Stanford | ONLINE

Unconventional Reservoir Geomechanics
Spring 2019

Homework 5: Reservoir Seismology

Due May 27, 2019 at 08:00 UTC
Please direct any questions to the Piazza Discussion Forum on the course page

Background

In this assignment we will review concepts related to reservoir seismology and shear stimulation of faults. We will use a catalog of microseismic events associated with hydraulic stimulation of 4 wells in the Woodford and Mississippi Lime formations. The details of this case study are presented in Ma & Zoback (2017). The .txt files on the course page contain the time, date, position and magnitude of microseismic events from Wells A-D.

Utilize a scientific computing and/or plotting program such as MATLAB, Python or Excel to follow the steps below. Then, answer the questions on the page below.

Part 1: Gutenberg-Richter analysis

a) Plot Gutenberg-Richter curves for each of the 4 wells. The y-axis will be the logarithm of the cumulative number of events above a certain magnitude, and the x-axis will be event magnitude. Please refer to Unit 12 Section 4 for examples.

b) Determine the lowest magnitude of catalog completion for the 4 wells. Consider this to be the lowest magnitude at which the cumulative number of events is 5% of the total number of events.

c) Determine the *b-value* for the 4 wells. How do these *b-values* compare to active tectonic areas? Fit a line to each Gutenberg-Richter curve up until the following lower magnitude cutoffs: Well A: -2.34; Well B: -2.24; Well C: -2.40; Well D: -2.29. These represent inflection points in the cumulative percent difference from the total number of earthquakes as function of magnitude.

d) Compare the number of events and *b-values* in the Woodford and Mississippi Lime formations. Consider the magnitude of catalog completion while making this comparison. Are there any systematic relationships within or between the two formations?

Part 2: Shear stimulation of faults

a) Determine the seismic moment, M_0, of the events in each well from the moment magnitudes, M_w, using the relationship below.

$$M_w = \frac{2}{3}\left(\log_{10} M_0 - 9\right)$$

b) Calculate the total surface area created by the microseismic events associated with stimulation in each well. Assume a unifrom stress drop for all events $\Delta\tau$ = 0.5 MPa. Use the equation below to calculate the surface area created by each microseismic event, which assumes a circular fault patch with radius, r. Please see Unit 12 Section 3 for details.

$$\pi r^2 = S = \pi\left(\frac{7M_0}{16\Delta\tau}\right)^{\frac{2}{3}}$$

c) Compare the surface area created by stimulation in each of the wells. Based on this information, in which well was stimulation most effective?

Part 3

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