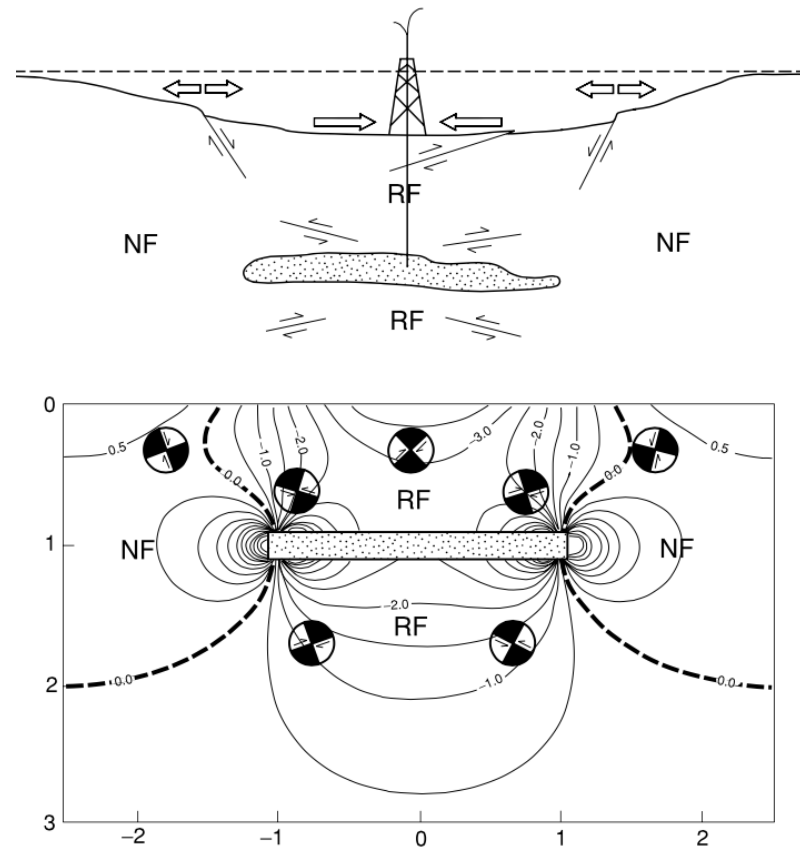
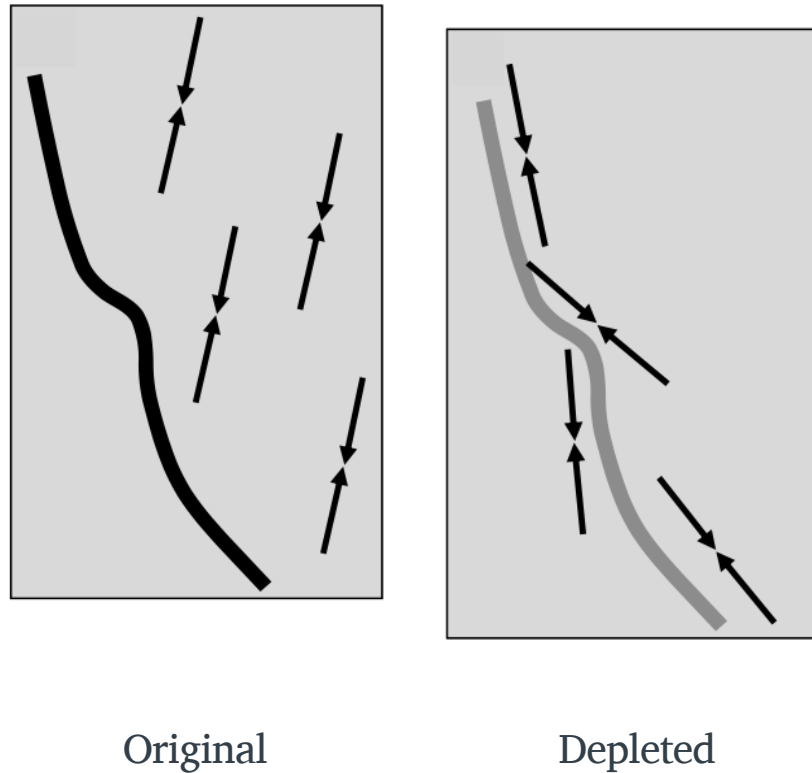


Effects of reservoir depletion



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Stress rotations with depletion



