National Exams May 2016

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) <u>in the answer booklet</u> next to the number.

1. Coaxial strain does not involve shear.
2. Flexural slip lineations are normally parallel to the fold axis.
3. The dip of the axial surface is normally less than the plunge of a fold axis.
4. A Mohr circle represents the state of stress on an infinite number of planar orientations.
5. Elongation strain does not require the presence of tensile stress.
6. At great depth, apparent friction angle increase with increasing pressure.
7. Continental crust is normally thicker than oceanic crust.
8. Cleavage planes in a metamorphic rock are aligned normal to the direction of shortening.
9. Normal and reverse faults dip approximately parallel to the syntectonic σ_2
10. Volcanic island arcs are associated with transverse shear faulting.
11. Blocky veins indicate gradual and trans-tensional strain.
12. In active folding regions gold prospecting focusses on the fold limbs for ore potential.
13. The apparent thickness of layered strata can never be less than the true (normal) thickness.
14. In upright folds the younging direction is always up.
15. Softer rock units within a sequence will have fewer joints than stiff rock units.
16. A viscous material continues to deform over time without an increase in stress.
17. Bedding thickness does not need to be preserved in a balanced section.
18. In a single outcrop, continuous joints are older than offset, discontinuous joints.
19. Dislocation creep is a viscous mechanism of volume reduction.
20. A higher fracture frequency results in an increased RQD.

QUESTION B (3 marks each + 1 for style and clarity = 24 marks)

For **ANY and ONLY 8** of the following, in two or three sentences PLUS a sketch

Describe and distinguish clearly between:

1. Normal va Reverse Fault
2. Allocthon and Autocthon
3. Cohesion and Friction
4. Fault Breccia and Cataclasite
5. Fault-Bend Fold vs Fold-Thrust Belt
6. Fold Plane and Hinge Line
7. Horst and Graben
8. Joint and Cleavage Plane
9. Parallel Folding and Similar Folding
10. RQD and RMR
11. Simple Shear and Pure Shear
12. True Dip and Apparent Dip

Answer in the answer booklet

QUESTION C (4 marks each + 1 for style and clarity 30 marks)

Answer **ANY and ONLY 6** of the following questions in reasonable detail (1/3 to 2/3 of a page in the answer booklet)

In addition, use Sketches where appropriate.

1. Describe two large scaled structural features and one small scale/microscopic feature resulting from each of: extensional, compressional, and strike slip shear terrain.
2. Describe and illustrate with a diagram at least four types of brittle structures associated with simple active folding of competent strata
3. Describe four different primary structures which can be used for determining the younging direction. Explain with a figure how this is determined in each case.
4. Describe four types of structural traps key to the formation of hydrocarbon reserves.
5. Describe four typical components of a rockmass classification scheme for engineering geology. How does each element impact on excavation support requirements.
6. Describe four failure modes in slopes or tunnels associated with joint sets or intersecting joints. How would you mitigate each mode?
7. Describe how confining pressure (depth), temperature, strain rate, and the presence of fluids affects the strength and ductility of geomaterials.
8. Explain with text and figures the formation of undulose extinction, subgrain boundaries and mechanical twinning.
9. Using a Mohr diagram and a complete Mohr-Coulomb strength envelope, illustrate the mechanics of cyclical fault pumping due to fluid pressure. Describe the nature of the resultant vein infilling.

QUESTION D (13 marks)

Place Answers here and in Answer Booklet as appropriate.

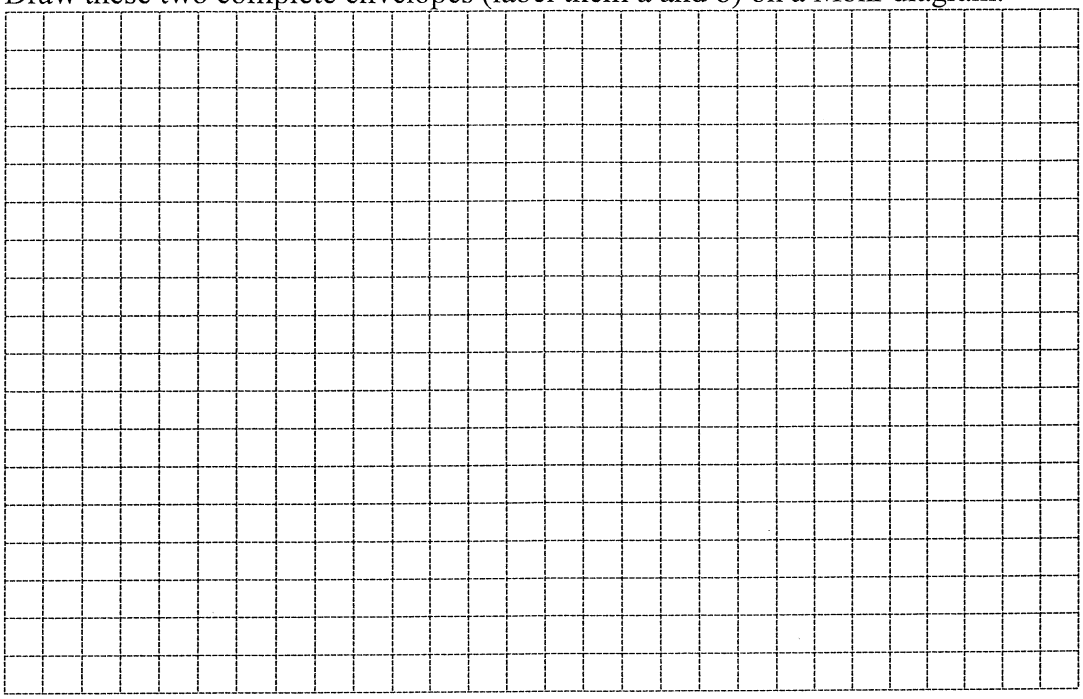
A typical granite (S.G. = 2.7) has a Mohr-Coulomb strength envelope corresponding to

