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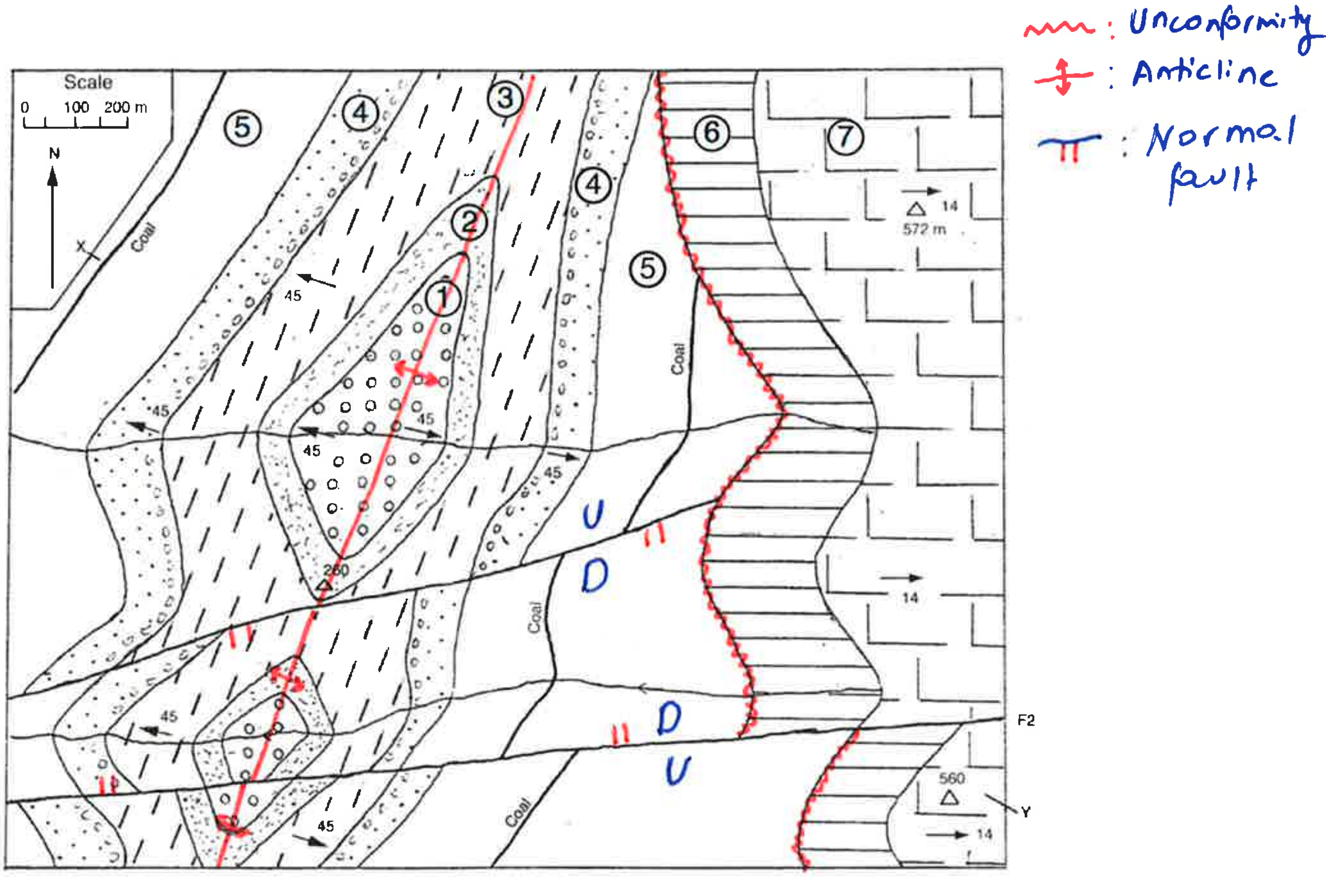
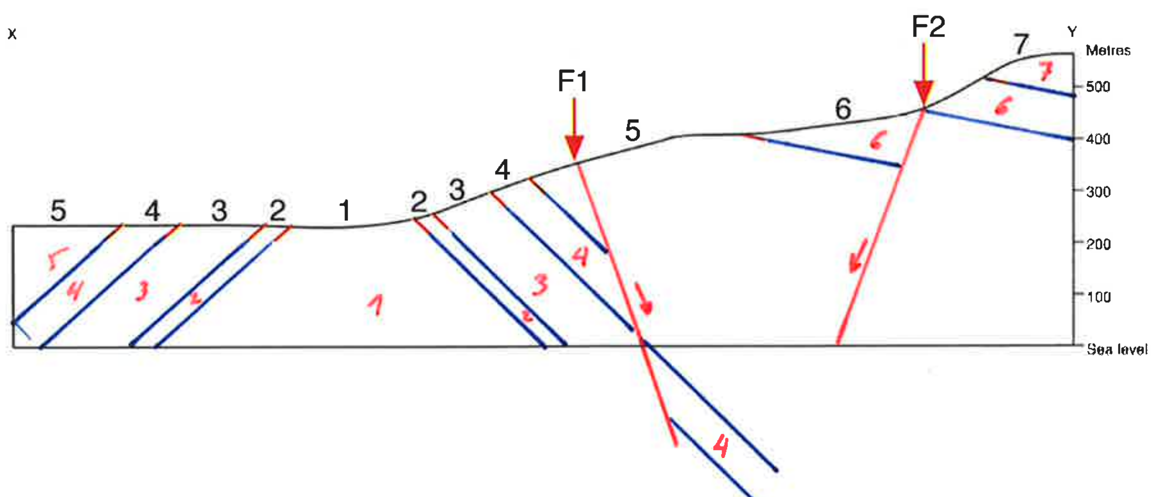
GEO210 Structural Geology
Final test. November 9, 2017