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Rotation angle, γ near the fault due to depletion

$$\gamma = \frac{1}{2} \tan^{-1} \left(\frac{Aq \sin(2\theta)}{1 + Aq \cos(2\theta)} \right)$$

with

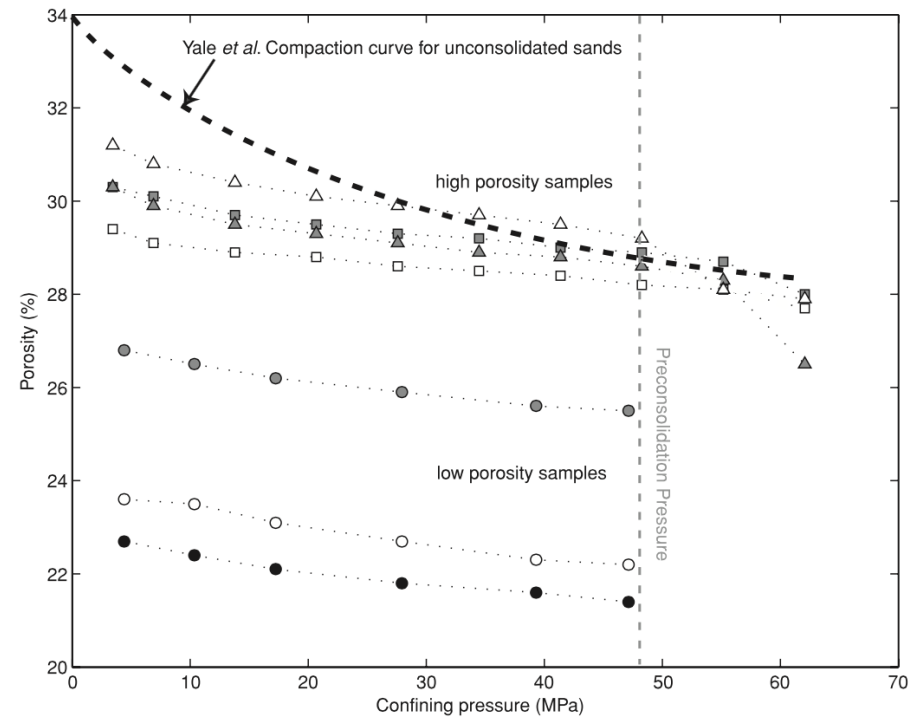
$$A = \frac{\Delta S_{hmin}}{\Delta P_p}$$

and

$$q = \frac{\Delta P_p}{S_{Hmax} - S_{hmin}}$$

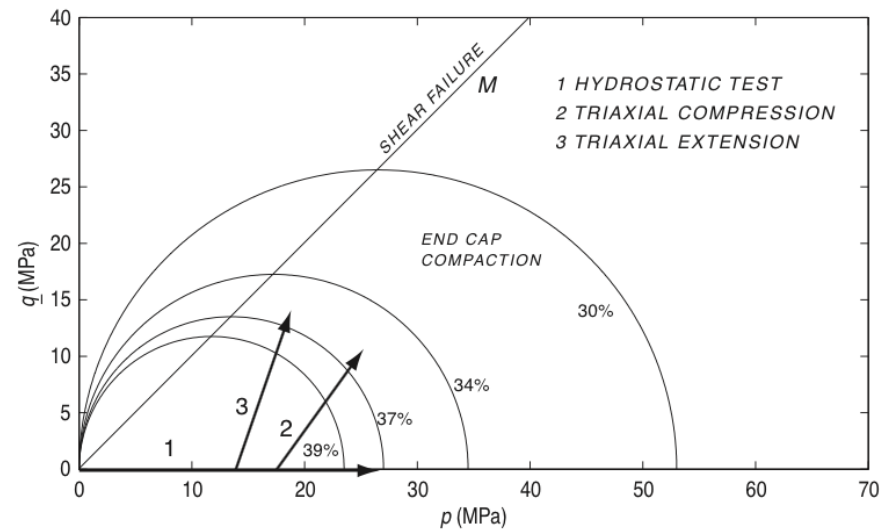
Deformation in depleting reservoirs

Recall: Compaction curves



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Recall: End-cap models



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$$p = \frac{1}{3}(S_1 + S_2 + S_3) - P_p$$

