Lab 10: Stress transformations

Consider a hypothetical state of stress near the surface of the Earth in a volcanically active region which we assume to be uniform over the region. We wish to find the orientation of dikes that might erupt in fissure eruptions (for Part 1) and how a pre-existing set of vertical fractures might slip as faults (for Part 2). For our reference frame, x = east, y = north, z = up.

$$\left[\sigma_{ij}\right] = \begin{bmatrix} \sigma_{xx} = -1.50 & \sigma_{xy} = 1.70 \\ \sigma_{yx} = 1.70 & \sigma_{yy} = -1.50 \end{bmatrix} MPa$$

1 MPa (mega-pascals) ≈ 10 atmospheres (bars); 1 MPa ≈ 10 bars; 100 MPa ≈ 1 kbar

Part 1: Dike prediction (**57 pts**)

You will need to turn in 5 pages for this part:

Page 1: This page as a cover page (you will also need to turn in the next page!).

Page 2: Plots with the four map-view illustrations for steps a, b, f, and g

Page 3: A plot with the Mohr diagram of step c.

Page 4: The calculations for step d.

Page 5: The Matlab printout for step e.

a In the upper left quadrant of "page 2", draw a neat box and label the all stress components acting on all sides of the box. Draw positively directed stress arrows (**4 pts**) and label the magnitudes of the stress components (**4 pts**). Inside the box include axes for the x,y reference frame (**2 pts**) and a north arrow (**1 pts**). **(11 pts)**

b In the upper right quadrant of "page 2", draw a second neatly labeled box showing the tractions above acting on the sides of the box. Draw positively directed traction arrows (**4 pts**) and label the magnitudes of the traction components (**4 pts**). Inside the box include axes for the x,y reference frame (**2 pts**) and a north arrow (**1 pts**). <u>Outside the box draw n, s axes on the four sides of the box</u> (**4 pts**). **(15 pts)**

c Solve for the <u>magnitude</u> and <u>orientation</u> of the principal stresses by using a <u>Mohr circle for tractions</u> (see example in lecture 17, p. 9- 10). On the Mohr diagram, <u>assign a reference frame</u> (x'-y') to the principal directions, with the x'-axis along the direction of the most tensile (or least compressive) stress. (**2+2+4+2 = 8 pts**)

d Solve for the magnitude **(4 pts**) and orientation **(4 pts**) of the principal stresses by the eigenvector/eigenvalue method - <u>long hand</u> (see lecture 19, p.16-18). **(8 pts)**

e Solve for the magnitude **(2 pts**) and orientation **(2 pts**) of the principal stresses by using the eigenvector /eigenvalue method using <u>Matlab</u> (see lecture 19, p. 20). Include a copy of your printout. **(4 pts**)

f In the lower left quadrant of "page 2", draw a third neatly labeled box showing the principal stresses acting on the sides of the box. Draw positively directed principal stress arrows (**2 pts**). Label the principal stresses σ_1 and σ_2 (**2 pts**). Within the box include axes for the x',y' reference frame, with x' parallel to σ_1, and y' parallel to σ_2 (**2 pts**); these axes are to help you relate the Mohr diagram to your drawing. (**6 pts**)

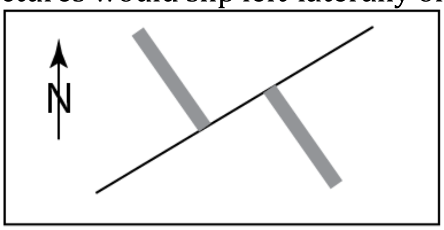
g In the lower right quadrant of "page 2", plot the predicted strike of the dikes in map view (**2 pts**), making sure to include a north arrow (**1 pt**). Explain near your drawing why you expect the dikes to have the predicted orientations (**2 pts**). (**5 pts**)

Part 2: Prediction of faulting **<u>along a pre-existing vertical fracture striking 59</u>**°. (**20 pts**)

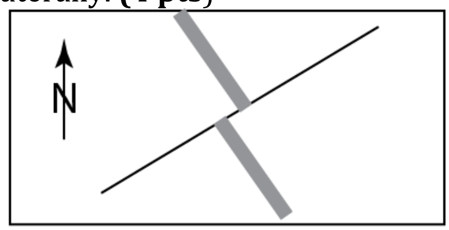
a) Using the stress values on the first page, determine the normal and shear tractions acting on planes parallel to the fracture. The method you use is up to you. Explain your work, and include a page with your calculations or your Matlab coding. (**10 pts total; 7 pts for your calculations and 5 pts for your explanation**)

b) Draw a neatly labeled picture in map view showing the <u>fracture</u> and the <u>normal and shear tractions</u> acting on the plane of the fracture. <u>Include north arrow</u>. (**1+2+1 = 4 pts**)

c) Assuming the fractures slip as strike-slip faults, explain why you predict that the fractures would slip left-laterally or right-laterally. **(4 pts**)



Left-lateral



Right-lateral

d) The laboratory friction data of Byerlee (1978) indicates the magnitude of the shear traction on a fracture $|\tau_s|$ would need to exceed 0.85 $|\tau_n|$ for the fracture to slip, where $|\tau_n|$ is the magnitude of the normal traction resolved along the plane of the fracture. If the compressive traction acting on a fracture yields a frictional resistance to slip that is too high for the shear traction to overcome, then the fracture walls cannot slip past one another, and the fracture is "locked". Based on your answers to (a) and (b), and assuming "Byerlee's Law" applies to the fracture here, explain why you think the fracture will or will not slip as a fault. **(2 pts**)