Thermal effects on wellbore stress

Strongly time dependent

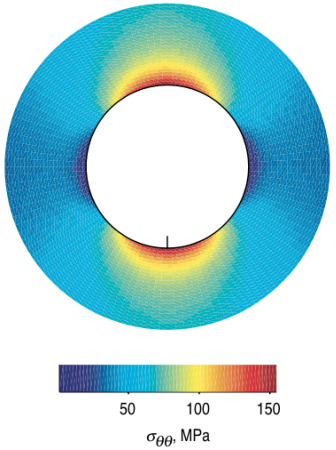
$$\frac{\partial T}{\partial t} = \alpha_T \nabla^2 T$$

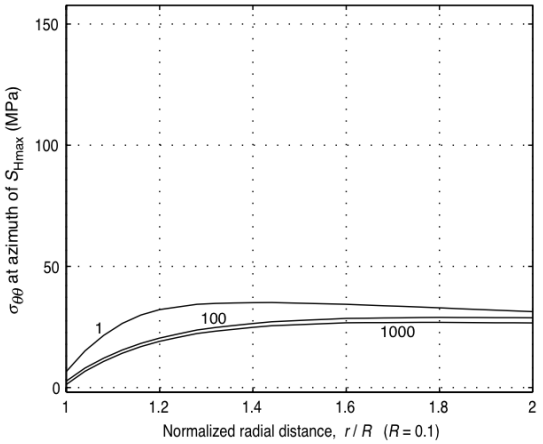
$\alpha \rightarrow$ strongly depenendent of the silica content of the rock.

