National Exams May 2019

**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. One of two calculators is permitted - any Casio or Sharp approved model. 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. Layer thickness is the primary factor that dictates *fold wavelength.*
2. *Strain* results from rigid-body deformation either through translation and/or rotation.
3. *Byerlee's law* demonstrates a non-linear correlation between confining pressure and rock strength.
4. Purely *dip slip faulting* can show evidence of strike separation.
5. *Mode 2 fractures* are produced by a shear stress acting parallel to the plane of the crack and parallel to the crack front.
6. *Nonrigid deformation* involves dilation and/or distortion.
7. *Axial planar cleavage* forms during the homogeneous strain stage of fold development.
8. For *ideal viscous* material strain rate is linearly related to stress.
9. In theory, buckling involving *flexural slip folding* produces Class 1b folds.
10. *von Mises criterion* refers to transtensional tensile behavior during deformation.
11. *Hydrostatic stress* is characterized by the absence of shear stress in all directions.
12. Solid state diffusion involving *Nabarro-Herring creep* occurs along grain boundaries.
13. *Poisson's ratio* describes the ratio of lateral strain to longitudinal strain.
14. *Stress tensor* is a vector quantity that considers the magnitude of a force per unit area.
15. Lines that represent the *principal strain axes* were perpendicular before the strain.
16. For *non-coaxial strain*, the principal strain axes have no net shear strain.
17. The *stress tensor* is a vector quantity that considers magnitude of force in relation to the area of the surface it acts upon.
18. A *screw dislocation* is oriented parallel to the Burgers vector.
19. Principal strain axes for *simple shear* have zero net shear strain.
20. *Differential 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 microcracks: _____ and _____.
2. _____ involves the combination of grain boundary sliding and grain boundary diffusion.
3. _____ represents the intersection between the axial surface and any other surface.
4. _____ connect points of equal inclination on the outer and inner bounding surfaces of a folded layer.
5. Curved limb segments of opposing convexity join at locations known as _____.
6. _____ is the actual 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 line 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. *Coaxial Strain* versus *Non-coaxial Strain* /4

2. *Fold Axis* versus *Fold Hinge Line* /4

3. *Fault Scarp* versus *Fault Line Scarp* /4

4. *Reclined Fold* versus *Recumbent Fold* /4

5. *Homogeneous Strain* versus *Inhomogeneous Strain* /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 ($\sigma 1$) = 120 MPa;
   Horizontal min. principal stress ($\sigma 3$) = 40 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, normal stress and shear stress acting upon this plane. 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

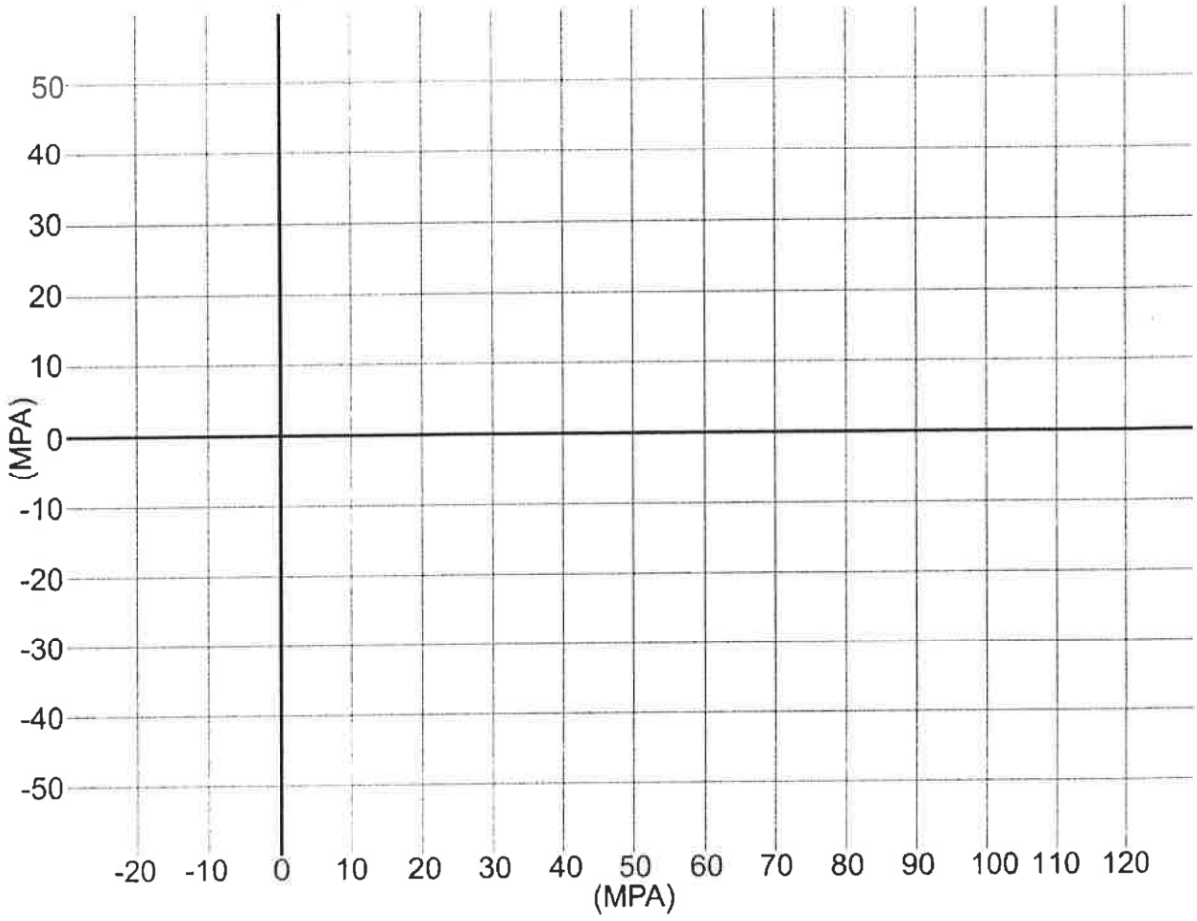
**(d)** i. For the pre-existing plane of weakness, calculate what the shear stress at failure must be. /2

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 (dii & diii) by plotting the data in a <u>fully</u> labelled Mohr circle diagram using the template below. ***/10***

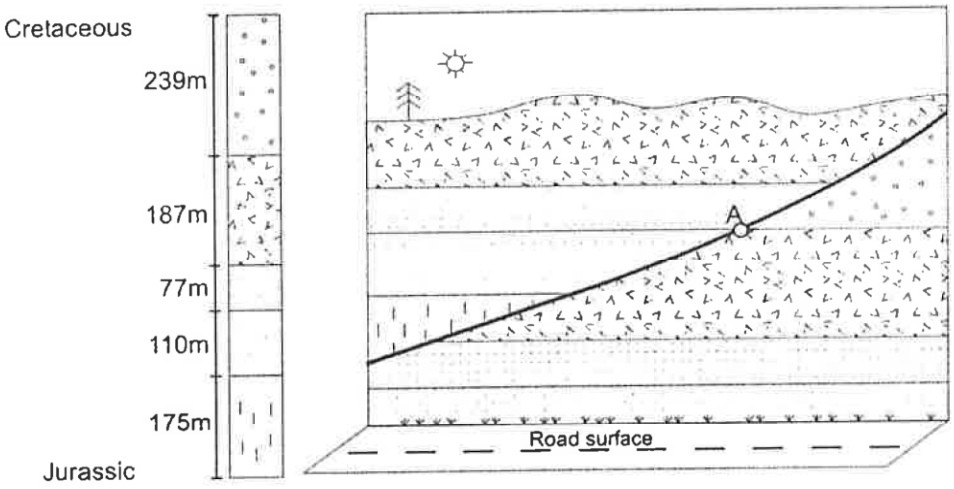


## QUESTION D. – Faults, Folds, Deformation Mechanisms & Kinematic Analyses (25 marks)

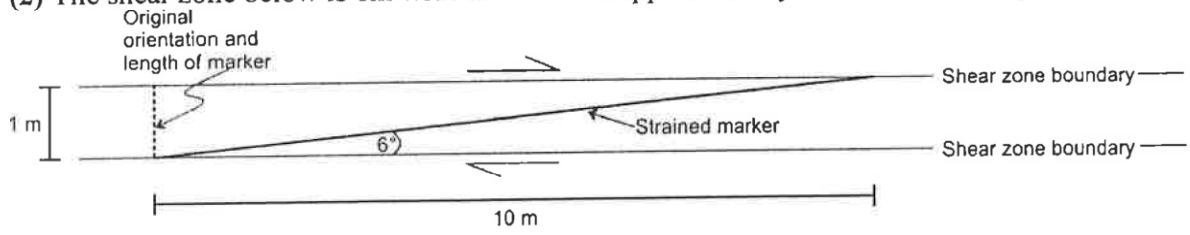
(1) Referring to the sketch below:

(a) Fully name the fault that cuts the vertical road cut shown below. /2

(b) What is the approximate stratigraphic throw in metres at point A? /2



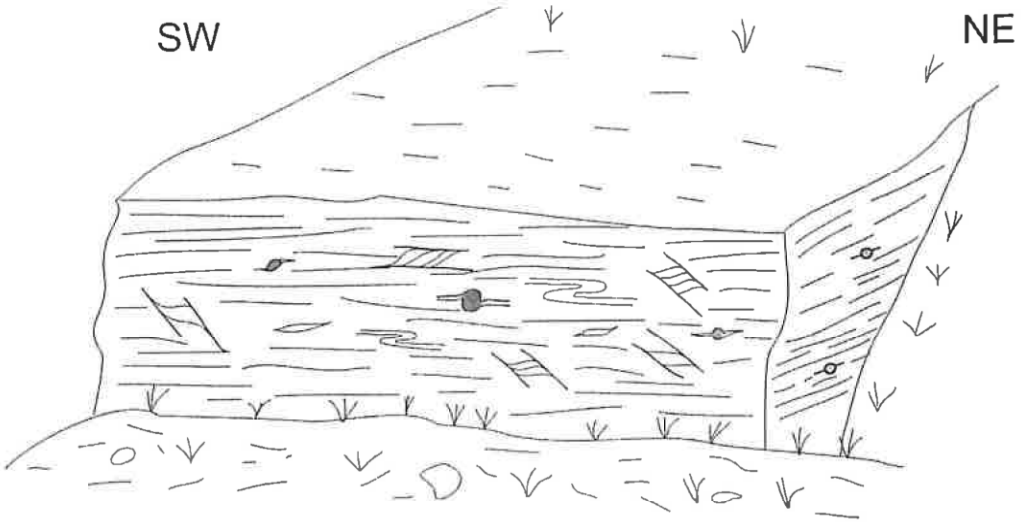

(2) The shear zone below is 1m wide and has had approximately 10m of dextral slip




a) What is the angular shear ($\psi$) and shear strain ($\gamma$) on the shear zone? {assume an initially perpendicular marker across the shear zone has had one end displaced 10m relative to the other} /4

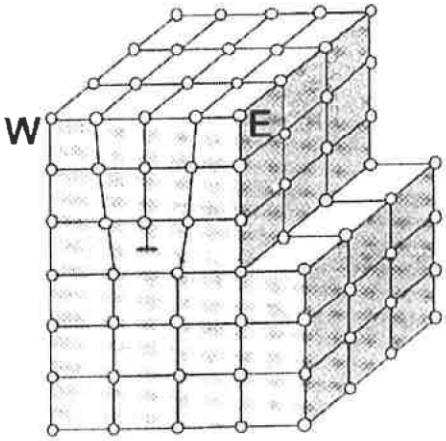
b) What is the elongation (e) of the offset marker (provide answer to 1 decimal place)? /2

**(3)** For the line drawing below, identify the sense of shear. Circle and name three different types of shear sense indicators that support your interpretation. */4*

