UNIVERSITY of SOUTH AUSTRALIA
School of Natural and Built Environments, Mawson Lakes
ENGINEERING and ENVIRONMENTAL GEOLOGY (EART 3012)

Field practical *Wednesday*
Week 6 *29 August 2011*

Palmer, Reedy Creek and Mannum

INTRODUCTION

This field trip takes us across the Adelaide Hills via the town of Birdwood. Just as the western side of the hills is bounded close to the Mawson Lakes Campus by the Para Fault, so on the eastern side they are bounded by the Palmer Fault, close to the village of Palmer (Fig. 1). The lookout over this fault scarp is our first locality, and we will see the fault itself at our second locality. On the down-faulted block, in the vicinity of Reedy Creek, we will then study some relationships between a felsic intrusive igneous body and some intruded metasedimentary rocks. Our final study locality is a granite quarry on the eastern side of the River Murray, where we will observe some more igneous relationships and tectonic structures.

On completion of this practical, you should be able to:

- observe and comprehend rock relationships in a field setting;
- understand rock weathering processes and their characteristic outcomes;
- infer the controlling influence of fault activity on landscape evolution;
- recognise evidence for partial melting and be able to interpret such evidence with reference to the formation of magma;
- explain the relationship between the cooling history of a magma and the crystalline textures of igneous rocks.

GEOLOGICAL SETTING

On this excursion, we will have an opportunity to inspect the rocks that make up the Mount Lofty Ranges and Murray Basin, and see a variety of evidence relating to their history of formation. There are a number of rock groups that are found these regions, as shown in Fig. 1.

Palaeoproterozoic Barossa Complex

The oldest rocks of the Mt Lofty ranges are gneisses and schists of the Barossa Complex. These rocks occur as a number of inliers in the cores of large anticlines (fold structures), and form the basement (bedrock) on which the younger Adelaidean sedimentary rocks were deposited.

The main rock types present in the Barossa Complex are granitic gneiss, pegmatite, mica schist and quartzite. All of these rocks have been metamorphosed and deformed, and this has masked their original character. Despite a number of investigations, the original nature, metamorphism, structure and age of these rocks has not been clearly defined.

It is postulated that sedimentary rocks that are now part of the Barossa Complex were deposited at least 1600 million years ago and were later intruded by granite batholiths. Metamorphism and deformation at high temperature converted these rocks into schist and gneiss at ~1590 Ma.

Neoproterozoic Adelaide Geosyncline

Rocks of the Adelaide Geosyncline extend from Kangaroo Island, through the Mount Lofty Ranges, to the Flinders Ranges. They unconformably overlie Palaeoproterozoic schists and gneisses of the Barossa Complex. The Adelaide Geosyncline comprises a thick sequence of sandstones, siltstones, mudstones and carbonates that were deposited in fluvial to shallow marine conditions. These rocks have subsequently been folded and metamorphosed to form slate, schist, quartzite and marble.

The Adelaidean sediments were deposited from 800–600 Ma and were deformed and metamorphosed during the Cambrian–Ordovician Delamerian Orogeny (514–490 Ma).

