# An Introduction to Geological Maps

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# An introduction to Geological Maps

## Introduction

Underlying all of Australia's unique environment is the continent's geology — the rocks and minerals. The rocks and minerals influence the landforms — the mountains, valleys and plains — and the soil on which our unique flora and fauna depend.

Having an understanding of the geology of our continent will lead to a greater appreciation of the importance of Australia's wonderful environment.

Geology is the study of the Earth. It includes the study of the rocks on the Earth including the minerals and fossils they contain, the way the rocks are positioned, the processes which formed them and the age of the different layers. Geology also includes the study of the weathering (breakdown) of those rocks and the soils they form. A geological map shows many of these features — especially the types of rocks and their relationship to each other — both in age and location. A geological map makes it possible to develop an understanding of the geological history of an area.

### *Why use a map of Mt Todd?*

The map included in this booklet is real. Mt Todd is a location in the Northern Territory slightly north-west of Katherine where geologists collected data to produce the map in the 1960s. The map has been reprinted here at a different scale to help you learn about geological maps.

The geology shown on this map of the Mt Todd area is relatively simple. There are many interesting geological features and landforms in the Mt Todd area. This booklet will help you to understand some of the interesting features of Mt Todd, and equip you with the skills you will need to read other geological maps.

### How to use this booklet

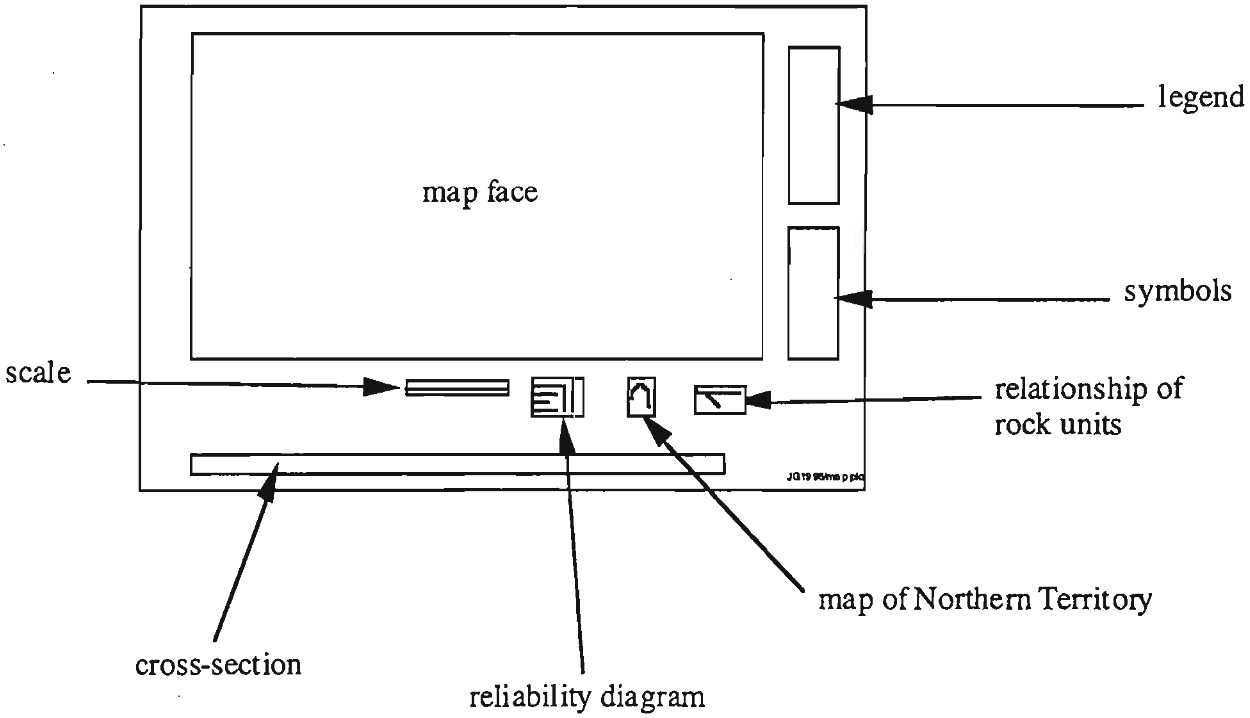
This booklet has been designed to show you how to read a geological map by learning a concept or skill then doing an activity which shows how the concept or skill is used on geological maps. (The activity symbol, shown on the right of this text, indicates an activity related to the information being discussed.) You will need no special material or equipment — other than some string. The suggested answers to the activities can be found at the back of the booklet for you to check your progress.

As well as this booklet the kit contains:

- a copy of the Mt Todd Map Sheet — geology on one side, topography on the reverse
- a plastic Map Card

# The Map

The map is made of many components which contribute to the overall picture of the geology of the Mt Todd area. The diagram below shows the main features of the map, and the information which follows explains how to use them.



## The Map Face

The information which follows gives details of how the map has been drawn. It is important to be familiar with map projections, scale, and latitude and longitude.

### Map Projections

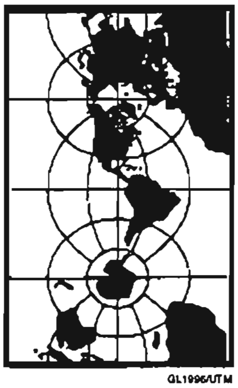
The surface of the Earth is curved. This means that a flat map will misrepresent the exact curved surface. To minimise the distortion, map makers (cartographers) use map projections to portray all or part of the round Earth as accurately as possible on a flat surface. There are many different types of map projections. The cartographer chooses one best suited to the area of the Earth's surface being mapped.

Most geological maps, including the one of Mt Todd, have been mapped using the Universal Transverse Mercator (UTM) map projection.

### Map Age

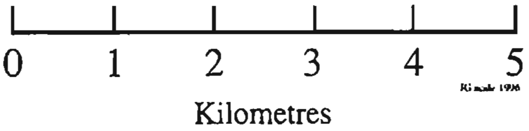
It is important, especially if a map is going to be used for navigation, that you take into consideration the age of the map. Obviously cultural features, such as roads etc will change over time. The Mt Todd Map geology map was drawn in the 1950s, while the topographic map was drawn in the 1990s.

Universal Transverse Mercator



## Scale

The Mt Todd map is at a scale of 1:75 000. This means that 1cm on the map equals 75 000 cm (or 750 m) on the ground.
To help you measure distances, a map card is included in the kit (one for each map copy) which has a line scale as well as latitude and longitude scales and a compass rose) A line scale like the one below is also shown in the centre lower part of the map, .



## Latitude and Longitude

Latitude and longitude are the elements of a grid system used to locate any point on the surface of the Earth.

### *Latitude*

Latitude is the distance north (N) or south (S) of the equator and is measured in degrees, minutes and seconds. The Equator is at latitude zero degrees and the South Pole is at latitude 90°S (the North Pole is at 90°N).

Each degree is divided into 60 minutes and each minute is divided into 60 seconds. With the use of computers, more often now these coordinates use a 'digital style' where minutes are given as a decimal rather than in 60ths. In this kit however, degrees, minutes and seconds will be used.

The following symbols are used to represent degrees (°), minutes (') and seconds ('').

The Mt Todd map covers the area between 14°00'S (14 degrees and 00 minutes south of the equator) and 14°15'S (14 degrees and 15 minutes south of the equator)

*Longitude*

Longitude is the distance east or west from an imaginary line which runs from the North Pole, through the London suburb of Greenwich in England and down to the South Pole. This is often known as the Greenwich line. Why Greenwich? This is the location of the Royal Observatory and all maps drawn by the British during the early development of maps used this line as 0° longitude line. Today, all maps use the Greenwich line for 0° longitude. Like latitude, longitude is measured in degrees, minutes and seconds.

The Mt Todd map covers the area between 132°00'E and 132°30'E.

Latitude and longitude (lat/long) lines are marked on the Mt Todd Map. The value of each line is written on the map edge. Each line represents 5 minutes, so the top left corner is 14°00', the next latitude line down the side is 14°05', etc. There is also a dashed line marked right on the edge of the map — each 'dash' represents one minute.

There is a plastic map card in the pocket at the back of this booklet. It can be used to help measure latitude and longitude, as well as direction and scale. Each larger division on the lat/long scales represents one minute. Each smaller division represents six seconds.

Note that because of the curvature of the Earth, the lines marked on the map may not be equally spaced. Do not assume that they are! This means that in some places the map card may appear to have a six second error.