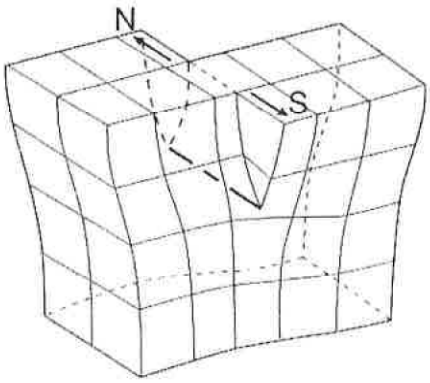



**(4)** Using the sketches provided:

(a) Please name the type of dislocation, identify the glide plane, and determine the Burgers vector (make sure you include the direction of the Burgers vector). */3*




(b) Please name the type of dislocation and determine the Burgers vector. */2*

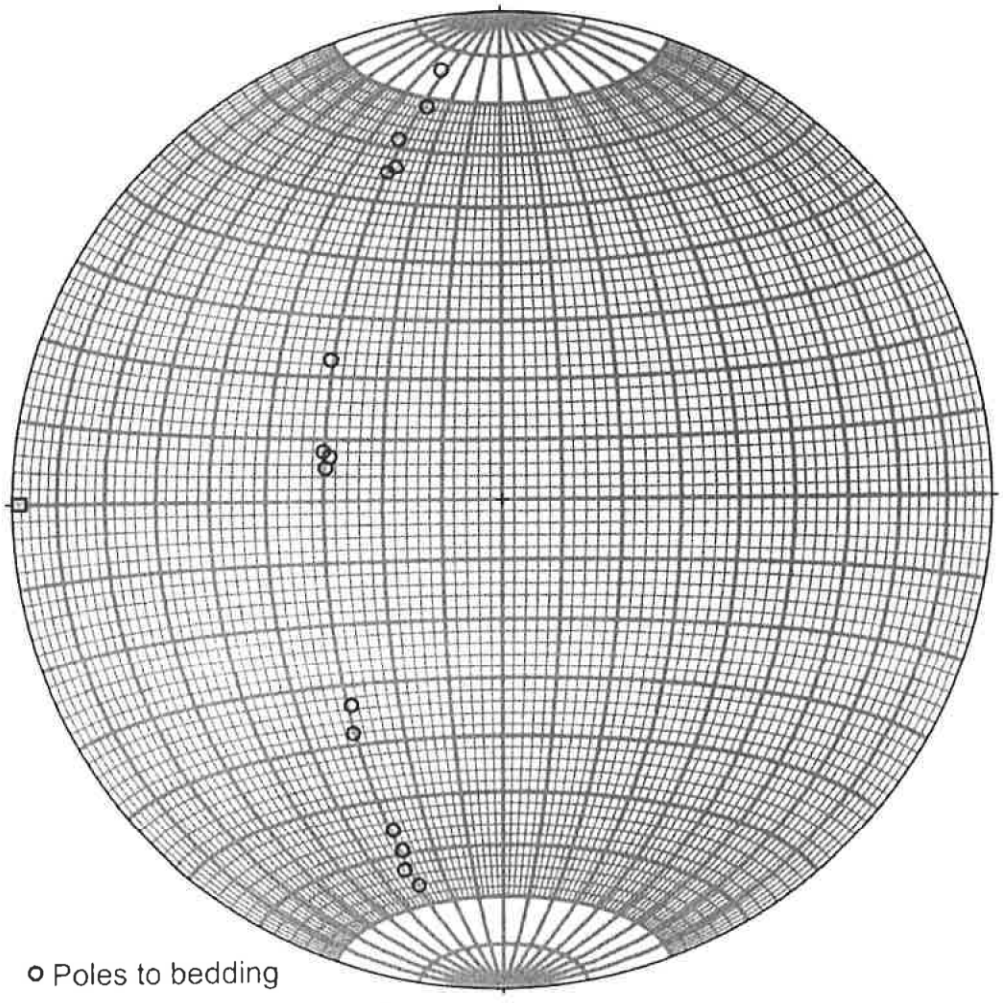


(5) Please answer the following questions using the data plotted from a cylindrical fold on a lower hemisphere equal-area net below.

(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