PGE 334 – Homework #4 **Instructor: DNE**

1. Let's compare reservoirs with normal and reverse faulting regimes (onshore). For both regimes, plot the limits of S_1 and S_3 versus depth from 0 to 5 km assuming hydrostatic pore pressure and a state of stress limited by frictional strength of faults. Assume sliding friction coefficient is μ=0.6. For both regimes, how does changing μ from 0.6 to 1.0 change the maximum possible differential stress S_1-S_3 at a fixed depth of z=5km? Explain what that friction coefficient change physically means.

2. A given site offshore (sea floor at 500 ft) is subjected to a Normal Faulting stress regime. Over-pressure is first detected at 1500 ft (TVD) and at 2000 ft overpressure is λ_p=0.78. Calculate the total minimum horizontal stress S_{hmin} at this depth assuming frictional equilibrium of faults and friction angle 30°. Draw the corresponding Mohr circle with a solid line and draw an additional Mohr circle with a dashed line assuming hydrostatic pressure. (Assume typical water and lithostatic gradients)

3. Find out the orientations of (a) a hydraulic fracture and (b) a shear fracture both created in a site subjected to stresses $S_v < S_{hmin} < S_{Hmax}$ where S_{Hmax} strikes E-W and μ=0.8.

4. Find out the orientations of (a) a hydraulic fracture and (b) a shear fracture both created in a site subjected to stresses $S_{hmin} < S_v < S_{Hmax}$ where S_{Hmax} strikes W20°N and μ=0.5.

5. For the following faults: (i) draw the corresponding points in a stereonet (lower hemisphere projection) map, (ii) convert to strike to azimuth convention, and (iii) draw equivalent geological map symbols.
   (a) N55°E, 45°SE
   (b) E20°S, 60°NE
   (c) N20°W, 25°SW
   (d) S10°W, 60°NW

6. In a given reservoir under study stresses are S_{hmin}=40 MPa, S_{Hmax}=60 MPa, S_v=45 MPa, P_p= 20MPa, and S_{hmin} acts E-W. For each of the faults below, calculate (using the Mohr Circle method <u>if possible</u>) the normal and shear stress on the plane of the fault and then determine if the fault is prone to slip (μ=0.6).

   a. Fault with strike north-south, dip 65° to the east
   b. Fault with strike east-west, dip 35° to the north

c. Fault with strike 060°, dip 90°
d. Fault with strike 030°, dip 25°

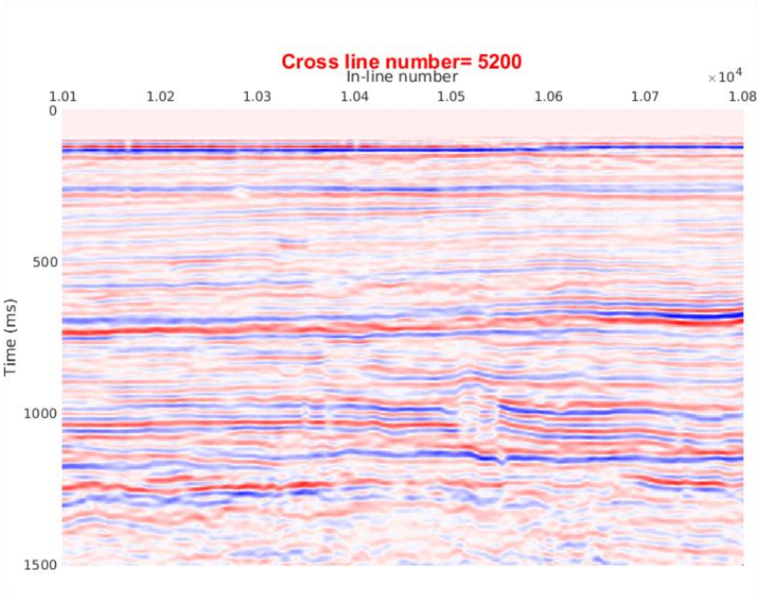
7. (<u>Optional</u> - See class notes) Write a Matlab code that can obtain (S_n, τ_d, τ_s, σ_n) on an arbitrary fault with orientation (strike, dip) for a given state of stress (S_P, α, β, γ).
   a. Verify with problems solved in lecture slides
   b. Apply to solve <u>all</u> cases in problem 6
   c. Apply code to solve stress on 100 fractures randomly oriented. Plot all results the respective 3D Mohr circle.
   d. A nearby injection wellbore will perform water flooding. What is the <u>additional</u> pore pressure needed to start reactivating faults?