This test is closed book and closed notes. You have two hours to complete the test. Please be sure to show all your work. The total value of the test is 100 points. The point value of each question is shown.

Question 1 (40 points) The map below shows an area of seven (1 to 7) folded and faulted rock units. The arrows with numbers show the dip direction and dip of these units.





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a. There is an unconformity in the map. Clearly mark it with a color.

See map

b. Insert the fold axial surface trace in the map. What kind of fold is this? Label the fold axial surface trace accordingly.

Anticline. See map

c. There are two faults, F1 and F2. Both have a throw of 100 m, but what is their relative age? i.e. what is the age of the faults relative to each other, the fold, and the unconformity?

F2 ———— youngest
Unconformity
F1
Fold ———— oldest

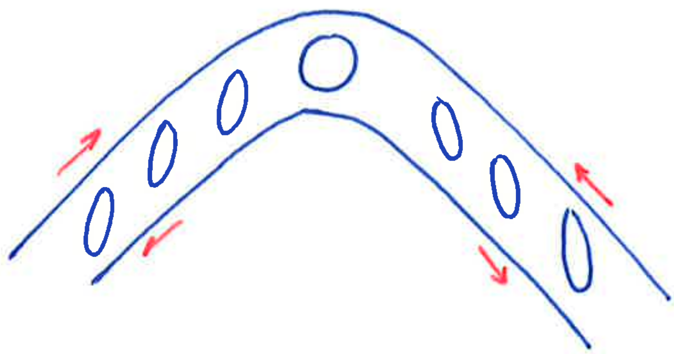
d. Mark in the map the upthrown (U) and downthrown (D) blocks of faults F1 and F2.

See map

d. Complete the section along the line X-Y. For convenience, the location of units contacts and faults, as well as the dip at the unit contacts are shown. Assume that both faults are **normal** and give them a dip in the section of **70°**.

See cross section

e. The fold in the map was formed by bedding-parallel slip (i.e. flexural slip). Draw below the profile geometry of two units (e.g. units 1 and 2) in the fold and show the sense of shear (with arrows) and strain ellipses.



