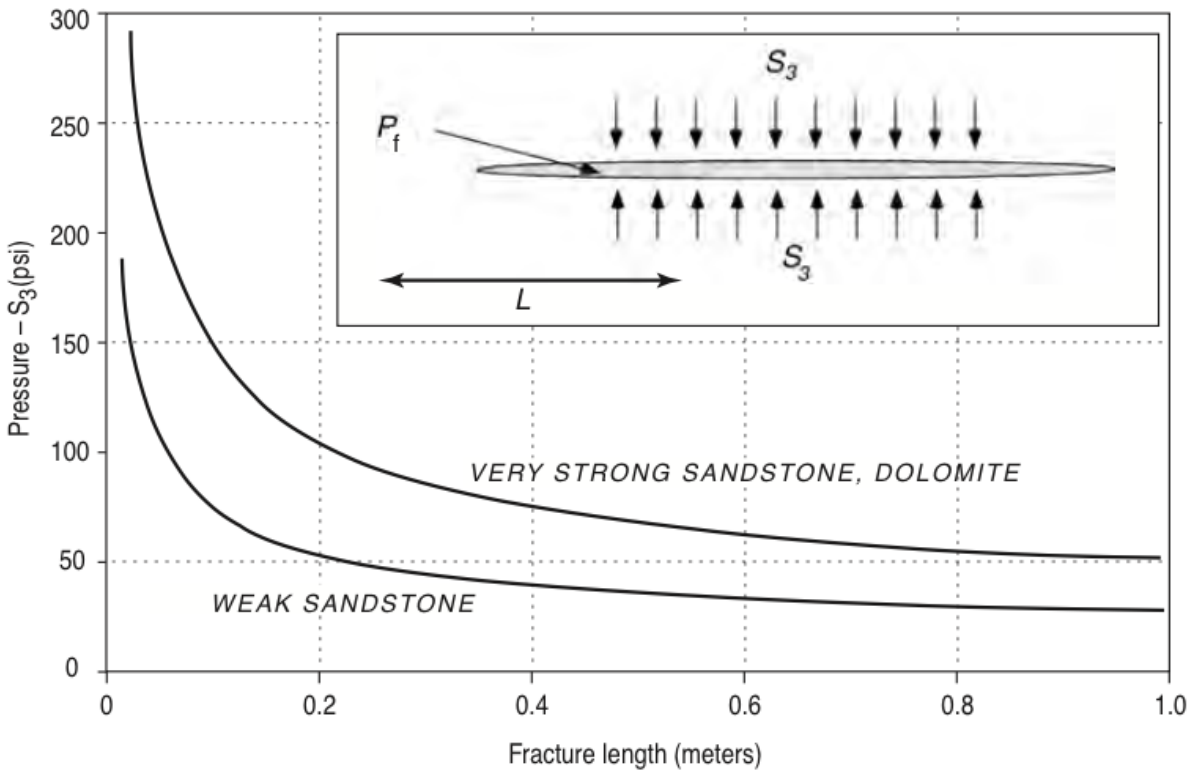
Tensile strength of rocks

- Relatively unimportant!

- Reasons:
  - Tensile strength is low compared to compressive strength.
  - When a large enough volume of rock is considered, flaws are bound to exist making the tensile strength near zero.
  - *In situ* stress at depth is never tensile.

Opening mode fracture (Mode I)

