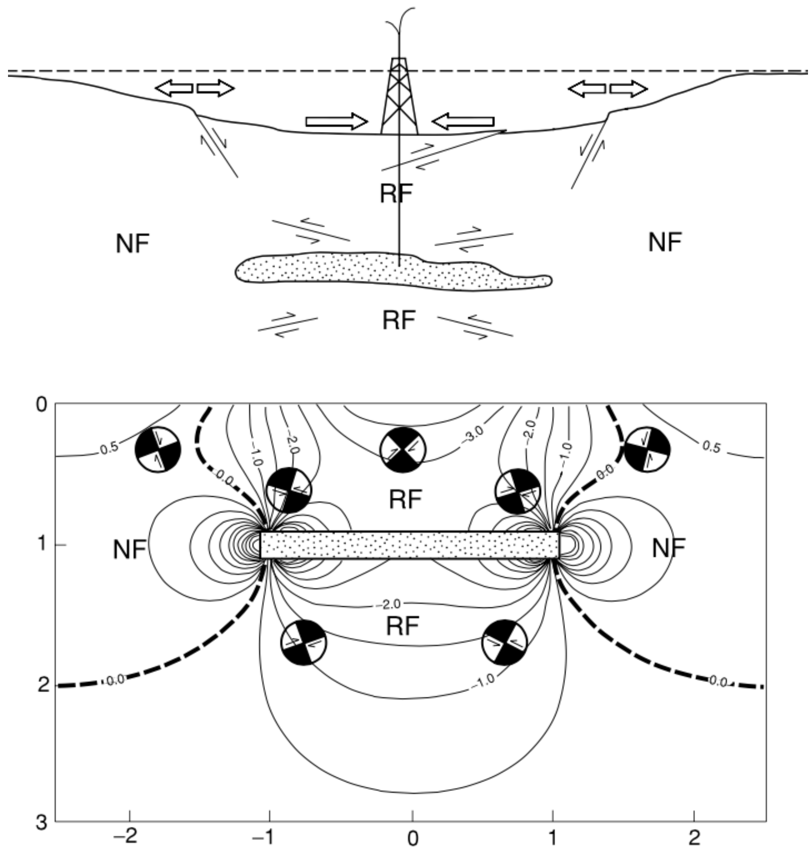
Effects of reservior depletion



Estimating stress changes in depleting reserviors

$$S_{Hor} = S_{Hmax} = S_{hmin} = \frac{\nu}{1-\nu} S_v + \alpha P_p \left(1 - \frac{\nu}{1-\nu}\right)$$

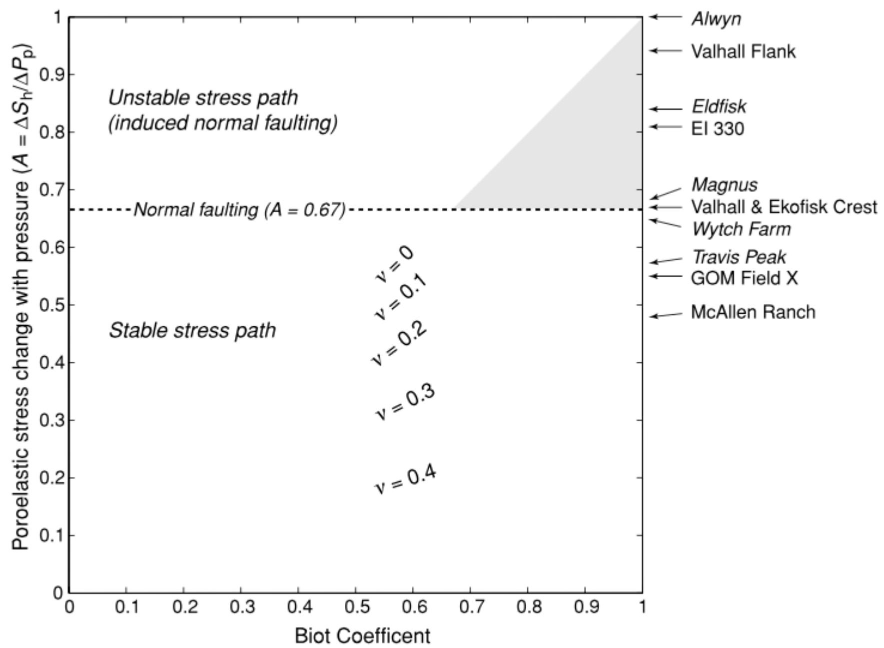
$$\frac{\mathrm{d}S_{Hor}}{\mathrm{d}P_p} = \alpha \frac{1-2\nu}{\nu - 1} \qquad \text{during production}$$

$$\Delta S_{Hor} = \alpha \frac{1-2\nu}{\nu-1} \Delta P_p$$

Taking $\nu = \frac{1}{4}$ and $\alpha = 1$

$$\Delta S_{Hor} \sim \frac{2}{3} \Delta P_p$$

Comparison of theory and observation



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Production induced faulting

$$\frac{S_v - (Pp - \Delta P_p)}{(S_{hmin} - \Delta S_{hmin}) - (Pp - \Delta P_p)} = (\sqrt{\mu^2 + 1} + \mu)^2$$