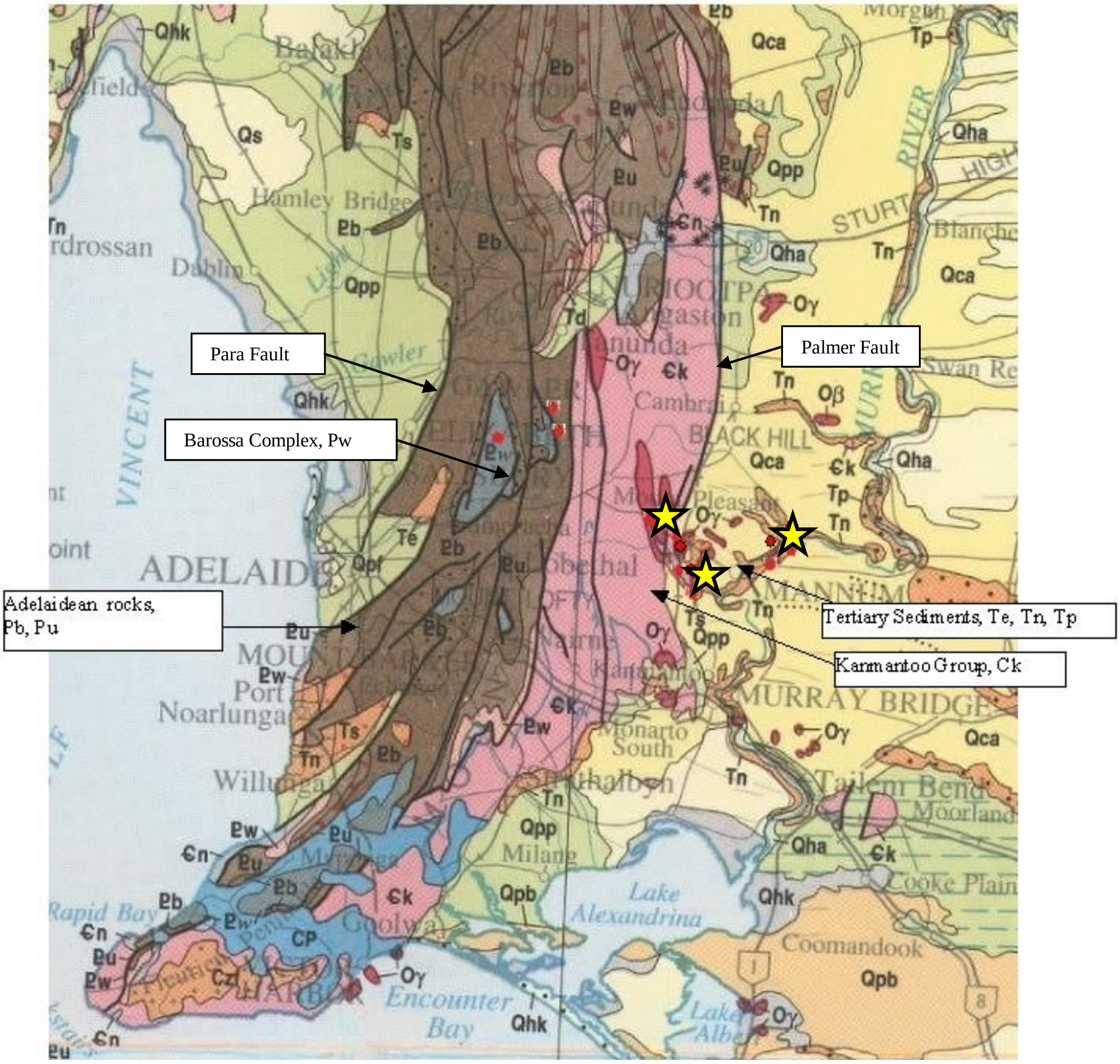


Figure 1. Geological map of the Mt Lofty Ranges and Murray Basin (after Cowley & Freeman, 1993). Major rock types described above are indicated. Stop locations are also shown as yellow stars.

Cambrian Kanmantoo Group

The Kanmantoo Group consists of a thick sequence of sandstones and mudstones that were deposited in shallow to deep marine conditions during the Cambrian. These rocks were folded and metamorphosed during the Delamerian Orogeny, resulting in schists, gneisses and migmatites.

Cambrian Granitic Rocks

Granitic rocks intruded the Kanmantoo group during the Delamerian Orogeny. The granites occur mainly on the eastern margin of the Mount Lofty Ranges and intrude in the regions of highest grade metamorphism (Fig. 2).

Tertiary Sediments

Flat-lying Tertiary sediments occur in the St Vincent Basin (to the west of the Mt Lofty Ranges) and the Murray Basin (to the east of the Mt Lofty Ranges). These basins contain shallow marine sediments that are predominantly limestones and calcareous sandstones. These basins formed as a result of the separation of Australia from Antarctica and the uplift of the Mount Lofty Ranges by faulting. River gravels and lacustrine (lake) deposits were also formed at this time.