$$K_{Ic} \geq K_I = (P_f - S_3)\pi\sqrt{L}$$



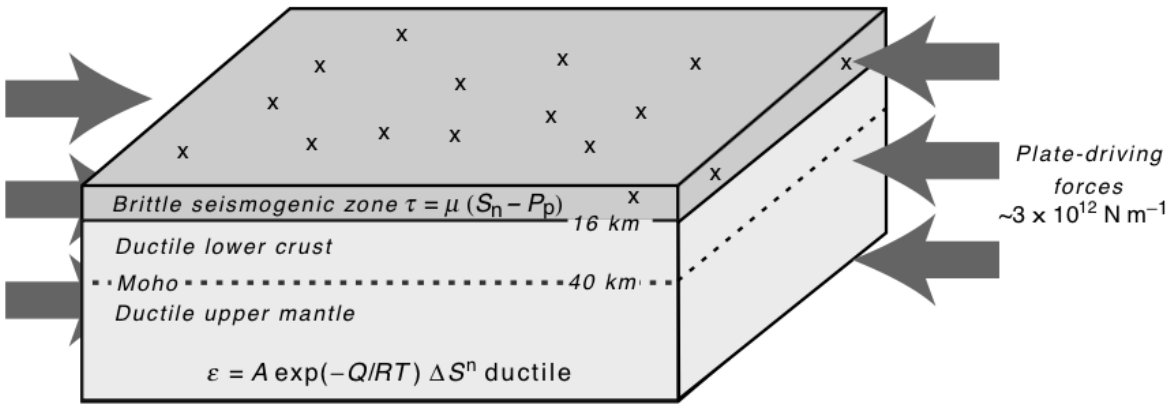
Recall: Slip on faults

$$\frac{\tau}{\sigma_n} = \mu$$

Coulomb failure function

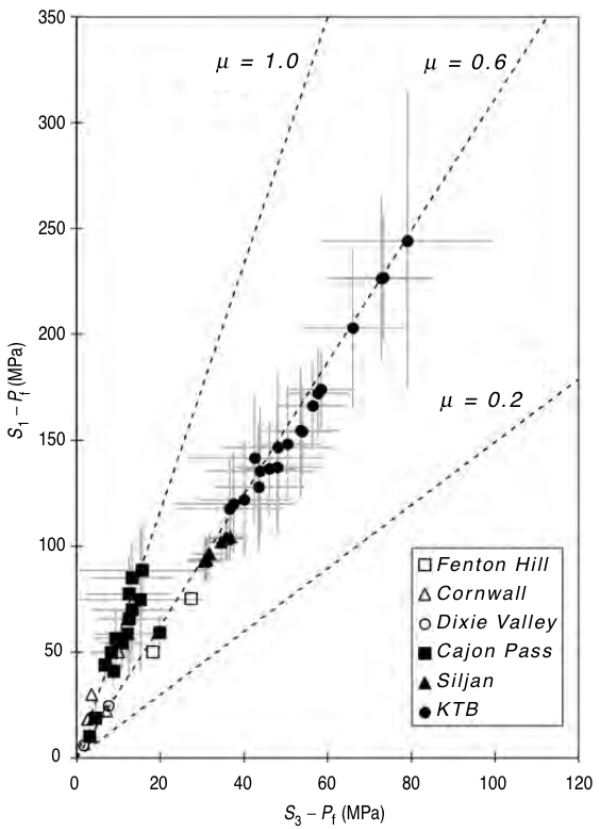
$$f = \tau - \mu\sigma_n \leq 0$$

Critically stressed crust



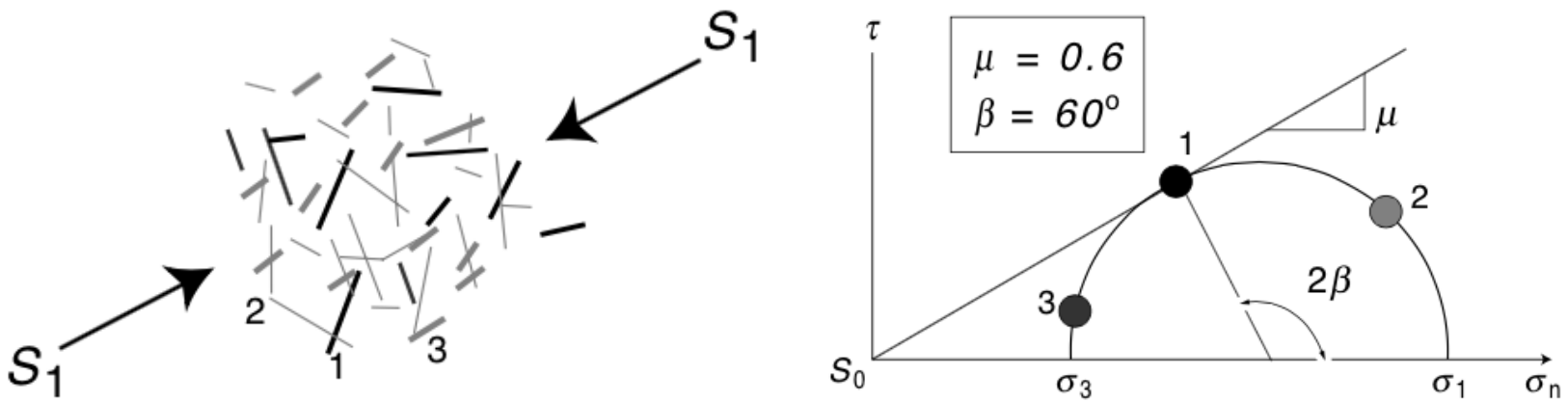
 Zoback, *Reservoir Geomechanics* (Fig. 4.25, pp. 129)

Stress magnitudes controlled by frictional strength



 Zoback, *Reservoir Geomechanics* (Fig. 4.26, pp. 129)

Limits on *in situ* stress



Optimal angle for frictional sliding:

$$\beta = \frac{\pi}{4} + \frac{1}{2}\tan^{-1}\mu$$

 Zoback, *Reservoir Geomechanics* (Fig. 4.27b,c, pp. 131)

