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National Exams May 2017

04-Geol-A4, Structural Geology

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. This is an OPEN BOOK EXAM.
   Any non-communicating calculator is permitted.

3. All questions constitute the complete exam paper. (100 marks)
   There are choices in each main question (read instruction line)

4. Some questions require an answer in short answer or short essay format with figures as appropriate. Clarity and organization of the answer are important.

QUESTION A. 20 Marks

(1 mark per correct answer -0.5 marks for an incorrect answer blanks = 0)

Answer all of the following T (True) or F (False) in the answer booklet next to the number.

1. Axial surfaces of upright folds dip more steeply than bedding.

2. Folding of rock is generally associated with brittle loss of cohesion, while fracturing is related to ductile transformation.

3. If stress conditions of σ_s and σ_n lie outside of the Mohr Envelope, the rock mass will generally be stable, and not undergo brittle rupture.

4. High internal pore fluid pressure in rocks effectively shift the Mohr circle to the left of the Mohr diagram.

5. A Mode I fracture may form from either positive or negative normal stresses.

6. A perfect plastic material is one that will undergo permanent, recoverable deformation.

7. Compression and extension are not commonly associated with strike slip faults.

8. Slickensides are reliable shear sense indicators.

9. Bedding is steeper than cleavage in upright folds.

10. An intersection lineation between bedding and cleavage, provides the orientation of the fold axes.

11. Increasing the strain rate of deformation results in decreasing the strength of rocks.

12. The plane of flattening is the S_1–S_2 plane of the strain ellipse.

13. A Mode I crack formed in compression opens perpendicular to σ_1.

14. The yield point in a rock deformation experiment is the onset of inelastic deformation.

15. A mylonite is a brittle fault rock.

16. Thrust faults have steep dips.

17. Coaxial strain is a pure shear.

18. Stretching lineations always form parallel to the long axis of the strain ellipse.

19. The brittle-ductile transition is independent of rock type.

20. High-angle reverse faults can be formed by reactivating normal faults.

QUESTION B. (6 marks each for style and clarity: 30 marks)

Answer **ANY and ONLY 5** of the following questions in reasonable detail (1/3 of a page in the answer booklet)

In addition, use sketches where appropriate.

1. Describe and illustrate with a diagram what a thrust *duplex* and an *imbricate fan* are. In addition, describe the difference between the two.
2. Draw stress – strain curves to illustrate the effects of increasing temperature, confining pressure, pore fluid pressure and strain rate have on rocks. There should be 4 independent stress-strain curves; one for each variable.
3. List and describe four shear sense indicators that can be found in shear zones.
4. Describe the relationship between mylonitic foliation, stretching lineation and the plane of observation for shear sense indicators in ductile shear zones.
5. Describe the differences between Parallel Folding and Similar Folding. Indicate in which structural setting you would expect to find each type of fold.
6. Describe what is required to calculate the True Net Slip on brittle faults.
7. Explain with text and figures the mechanism of dislocation creep in rocks.
8. Describe the difference between coaxial and non-coaxial strain. List two examples of structures that have formed by coaxial strain and non-coaxial strain.
9. Draw and label a Mohr diagram with a failure envelope that depicts a stable state of stress. Explain the concept of 'effective stress" and using your Mohr diagram, illustrate how effective stress can promote failure in rocks.

QUESTION C. (6 marks each: 24 marks)

For **ANY and ONLY 4** of the following.

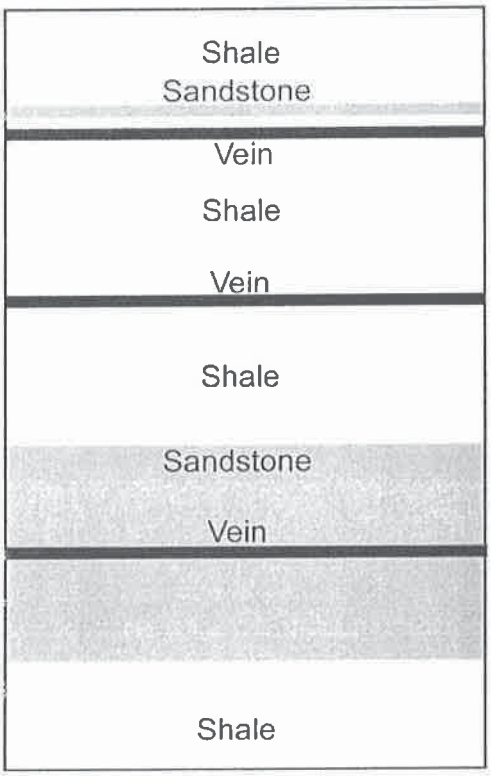
1. Below are several map views of strike-slip faults, with the sense of offset indicated by the arrows. Strike-slip faults can generate subsidiary structures, such as folds and faults. For each fault system below, sketch the requested structures that can form in association with this type of faulting.

