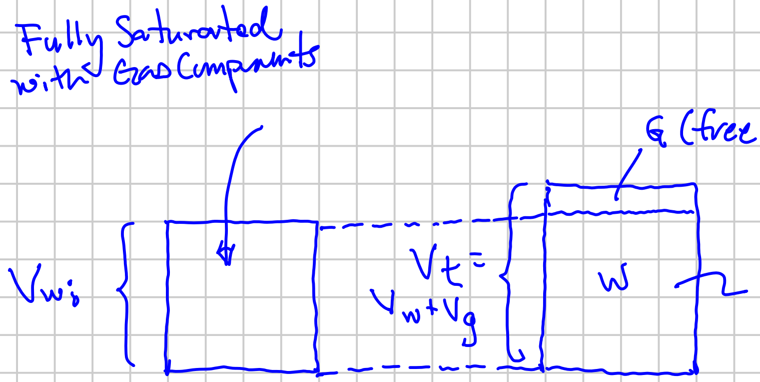


$c_w \sim 2.5 - 4 \cdot 10^{-6} \frac{1}{psi}$

No gas in solution!

H_2O

$y_i = 10^{-x} \quad 0.5 \quad 0.4 \quad 0.1$



$x_i = 0.99 \quad [0.05 \quad 0.85 \quad 0.1] \times 0.01$

$H_2O \quad CO_2 \quad C_1 \quad C_2$

p_{Ri}, T_R

$p_R < p_{Ri}, T_R$

$$\bar{C}_{tw} = \bar{C}_w = \frac{1}{V_{wi}} \cdot \frac{(V_w + V_g) - V_{wi}}{p_i - p} = \frac{1}{V_{wi}} \cdot \frac{V_t - V_{wi}}{p_i - p}$$

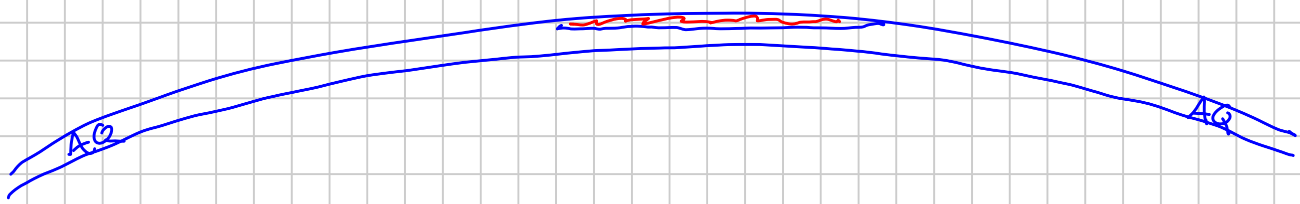
↑ w + g

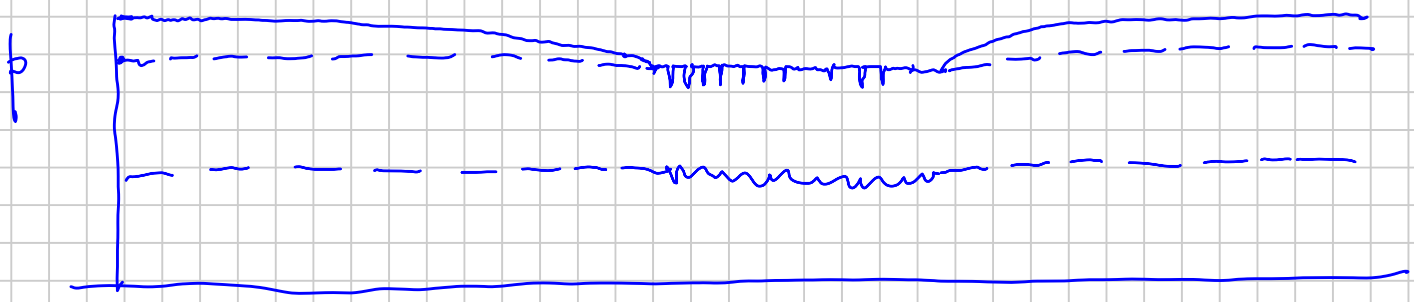
constant ↓ (M) $\qquad V_{AQi} + V_{NNPi}$

$$\bar{C}_e(p) = \frac{C_f(p) + \bar{C}_{tw}(p)\, S_{wi} + M\left(C_f(p) + C_{tw}(p)\right)}{1 - S_{wi}}$$

$$\frac{p}{Z}\underbrace{\left[1 - \bar{C}_e(p)\,(p_{Ri} - p_R)\right]} = \left(\frac{p}{Z}\right)_i \left(1 - \frac{G_p}{G}\right)$$

$(\bar{p}_R)_{HCPV_g} \simeq \bar{p}$ all connected water "immediately" (w/in months)





Applications of Gas M.B.

① Estimate of G (IGIP) and Remaining Reserves $(G-G_p)$

& Water Volume (V_{AQ}, V_{NNP}) & $\bar{c}_e(p)$
"M"

Best Est. of M & $c_e(p)$