a) $\tau_{max} = 40MPa + \sigma_n \tan 45°$, Tensile strength is tested to be 10 Mpa

Rough pre-existing joint surfaces dipping 45 degrees to the north in this limestone have been tested in direct shear to have the following strength:

b) $\tau_{max} = 5MPa + \sigma_n \tan 30°$

1) Draw these two complete envelopes (label them a and b) on a Mohr diagram.



The stresses at depth are anisotropic isotropic (k=2). Consider a point in the centre of a horizontal tunnel roof. Due to stress concentration, the maximum stress (σ_1) parallel to the roof and oriented perpendicular to the tunnelling direction is known to be (3k-1) times the initial rock vertical stress (existing before the tunnel is built).

2) For a tunnel situated at 350m depth, draw the Mohr circle for the in situ (initial) stress state (label c), for a vertical plane striking perpendicular to the tunnel (label d)

3) What is the depth at which <u>new</u> fractures will form near the wall of a horizontal circular tunnel in this rock?

4) At what depth would the existing fractures be remobilized in the centre of the roof.

Show work here or in your workbook.

QUESTION E (13 marks)

Place Answers here or in the exam paper

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

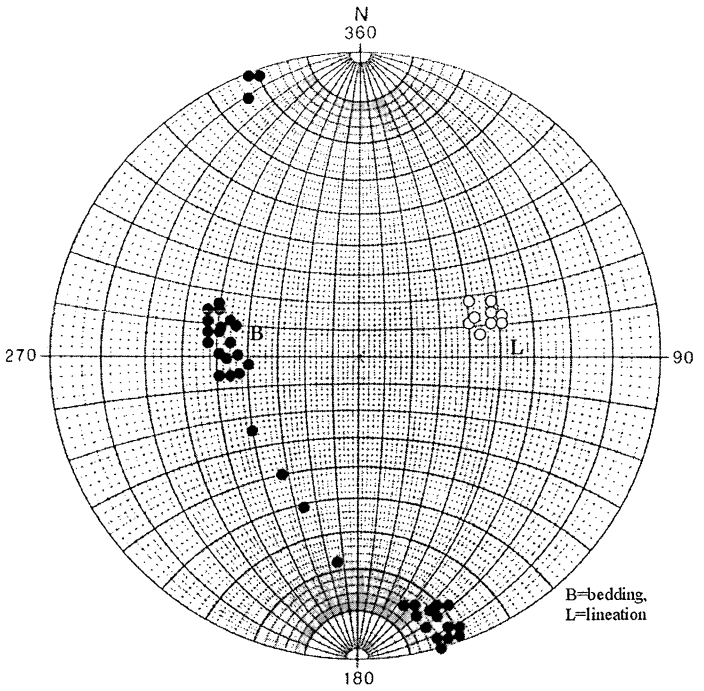
a) Fold Axis: label and give approximate trend

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 200

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

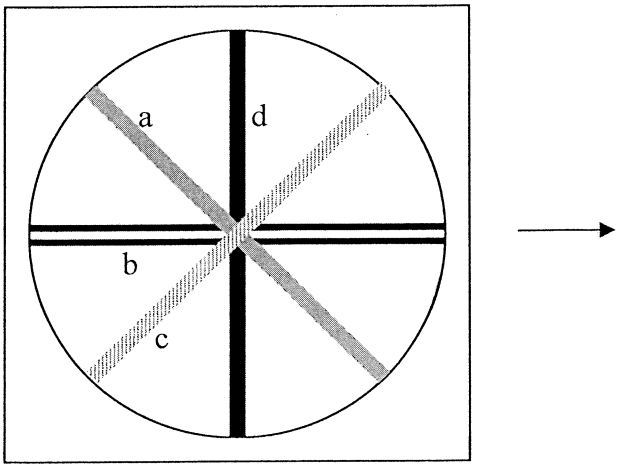


f) Sketch the following reference object (square, circle, lines) AFTER deformation.

g) Label all lines and illustrate the most likely deformed states
Folding, Boudinage, Stretching, etc

The deformation can be described as: Plane strain (in the plane of the page)
Simple shear of 45 degrees (dextral) about the horizontal.
Assume: Lines a, b and c represent dykes that are more competent than the ductile Host and that Line d represents a material that is identical to the host.

h) After deformation label the axis of minimum finite stretch (Label accordingly)



BEFORE AFTER