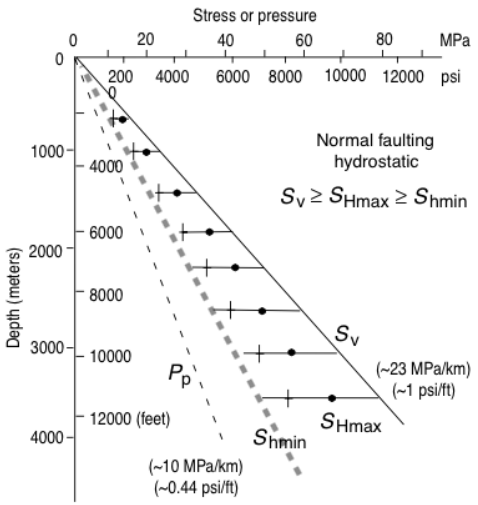
Principle stress ratio

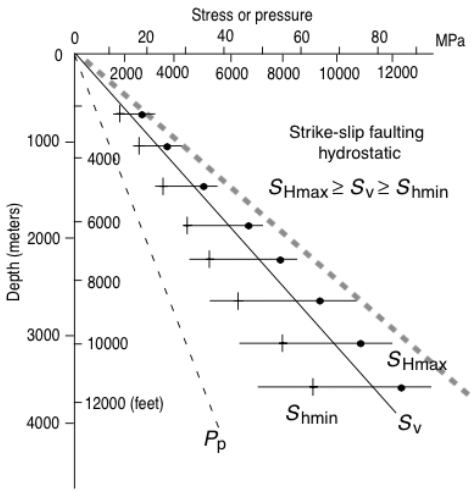
$$\frac{\sigma_1}{\sigma_3} = \frac{S_1 - P_p}{S_3 - P_p} = \left(\sqrt{\mu^2 + 1} + \mu^2\right)^2$$

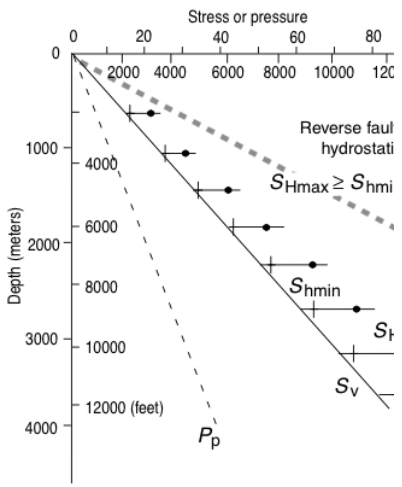
Asuming $\mu = 0.6$

$$\frac{\sigma_1}{\sigma_3} = 3.1$$

Stress bounds





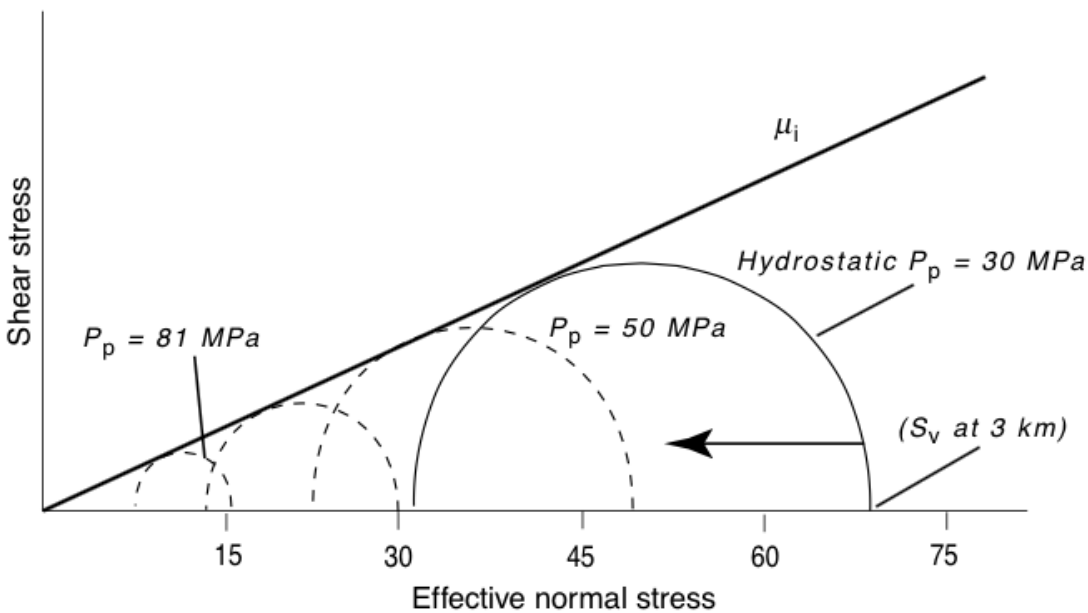


$$\frac{S_v - P_p}{S_{hmin} - P_p} \leq \left(\sqrt{\mu^2 + 1} + \mu^2\right)$$

$$\frac{S_{Hmax} - P_p}{S_{hmin} - P_p} \leq \left(\sqrt{\mu^2 + 1} + \mu^2\right)$$

$$\frac{S_{Hmax} - P_p}{S_v - P_p} \leq \left(\sqrt{\mu^2 +}\right.$$

Pore pressure, stress difference, and fault slip



 Zoback, *Reservoir Geomechanics* (Fig. 4.30, pp. 136)