Under steady-state conditions,

$$\Delta\sigma_{\theta\theta}^{T} = \frac{\alpha_T E \Delta T}{1 - \nu}$$

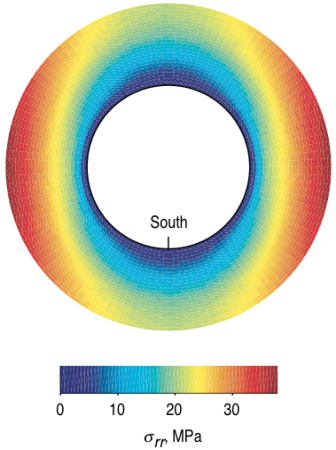
Time-temperature effects

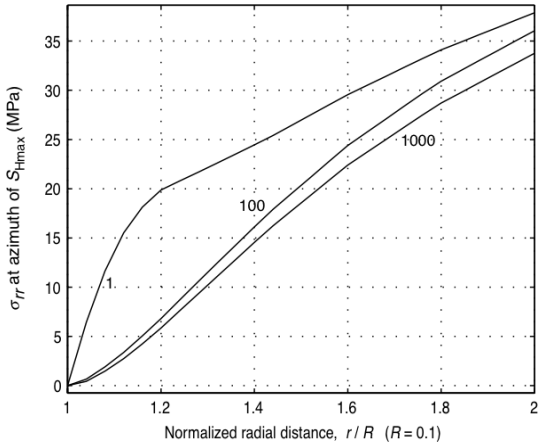




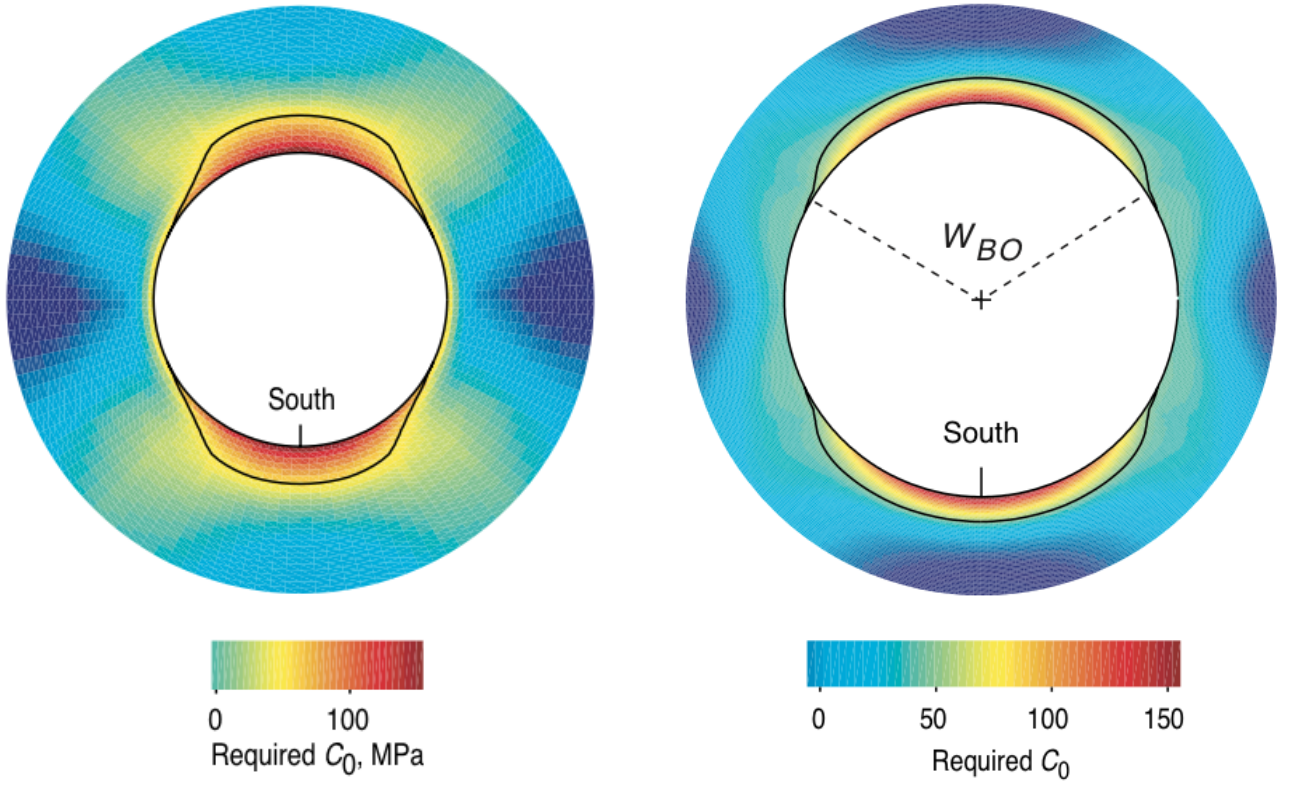
ΔT =25˚ C

ΔP =6 MPa





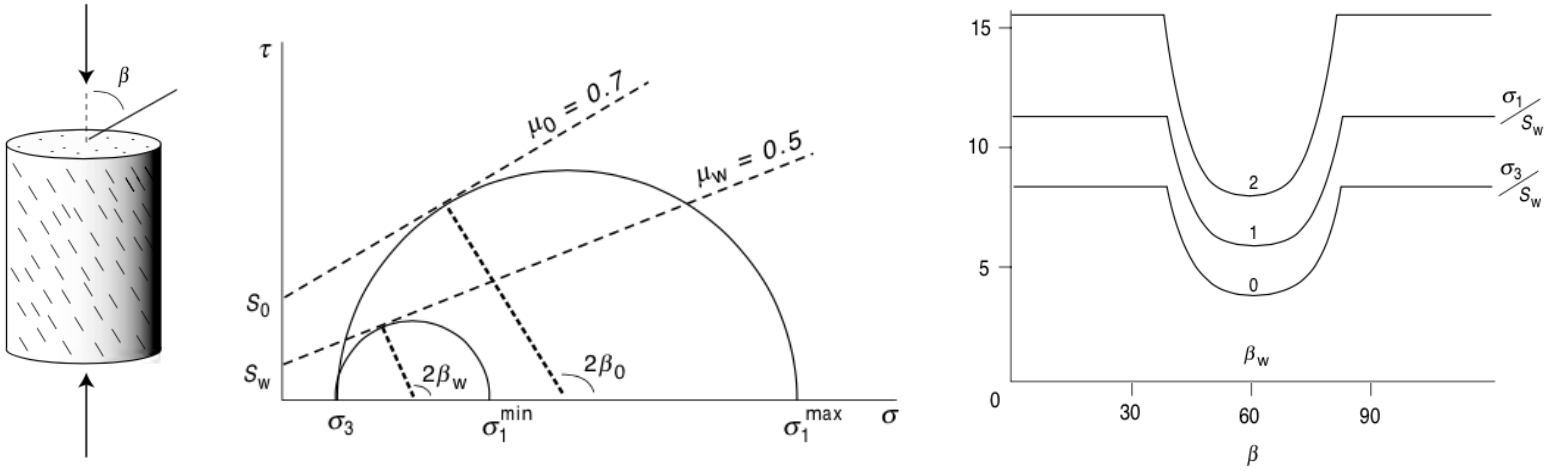
Stability through cooling?