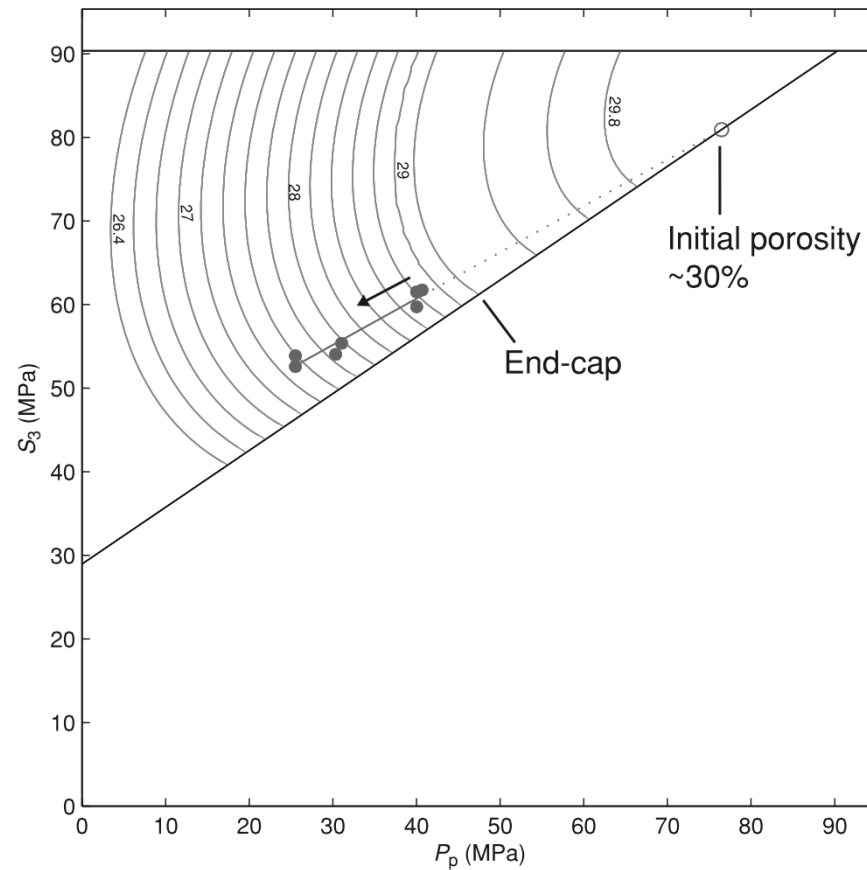
$$q^2 = \frac{1}{2}((S_1 - S_2)^2 + (S_2 - S_3)^2 + (S_1 - S_3)^2)$$

$$M^2 p^2 - M^2 p_0 p + q^2 = 0$$

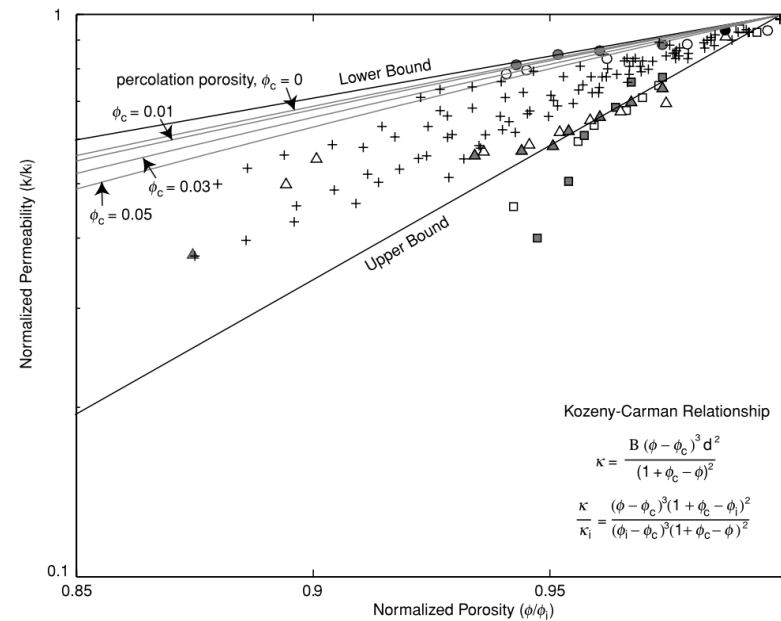
$$\begin{aligned}
& 9P_p^2 + \left(1 + \frac{9}{M^2}\right) (S_v^2 + S_{Hmax}^2 + S_{hmin}^2) \\
& + \left(2 - \frac{9}{M^2}\right) (S_v S_{Hmax} + S_v S_{hmin} + S_{Hmax} S_{hmin}) \\
& + 9P_p p_0 - 3(2P_p + p_0)(S_v + S_{Hmax} + S_{hmin}) = 0
\end{aligned}$$

$$M = \frac{6\mu}{3\sqrt{\mu^2 + 1} - \mu} \quad \text{From Mohr-Coulomb assuming } C_0 \text{ is negligible}$$