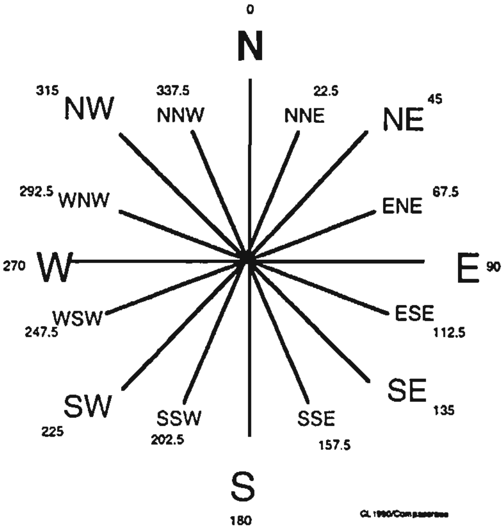
When using this method of finding a location, the latitude is always given before the longitude i.e. Edith Falls is located at 14°11'S, 132°12'E. The first number in the latitude refers to the whole number of degrees, and the next number after the point refers to the number of minutes towards the next latitude line or, more simply, the number of 60ths towards the next latitude line. The same applies to the longitude numbers. If the second number is 00, this means that the location is exactly on the latitude or longitude line.

## North, south, east, west

Unlike most maps, this map does not have an arrow which shows the direction of north (a north point). However, like most maps, north is to the top of the map, south to the bottom, east to the right and west to the left. The other directional points on the compass are shown in the diagram on the next page, as well as on the map card.

Often directions are given as a compass bearing — an angle in degrees with north being 0°, east being 90°, south being 180° and so on. If you were walking to a bearing of 135°, for example, you would be walking to the south-east. Note that the bearing 360° is also north! The bearings of the major map points are marked on the map card.

**Compass Points**



## The Legend

The Mt Todd geological map has a legend down the right-hand side which summarises the geological information. Each major rock unit found in the area is represented by a colour and a symbol on the map. (A rock unit is a geologically mappable area of similar rock types. A single unit can be identified in different parts of a map area.) The rock unit symbol is normally a two or three letter code that helps distinguish colours which are similar e.g. Qa for Quaternary. The legend has the corresponding colour and symbol in a small box.

A description of the rocks is written next to the box. In some places a number of different rock types are found and so more than one type are listed. A glossary of terms to help you understand the descriptions can be found at the back of this booklet.

### Rock Types

Geologists place rocks into three categories :

*Igneous rocks*

These are rocks that have formed from the cooling of molten rock material.

*Sedimentary rocks*

These are rocks that have formed from the consolidation of sediments, such as sand, pebbles, clay or mud. These sediments can contain fragments of rocks, animals and plants.

*Metamorphic rocks*

These are rocks that have changed their nature (recrystallised) from the original rock material because they have been heated, but not melted, and/or placed under great amounts of pressure.

## Rock Type Summary Table

**Igneous**
*Cooled below ground (plutonic)*
gabbro
diorite
dolerite
granite

*Cooled above ground (volcanic)*
basalt
dacite
toscanite
rhyolite

**Sedimentary**
sandstone
conglomerate
shale
greywacke
mudstone
limestone
coal
siltstone

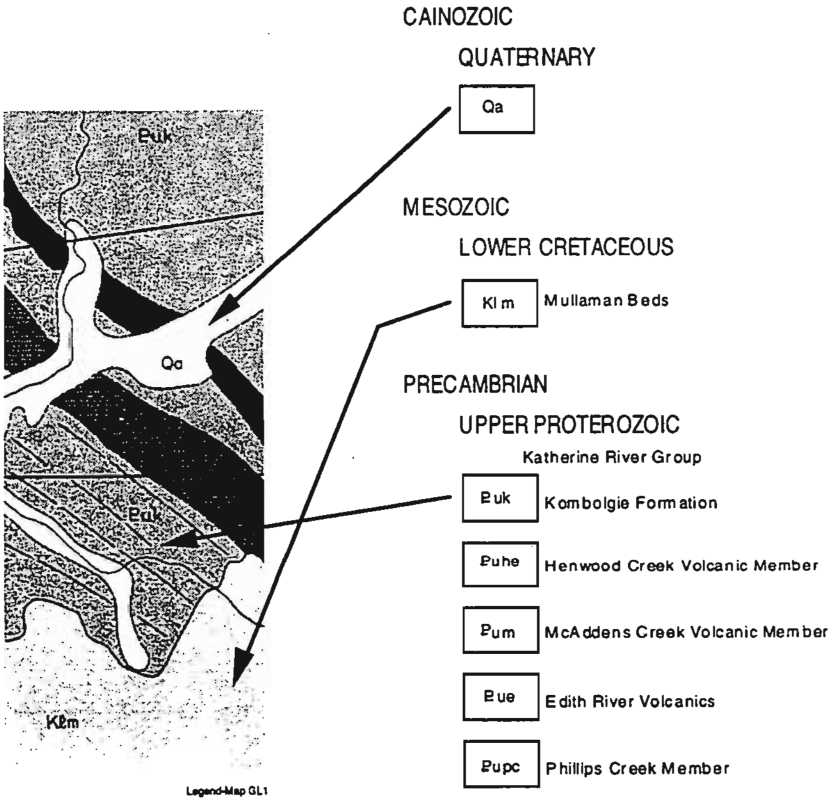
*unconsolidated sediments*
sand, alluvium, soil

*Sedimentary rocks made up of volcanic material such as ash and rock fragments are known as* pyroclastics.

**Metamorphic**
quartzite
slate
gneiss
phyllite
marble
schist

See the glossary at the end of this booklet for descriptions of some of the other terms used on the map.

The legend is also designed to show the age relationships of each of these rock units.



## The age of rocks

Geologists measure time in millions of years. A geological timescale or time line is used to show the age of the Earth from its 'birth', some 4600 million years ago, to the present day.

Geologists use fossil evidence and/or radiometric dating to age the rocks. To make the geological timescale easier to use, geologists have divided the age of the Earth into units known as eras (Cainozoic to Palaeoproterozoic) and periods (Quaternary to Siderian). A simplified geological time scale is shown on the next page.

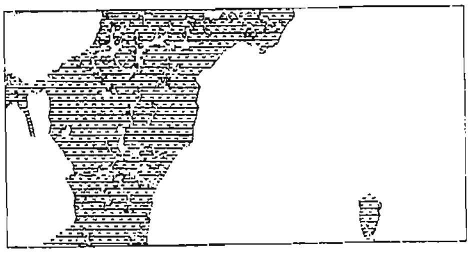
The oldest rocks on the map (which formed in the Proterozoic) are listed at the bottom of the legend, and rock units get progressively younger as you move upwards through the legend. Therefore the youngest rocks are shown at the top of the legend.

## Groups and Formations

Geologists place a known sequence or layers of different rock units found in the same area together and call the combined layers 'groups' such as the *Katherine River Group* and the *Finniss River Group*. Groups are divided into formations, such as the *Kombolgie Formation* and sometimes formations are further divided into members or units such as *Henwood Creek Volcanic Member*. Both the *Kombolgie Formation* and the *Henwood Creek Volcanic Member* belong to the *Katherine River Group* of rocks.

The groups and formations (refer to glossary for a description of rock terminology) and their distribution on the map are :

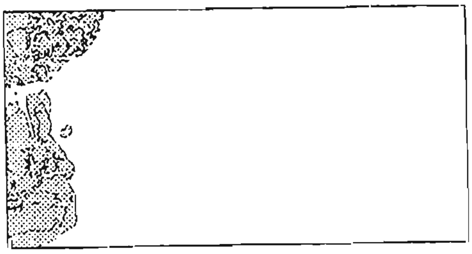
### *Finniss River Group (Burrell Creek Formation)*



This Group of rocks has only one unit outcropping in the map area, referred to on the map as the Burrell Creek Formation which is made up of siltstone and greywacke (muddy sandstone). These rocks are the oldest on the map and formed some 2500 million years ago on the floor of an ancient sea. Since then they have been folded and heated and in some places the rocks have been metamorphosed to form phyllite.