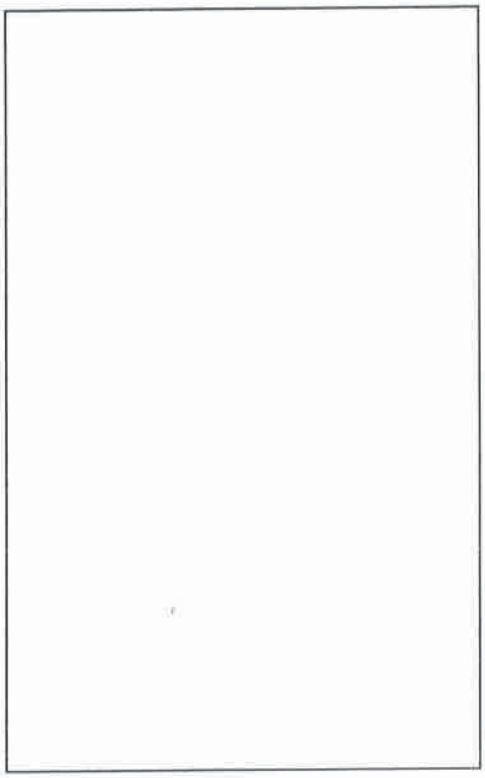
a) Sketch the orientation of Riedel Shears (R & R') and P Shears *(use arrows to show the sense of shear on each of these minor structures)*

b) Sketch the orientation of normal and reverse faults, and the orientation of the axial trace of folds (indicate clearly with labels or the correct symbols the type of faulting, draw on orientation of strain ellipse)

c) Restraining and releasing bends: For a dextral strike slip fault, sketch a restraining bend and a releasing bend, with the expected structures in the fault bends.

2. Sketch (in the box provided below) the shape of the folds likely to be produced by layer parallel shortening of the layers shown below. Note that the black layers are veins, grey are sandstone, and white is shale; also $\mu_{vein} \approx \mu_{sandstone} > \mu_{shale}$.; μ is rock viscosity. Explain your answers.



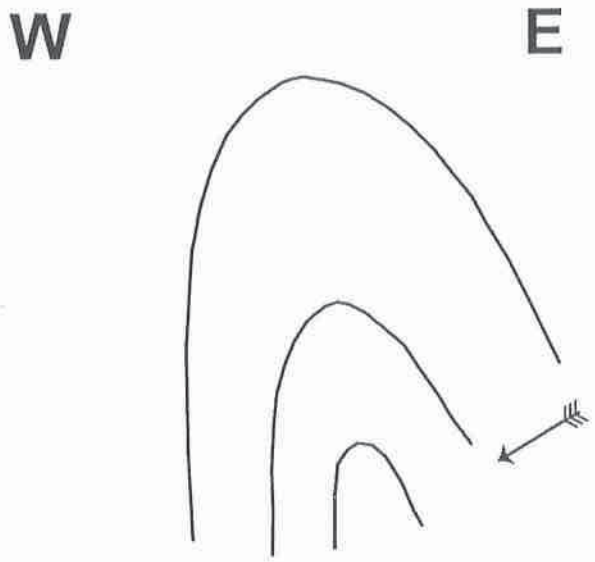


3. Describe (with examples) the difference between foliation and lineation rock fabric.

4. Thicker beds tend to produce _____ spaced joints than/as thinner beds. Fill in the blank with *wider/closer/similarly*. Explain your answer.

5A.
You observed a fold in the field and measure the orientation of the fold axis. The fold axis has an azimuth of 000° and plunge of 20°. You made the following sketch of the fold profile plane. Classify the fold using five different descriptors. Note that the younging direction is indicated with an arrow on the drawing below.

_____
_____
_____
_____
_____



5B. Which fold class (based on the dip isogon pattern and bed thickness variation) does this fold classify as? Why?

QUESTION D. (13 marks)

Place Answers here and in Answer Booklet as appropriate.