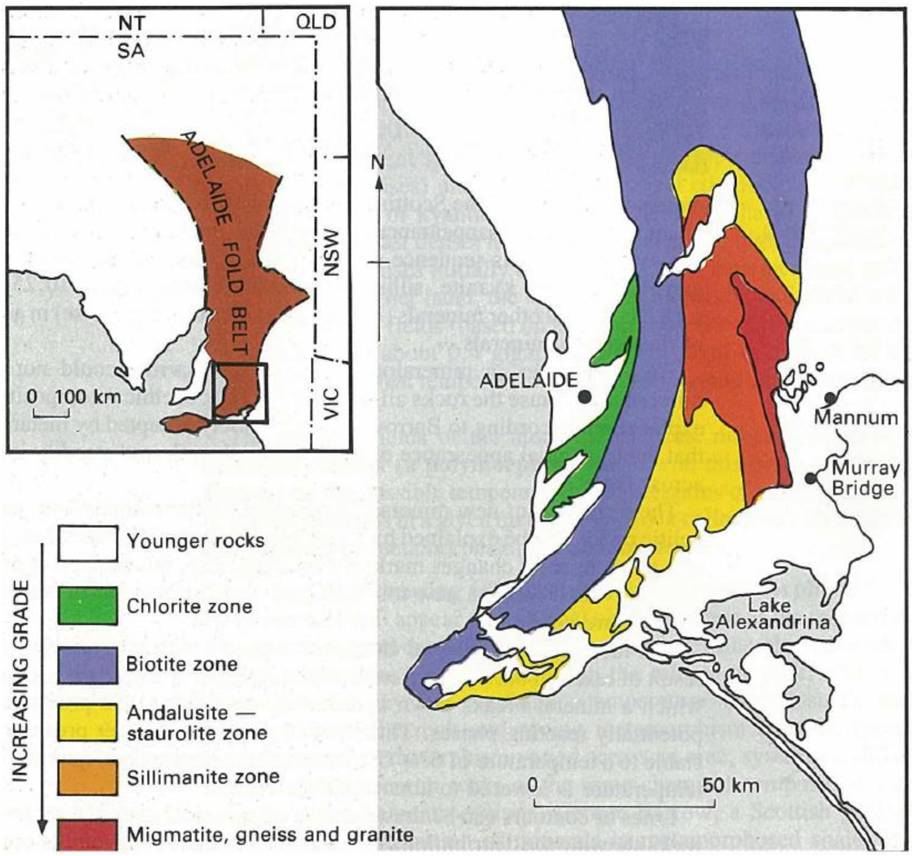


Figure 2. Metamorphic isograds of the Mt Lofty Ranges (after Clark & Cook, 1983). Note the distribution of metamorphic index minerals around the intrusive granitic bodies shown as red colours in Fig. 1.

STOP 1: LOOKOUT OVER PALMER

- Rocks outcropping as slab-like masses between Birdwood and Palmer are mostly foliated metamorphic rocks formed from sedimentary protoliths of the Adelaide Geosyncline during the Delamerian Orogeny at ~500 Ma.

- Rocks outcropping as rounded boulders (tors) towards the east are mostly granite. Granitic magma intruded as large masses (plutons or batholiths) in the core of the fold belt (mountain range) that formed during the Delamerian Orogeny.

- It has been estimated from laboratory studies that the igneous and metamorphic rocks outcropping at this locality formed at depths of 10–15 km. Thus, at least that thickness of rock has been eroded to expose these rocks at the surface in the present day. Erosion has stripped away much of the regolith, exposing core stones as tors in outcrop (Fig. 3). The relationship of core stones to regolith can be observed in road cuttings towards Palmer.

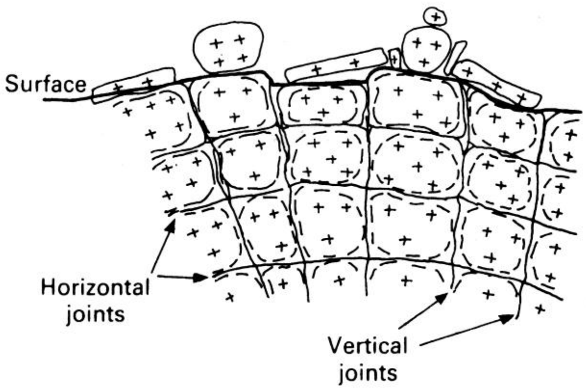


Figure 3. Diagram illustrating the relationship between joint patterns and tor formation (after Gilluly et al., 1959).

- The eastern extent of the Delamerian Orogen is not well-established due to younger overlying rocks in the Murray Basin and other factors, but it might have been broadly comparable in size to the present-day Andes, along the western margin of South America.

- This type of geological setting is summarised in the diagram below (Fig. 4).

