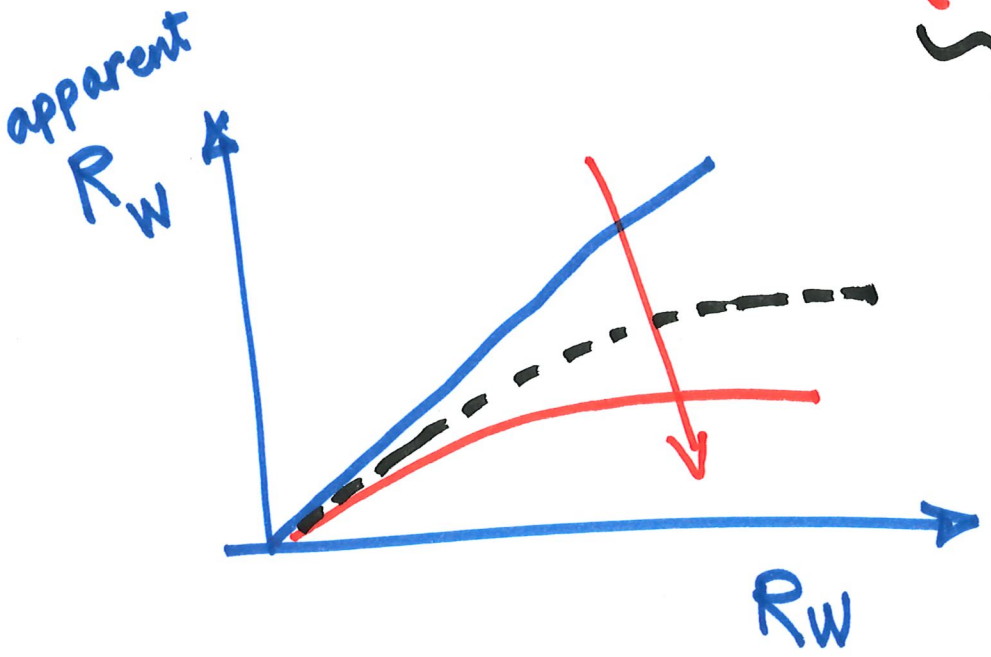
9/21/23

$$\sigma = \frac{1}{F}\left[\sigma_w + \frac{\sigma_{surf}}{(\Lambda/2)}\right]$$

Λ = Pore Vol. / Pore surf.