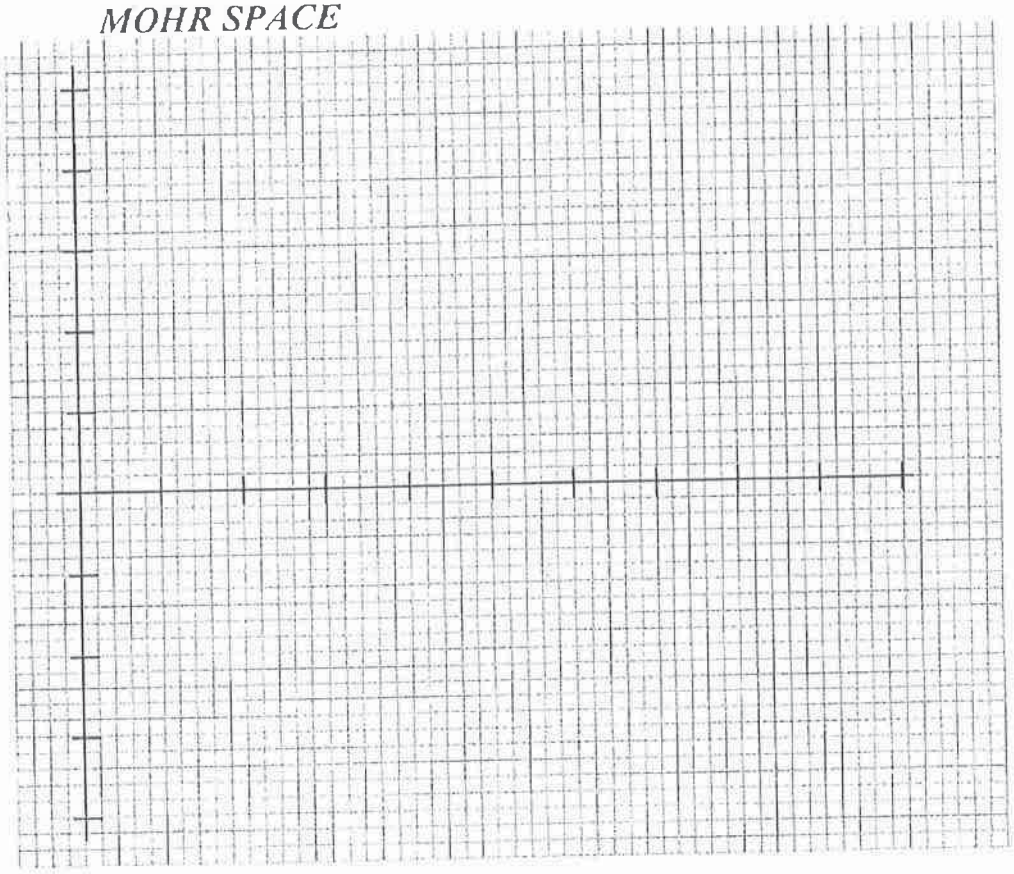
Regionally σ_1 is vertical and equal to 82 MPa and σ_3 is horizontal, east-west, and equal to 30 MPa.

A. Using a real (physical) space and Mohr space construction, determine the normal and shear stresses on a pre-existing fault within a homogeneous porous sandstone unit that strikes north south and dips 40°west.

B. If the Couloumb coefficient of friction of the sandstone is 0.5 and the cohesion is 10 MPa, will the rock fail? Show on diagram below.

C. If not, how much pore pressure (MPa) would be required in order for the sandstone to fail?

MOHR SPACE



QUESTION E. (13 marks)

Place Answers here or in the exam paper

On the following stereoplot, DRAW, IDENTIFY and SOLVE for:

a) Fold Axis: label and give approximate trend

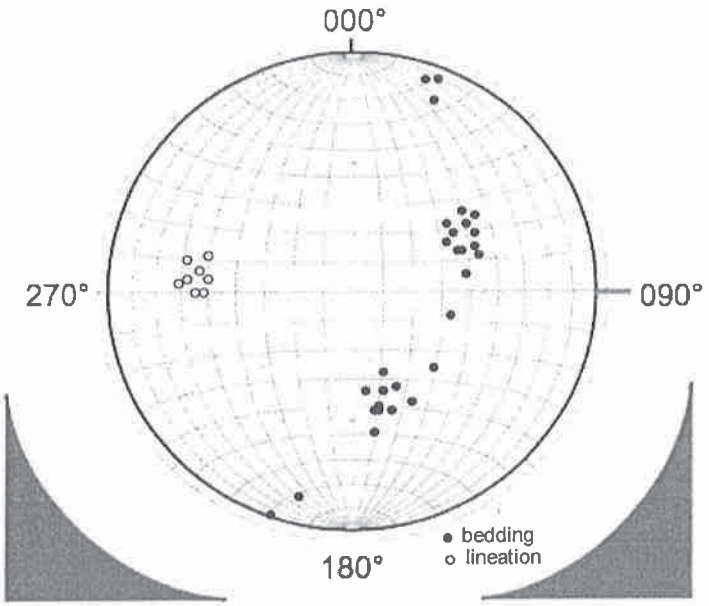
b) Profile plane: label and give approximate strike and dip (estimate)

c) Axial plane: label and give approximate strike

d) Apparent dip of the profile plane on a vertical cliff striking 100

e) Describe the fold completely (using three standard terms)

f) Draw a sketch of the fold in the profile plane


000°
270°
090°
180°
bedding
lineation