Cooling

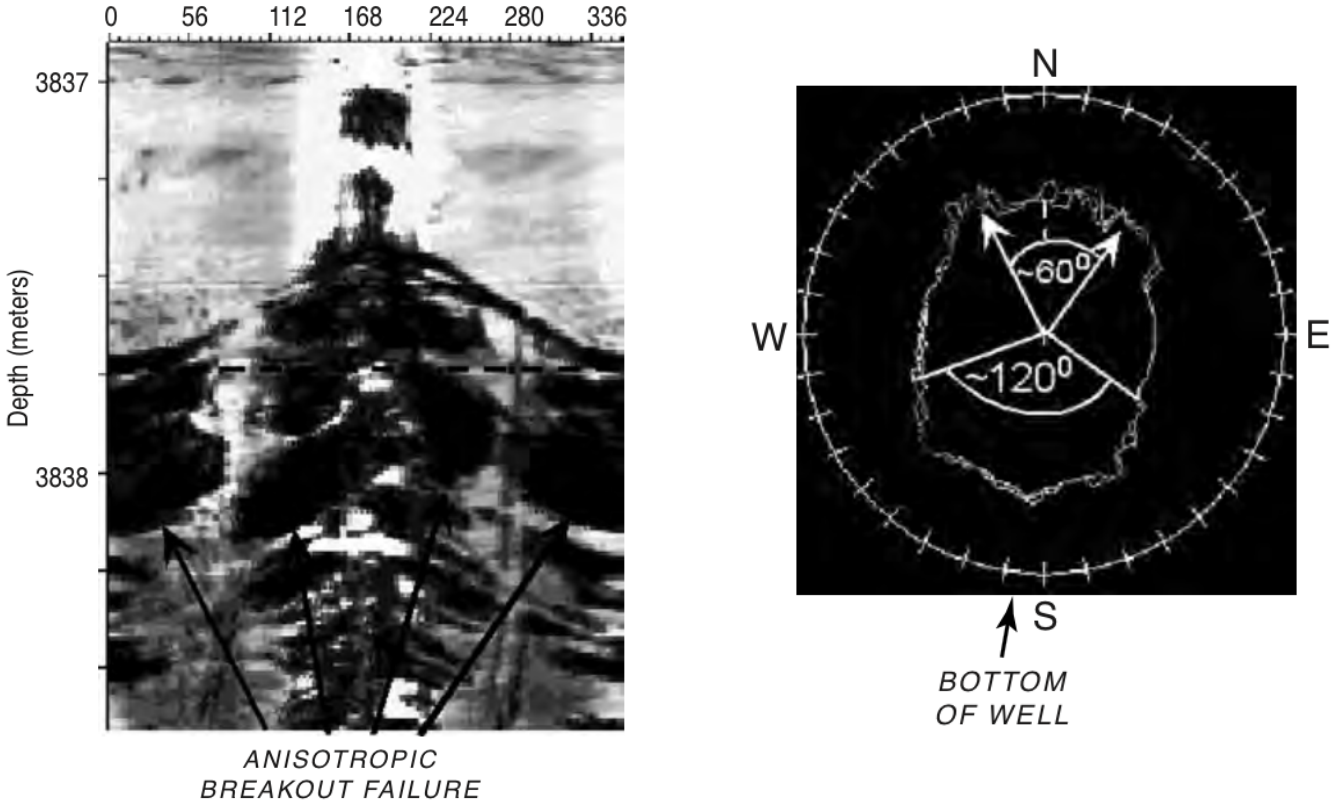
Reference

Rock strength anisotropy



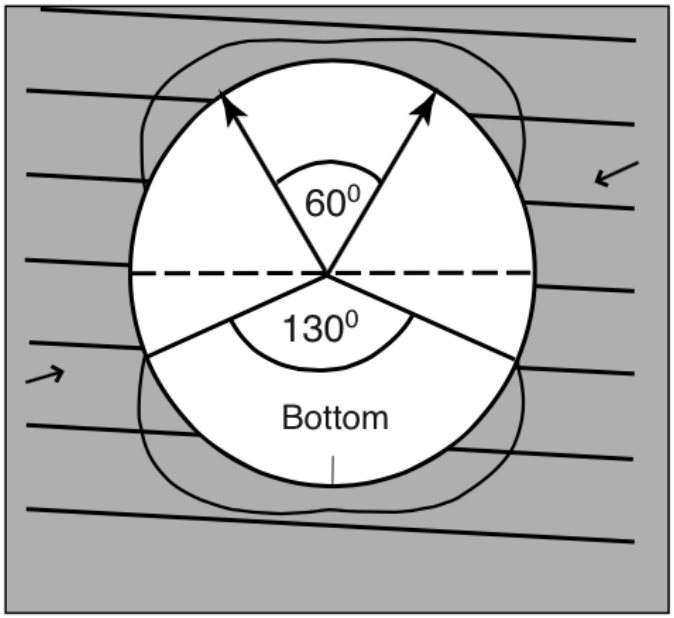
$$\sigma_1 = \sigma_3 \frac{2(S_w + \mu_w \sigma_3)}{(1 - \mu_w \cot \beta_w) \sin 2\beta}$$

Rock strength anisotropy effects on breakouts



Two mechanisms

- Stresses exceed intact rock strength
- Stresses activate slip on weak bedding planes