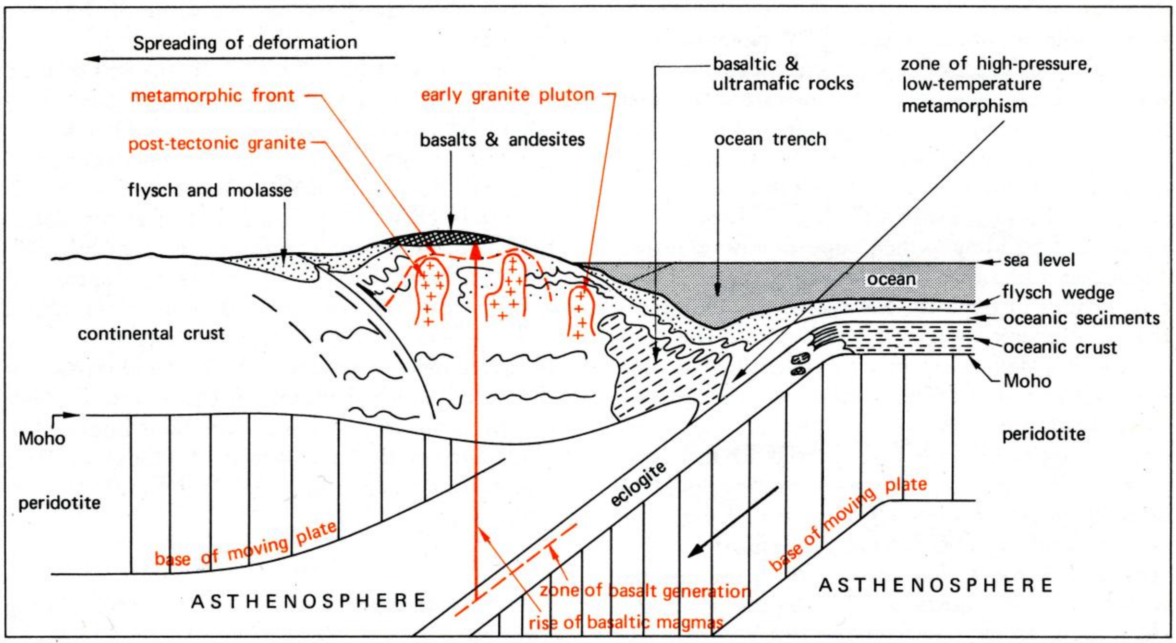


Figure 4. Characteristic geological features of a convergent plate margin (subduction zone). Note in particular the relationships between igneous and metamorphic rock types and deformational structures in the overriding continental plate. Key features are highlighted in red (after Sutton, 1971).

STOP 2: PALMER FAULT

- Palmer sits at the eastern margin of the Palmer Fault Block. The Palmer Fault itself can be seen at this stop, where the bedrock is crushed to a rock containing angular fragments that weather to clays. This rock is known as a fault breccia – it is evidence of brittle deformation during fault movement.

- The down-faulted block was flooded by rising sea levels during the Miocene (mid-Tertiary) at ~25 Ma, and a shallow inland sea covered the Murray Basin to the east (Fig. 5). Accumulated shelly remains of marine animals formed limestone which is rich in calcium carbonate ($CaCO_3$).