$$\sigma_{surf} = n' q B$$

n' = # of ions per unit surf. area

$$\sigma = \frac{1}{F}\left[\sigma_w + B\frac{n' q S_p}{V_p}\right]$$

$$= \frac{1}{F}\left[\sigma_w + BQ_v\right]$$

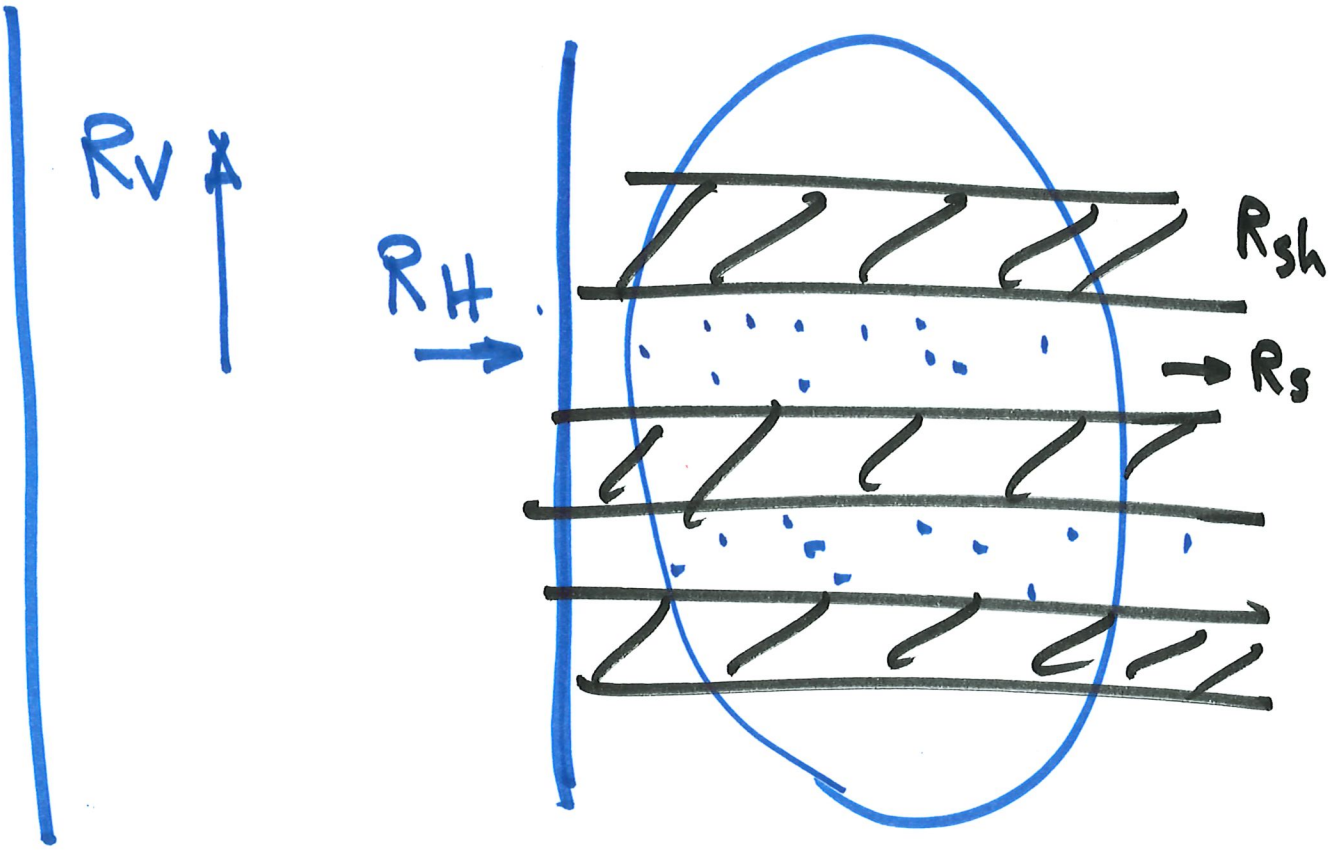
Q_v

$$\frac{1}{R_t} = \frac{\phi_t^{\,m}\, S_{wt}^{\,n}}{a R_w}\left[1 + BQ_v \frac{R_w}{S_{wt}}\right]$$

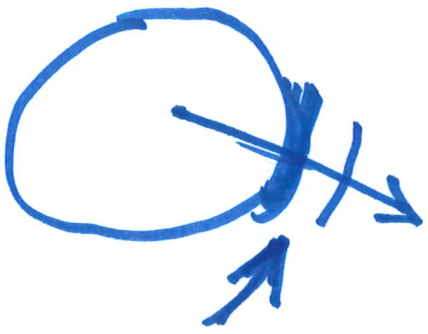
$\rightarrow S_{wt}$ /

Dual-water Model

$$\frac{1}{R_w'} = \frac{1}{R_w} + \frac{1}{R_{wb}}$$



$$\begin{cases} R_V = C_{sh} R_{sh} + (1 - C_{sh}) R_s \\ \dfrac{1}{R_H} = \dfrac{C_{sh}}{R_{sh}} + \dfrac{1 - C_{sh}}{R_s} \end{cases}$$



Example:

pure shale

$GR_{sh} = 94$ GAPI

$\phi_{D,sh} = 26.5\%$ ss

$\phi_{N,sh} = 45\%$ ss

$R_{sh} = 0.9\ \Omega \cdot m$

5522 ft

$$C_{sh} = \frac{GR - GR_s}{GR_{sh} - GR_s} = \frac{46 - 25}{94 - 25} = 30.4\%$$

$\phi_N = 23.5\%$

$\phi_D = 39\%$

$$\phi_N^{(sh)} = \frac{\phi_N - C_{sh}(\phi_N)_{sh}}{1 - C_{sh}}$$

$$= \frac{0.235 - 0.304\,(0.45)}{1 - 0.304}$$

$$= 14.09\%$$

$$\phi_D^{(sh)} = \frac{\phi_D - C_{sh}(\phi_D)_{sh}}{1 - C_{sh}}$$

$$= \frac{0.39 - 0.304\,(0.265)}{1 - 0.304}$$

$$= 44.47\%$$

$$\phi_s = \sqrt{\frac{14.09^2 + 44.47^2}{2}} = 33\%$$

$$\frac{1}{R_t} = \frac{C_{sh}}{R_{sh}} + \frac{1-C_{sh}}{R_s}$$

$$\frac{1}{2.8} = \frac{0.304}{0.9} + \frac{1-0.304}{R_s}$$

$$\Rightarrow \underline{R_s = 36.55\ \Omega.m}$$

$$R_s = R_w \frac{a}{\Phi_s^m S_w^n}$$

$$36.55 = 0.0536 \; \frac{1}{0.33^2 \, S_w^2}$$

Estimate it!

$$\Rightarrow \boxed{S_w = 11.6\%}$$

$$S_{HC} = 1 - 0.116 = 88.4\%$$

$$HPV = \phi_s (1 - S_w)(1 - C_{sh})$$ ✓

$\rho_f = ?$ ρ_{HC}