

## Reservoir Geomechanics

### Homework No. 6 – Constraining the Maximum Horizontal Stress from Wellbore Failure

Due 8:00 UTC March 30<sup>th</sup>, 2020

If you want to see the current time in UTC, please google: current time in UTC

The condition for a tensile fracture forming in the wellbore wall in a vertical well when a thermal stress is ignored is (Zoback, 2007),

$$S_{hmin} + S_{Hmax} - 2(S_{Hmax} - S_{hmin}) - 2P_p - (P_m - P_p) = T_o \quad \text{Eqn. 1}$$

It may be assumed that at the maximum angle of a breakout initiation, a circumferential stress is equal to the unconfined compressive rock strength (Barton et al., 1988),

$$S_{hmin} + S_{Hmax} - 2(S_{Hmax} - S_{hmin})\cos(\pi - w_{bo}) - 2P_p - (P_m - P_p) = C_o \quad \text{Eqn. 2}$$

If faults are in frictional equilibrium (Zoback, 2007),

$$\frac{S_1 - P_p}{S_3 - P_p} = (\sqrt{(\mu^2 + 1)} + \mu)^2 \quad \text{Eqn. 3}$$

in which  $S_{hmin}$  is a minimum horizontal stress,  $S_{Hmax}$  is a maximum horizontal stress,  $P_p$  is a pore pressure,  $P_m$  is a mud pressure,  $T_o$  is a tensile strength,  $w_{bo}$  is a breakout width,  $C_o$  is an unconfined compressive strength,  $S_1$  is a maximum principal stress,  $S_3$  is a minimum principal stress, and  $\mu$  is a coefficient of sliding friction.

*Use the following unit in your calculation: 'psi' for maximum horizontal stress and minimum horizontal stress*

#### I. Answer the questions on the page below

In a vertical well, assuming a pore pressure of 4400 psi, an overburden stress of 11000 psi, a coefficient of sliding friction of 0.6, a mud pressure of 5900 psi, a tensile strength of 0 psi, a breakout width of 0°, and an unconfined compressive strength of 14000 psi, calculate values of the minimum horizontal stress and the maximum horizontal stress at points 1, 2, 3, 4, and 5 in Figure 1.

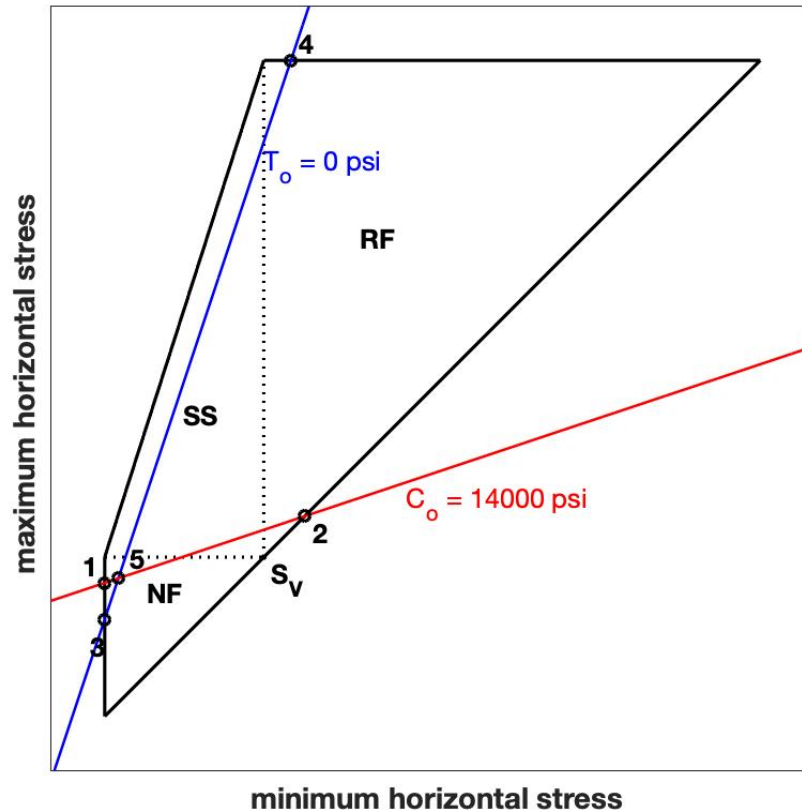


Figure 1. A stress polygon assuming a pore pressure of 4400 psi, an overburden stress of 11000 psi, a coefficient of sliding friction of 0.6, a mud pressure of 5900 psi, a tensile strength of 0 psi, a breakout width of  $0^\circ$ , and an unconfined compressive strength of 14000 psi. A  $C_o$  line represents a breakout, and a  $T_o$  line represents a drilling induced tensile fracture.

Please do not write a unit in an answer, just write a number.

Zoback, M. (2007). Reservoir Geomechanics. Cambridge: Cambridge University Press.  
doi:10.1017/CBO9780511586477

Barton, C. A., Zoback, M. D., and Burns, K. L. (1988). In-situ stress orientation and magnitude at the Fenton Geothermal Site, New Mexico, determined from wellbore breakouts. Geophysical Research Letters, Volume 15, Issue 5, doi: 10.1029/GL015i005p00467