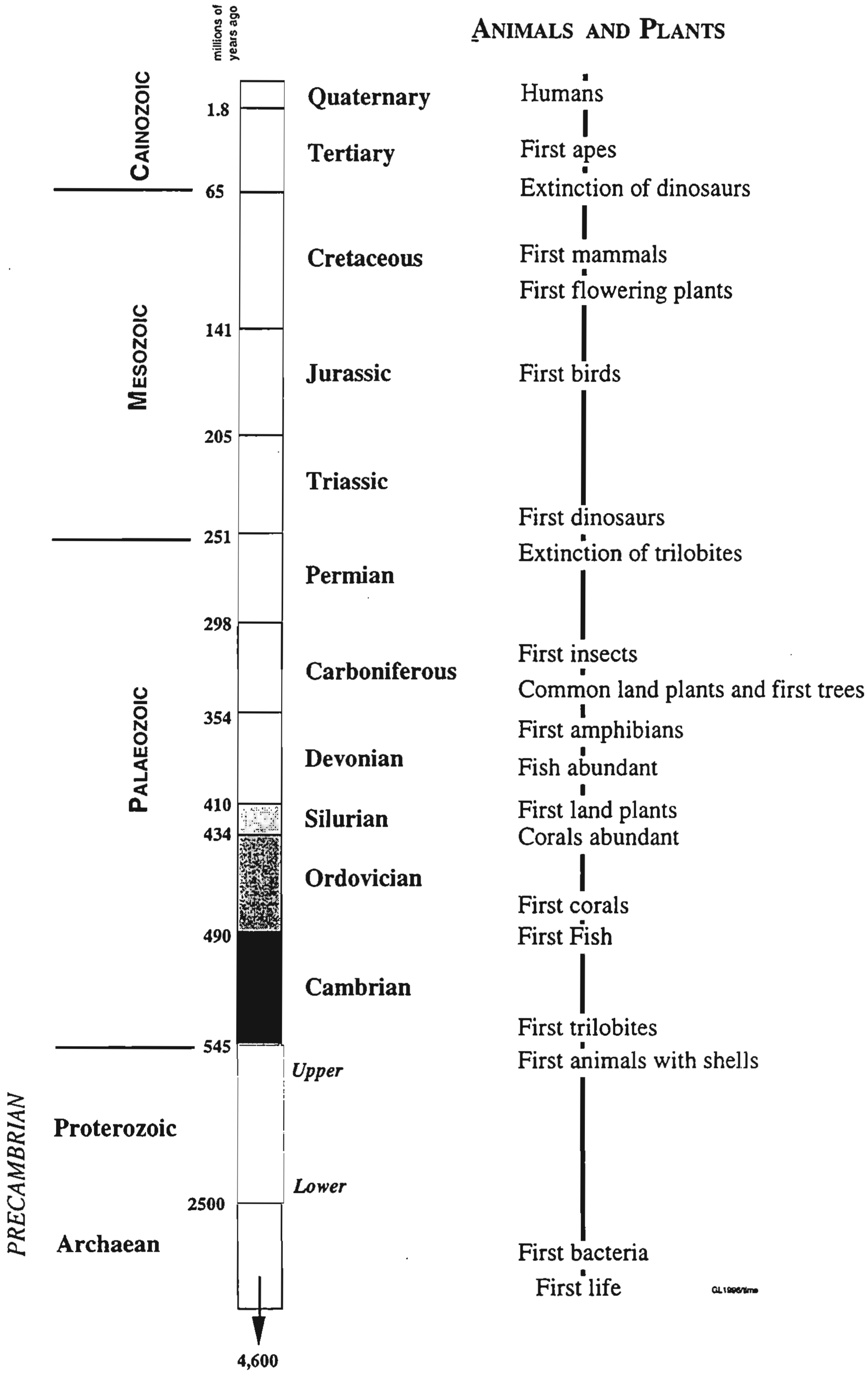
The geologists making the map have not mapped all the folds but have used trend lines to indicate the general folding pattern.

### *Cullen Granite*



The Cullen Granite is an intrusion which cooled well below the Earth's surface some 2000 million years ago. The granite most probably intruded the Burrell Creek Formation in four stages — each stage having a slightly different composition leaving four slightly different granite types (fine-grained, fine-grained hybrid, coarse-grained porphyritic hornblende-rich and coarse-grained). The four types of granite are marked separately on the map.

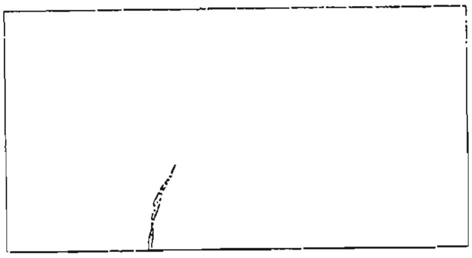
# Geological Time Line



### *Katherine River Group*

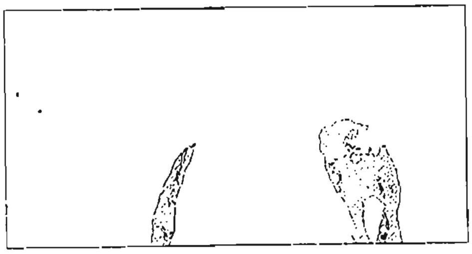
This group of rocks is made up of five different rock units. These units formed between around 1000 million years and 600 million years ago. These rocks formed in a volcanic environment probably similar to the North Island of New Zealand. The layers are made up of the remnants of volcanic eruptions and ocean sediments deposited on the sea floor close to a volcanic chain.

*Phillips Creek Member*



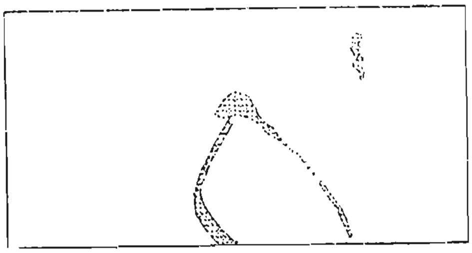
This is the oldest member of the Katherine River Group. It is made up of predominantly ocean sediments (greywacke, shale and conglomerates). Occasional volcanic eruptions deposited volcanic ash (tuff) in some places.

*Edith River Volcanics*



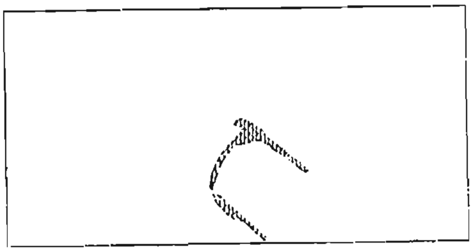
This member of the Group is made up completely of rocks created by volcanic processes. Lava flows (rhyolite, dacite, etc) are interlayered with rocks made up of volcanic eruption fragments known as pyroclastics. The distinguishing feature of these layers is that almost all of the volcanic rocks are quite rich in quartz and therefore the rocks are light in colour.

*McAddens Creek Volcanic Member*



This rock unit is made up predominantly of basalt — a black quartz-poor volcanic rock. Interlayered with the basalt flows are more pyroclastic rocks. The rocks are easily distinguishable from the Edith River Volcanics as they are very dark in colour.

*Henwood Creek Volcanic Member*

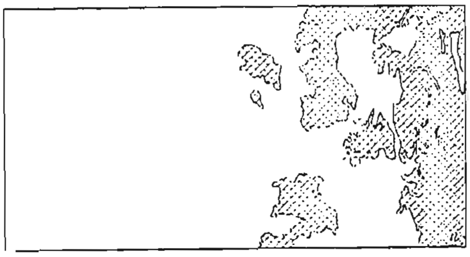


This member is slightly different from the McAddens Creek Volcanic Member as it contains the volcanic rock dacite. Dacite contains quartz and is lighter in colour than basalt.

*Kombolgie Formation*

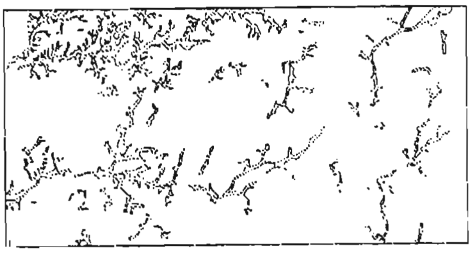
This is the youngest unit of the Katherine River Group. It is made up of predominantly non-volcanic sediments deposited on an ancient sea floor (quartz sandstone, greywacke, conglomerate). However, volcanism was still occurring intermittently at the time and some volcanic ash (tuff) and volcanic fragments (feldspar rich) were incorporated into some of the sandstone layers.

***Mullaman Beds***



The sedimentary rocks making up the Mullaman Beds were deposited in a shallow sea and inland lakes and rivers around 120 million years ago. These rocks are around 600 million years younger than the youngest units of the Katherine River Group! The rocks are lying almost horizontally on top of the other rocks in the area.