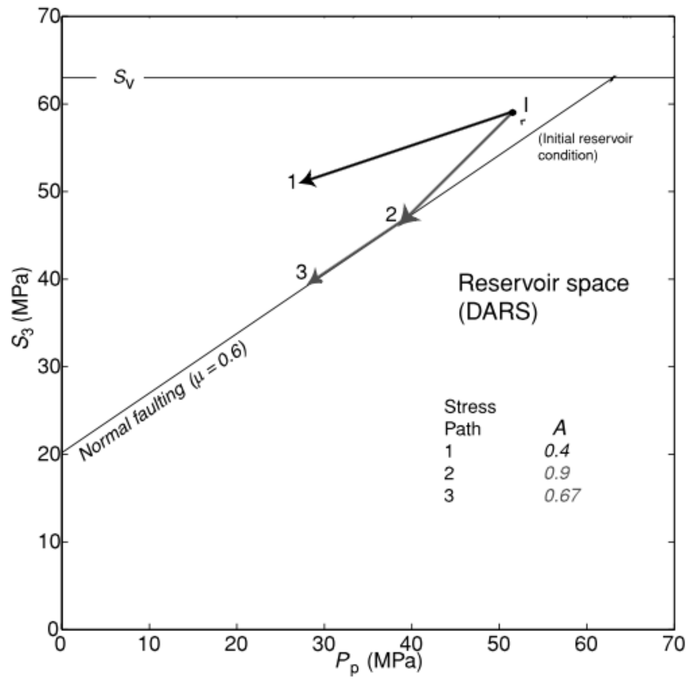
Simplification leads to

$$\frac{\Delta S_{Hmin}}{\Delta P_p} = 1 - \frac{1}{(\sqrt{\mu^2 + 1} + \mu)^2}$$

For $\mu = 0.6$

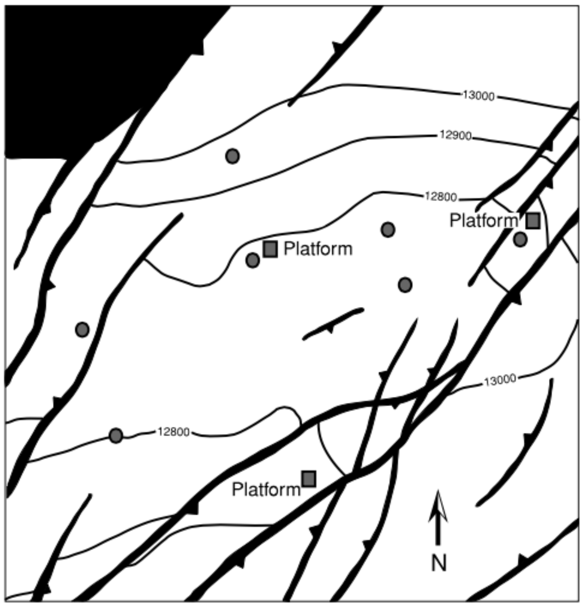
$$\frac{\Delta S_{Hmin}}{\Delta P_p} = 0.67$$

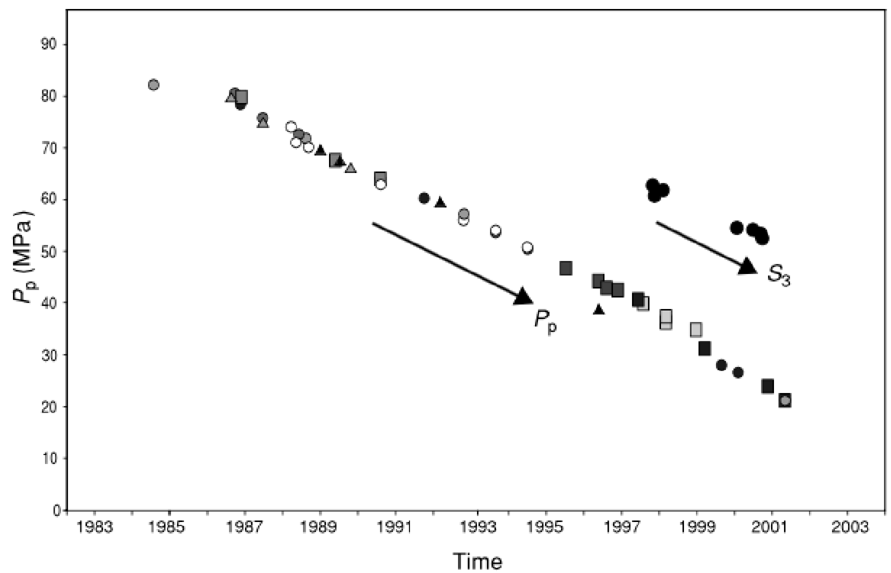
Reservoir space plot



 Zoback, *Reservoir Geomechanics* (Fig. 12.4a, pp. 386)