Hint for problem 7:

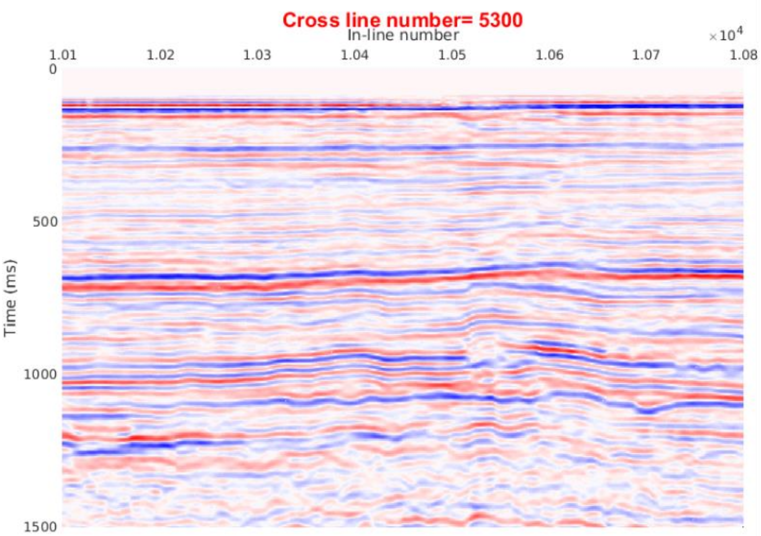
- Matlab function 'rand' can be used for creating an array of random values;

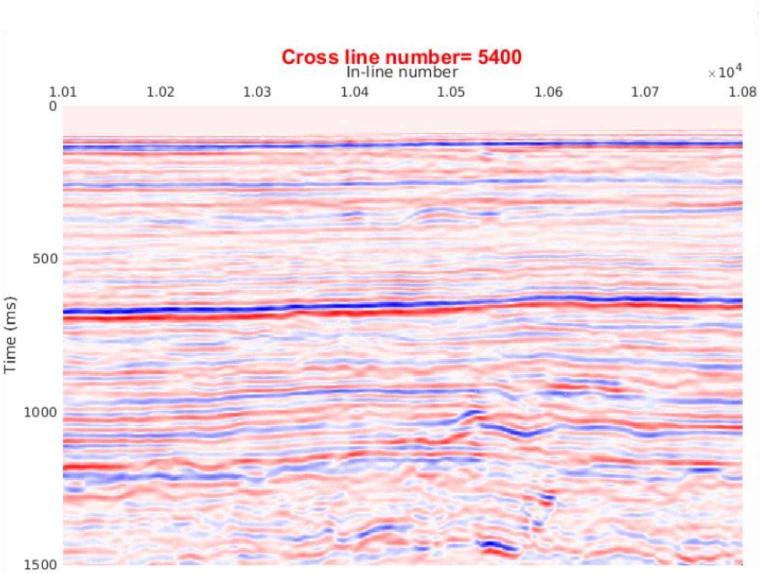
r = a + (b-a)*rand(N,1) creates an array r (Nx1) of values in interval [a,b]

8. (<u>Real application problem</u>) The following page contains seismic images (http://www.glossary.oilfield.slb.com/Terms/c/crossline.aspx) of a section the subsurface in the North Sea. We are interested in the Frigg sandstone formation. This is a hydrocarbon-bearing formation and it is located at about 1790 m of TVDSS.
   a. Calculate the water depth by measuring the two-way travel time and assuming V_P(sea-water) = 1450 m/s.
   b. Find the location of the Frigg Formation in the time axis assuming V_P(sediments) = 3000 m/s.
   c. Evaluate qualitatively the faulting at the reservoir depth. Describe how faulting could affect fluid flow.

