National Exams May 2013

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. FOUR questions constitute a complete exam paper.
   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 15 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.

Answer 15 of these 20 questions (leave others blank) - First 15 answers will be marked.

1. Coaxial refolding can be the result of a single deformational event.
2. A higher fracture frequency results in a decreased RQD.
3. A Mohr circle represents the state of stress on one unique plane.
4. Normal and reverse faults strike approximately parallel to the syntectonic σ_2.
5. Transpressional deformation is associated with hydrothermal ore emplacement.
6. Vertical slopes cut parallel to inclined jointing are more stable than perpendicular.
7. In an ideal plastic material the strength is independent of the magnitude of strain.
8. In a single outcrop, continuous joints are older than offset, discontinuous joints.
9. In active folding regions gold prospecting focusses on the fold limbs for ore potential.
10. Solution cleavage is one mechanism of volume increase.
11. Friction angle decreases with increasing temperature and pressure.
12. Grabens can be associated with strike-slip systems.
13. Significant shortening results in negative "stretch".
14. Fold thrust belts are associated with very high grade metamorphism.
15. Distributed conjugate shear fracture sets represent large localized strain.
16. Blocky veins indicate very gradual and trans-tensional strain.
17. Deviatoric or differential pressure always increases as depth below surface increases.
18. Elongation strain does not require the presence of tensile stress.
19. All structural features in a rock reflect the current state of stress.
20. Continental crust is normally thinner than oceanic crust.

QUESTION B (2 marks each + 0.5 for style and clarity = **25 marks**)

For **ANY and ONLY 10** of the following, in two or three sentences (you may use clear sketches or stereonets where appropriate) describe and distinguish clearly between:

1) Porphyroblast and Porphyroclast
2) True Dip and Apparent Dip
3) Parallel Folding and Similar Folding
4) Elastic Stiffness and Ductility
5) Cohesion and Friction
6) Fault-Bend Fold vs Fold-Thrust Belt
7) Simple Shear and Pure Shear
8) Strike slip and Strike separation
9) Listric and Imbricate faulting
10) Fold Plane and Hinge Line
11) Horst and Graben
12) RQD and RMR
13) Equal Angle and Equal Area Stereonet Projection
14) Cleavage and Stretch Lineation

QUESTION C (4 marks each + 1 for style and clarity **25 marks**)

Answer **ANY and ONLY 5** of the following questions in reasonable detail (1/3 to 2/3 of a page) In addition, use Sketches where appropriate.

1) Describe and illustrate with a diagram at least 4 types of brittle structures associated with simple active folding of competent strata
2) 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.
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) Explain with text and figures the formation of cleavage, undulose extinction, subgrain boundaries and mechanical twinning.
5) Describe how confining pressure (depth), temperature, strain rate, and the presence of fluids affects the strength and ductility of geomaterials.
6) What are four typical elements of a rockmass classification scheme? How does each element impact on rock strength or excavation support requirements?
7) Describe two typical interference patterns for polyphase folding. Illustrate the relationship between the two component folds in each case.
8) Describe two large scaled structural features and one small scale or microscopic feature of extensional, compressional, and strike slip shear terrain.

QUESTION D (15 marks)

ONE and ONLY ONE of the following (D-I or D-II)
Place Answers in Answer Booklet

D-I

A typical marble (S.G. = 2.5) has a Mohr-Coulomb strength envelope corresponding to

$\tau_{max} = 30MPa + \sigma_n \tan 40°$, Tensile strength is tested to be 5 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:

$\tau_{max} = 5MPa + \sigma_n \tan 25°$

1) Draw these two complete envelopes on a Mohr diagram. Fully label the diagram.

The stresses at depth are isotropic (k=1). 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 double (2 x) the initial rock pressure (existing before the tunnel is built). The stress perpendicular to the wall is zero for a dry tunnel (σ_3). The intermediate stress in the roof is directed parallel to the tunnel direction and is equal to the initial pressure.

2) For a tunnel situated at 400m depth, draw the Mohr circle for: a) the in situ (initial) stress state, b) for the stresses in the roof in a vertical plane striking parallel to the direction of tunneling, and c) in a vertical plane striking perpendicular to the direction of tunneling.

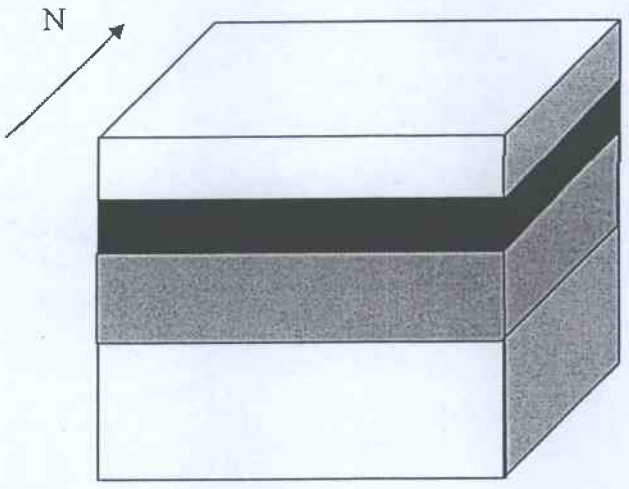
3) A tunnel liner is designed to seal off the rock and allow the water pressure to build up behind the liner. How much water pressure is required to create tension fractures in the rock (show on your Mohr plot for Question 2).

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

5) At what depth would the existing fractures be remobilized in the centre of the roof?

D-II

Starting with the following initial stratigraphy:



DRAW A BLOCK DIAGRAM for:
(separate drawing for each question)

1) Recumbent moderately-plunging box fold

2) Tight Dome and Basin (TYPE 1) double folding

3) Tight upright slightly plunging chevron folding with fold axis to the north followed by steep normal faulting with minor dextral offset.

4) Type 3 (F2) Coaxial refolded isoclinal (F1) fold.
Both axes have trend E-W with plunge=0.
Foliation planes S1=S2 dipping 45 degrees to the south.