GOM Field X





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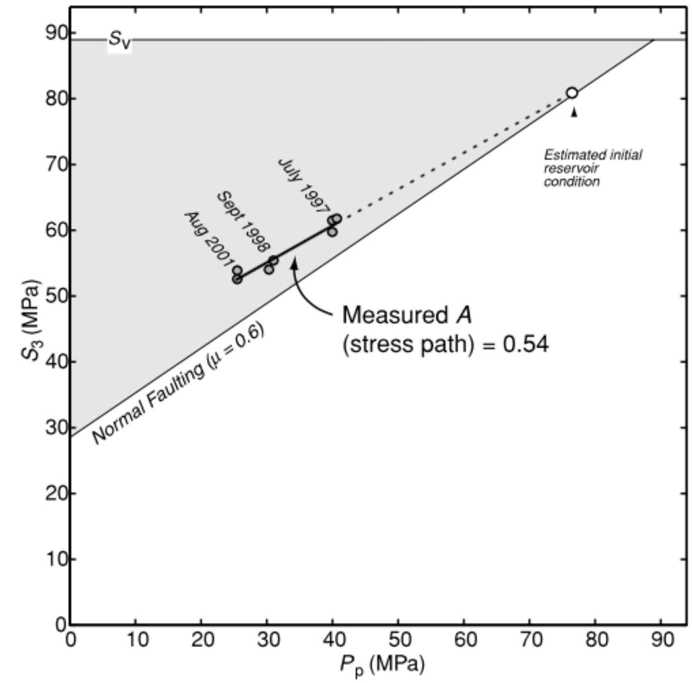
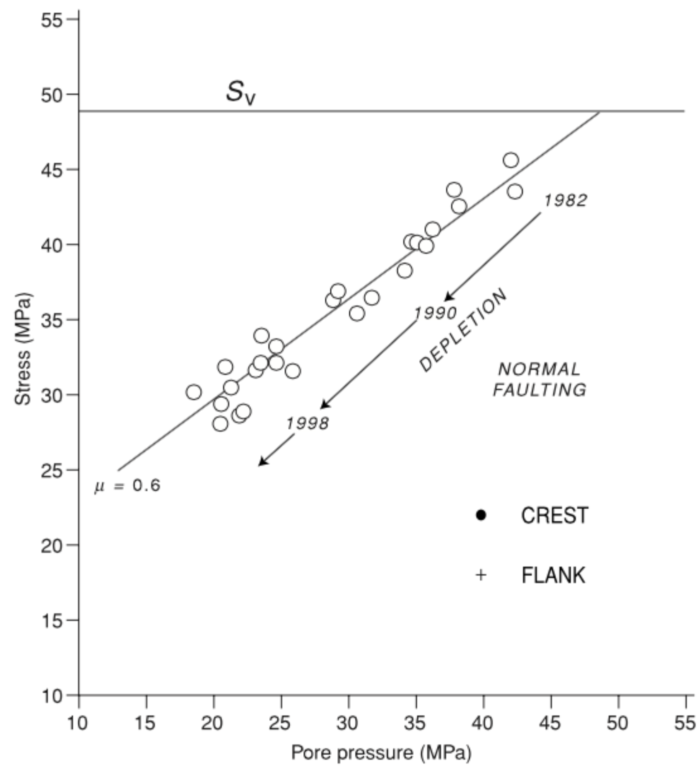
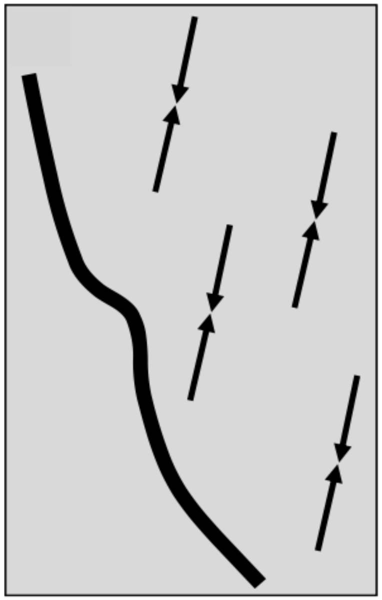


 Zoback, *Reservoir Geomechanics* (Fig. 12.4b, pp. 387)

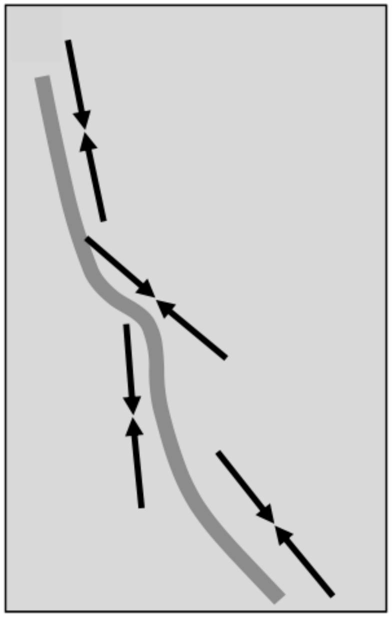
Valhall field in North Sea



Stress rotations with depletion



Original



Depleted

 Zoback, *Reservoir Geomechanics* (Fig. 12.6ab, pp. 391)

Rotation angle, $\boldsymbol{\gamma}$ 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

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