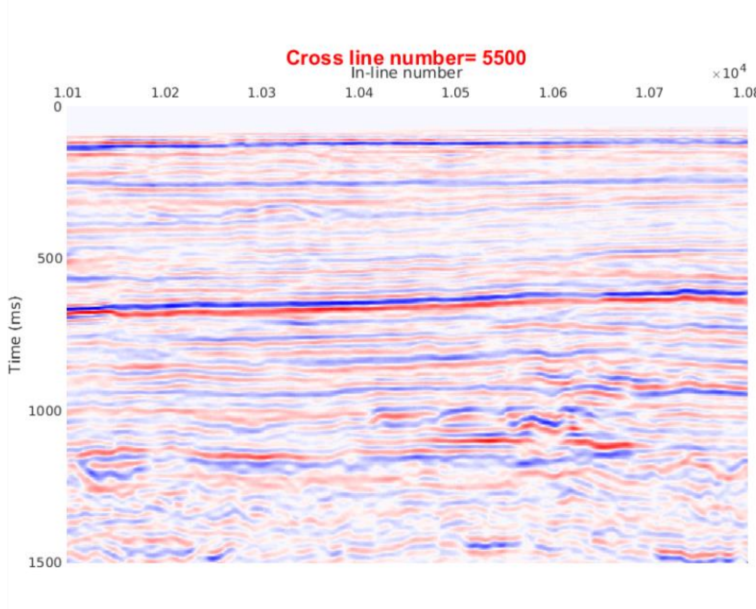


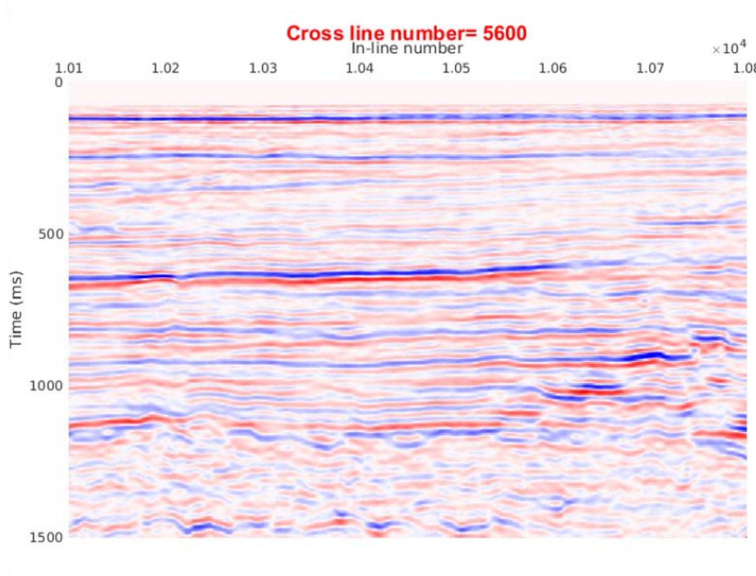
11-Oct-2017 14:

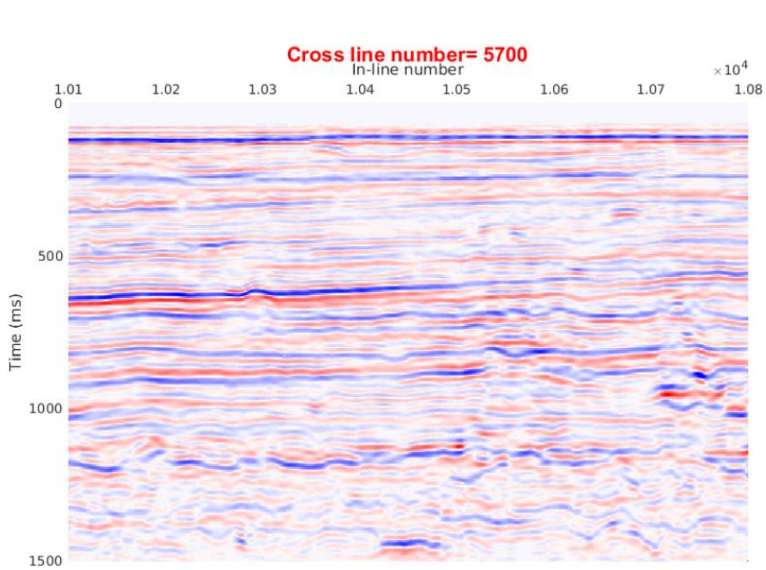




11-Oct-2017 14:







11-Oct-2017 14: