National Exams December 2018

**18-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 a CLOSED BOOK EXAM.
3. Approved Casio or Sharp calculator, a protractor, drawing compass and ruler are permitted.
4. All questions constitute the complete exam paper. (100 marks)
5. 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 – True or False & Fill in the Blanks (30 Marks)

**Answer the following T (True) or F (False) next to the number.**

***[1 mark per correct answer; -0.5 marks for an incorrect answer; blanks = 0]***

1. Rocks that have undergone purely strike slip faulting can show evidence of dip separation.
2. *Axial planar cleavage* forms during the heterogeneous strain stage of fold development.
3. The *fold hinge* marks a point on the folder layer where the curvature changes from convex to concave or vice versa.
4. In theory, buckling involving *flexural flow folding* produces Class 2 folds.
5. *Stress traction* refers to stress on a plane.
6. The *Deformation Path* must represent the shortest distance from initial to final position of a material point in a deforming volume.
7. *Mode 3 fractures* are produced by a shear stress acting parallel to the plane of the crack and parallel to the crack front.
8. *Rigid body deformation* involves translation and distortion.
9. For *ideally elastic* material strain is linearly related to stress.
10. *Griffith's law of failure* refers to transtensional tensile behavior during deformation.
11. Solid state diffusion involving *Coble creep* occurs along grain boundaries.
12. *Hooke's Law* describes the ratio of lateral strain to longitudinal strain.
13. *Elastic deformation* involves some component of non-recoverable deformation.
14. Lines that represent the *principal strain axes* were perpendicular before the strain.
15. For *coaxial strain*, the instantaneous shortening axes are inclined at 45° to the shear plane.
16. The *stress tensor* is a vector quantity that considers magnitude of force in relation to the area of the surface it acts upon.
17. An *edge dislocation* is oriented parallel to the Burgers vector.
18. *Hydrostatic stress* is characterized by the absence of shear stress in all directions.
19. Principal strain axes for *pure shear* are always irrotational.
20. *Deviatoric stress* is the non-hydrostatic component of stress that tends to produce distortion.

**Fill in the blanks** ***[Each blank is worth 1 mark]***

1. Name two types of line defects _____ and _____.
2. _____ is the study of the response of rocks to stress.
3. _____ is the term for the line that connects points of maximum curvature on a folded surface.
4. _____ is a fault melt that freezes to glass.
5. _____ are offsets or steps in the land surface that coincide with locations of faults.
6. _____ is the apparent relative displacement related to a fault.
7. When rocks fail in tension by a combination of Mode 1 and Mode 2 fracturing, this is called _____.
8. Name two types of point defects: _____ and _____.

## QUESTION B – Definitions *(Each question is worth 4 marks, for a total of **20 marks**)*

Explain the fundamental difference between the terms in each of the following groups. A well-labeled sketch may help. It is important to demonstrate the meaning of the terms in the answer:

1. *Pure shear* versus *Simple shear* */4*

2. *Anticline* versus *Antiform* */4*

3. *Stress traction* versus *Stress tensor* */4*

4. *Incremental strain ellipse* versus *Finite strain ellipse* /4

5. P*lastic* versus *Viscous* deformation /4

## QUESTION C. – Quantitative Analyses (25 marks)

1. For questions **a**, **b**, **c**, **d** & **e** you have been given the following information:
   Vertical max. principal stress ($\sigma 1$) = 100 MPa;
   Horizontal min. principal stress ($\sigma 3$) = 30 MPa;
   $\phi_f = 40°$;
   Pre-existing plane of weakness dips 30°

   **(a)** Using an accurate line drawing, show the real-world configuration of the pre-existing plane of weakness and the orientation of the principal stresses. Also indicate in your drawing the sense of shear that would develop along this plane if it failed. Would it be right lateral or left lateral? /5

**1.** Continued - Using the Fundamental Stress Equations, calculate (provide answer to 1 decimal place):

**(b)** The normal stress. */2*

**(c)** The shear stress. */2*

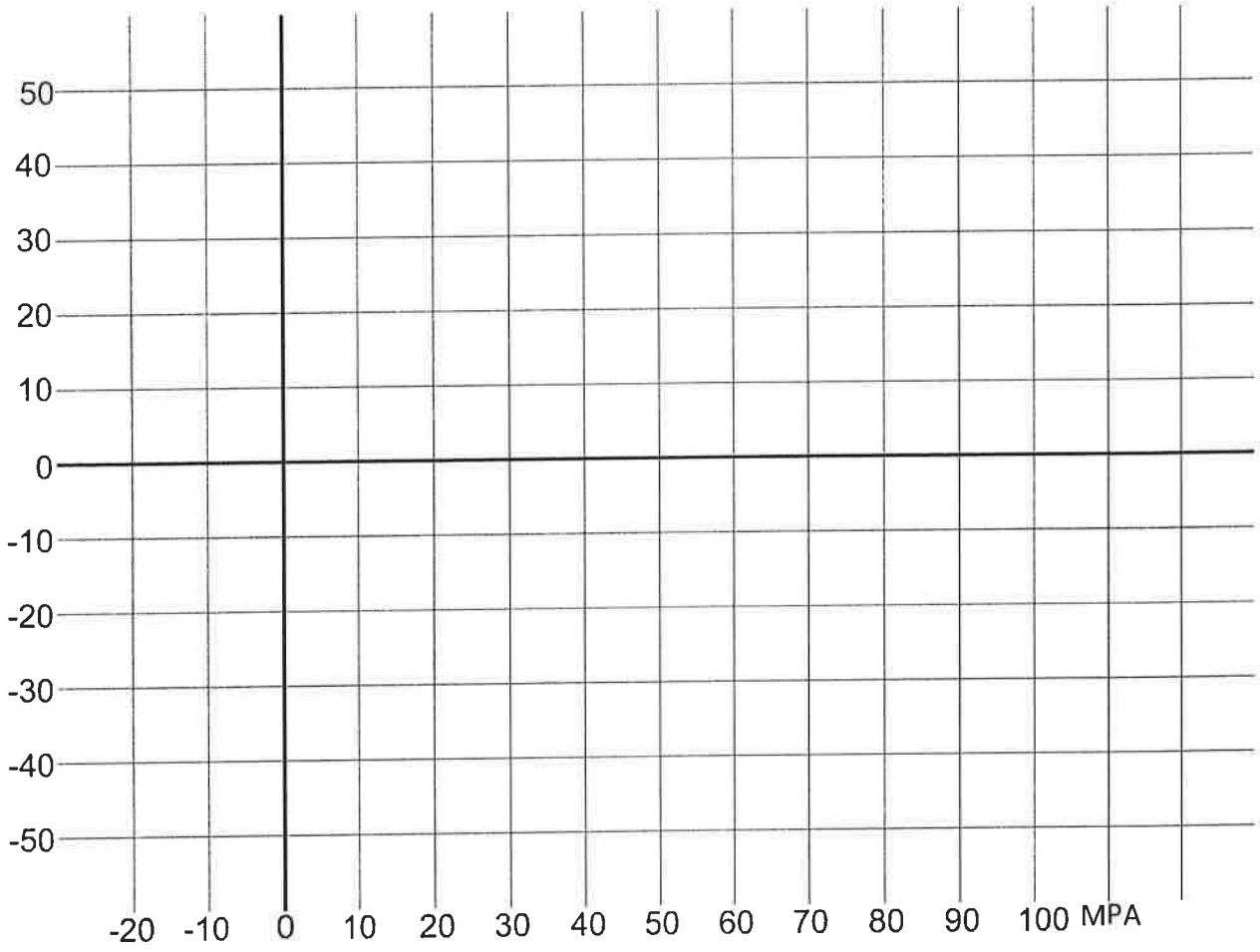
**(d)** i. For the pre-existing plane of weakness, calculate what the shear stress at failure must be. */2*

ii. Assuming dry conditions, will the plane fail according to your calculations above? Why? */2*

iii. If not, how much pore fluid pressure (Pp) would be required to cause failure? */2*

**1. Continued:**

**(e)** Now check your answers for (b), (c) and (d) by plotting the data in a fully labelled Mohr circle diagram using the template below. */10*



## QUESTION D. – Folds, Faults, & Kinematic Analyses (25 marks)

**(1)** For the fold shown below, please provide the following information: /7

**(a)** Label the Hinge Point

**(b)** Label the inflexion points

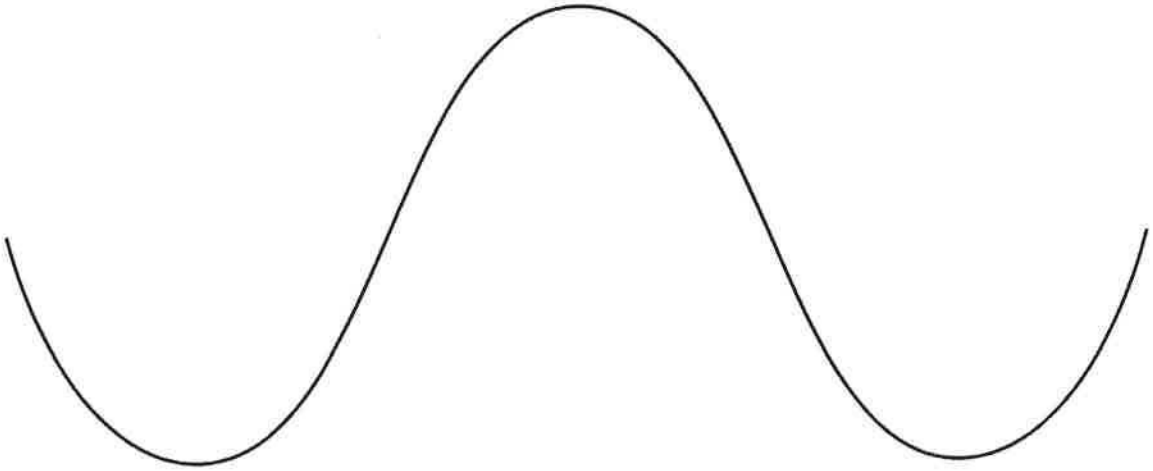
**(c)** Show and label the Median Line

**(d)** Determine the Amplitude (cm)

**(e)** Determine the Wavelength (cm)

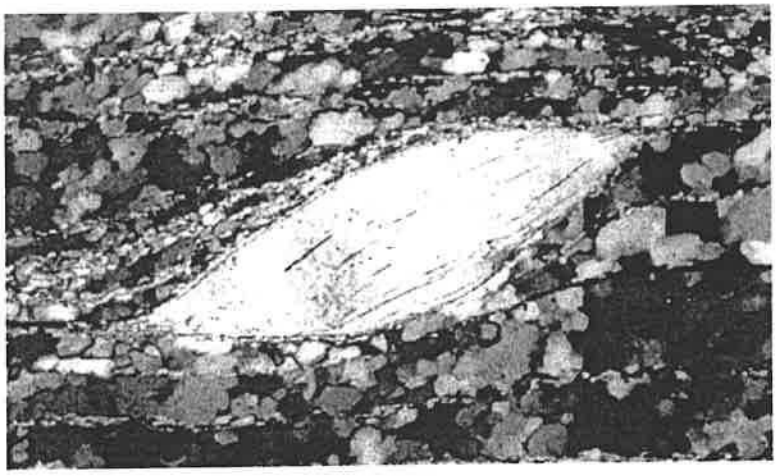
**(f)** Determine the Interlimb Angle

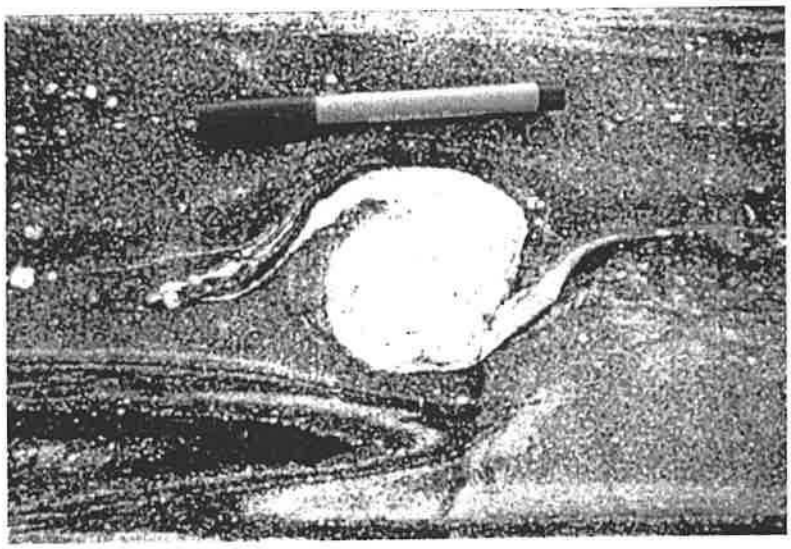
**(g)** Classify the fold tightness

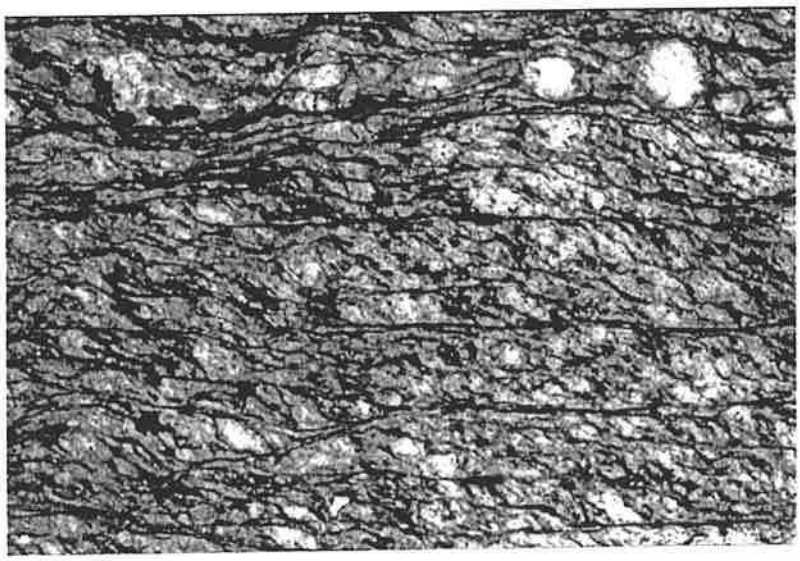


**(2)** Ductile faulting is recognized to be very common in the middle and deep crust.
Draw a ductile fault zone with an offset marker (e.g., a dike). /2
In the drawing, show a possible fabric trajectory across the zone with associated strain ellipses if the shearing is most intense in the centre and weakens outward toward the margins of the shear zone. /4

(3) For each of the photographs shown below, identify the sense of shear and name the type of shear sense indicator that support your interpretation. /6





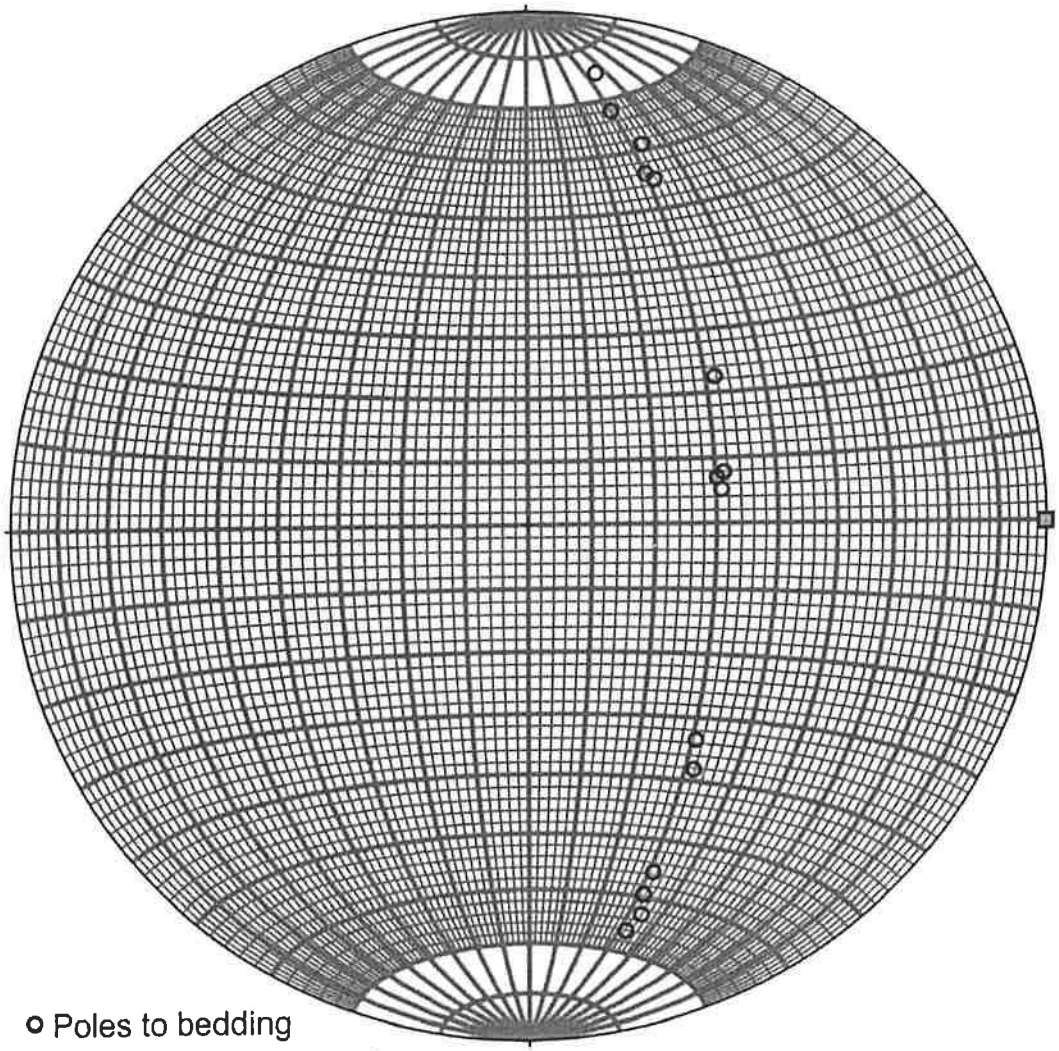


**(4)** Please answer the following questions using the data plotted from a cylindrical fold on a lower hemisphere equal-area net below.

(a) What is the orientation of the Pi circle? */2*

(b) What is the orientation of the Pi axis? */2*

(c) What is the orientation of the axial plane? */2*



o Poles to bedding

□ Axial trace measurement