Reservoir Geomechanics

Homework No. 7 – Development of a Geomechanical Model
Due 8:00 UTC April 6th, 2020
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In this homework assignment, you will constrain a maximum horizontal stress in a site of the Barnett shale of the first, third, and fifth homework assignments. The relationship for faults in frictional equilibrium modified from (Zoback, 2007) is,

$$\frac{S_1 - P_p}{S_3 - P_p} \leq (\sqrt{(\mu^2 + 1)} + \mu)^2$$

if a tensile fracture does not occur, the condition in the wellbore wall in a vertical well modified from (Zoback, 2007) when a thermal stress is ignored is,

$$S_{h\min} + S_{H\max} - 2(S_{H\max} - S_{h\min}) - 2P_p - (P_m - P_p) \geq T_o$$

if a breakout of a certain width does not occur, modified from (Barton et al., 1988), it may be assumed that a circumferential stress is smaller than an unconfined compressive rock strength,

$$S_{h\min} + S_{H\max} - 2(S_{H\max} - S_{h\min})\cos(\pi - w_{bo}) - 2P_p - (P_m - P_p) \leq C_o$$

from (Angelier, 1979), a ϕ is,

$$\phi = \frac{S_2 - S_3}{S_1 - S_3}$$

from (Simpson, 1997), an Aϕ parameter, which scales relative stress magnitudes from 0 to 3 based on faulting style, is given by,

$$\mathrm{A}\phi = (n + 0.5) + (-1)^n(\phi - 0.5)$$

in which S_1 is a maximum principal stress, S_3 is a minimum principal stress, P_p is a pore pressure, μ is a coefficient of sliding friction, S_{hmin} is a minimum horizontal stress, S_{Hmax} is a maximum horizontal stress, 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_2 is an intermediate principal stress, and n = 0, 1, and 2 for normal, strike-slip, and reverse faulting types, respectively.

I. Constrain the magnitude of the maximum horizontal stress

In the site at a depth of 5725 feet, the minimum principal stress gradient estimated from an instantaneous shut in pressure at the end of a fracturing stage is about 0.65 psi/ft, the lower bound of a pore pressure gradient is determined from mud weight as 0.48 psi/ft, a coefficient of sliding friction is 0.75, and a mud pressure gradient is 0.53 psi/ft (Vermylen, 2011). For this homework assignment, use 0.48 psi/ft as the pore pressure gradient. At the depth of 5725 feet, the image log from which natural fractures were picked in the fifth homework assignment shows no signs of drilling induced tensile fractures or wellbore breakouts. For this homework assignment, assume that a tensile strength is 0 psi, and assume that a breakout width is 0°. An overburden stress versus depth of the site was calculated in the first homework assignment, and an unconfined compressive strength versus depth of the site was calculated from a sonic log in the third homework assignment. Calculate an upper bound of an A_ϕ of the site at the depth of 5725 feet.

II. Answer the questions on the page below

Numerical entry responses have a range of acceptable values and are graded electronically. Adhere to the values given here.

Zoback, M. (2007). Reservoir Geomechaincs. 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

Vermylen, J. (2011). Geomechanical studies of the Barnett shale, Texas, USA (Doctoral dissertation). Retrieved from https://stacks.stanford.edu/file/druid:zf098jx2047/Vermylen%20Dissertation%20%28Registrar%29-augmented.pdf

J. Angelier. Determination of the mean principal directions of stresses for a given fault population. Tectonophysics, 56 (1979), pp. T17-T26, doi: 10.1016/0040-1951(79)90081-7

R.W. Simpson. Quantifying Anderson's fault types. Journal of Geophysical Research, 102 (1997), pp. 17909-17919, doi: 10.1029/97JB01274