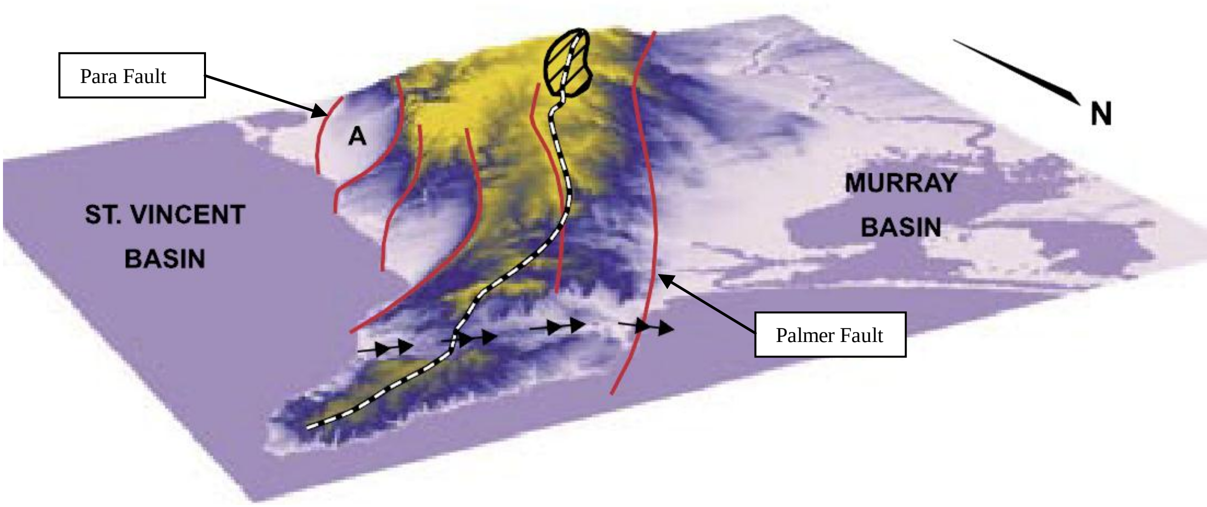


Figure 5. Major fault structures of the Mt Lofty Ranges (including the Palmer Fault), which are responsible for the uplift of a broad orogenic zone between the St. Vincent Basin to the west and the Murray Basin to the east (after Tokarev & Gostin, 2005).

STOP 3: ROAD CUTTING AT REEDY CREEK

- The exposure at the Reedy Creek road cutting reveals an igneous body that has an intrusive relationship with foliated regional metamorphic rocks.

- The diagram on page 8 shows a series of composite photos of the exposed rocks at this location. The lines indicated by the letters A–A to E–E signify markers along the cutting; e.g. D–D at the right of the third composite photo overlaps with D–D at the left of the fourth.

- On this diagram, clearly indicate the locations of the features to which you refer in your responses to the questions below. ***Five marks*** are allocated for correct and appropriate labels.

- Record your responses to the questions below ***on your own note paper*** (see Assessment Details on page 11).

- Where appropriate, use photographs and/or sketches to illustrate your answers.

- Use relevant technical terms that we have discussed in the lectures and practicals.

From your observations of the rocks in this cutting:

(a) Is the igneous rock a dyke or a sill? *Explain* your answer. **(1 mark)**

(b) What is the mineral composition of the igneous rock? **(3 marks)**

(c) *Provide names* that distinguish between two different textural varieties of the igneous rock and *describe* the differences between them. You should discuss things such as the different minerals present and their relative abundances, along with any differences in grain size and shape that you observed. **(2 marks)**

(d) *Describe, illustrate* and *account for the origin* of the most coarsely grained igneous rock. You should consider the spatial relationship between fine and coarse grained segments of this rock, and how such significant differences in grain size can occur on the small scale. **(3 marks)**

(e) What is the black mineral that occurs in the foliated metamorphic rock? **(1 mark)**

(f) There is some evidence of 'frozen' anatexis (partial melting) in the metamorphic rock. *Describe, illustrate* and *explain* an example of this evidence. Remember to discuss any mineralogical or compositional controls on this process. **(3 marks)**

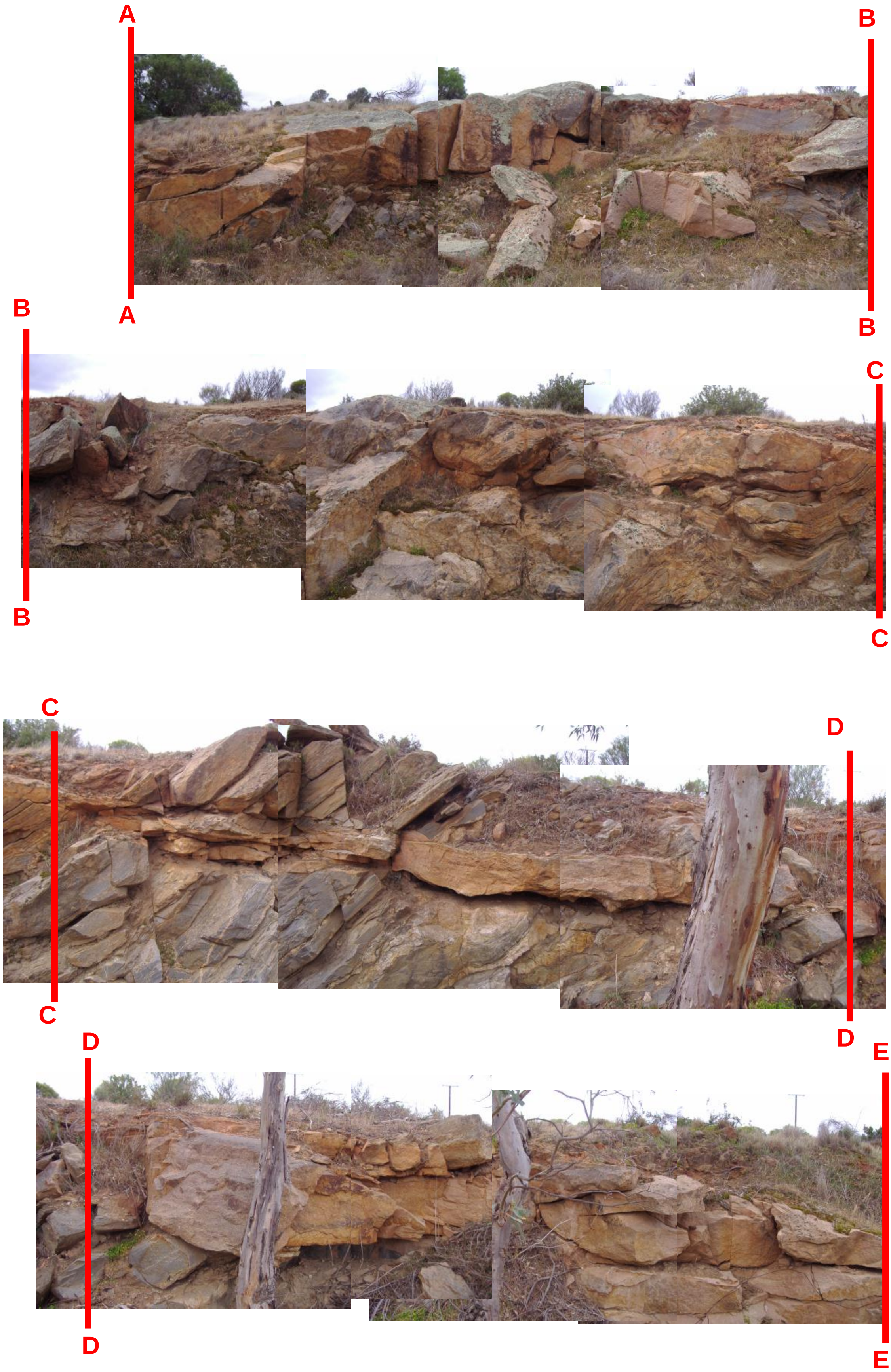
(g) There are many examples of small scale cross-cutting relationships. *Describe, illustrate* and *explain* an example of this type of relationship. Remember to discuss how this relationship can be used to determine relative age. **(3 marks)**

(h) The intruded rock has been described by some geologists as migmatite. Do you think that this is an appropriate term? *Explain* your answer. **(1 mark)**

(i) *Describe, illustrate* and *account for the origin* of any **OTHER** feature of the geology that you observe at this site. **(3 marks)**

On this diagram, clearly indicate the locations of the features to which you refer in your responses to the questions above. **Be sure to include this sheet in your practical report!**

(5 marks)



STOP 4: MANNUM QUARRY

A sketch and composite photograph on the following page illustrate many of the features of this quarry. Features **A–G** are labelled and relate to the questions below.

From your observations of the rocks in this quarry:

(a) What minerals can you identify in the rock that occurs at feature **A**? **(3 marks)**

(b) *Describe* how the texture of this rock varies and *account for* the variation that you observe. You should consider the spatial relationship between different textural segments of this rock, and how similar or different these features are to those seen at Reedy Creek. **(4 marks)**

(c) *Name*, *describe* and *account for the origin* of feature **B**. Remember to discuss any mineralogical or compositional controls on the process that produced this feature. **(3 marks)**

(d) What is feature **C**? How have these features formed in the granite? **(2 marks)**