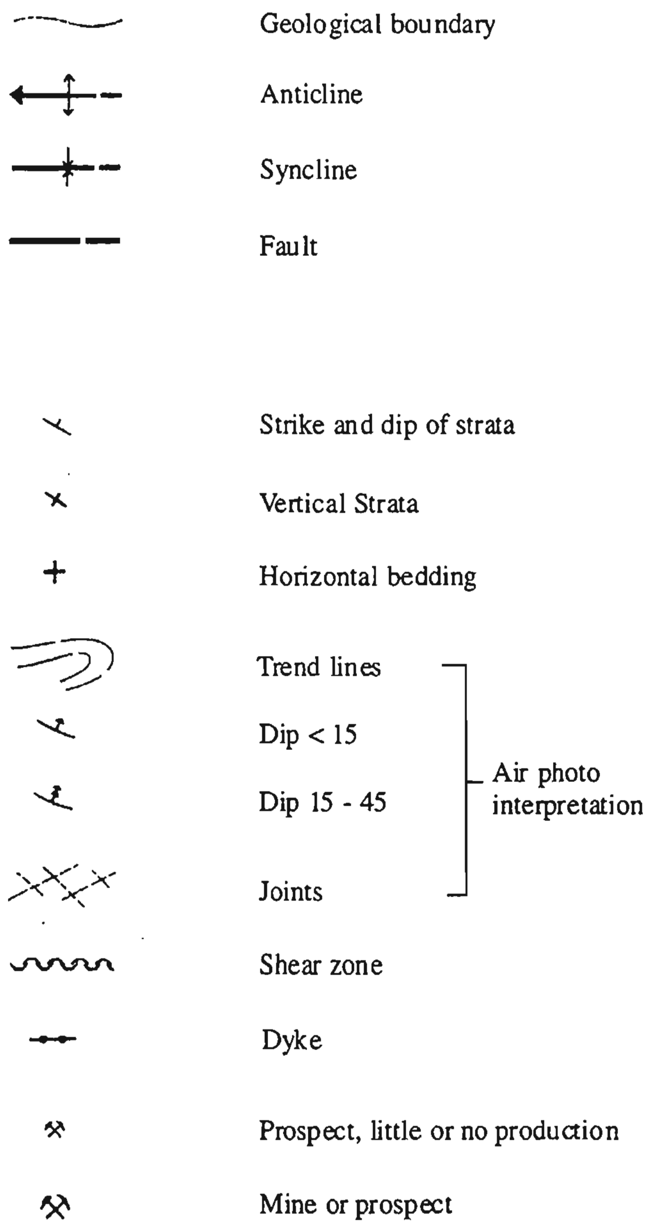
***Quaternary Alluvium***



These unconsolidated sediments line the creek and river banks in the area. They are made up of sand and gravels formed from the weathering and erosion of the rocks in the area. In some places where they have been protected from erosion by the rivers they have formed soils.

## Symbols

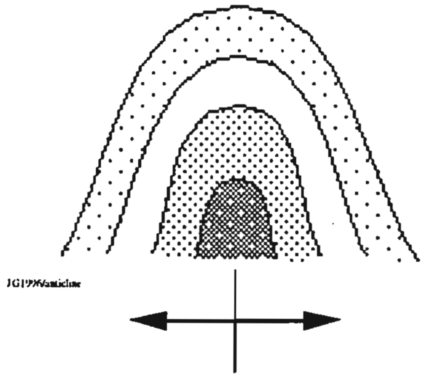
A table at the bottom right-hand side of the map displays the other symbols used. Most of these symbols are self-explanatory. However, the main geological symbols used are described below. Note that when the lines used to represent faults, folds etc, are 'dashed', they indicate that the features are only 'inferred' i.e. they can't be seen but the geologists believe them to exist due to other evidence.



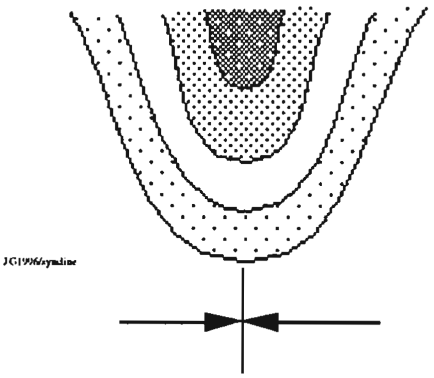
*Geological boundary* — the boundary between two rock units.

*Unconformity* — a geological boundary which indicates that a large amount of time has elapsed between the erosion of the older layers of rock and the deposition of younger rocks. The older rocks may have been folded and tilted, then eroded. After millions of years a new layer of rocks is deposited on top.

*Anticline, syncline* — these are geological structures where the rocks have been folded.



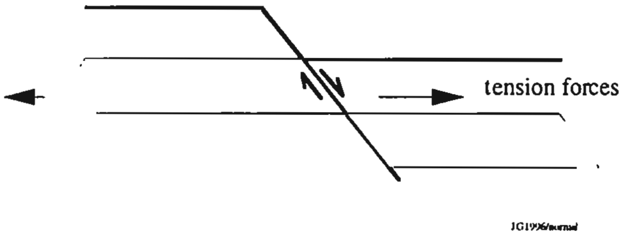
**Anticline**



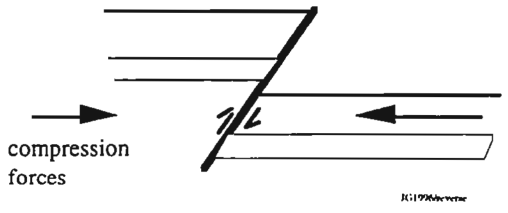
**Syncline**

*Fault* — a break in the rocks along which the rocks move when they are put under stress. An earthquake occurs when the rocks slide past each other along a fault. However, most faults are currently inactive. There are two main types of faults: normal faults and reverse faults.

*Normal fault* — due to tension pulling rocks *apart,* the rocks on the top of the fault have slipped down.



*Reverse fault (thrust)* — due to compression forces, causing one rock body to be pushed up over the top of another.



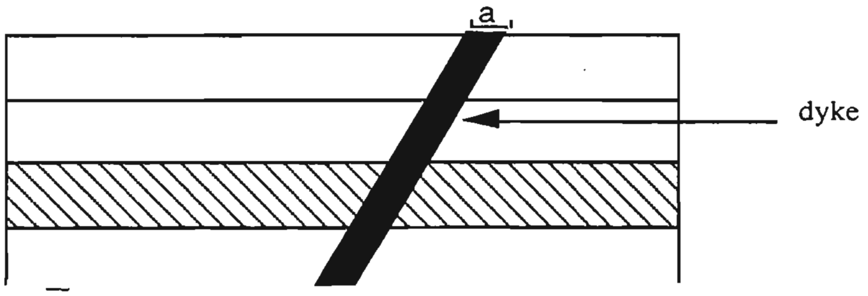
*Strike and Dip* — Dip is the maximum angle that a rock is dipping into the ground (relative to horizontal) and is measured in degrees. Sometimes geologists also record the dip direction — a compass direction (bearing) towards which the 'dip' points. Strike is the compass bearing of the line along which the rocks have zero dip i.e. at 90° to the dip direction. Instead of a bearing being recorded on the map a small line is drawn for strike. Off this line is a mark showing the direction of the dip and the dip angle.

*Trend Lines* — where these lines are shown, air-photo interpretation suggests that the rocks have been folded.

*Joints* — A joint is a fracture in the rock layers which is at an angle different to the layers along which the rocks were deposited. The rock layers do not move along these joints, distinguishing them from faults.

*Shear zone* — an area where many faults have occurred close together.

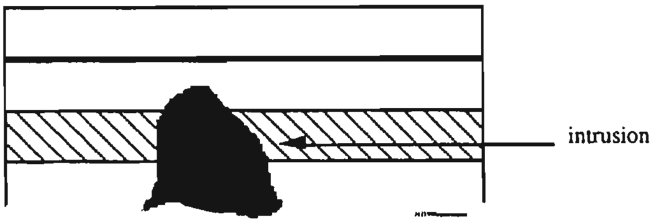
*Dyke* — a dyke is a type of intrusion (see *intrusion).* It cuts across layers of rocks, through a crack in the rock forming a sheet with thickness 'a'.



The dykes may consist of different types of rocks or minerals, indicated by the following symbols.

q- quartz (also known as quartz vein)
po - porphyry (fine grained rock with scattered large crystals)
g - greisen (a mineralised vein)
d - dolerite ( a dyke of basalt with slightly coarser grain size)

*Intrusion* — Rock which has formed from magma (molten rock) cooling below the Earth's surface is sometimes referred to as an intrusion. The rock 'intrudes' into another type of rock. Metamorphism of nearby rocks may occur due to the intense heat of the magma. The Mt Todd map shows a large intrusion of granite on its western edge— the Cullen Granite. Magmas are normally around 700 °C to 1000 °C when they intrude.