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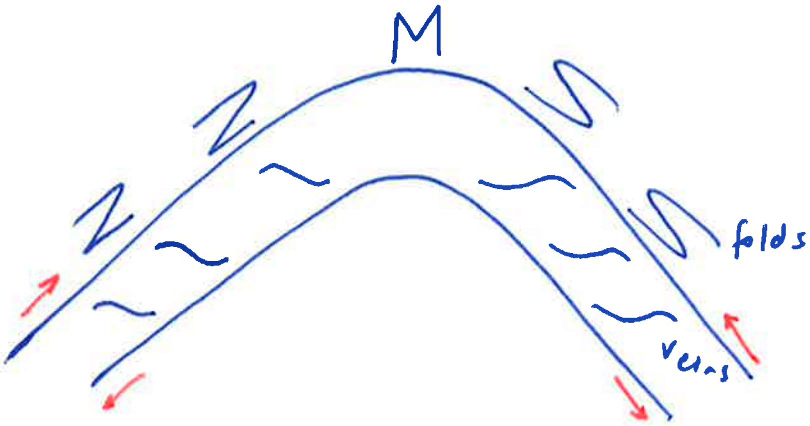
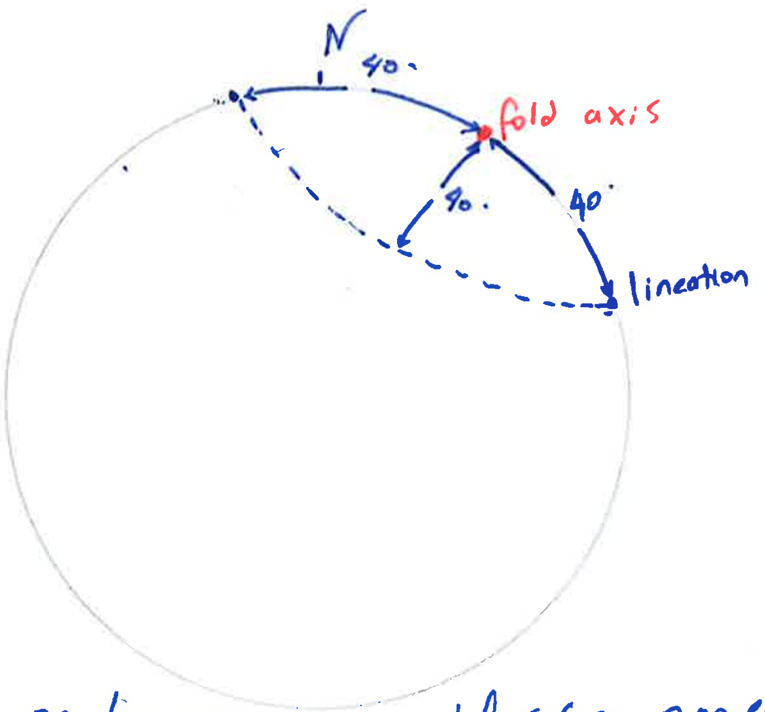
f. Draw the same profile of the fold below and show the distribution of sigmoidal veins, and minor folds S-M-and Z.



g. A lineation on the top of unit 1 makes and angle of 40° with respect to the fold axis. How would you expect this angle to vary across the fold? Show this schematically in a stereonet (assume the fold axis orientation is 030/0).



No strain on top of unit 1, therefore angle between fold axis and lineation is everywhere the same.

Lineaton follows a small circle with center at the fold axis.

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Question 2 (20 points): In the figure below the dashed lines are elevation contours of a fault, and the solid lines elevation contours of a marker surface. The fault dips to the north and length units are meters.

a. Does the marker surface on the map belong to the hanging wall or footwall?