 Zoback, *Reservoir Geomechanics* (Fig. 6.16c pp. 199)

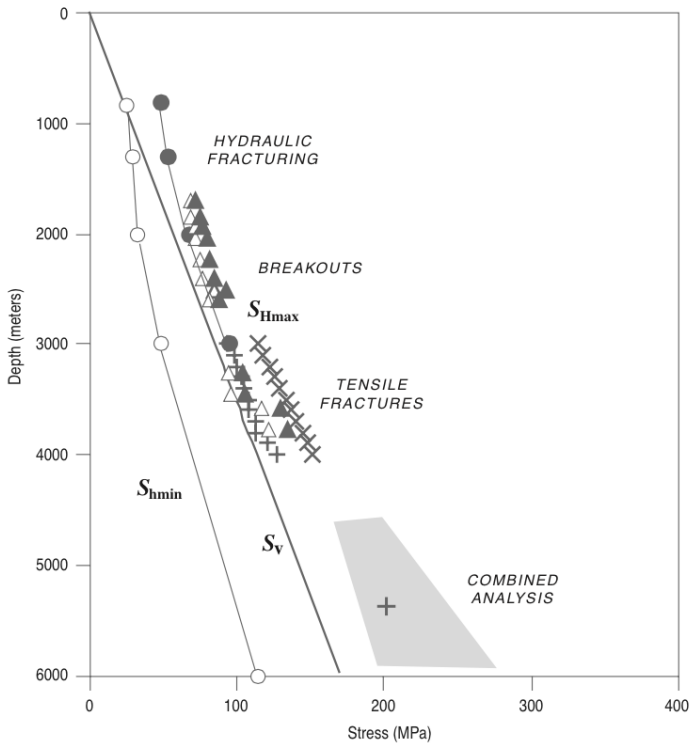
Chemical effects

- Water Activity ($A_w \sim \frac{1}{\text{salinity}}$) can to increased pore pressure

a# S_{Hmax} from breakout data

$$S_{Hmax} = \frac{(C_0 + 2P_p + \Delta P + \Delta\sigma^T) - S_{hmin}(1 + 2\cos(\pi - w_{bo}))}{1 - 2\cos(\pi - w_{bo})}$$