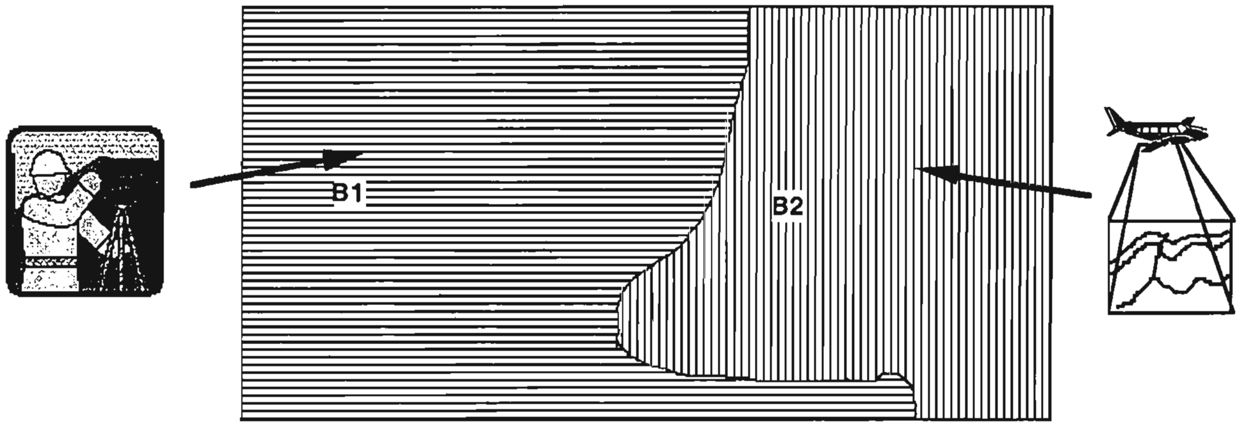


*Prospect* — a place where minerals have been located, but which has not yet been mined either because the amount of minerals is too small, or the price of extracting the minerals is too great.

# Geological Reliability Diagram

Geologists use different methods for mapping the geology of an area. Some methods are more precise than others. For instance, the data which has been collected from a detailed reconnaissance method (scientists actually walking the area and collecting samples) is going to be more precise than the data interpreted by air-photo investigations. More precise methods, such as multiple detailed traverses (a planned field trip covering a specific route in order to collect and/or check data) of an area by a team of geologists, are more time consuming and expensive than air-photo interpretations.

**GEOLOGICAL RELIABILITY DIAGRAM**



| | |
|---|---|
| B1 | Detailed reconnaissance - numerous traverses |
| B2 | Air-photo interpretation and traverses |

A Geological Reliability Diagram shows which parts of the map have been mapped using which method. The Mt Todd map shows two grades of reliability. The area marked B1 has been mapped using detailed reconnaissance. The area marked B2 has been mapped using air-photo interpretations.

## The Geologist's Lot in the Mapping of Mt Todd

A geologist is quite an adventurous person. A geologist camps under the stars, climbs over cliffs, dodges snakes and bushwalks for miles! Many geologists are well paid and may travel to spectacular places all over the world. Making a geological map requires knowledge, organisation, time, skill and the right equipment.

For example, the Mt Todd map was produced as part of a large project in the Northern Territory. Several other maps around this area were being made at the same time. The data collection phase of this project would have taken about 6 months to a year of fieldwork, spread over several years.

The time required to complete a geological map varies. It depends on the complexity of the geology and the terrain, and the scale that is required. After the data has been collected, the map is compiled, edited and printed. The whole project may take many people and, in some cases, years to complete.

In remote localities geologists operate from a base camp. A *base camp* was probably set up in the Mt Todd area. A typical geological base camp consists of:

4 - 6 geologists
4 - 6 field hands (assistants to the geologists)
a cook

a mechanic

Base camp equipment may include:

four-wheel drive vehicles
mechanical workshop
tents, camping equipment
cooking, cleaning and refrigeration facilities
generator
fuel dump
helicopter (perhaps)
office, communication and computer equipment
microscope

The base camp is the main meeting place for the group involved in the large project. Here the geologists collect provisions and refuel. The group splits up during the week to map different areas. For instance, 2 - 4 people were probably assigned to map the Mt Todd area. Because of the simplicity of the geology in this area, it would have taken only about 4 weeks to collect the data. They probably operated with four-wheel drive vehicles and two-way radios, and camped under the stars at night. They relied on billabongs for their bathing water, and took enough food and drinking water to last for the week.

Notice on the Mt Todd map the reliability diagram shows that only the west side of the map was completed by detailed reconnaissance. The geologist would have been able to drive along roads and through the vegetation quite easily on this side of the map. The east side has little road access, mainly because of the steep rocky escarpments. The geologist would have chosen one area to map carefully by foot. The rest of this side of the map was mapped using the black and white air photos. Helicopters are sometimes used in areas where there is rough terrain. They can be more cost effective and time saving than mapping the area by foot.

Making a geological map is like putting together the pieces of a jigsaw puzzle, except that most pieces are missing and the picture on the front of the jigsaw box is not available for reference! Not all the rocks are exposed. They are concealed by rivers, lakes, alluvium, vegetation and products of weathering (regolith). The geologist must fit together all the clues from the data and fill in the missing parts of the puzzle to produce a map.

These days geologists have the help of some very sophisticated equipment to help them find some of the missing pieces:

satellite images and multispectral scanners
sadiometric images
magnetic images
gravity images
GPS (Global Positioning System)
colour photography

Other modern conveniences also help the field trip run smoothly:

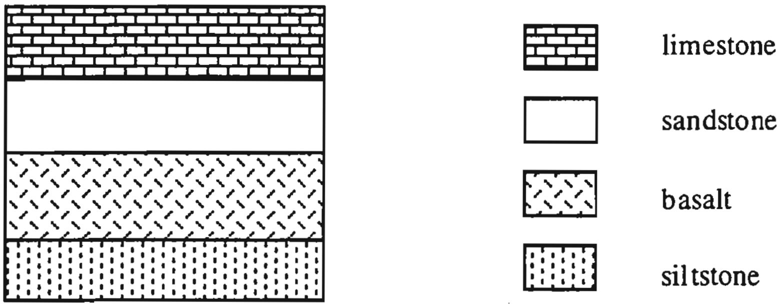
power steering ( makes driving over rough terrain easier!)
air conditioning
refrigerators
computers
satellite communications

# Geological Cross-sections

A cross-section is used to show the relationship of the rock units in an area. A cross-section clearly shows the rock units, faults, folds and erosion. It also shows the order in which these processes occurred. Usually, the rock unit on the bottom of the cross-section is the oldest rock, and the rock unit on the top is the youngest. (Unless the layers have been overturned!)
The data used to draw a cross-section can be obtained from outcrops (dip and strike), road cuttings etc. It is really an interpretation by a geologist of what happens to the rock units under the surface.

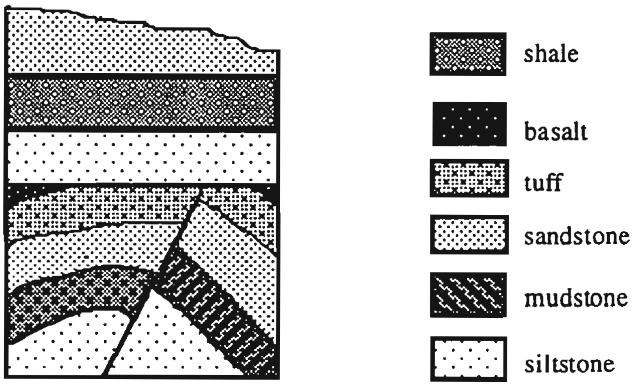
## Cross-sections and Geological Histories

Cross-sections can be used to work out a geological history of an area. A simple cross-section (section 1) is shown below.



Section 1

This cross-section shows that siltstone is the oldest rock layer and the limestone is the youngest rock layer. In this section no folding or faulting has occurred.



Section 2

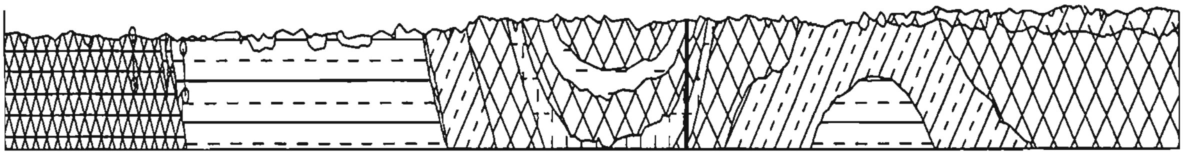
Section 2 shows a more complicated geological history. Rocks have been deposited, folded, faulted then eroded. Hundreds of millions of years may have passed before the deposition of the younger rock layers. This represents an unconformity. A more detailed history of this cross-section is :

1. Deposition of siltstone
2. Deposition of mudstone
3. Deposition of sandstone
4. Deposition of tuff
5. Eruption of lava, cooled to produce basalt
6. Folding
7. Faulting (normal fault)
8. Erosion (unconformity)
9. Deposition of siltstone
10. Deposition of shale
11. Deposition of sandstone
12. Erosion to present-day landscape

Notice that in this cross-section, the faulting occurred after the folding. This is evident because the fault line is unbroken. If the folding had occurred after the faulting, the fault line would have been broken or distorted.