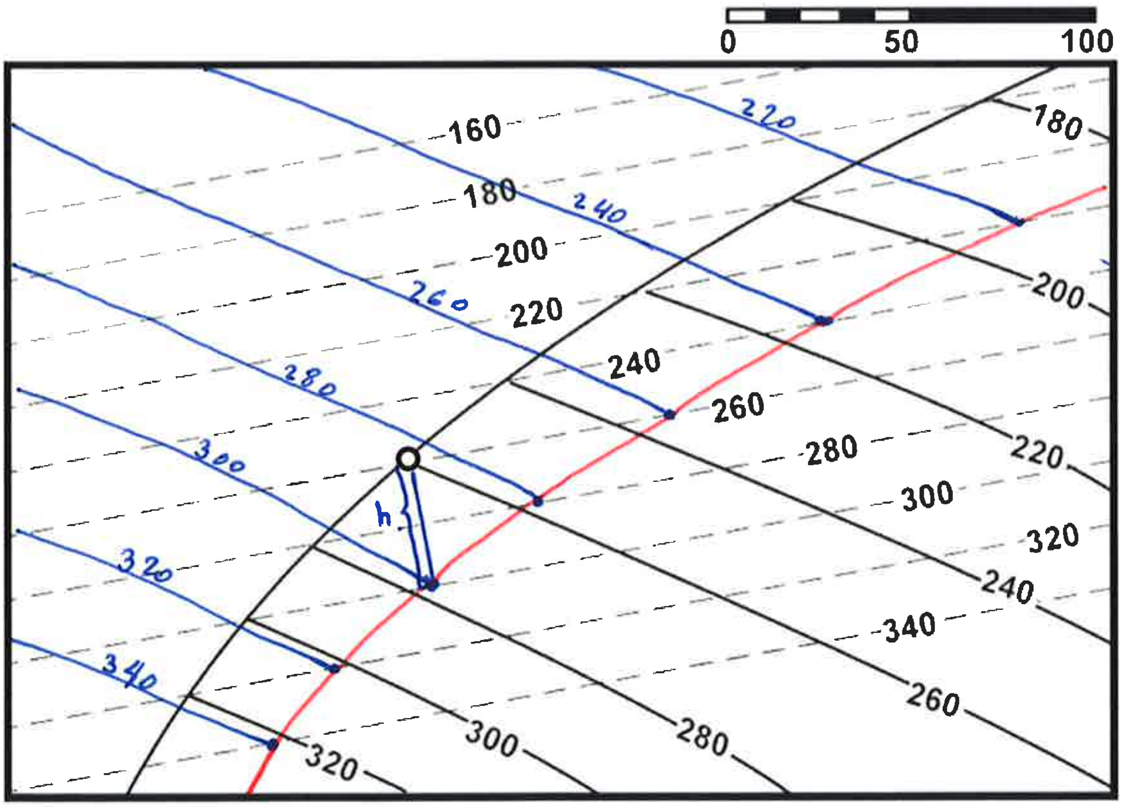
Footwall

b. The fault is a **reverse** fault. Construct the missing fault trace (fault cutoff) and missing marker horizon on the other block of the fault for a fault throw of 40 m.

See map

c. What is the heave of the fault for the point near the middle of the map (circle on fault trace)?

35 m



h : heave

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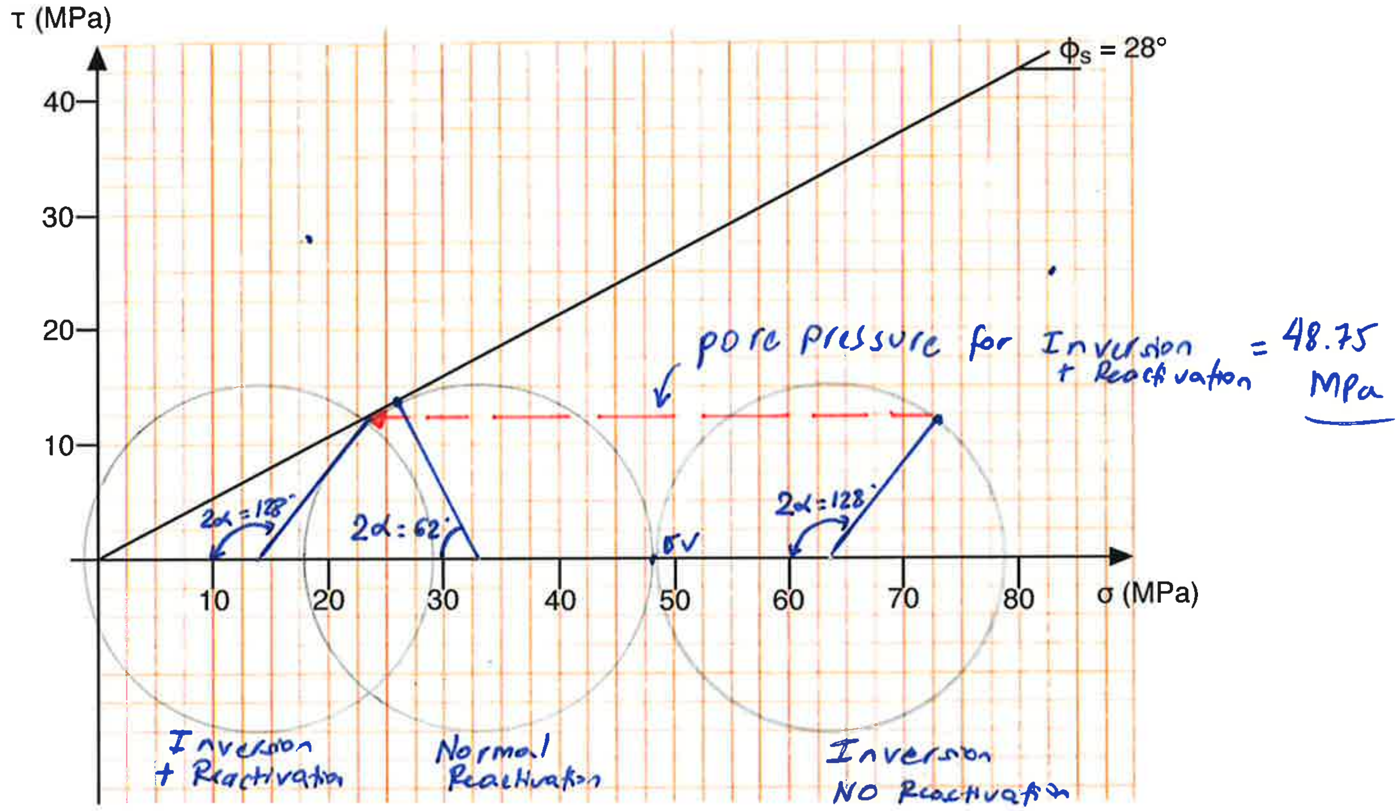
Question 3 (20 points): In a rift basin, faulting is described by the failure envelope below. The gradient of vertical stress is 24 MPa/km.