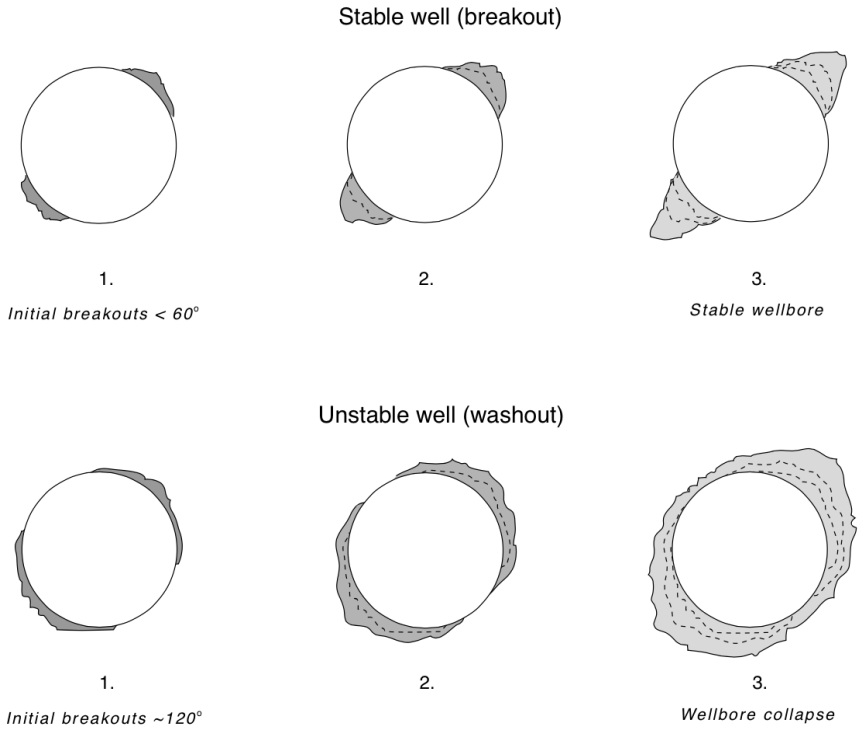
Example



 Zoback, *Reservoir Geomechanics* (Fig. 7.7 pp. 223)