### The Mt Todd Cross-section

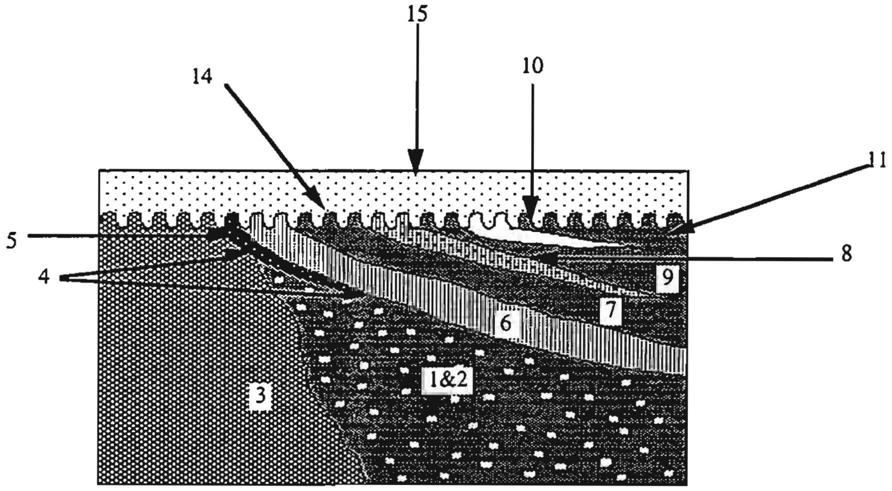
A cross-section of the Mt Todd area has been taken across the line marked A–B on the map. The cross-section is shown at the bottom of the map. It shows how the rocks would be seen if a slice were taken out of the earth across this line.



The section A–B shows the folding of the rock units, into a syncline and an anticline. (from left to right). A fault is also represented on the section. It may be difficult to see on this cross-section, but the rock layers to the left of the fault have been uplifted relative to those on the right. This is a reverse fault, caused by compression of these rock units. The section shows that erosion has occurred, leaving the present-day landscape.

## Diagrammatic Relationship of Rock Units

The diagrammatic relationship of the rock units shown below and on the map also shows the geological history very clearly. Use this together with section A–B to follow the geological history of the Mt Todd area, numbered below.



1. Deposition of the Finniss River Group (mainly sedimentary)
2. Folding of Finniss River Group
3. Intrusion of Cullen Granite (and metamorphism of local rocks due to the heat of the intrusion)
4. Uplift and erosion, exposing Cullen Granite (unconformity)
5. Deposition of the Phillips Creek Member (sedimentary) on top of the Cullen Granite and Finniss River Group
6. Deposition of the Edith River Volcanics (volcanic and sedimentary)
7. Deposition of the Kombolgie Formation (sedimentary — mainly sandstone)
8. Eruption of the McAddens Creek Volcanic Member interrupting sandstone deposition (volcanic — mainly basalt)
9. Deposition of more sandstone
10. Eruption of the Henwood Creek Volcanic Member (volcanic)
11. Deposition of more sandstone
12. More folding due to compression forces
13. Faulting — high angle reverse fault due to compression forces
14. Erosion for hundreds of millions of years (unconformity)
15. Deposition of Mullaman Beds in both marine and freshwater conditions (sedimentary)
16. Minor uplift and further erosion
17. Deposition of soil and alluvial sediments

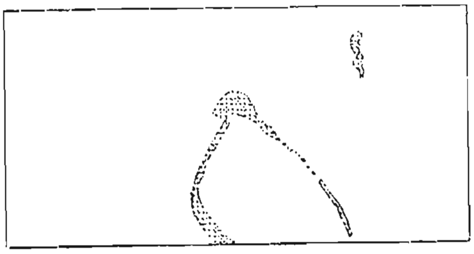
In summary, sedimentary rocks have been deposited, then folded and intruded by granite. The heat of the granite and the pressure of the folding has slightly metamorphosed (cooked) the sediments in some places, forming a rock called *phyllite*. Then uplift and erosion of these rocks has occurred. After some time more sedimentary rocks have been deposited unconformably on the eroded surface (unconformity 1). This deposition has been interrupted twice by the eruption of volcanic rocks. After this, the rocks have been folded, faulted and eroded. The last layers were not deposited until the Lower Cretaceous period. This 'break' in geological time is the second unconformity. The diagrammatic relationship of the rock units shows this unconformity more clearly. Finally, these rocks have been slightly uplifted and eroded to the present-day landscape with some deposition of soil and alluvium. If and when these sediments turn to rock this will represent another unconformity.

# Reading the Map Face - Geological Structures

The geological structures (folds, faults, unconformities and intrusions) which contort, bound and displace the rock layers are relatively simple on the Mt Todd Map. These notes will help you to describe the structures that appear on the map.

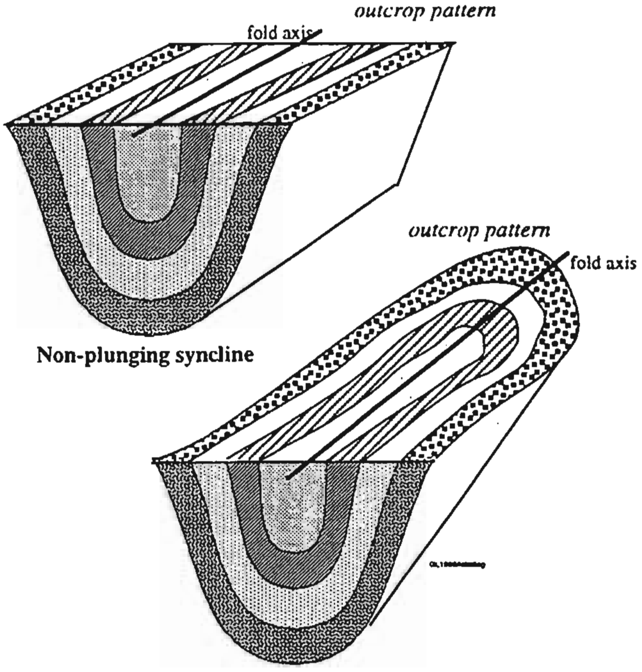
## Folds

By far the most obvious geological feature on the map face is the folded layers of the Katherine River Group rock units. These folds, the largest in the centre of the map being a syncline with an anticline immediately to the east and a smaller syncline to the north-east, are plunging folds. A plunging fold is one that dips down into the earth, i.e. the axis of the fold is not parallel to the Earth's surface. This 'plunging' is seen at the surface by the curved outcrop pattern of the layers, such as the McAddens Creek Volcanic Member.



Outcrop pattern of the McAddens Creek Volcanic Member

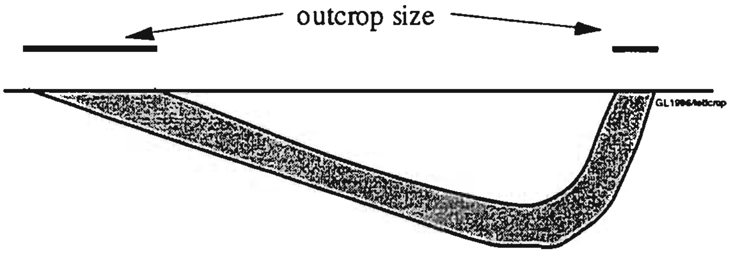
The outcrop pattern of non-plunging folds, in comparison, is one of parallel beds repeated each side of the fold axis line.



Non-plunging syncline

Plunging syncline

In addition to the folds plunging, the limbs of the folds are not symmetrical, i.e., the same bed on either side of the fold does not dip into the ground at the same angle. This makes the beds appear to be thicker on the western limb of the major syncline than on the eastern limb — again look at the McAddens Creek Formation. In fact the bed is roughly the same thickness throughout and it is the way the bed is positioned (the degree of dip) that gives it a larger outcrop surface to the west.



Topography also can produce distinctive outcrop patterns. The topography of Mt Todd, however, is relatively flat (highest to lowest point being only around 150 m) so no major topographic 'distortion' of the fold patterns is evident.
The folds are better explained when using both the map and the cross-section.

## Faults

The faults on the map displace the layers both horizontally and vertically. The horizontal displacement is easily seen on the map whereas the vertical displacement is difficult to see. You will note that many of the faults on the map are marked with dashed lines — these are faults that the geologists believe to exist because of displacement features but there was not enough evidence to mark them as known faults.

## Unconformities

The two unconformities on the map are not as apparent as the folds and faults. The change in the structure in the lower beds compared to those above highlights the unconformity.
The lower unconformity is between the Burrell Creek Formation and the Katherine River Group. The Burrell Creek Formation is strongly folded — the geologists have used trend lines to show the general way this formation has been contorted. The Katherine River Group on the other hand is more gently folded. The episode which folded the Katherine River Group refolded the already contorted Burrell Creek Formation.
The upper unconformity is between the top of the Katherine River Group (Kombolgie Formation) and the Mullaman Beds. The Katherine River Group is folded. The Mullaman Beds are flat-lying — they have not undergone any folding.
The Mullaman Beds would have once covered the entire map area. Erosion by the rivers has removed all of the Mullaman Beds from the western side of the map exposing the rocks underneath. To the east the Mullaman Beds have not been eroded away. In the central portion of the map remnants (called outliers) of the Mullaman beds can be found.

