PGE 334 – Homework #5 **Instructor: DNE**

1. Using equations of stresses around a cylindrical cavity, calculate near-wellbore effective radial σ_{rr} and hoop $\sigma_{\theta\theta}$ stresses for a vertical well 8in diameter in the directions of S_{hmin} (4500 psi – acting E-W) and S_{Hmax} (6000 psi) up to 3ft of distance considering that Pp=3200psi and
   a. P_W=3200 psi.
   b. P_W=4000 psi.

   The result should be presented as plots of stresses (σ_{rr}, $\sigma_{\theta\theta}$) as a function of distance from the center of the wellbore.

2. **Effect of overpressure**:
   Consider the problem solved in class (<u>Wellbore</u>: vertical; <u>Site</u>: onshore, 7000 ft of depth, S_{hmin} = 4,300 psi, S_{Hmax} = 6,300 psi; <u>Rock properties</u>: UCS = 3,500 psi, μ=0.6, T_s = 800 psi).
   a. Calculate wellbore pressure and corresponding mud weight for (i) w_{BO}=70°, (ii) w_{BO}~0° (P_{Wshear}), and (iii) for inducing tensile fractures (P_b) for λ_p= 0.52 and λ_p= 0.60. Compare with λ_p= 0.44 solved in class. How does the drilling mud window change with overpressure?
   b. Assume horizontal stress directions near Dallas-Forth Worth region. What would the azimuth of breakouts and drilling induced fractures be? http://dc-app3-14.gfz-potsdam.de/pub/stress_data/stress_data_frame.html

3. **Effect of stress anisotropy (differential stress)**:
   Consider the following problem, <u>Wellbore</u>: vertical; <u>Site</u>: onshore, 2 km of depth, λ_p= 0.44, σ_{hmin} = 0.4 σ_V; <u>Rock properties</u>: UCS = 7 MPa, q=3.9, T_s = 2 MPa. Calculate wellbore pressure and corresponding mud weight for (i) w_{BO}=45°, (ii) w_{BO}~0°, and (iii) for inducing tensile fractures for
   a. σ_{Hmax} = 0.6 σ_V.
   b. σ_{Hmax} = 0.8 σ_V.
   c. σ_{Hmax} = 1.0 σ_V.
   d. How does the drilling mud window change with $\sigma_{Hmax}/\sigma_{Hmin}$?

4. **Offshore**:
   Consider the same formation as above but in offshore conditions, <u>Wellbore</u>: vertical; <u>Site</u>: offshore, 2 km of <u>total</u> depth, 500 m of water, hydrostatic pore pressure, σ_{hmin} = 0.4 σ_V, σ_{Hmax} = 0.8 σ_V; <u>Rock properties</u>: UCS = 7 MPa, q=3.9, T_s = 2 MPa. Calculate wellbore pressure and corresponding mud weight for (i) w_{BO}=45°, (ii) w_{BO}~0°, and (iii) for inducing tensile fractures.

5. **Horizontal wells:**

Evaluate wellbore stability for horizontal wells that you will need to exploit in a gas reservoir subjected to a strike-slip stress environment.

a. Draw cross-sections of wellbores drilled parallel to S_{hmin} and S_{Hmax}, identify involved stresses, and clearly mark expected positions of tensile fractures and wellbore breakouts.

b. The horizontal wells lie at about 8000ft depth where it is estimated that S_{hmin}=50MPa, S_{Hmax}=70MPa and λ_p=0.6. The unconfined compressive strength of the rock is 8500psi, μ=1.0, and T_s=0 psi is a good estimate for tensile strength, given the large density of natural fractures. Determine the mechanical stability limits on wellbore pressure for both horizontal well directions considered.

c. Determine mud density window appropriate for these wells (keep in mind potential lost circulation).

d. Which one appears to have a wider mud window? Justify