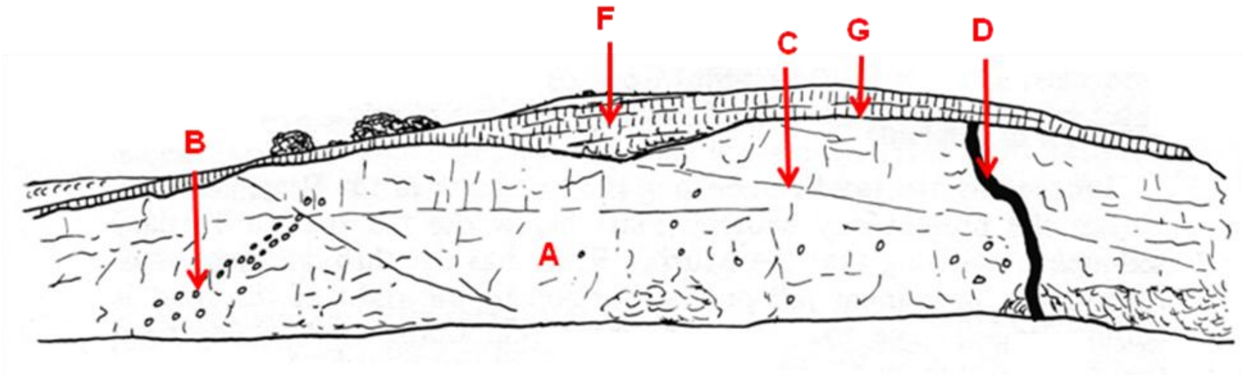
(e) What kind of igneous rock comprises feature **D**? *Describe* this rock and *account for its origin*. Remember to consider concepts such as relative age. **(3 marks)**

(f) There are numerous large pieces of the rock **F** on the quarry floor.
Describe, *name* and *account for the origin* of this rock. You should consider such things as its grain shape, size and sorting, its mineralogy, and its depositional environment. **(3 marks)**
N.B. Do not attempt to examine this rock at the top of the quarry face!

(g) Hence, what is the surface labelled **G** and how did it originate? **(2 marks)**

(h) On the far right hand side of the quarry there is a substantial dark rock mass, feature **E**.
Some people have thought this to be an igneous intrusion, whereas others have identified it as a xenolith. What is your interpretation of this feature?
Describe the evidence that supports your answer. **(2 marks)**

(i) *Describe*, *illustrate* and *account for the origin* of any **OTHER** feature of the geology that you observe at this site. **(3 marks)**



Composite image of the granite quarry at Mannum

ASSESSMENT DETAILS

You will need to respond to ALL questions listed above in a prepared field report. However, only a selection of the questions will be marked – 25 marks in total are available.

There are **25 marks** in total for this assessment piece. It counts for 7.5% towards the total course assessment.

Your report will need to be prepared using word processing software from your field notes. This handout can be downloaded from the course home page for you to insert answers into. Include sufficient space between your answers for me to provide feedback on them.

Ensure that all your answers relate to specific observations that you made from the field site itself. **Do not discuss granites or metamorphic rocks in general – I want to know what you saw in the field and how you have interpreted it.**

Illustrations that you include may be hand-drawn sketches or digital photographs that are **clearly annotated**. All annotations should be sufficiently detailed and include relevant **technical terms** discussed in the lectures and practicals. All illustrations must also be referred to in your answers – do not include them without context. A good idea is to present a field photo alongside a sketch that highlights its most important features and explains their geological significance.

Indicate **scale and orientation** on all illustrations. This means (a) indicating whether you were facing north, south, southwest, etc. when the photograph was taken; and (b) quantifying a feature in the photograph (e.g. pen is 10 cm, coin diameter is 3 cm).

Be sure to include page 8 of this handout, appropriately labelled, in your practical report. **5 marks are allocated for correct and appropriate labels on this diagram.**

You may use photographs that were taken by a fellow student, but you MUST acknowledge the photographer.

Your report is due **at 3.00 pm on Monday 10 September**. I will collect your submissions at the start of the lecture in room H1-35. Late submissions will incur a penalty of 10% per day and no submissions will be accepted after 9.00 am on Friday 14 September. You must include a **cover sheet** that contains **your name and student ID**.

References

Clark, I.F. & Cook, B.J. (eds.), 1983, *Perspectives of the Earth.* Australian Academy of Science, Canberra.

Cowley, W.M. & Freeman, P.J., 1993, *Geological Map of South Australia*. 1: 2,000,000 scale, Geological Survey of South Australia, 1v, map.

Gilluly, J., Waters, A.C. & Woodford (1959) *Principles of Geology*. Freeman, New York.

Sutton, J. (1971) Orogeny. In: I.G. Gass, P.J. Smith & R.C.L. Wilson, *Understanding the Earth.* Artemis, Sussex.

Tokarev, V. & Gostin, V., 2005. Mount Lofty Ranges, South Australia. In: R.R. Anand & P. de Broekert (eds.), *Regolith landscape evolution across Australia.* CRC LEME, Perth.

Photographs and sketch by J.H. Cann.