## Intrusions

Intrusions come in a variety of shapes — they are not all rounded and smooth. The Cullen Granite shows quite an irregular outcrop shape with offshoots of the intrusion reaching into the surrounding rocks and some fingers of surrounding rock protruding into the granite. While it appears that there are three separate granite bodies they are probably all joined under the ground to form one granite body. The cross-section shows, for example, how the small granite body near Lucy's Camp is attached to the main body.

# Geology and Topography

Studying the geological map of an area will allow users to gain an understanding of the geological history and structure. However, the way we 'see' the area is by looking at the landscape — the landforms, flora and fauna and the land use. This is the realm of the topographic map and, together with the geological map information, can give us a picture of the area as a whole, including the rocks and structures which lie below our feet.

Activities for this section use the AUSLIG Mt Todd 1:75 000 Topographic Map which is printed on the back of the geological map.

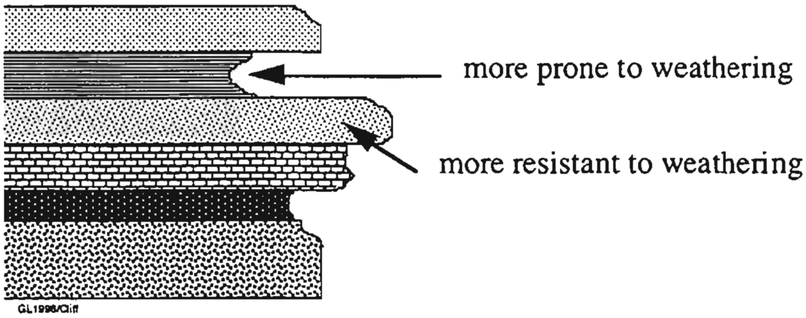
## Landforms

Three major factors which influence development of the natural landscape are the climate, time and the underlying geology. In the Mt Todd area the influence of the underlying geology of the landforms can be clearly seen. The major geological influences are the different rates of weathering and erosion of the rock layers and the geological structures which occur in the area.

### Weathering and Erosion

Rocks break down over time due to the chemical and/or physical change in the minerals which make up the fabric of the rock. The rate at which a rock breaks down (weathers) is therefore controlled by the minerals it contains along with the size of the mineral grains and the way they are 'held' together in the rock — i.e. cemented or interlocking grains. Because rocks are slightly different, they will weather at different rates.

This can often be seen in cliff lines where one rock layer has weathered more than the surrounding layers.



In the Mt Todd area the most resistant of the Upper Proterozoic rocks to weathering and erosion are those of the Henwood Creek Volcanics and the McAddens Creek Volcanics. The boundaries of these two rock layers form cliff faces and steep slopes.

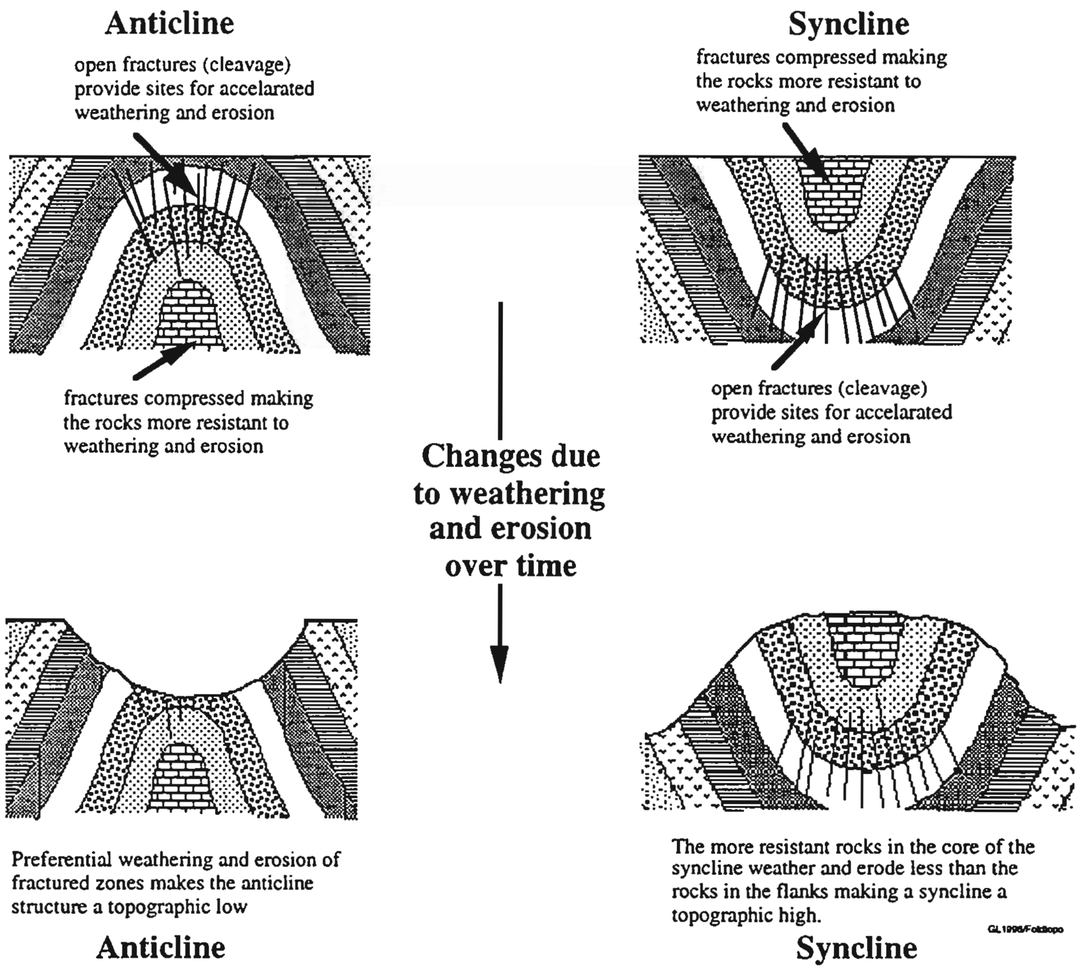
The Cullen Granite, being more prone to weathering and erosion than the other rocks in the area, has formed a topographic low area on the western side of the map (average elevation of approx. 140 m above sea level).

The active rivers in the area are cutting down through the rock layers to form valleys across the area. In these valleys are the remains of the weathered bedrock which has been eroded and deposited in the form of sand and gravel (alluvium). This material is highly erodible itself — a major flood can scour out these river valleys and redeposit the material many kilometres downstream or carry the sediment load out to the ocean.

## Geological Structures

### Folds

When layers of rock are folded pressure causes the rocks to fracture. Where the rock is being stretched around the outside of the fold, such as in the top of an anticline, the fractures (known as cleavage) are open and provide sites for water, ice and air to get into and weather the rocks. Where the rock is being compressed, such as in the core of an anticline, the fractures are squashed closed and the rock becomes more resistant to weathering. This means that the rocks on the top of the anticline weather and erode faster over time than the rocks on the side of the anticline so a valley forms. By contrast, with a syncline, the rocks on the side of the fold weather and erode faster than the core of the fold so a hill forms.



**Anticline**

open fractures (cleavage) provide sites for accelarated weathering and erosion

fractures compressed making the rocks more resistant to weathering and erosion

**Syncline**

fractures compressed making the rocks more resistant to weathering and erosion

open fractures (cleavage) provide sites for accelarated weathering and erosion

**Changes due to weathering and erosion over time**

Preferential weathering and erosion of fractured zones makes the anticline structure a topographic low

**Anticline**

The more resistant rocks in the core of the syncline weather and erode less than the rocks in the flanks making a syncline a topographic high.

**Syncline**

The Upper Proterozoic rocks (Katherine River Group and Edith River Volcanics) in the Mt Todd area are folded into a large syncline, an anticline and a smaller syncline when moving west to east.

These folds are plunging into the ground to the north. The synclines have formed topographic highs (average height of approx. 280 m above sea level) and the anticline a topographic low (Average height of 180 m above sea level). The edges of these structures are marked by cliffs along which numerous waterfalls occur, such as Edith Falls (14°11'S, 132°12'E).

### Flat-lying beds

The Lower Cretaceous Mullaman Beds, which were deposited unconformably on top of the Upper Proterozoic folded layers, are flat lying. They are quite resistant to weathering and erosion. Being the youngest rocks in the area, situated on top of all the other layers, they form the highest landform feature — a flat plateau in the east of the map (max. height of 344 m above sea level). Wherever these layers extend over different types of rocks they form a protective barrier to erosion.