a. At a depth of 2 km, what is the differential stress ($\sigma_1 - \sigma_3$) for fault reactivation? Draw a Mohr circle for this case.

At 2 Km $\sigma_v = 48$ MPa

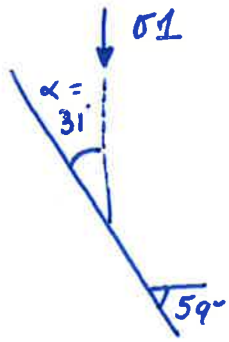
For normal faulting $\sigma_1 = \sigma_v$

$\sigma_3 \simeq 18$ MPa

$\sigma_d = \sigma_1 - \sigma_3 = 30$ MPa

b. What is the dip of the fault? You can use Anderson's theory of faulting to estimate the dip angle precisely.

Dip of fault $= 45 + \frac{\phi}{2} = 59°$



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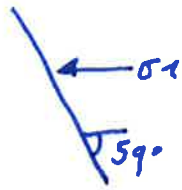
c. Now, suppose that in a latter phase of positive tectonic inversion, the differential stress is the same as the one computed in a. Would the fault in b be reactivated? Draw a Mohr circle for this case.

No, the fault in b will not be reactivated

$\sigma_3 = \sigma_v$

$\sigma_1 = 78$ MPa.



$\alpha = 59°$

d. What is the value of the fluid pore pressure necessary to produce reactivation and inversion of the fault in b? Draw a Mohr circle for this case.

48.75 MPa. See Mohr circle.

≈ 49 MPa

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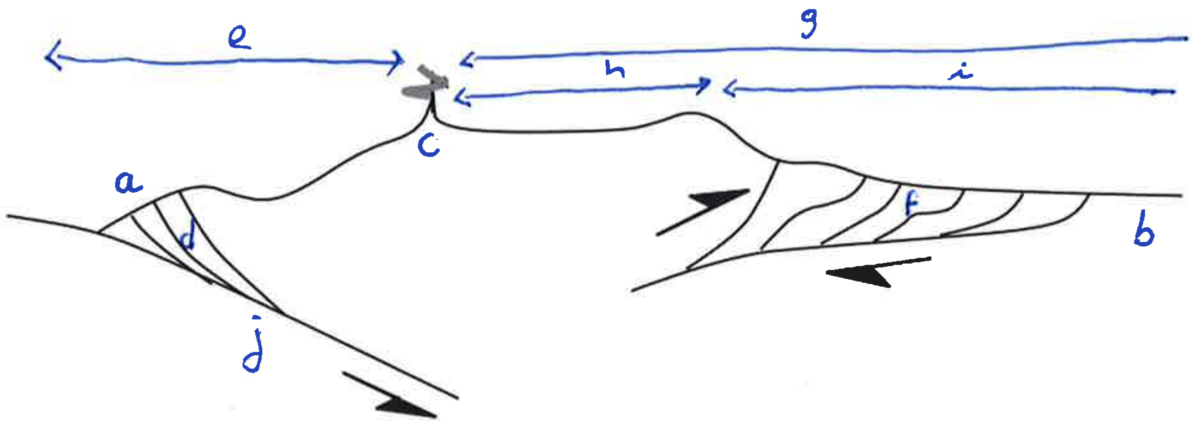
Question 4 (20 points): The Central Andes are the type example of a mountain belt formed at a plate boundary where oceanic crust is being subducted beneath continental crust. The figure below is a sketch cross section of this area.



Show in the cross section above the following elements:

a. Trench
b. Foreland basin
c. Arc
d. Accretionary wedge
e. Forearc
f. Foreland fold and thrust belt
g. Backarc
h. Hinterland
i. Foreland
j. Oceanic plate