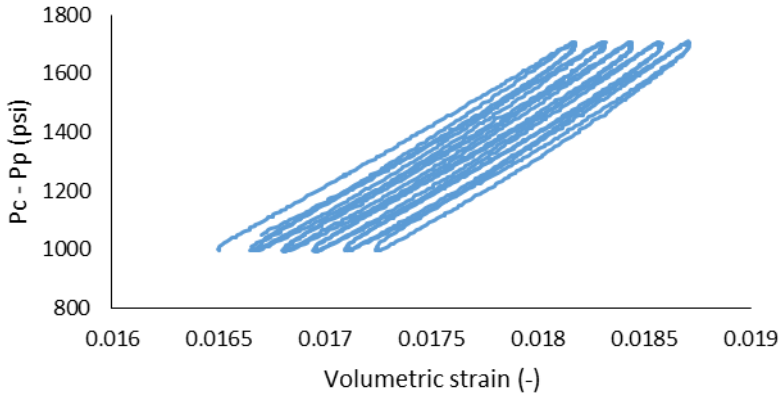
Project #5: Poroelasticity

1) Biot coefficient determination

The file "BiotCoeffExperiment.xlsx" has data from a laboratory experiment on a reservoir sandstone that shows axial and radial deformations caused by alternating variations of confining stress and pore pressure.

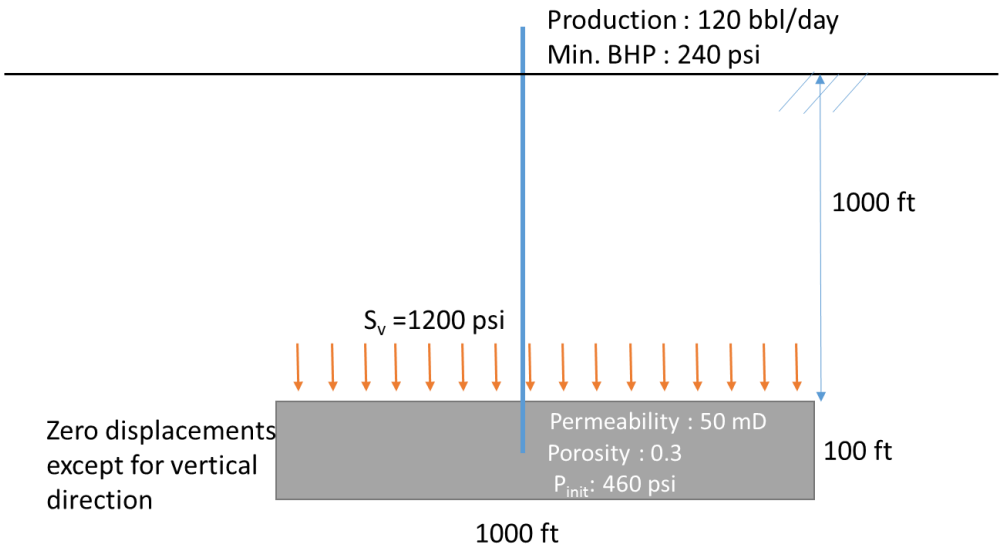
a. Plot pressure and stresses as a function of time.
b. What is dP_c/dt and dP_p/dt? If permeability is k = 100 mD and the fluid is water, would it be close to be undrained loading?
c. Fit a straight line to the data to obtain a unique relationship between ε_{vol} and σ_{mean} (effective), and calculate the bulk Biot coefficient α.
d. Plot together the volumetric strain with Terzaghi's and Biot's effective stresses.
e. EXTRA: Use the theory of transverse isotropic poro-elasticity to figure out the stress paths needed to calculate α_h and α_v.



2) Depletion stress path

For this problem you have to use the geomechanical module of reservoir simulator CMG (https://www.cmgl.ca/). The software is available in PGE computer lab, 3rd floor in CPE. Non-PGE students may need authorization, please email John Cassibry (jcassibry@austin.utexas.edu). For additional help email Jeffery Luo (jefferyluo@utexas.edu).

a. Review the files "CMG_Geomechanics_Tutorial.pdf" and "CMG_Running_InputFile.pdf"
b. Change the vertical stress and well schedule as shown in the figure below (example files: Injection1.dat and Production1.dat)



c. What is initial boundary condition in each direction? (i.e. constant stress or zero displacement)
d. Plot 1 - Plot minimum principal total stress (Total stress I), vertical total stress (Total stress K), and pore pressure (Pressure) vs time. (**Note: Please remove initial data (time = 0) when you plot)
e. Plot 2 - Plot minimum principal stress (y-axis) vs pore pressure (x-axis), and verify the slope of the curve is similar with $\alpha\frac{(1-2\nu)}{(1-\nu)}$ (α is the Biot coefficient and ν is Poisson's ratio - **Note: Please remove initial data (time = 0) when you plot pressure and stresses)
f. Run the simulation again using Biot coefficient from the previous laboratory problem, repeat the question "d" using the new simulation result and plot on the same figure
g. Plot the stress path with Mohr circles for the initial (0.1 days) and final time (100 days)
h. Plot the stress path in the p'-q space for the same period of time.
i. Plot the stress path of total stress as a function of pore pressure
j. What would the minimum pressure to create a hydraulic fracture be at bottom-hole pressure BHP = 240 psi? Compare with the analytical solution.