Unconventional Reservoir Geomechanics
Spring 2020

Homework 1: State of Stress in Unconventional Reservoirs
Due April 20, 2020 7:00 UTC

Instructions

This assignment focuses on constraining the state of stress in the Barnett shale, TX using density log data. Download the density log data by clicking 'next' in the upper right corner. Use a scientific computing program to follow the steps below. Then answer the questions on the edX page.

Part 1: Vertical stress and vertical stress gradient

a) Plot density as a function of depth. Put density on the x-axis and depth on an inverted y-axis.

b) Divide the density profile into 5 blocks. Designate 5 blocks of approximately constant density as a function of depth (e.g., 0-500 ft, 500-1000 ft, 1000-3000 ft, 3000-5000 ft, 5000-7000 ft). Compute the average density in each block and plot blocked density on the same axes as (a).

c) Calculate the vertical stress. Integrate both the continuous and blocked density profiles to calculate vertical stress in units of psi and MPa. Calculate a hydrostatic pore pressure gradient. Use 1000 kg/m^3 for the density of water and 10 m/s^2 for acceleration due to gravity. Plot vertical stress and pore pressure as function of depth.

d) Calculate the vertical stress gradient. Integrate the vertical stress profiles to calculate vertical stress gradient. Plot vertical stress gradient as a function of depth.

Part 2: Stress polygon

a) Calculate stress magnitude constraints for each faulting regime. Diagnostic fracture injection tests (DFIT) indicate that the instantaneous shut-in pressure (ISIP) is 38 MPa at 5500 ft depth. Use Coulomb faulting theory (Unit 3) to calculate stress magnitude constraints for each faulting regime. Use the following values:

   Depth, $d = 5500$ ft
   Coefficient of friction, $\mu = 0.6$
   Pore pressure gradient = 0.5 psi/ft
   Vertical stress, S_{v} = Value from part 1c blocked data

b) Repeat (a) for an ISIP of 28 MPa. If the reservoir is in frictional equilibrium and has both active normal and strike-slip faults, what are the range of allowable values of S_{Hmax} and S_{hmin}?

c) Construct the stress polygon. Plot your results from (a) on S_{Hmax} vs. S_{hmin} axes in units of MPa. Plot S_{v} on the same axes and draw in the boundaries between the faulting regimes as illustrated in Unit 3.

d) Repeat (a) and (c) using a pore pressure gradient of 0.7 psi/ft. What is the effect of overpressure on the stress polygon and the range of allowable stress states?

Part 3: Answer the questions in edX

Use the plots and calculations from Parts 1 and 2 to answer the questions on the page below. The solutions will be posted after the due date. Numerical entry types responses have a limited range of accepted values and are graded automatically, so follow the directions closely and adhere to the given values of constants to prevent misgrading of your submissions.