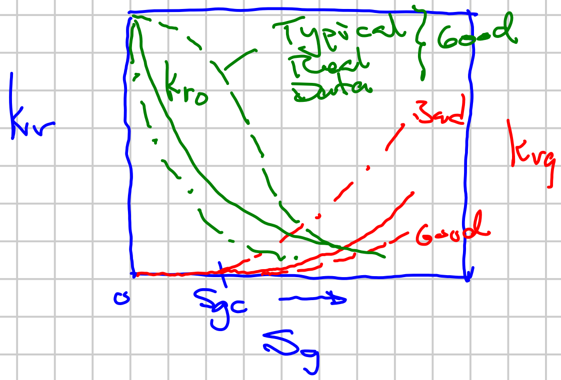
Note Title 11/12/2018

LNX Modeling of EOR Processes

└ Layered No-Crossflow

$k_z \approx 0$ $v_z \sim 0$

Depletion SGD Oil Reservoirs : 5 - (10 - 25%)   RP Bad   RP Good



Carey: $k_{ro} \propto (1-S_g)^{n_o}$, $n_o \sim 2-5$

--- k_{ro} : Chierici Gerault

EOR: Inject ⇒ Success | Failure

KPI | Key   Layer Permeability Variation

high-k , low-V layers

Distribution k (z)

horizontal x-y   depth (layer to layer) geological

1944 : Laws   k distribution

1948 : ① Trans. AIME

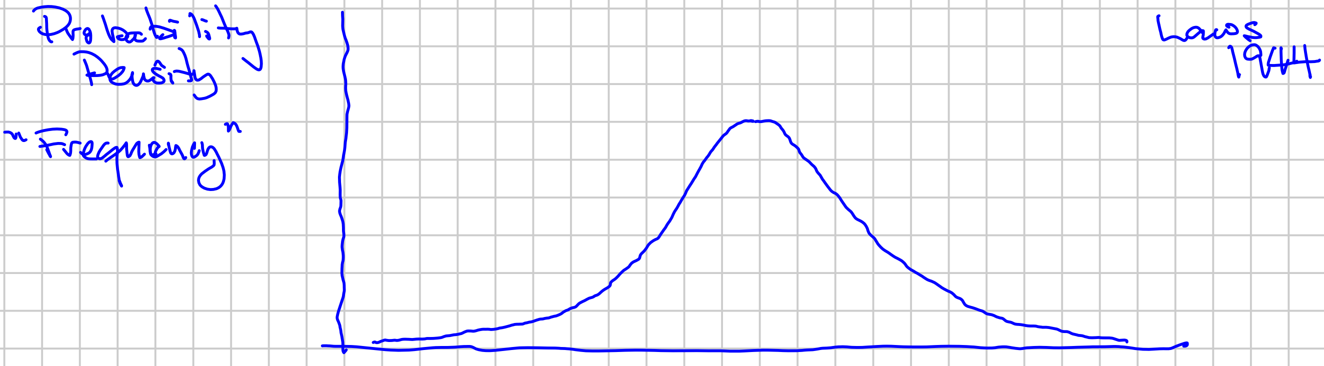
Standing, Lindblad, Parsons : Gas Cycling, Gas Condensate

"Charts" ② API : Dykstra & Parsons : Water Flooding
(Leaky Piston, Displ.)

Analytical ③ Muskat : / k = exponential
. Laws log-normal   Gas Cycling, Gas Condensate

June 1948 (Trans AIME 1949)

k(z) using a log-normal permeability distribution



Property
e.g. Grain Size / Porosity

ϕ : normal dist. $\qquad \bar{\phi} = \frac{1}{N} \sum \phi_i$

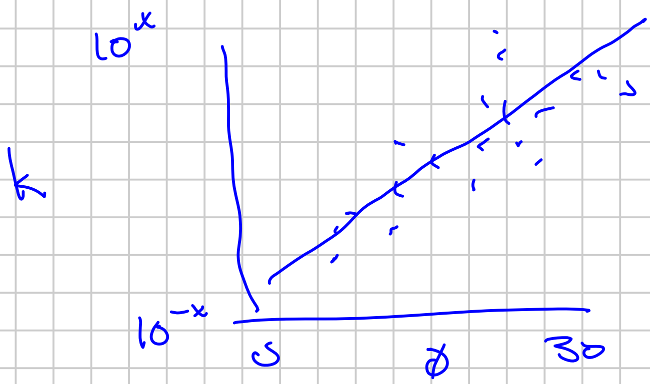
k : log-normal dist $\qquad \log \bar{k} = \frac{1}{N} \sum \log k_i$