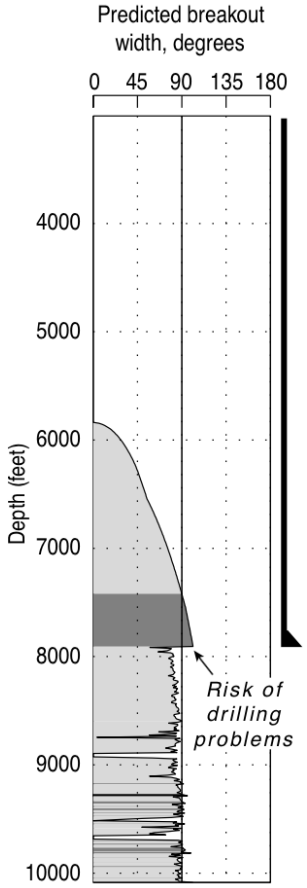
Wellbore stability

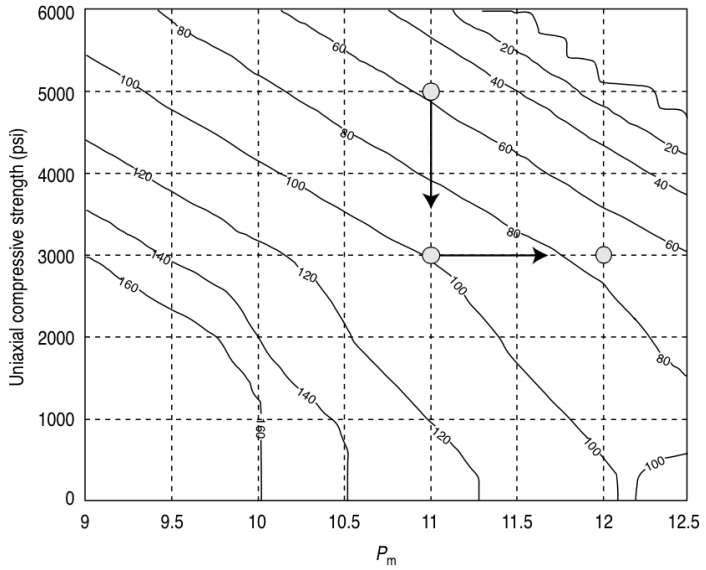
Defining a "stable" wellbore



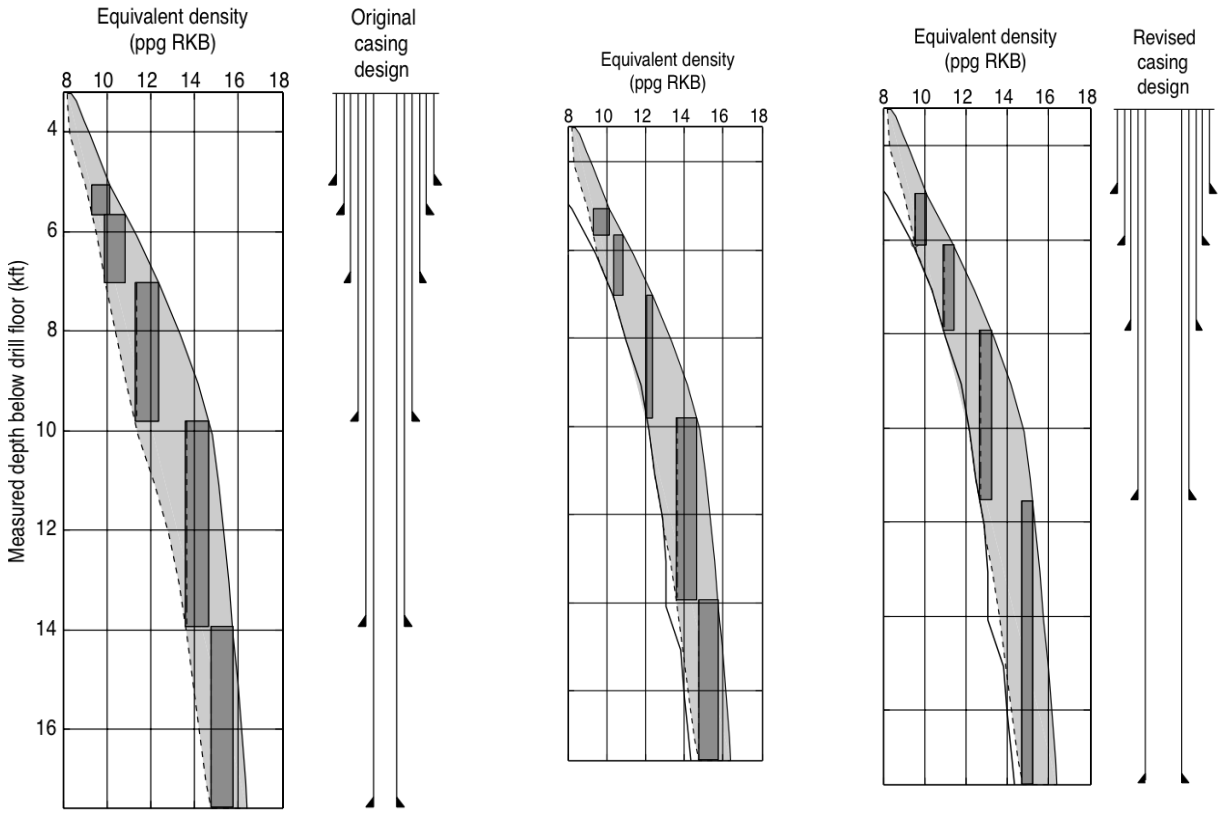
 Zoback, *Reservoir Geomechanics* (Fig. 10.1a,b pp. 304)

Emperical model: Maximum 90° breakouts





Comprehensive model



Design based on pore pressure and frac gradient

Model considering collapse pressure

Final design