Deformation Analysis in Reservoir Space (DARS) model of GOM Field X



Permeability change as a function of porosity change



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Modified Kozeny-Carman relationship

$$\kappa = B \frac{(\phi - \phi_c)^3}{(1 + \phi_c - \phi)^2} d^2$$

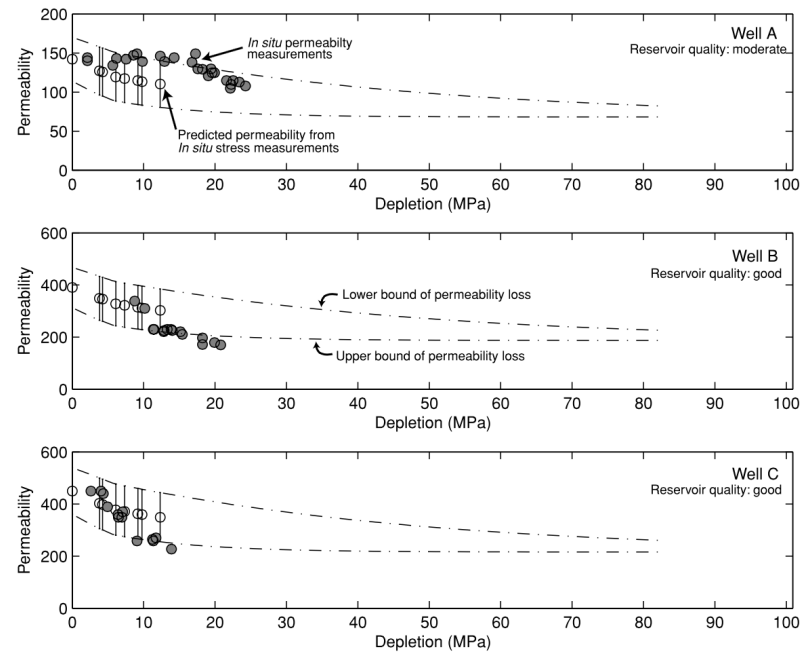
For change in permeability

$$\frac{\kappa}{\kappa_i} = \left(\frac{\phi - \phi_c}{\phi_i - \phi_c} \right)^3 \left(\frac{1 + \phi_c - \phi_i}{1 + \phi_c - \phi} \right)^2$$

Including a factor for grain size reduction

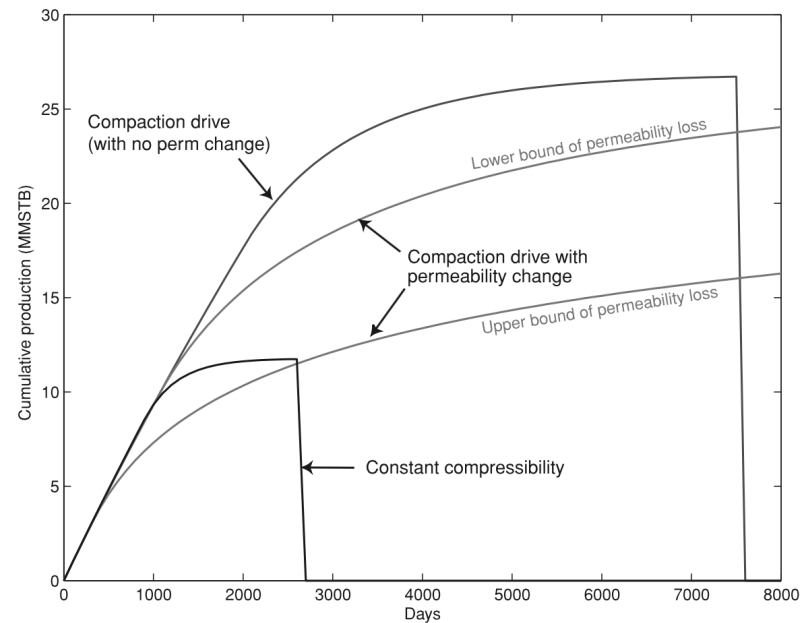
$$\Gamma = \frac{1 - d/d_i}{1 - \phi/\phi_i}$$
$$\frac{\kappa}{\kappa_i} = \left(\frac{\phi - \phi_c}{\phi_i - \phi_c} \right)^3 \left(\frac{1 + \phi_c - \phi_i}{1 + \phi_c - \phi} \right)^2 \left(1 - \Gamma \left(1 - \frac{\phi}{\phi_i} \right) \right)$$

Permeability loss with depletion in GOM Field Z



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Idealized resevoir study



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