$\Rightarrow$ Geometric Average

$$\bar{k}_G = \left(\prod k_i \right)^{1/N}$$

$\Rightarrow$ Approximation

$$\log k \sim a + b\phi$$



1949: • Muskat Trans AIME Gas Cycling

• Stiles WF EOR

Any k(z) distribution => Calculational Procedure N_{layers}

k, ϕ

Piston Leaky Displacement

1950 Muskat WF Analytical Solutions

k(z) linear

exponential

log-normal

Leaky Piston assumption

(1967) BL in each layer

Snyder & Ramey : log-normal dist

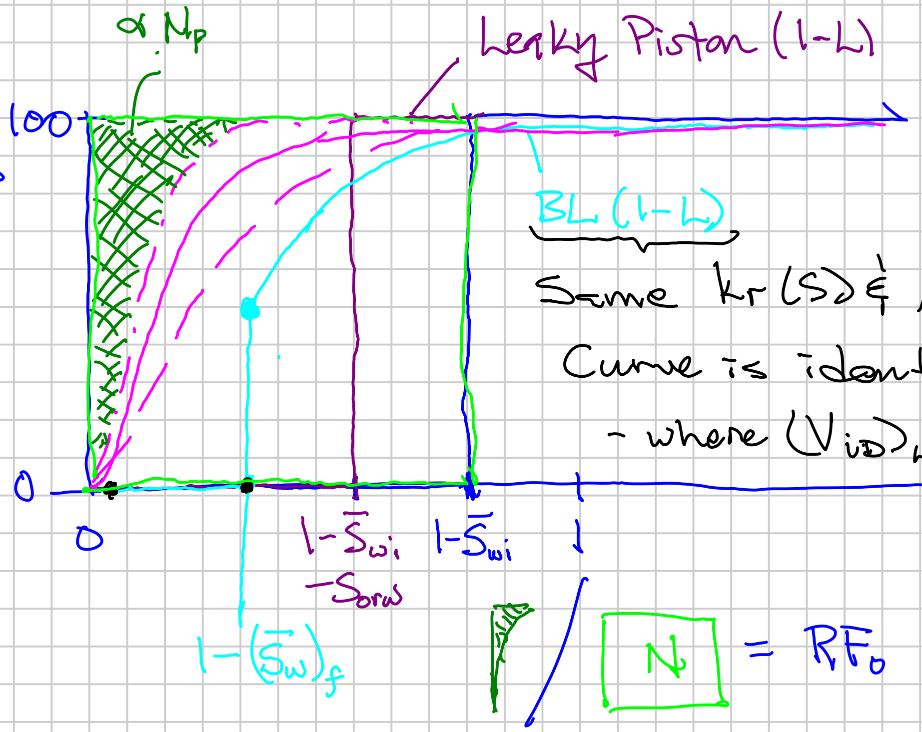
LNX EOR Publications History

⇒ Production Performance of LNX Systems

"F_w" = $\left(\dfrac{q_w}{q_w + q_o}\right)_P$

$\dfrac{STB}{STB}$

~ f_w related



Same $k_r(S)$ & μ_o/μ_w in each L

Curve is identical in each L

– where $(V_{iD})_L(t) = q_{iL} \cdot t$

$\propto k_{iL}\, t$

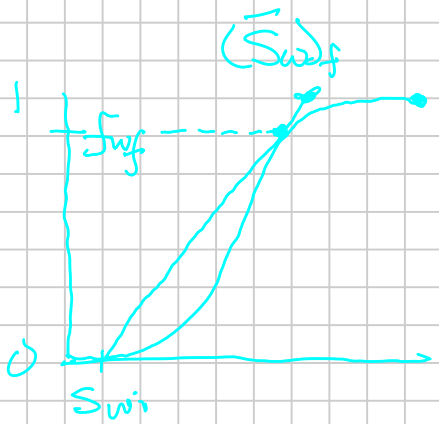
PVI

V_{iD}

$$f_w = \left(\frac{q_{wR}}{q_{wR} + q_{oR}}\right)_P$$

$$F_w = \frac{q_{oR}/B_o}{q_{wR}/B_w + q_{oR}/B_o}$$

B_w & B_o @ $\bar{P}_R$ in WF Unit



LNX

$$q_{wR}(t) = \sum_{L=1}^{N_L} f_w(V_{iD_L}(t)) \cdot q_{tL}$$

$f_w(V_{iD})$ same for all layers

⇔ V_{iD} different for all layers ∝ k_L

q_{tL} may vary somewhat over time

$$V_{iDL} \cong V_{iDt} \cdot \frac{k_L}{\bar{k}}$$

$$\bar{k} = \frac{\Sigma k_L}{N_L}$$

LNX : ① Earlier BT

② Lower $RF_o = N_p(t) / N$

↑ at a given time

} Larger the $k(z)$ Variation "V"

Laws (DP / Muskat / Standing ...)

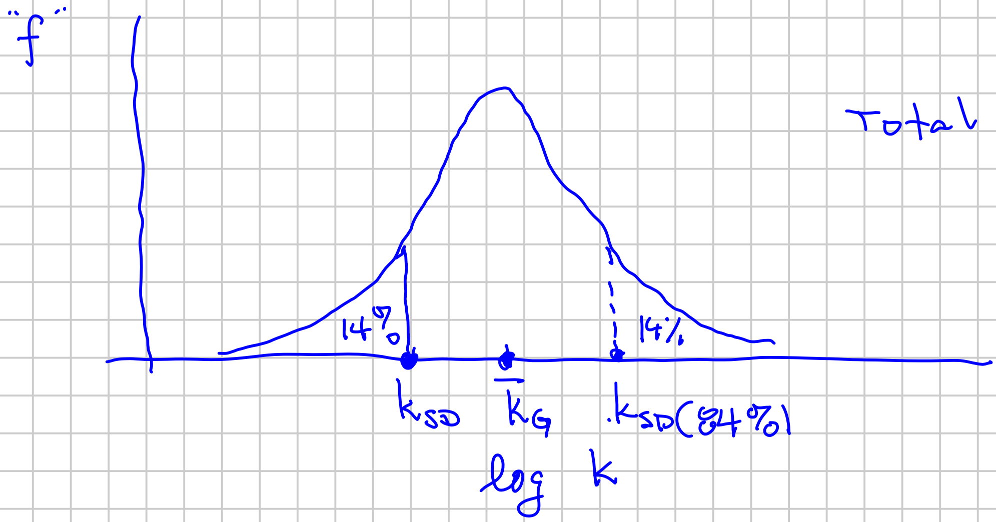
$$\text{"V"} \equiv \frac{|\bar{k}_G - k_{SD}|}{\bar{k}_G}$$

0 – 1

no max ∞

SD : standard deviation

(0.3 – 0.7) real data



Total Area = 1