### Faults

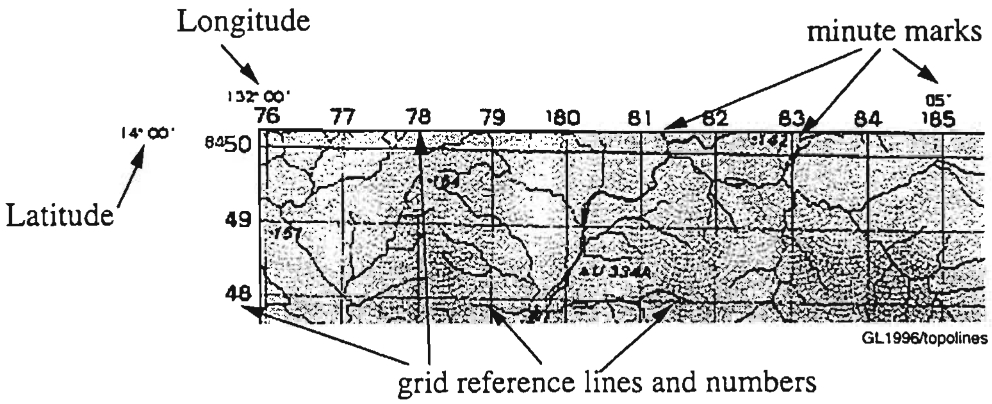
Because faults displace the geological layers, they can have a dramatic effect on landforms, such as forming cliff lines, offsetting features and providing a pathway for streams to follow. In the Mt Todd area the major fault, which offsets the rock units in the big syncline, has produced a cut through the landforms. While this is not greatly apparent on the topographic map, it can be clearly seen in airphotos and satellite images of the area.

## How to read a Topographic Map

There are a number of excellent books about reading topographic maps. This box contains some basic information to help you use the Mt Todd Special Topographic map to undertake the activities in this kit. You should note that the geological map and the topographical map cover exactly the same area and are at exactly the same scale (1:75 000).

### Latitude, Longitude and Grid References

Most topographic maps have a grid reference system printed on top of the information to assist in finding localities. The grid reference system is a series of vertical and horizontal lines with grid numbers on the edge of the map. As well as these lines, latitude and longitude marks are also shown on the map. The latitude and longitude of each map corner is shown as well as minute marks.



GL1996/topolines

With the increased use of Global Positioning Systems (GPS) — devices which use satellite signals to give your position on the Earth's surface — being able to use latitude and longitude is becoming an important skill. All activities in this kit use latitude and longitude references.

### Legend

A topographic map shows landforms (topography) and landuse as well as cultural features such as roads, railway lines, homesteads, towns, etc. The legend on the topographic map is self-explanatory. However, contours and spot elevations will be used or referred to in the activities.

#### *Contours*

Contours are lines on a map that join points of equal elevation (above sea level). On the Mt Todd Topographic Special Map the contour lines are brown and each contour line is 20m higher (or lower) than the next contour line. This is referred to as the contour interval. Those contour lines representing 100s of metres have the number written on them and are slightly thicker.
Contour lines which are close together show steep slopes. When the slope becomes so steep that it forms a cliff, a different symbol is used.

#### *Spot Elevations*

As well as contour lines, the Mt Todd Topographic Special Map has marked points of known height — spot elevations. These spot elevations are marked across the map and are in metres above sea level.

### Climatic Information

Climatic information for the area is summarised on the map in two graphs — temperature (pink) and rainfall (blue). The information shows that the region has minimal variation in temperature throughout the year with a pronounced wet and dry season. Although inland (see location map on the geological map face), the area is under the monsoonal influence of the Arafura Sea.

## Vegetation and Geology

Because the geology often governs the landforms as well as the type of soil that develops, the vegetation cover of many areas is directly affected by the underlying geology. The Mt Todd area is covered by medium-density scrub. However in the low lands produced by the erosion of the anticline, more scattered vegetation can be found.

## Landuse and Geology

In many areas these same geological factors will directly influence the landuse — rich soils on some volcanics will be used for intense farming, such as market gardens, while poor soils on other rocks may be used for grazing. A greater understanding of the relationship between the underlying geology and the vegetation and landuse will lead to a more sustainable development of these natural resources.

# Economic Geology

Numerous mineral deposits have been discovered in the Mt Todd area including gold (Au), tin (Sn), tungsten (W) and uranium (U). One of the important roles of the geoscientists is to study the relationships between the deposits and the surrounding rocks with the aim of developing a theory or model about the formation of the deposit. Once a model has been developed, mineral explorers can use this model to look for new deposits.

*History*

The first reports of mineral discoveries in the Mt Todd area were in the early 1870s when gold was being mined at Driffield to the north of Mt Todd. The rock containing the gold and tin was crushed using a battery — a device which consists of a number of pounding hammers which pulverise the material — then treated using a variety of methods to extract the metals. At the same time, some prospectors, many Chinese, were working alluvial deposits along the creeks.

The mining in the area closed down at the start of World War I and the deposits were abandoned.

During this time one explorer discovered deposits of tungsten — this was in the form of the mineral wolframite, $(Fe,Mn)WO_4$ — and the field, called the Yenberrie Wolfram Field, was worked briefly.

During the late 1930s some mining companies revisited the area and reworked some of the old mine dumps using new technology to remove any remaining metals. These companies moved the old battery to a new location — this is marked on the map as the New Mt Todd Battery. Further work started in the 1950s but lasted only a few years.

During the Korean War the demand for tungsten increased as it was needed for the manufacture of specialised alloys used in weapons, and some of the deposits in the Yenberrie Wolfram Field were worked for a few years.

In the 1950s the area was prospected for uranium. Numerous small prospects were discovered and some small exploratory shafts were developed. However none of these deposits were mined.

In the late 1980s small scale open cut gold mining took place in the Mt Todd area. In 1988 a mining company, Billiton Australia, discovered the huge Batman gold deposit which is currently owned and mined by Pegasus Gold Australia.

The Batman deposit comprises the main part of the Mt Todd Gold Mine (Latitude 14°8' Longitude 132°6') although a number of neighbouring prospects are planned to be mined.

## Deposit Geology

The mineral deposits in the Mt Todd area can be divided into three types —

- Deposits in the Cullen Granite
- Deposits in the Burrell Creek Formation
- Alluvial deposits

### *Deposits in the Cullen Granite*

The Cullen Granite has a number of deposits of uranium (U) in the southern main body and tungsten (W) in the small body marked 'Hores Lode'. The northern part of the Cullen Granite has one small tungsten deposit but the rest is barren. The deposits occur as concentrations within the granite — they do not appear to be associated with any dykes or other feature.

### *Deposits in the Burrell Creek Formation*

Within the Burrell Creek Formation and the Cullen Granite exist numerous dykes or veins — these are marked on the map. Many of these veins are made of the mineral quartz and can contain small amounts of gold. Other veins contain sulfide minerals such as pyrite ($FeS_2$) and also contain some gold. These gold bearing deposits tend to form a line which runs from around the Mt Todd Gold Mine towards the north -east. Geologists working in the area refer to this as the 'gold corridor'. Numerous historical workings can be found within the corridor such as the Jones Bros. workings and Quigleys Shaft. It is an interesting point that most of these prospects occur on hills — possibly the hill has formed as the veins are more resistant to weathering and erosion than the surrounding Burrell Creek Formation. The Mt Todd Mine was working these quartz and sulfide veins within the gold corridor until recently.

Within the Burrell Creek Formation is another corridor running roughly north to north west. This is the tin corridor and contains the historical workings marked as Morris, the Horseshoe Tin Field and the Emerald Creek Tin Field. These deposits do not seem to be associated with the dykes.

### *Alluvial Deposits*

Erosion of the existing deposits releases the metals into the local creeks. Over time these can become concentrated by stream deposits forming alluvial deposits. Both gold and tin alluvial deposits are found in the area and both have been worked by prospectors and some small companies.

## Mt Todd Gold Mine

The Mt Todd Gold Mine operated on a large-tonnage - low-grade ore body This means that while the concentration of gold in the deposits is very small, the size of the deposit is so large that the operation was economic until the price of gold fell and the mine closed in November 1997.

Most of the known gold at Mt Todd occurs within the Batman deposit. Gold mineralisation in the Batman deposit occurs mainly in thin quartz-sulfide (mainly pyrite near the surface and pyrrhotite at depth) veins within interbedded shales and greywackes of the Burrell Creek Formation.

The ore reserves at the Batman pit (Dec 94) were 104.28 million tonnes with each tonne containing 1.05g of gold.

# Aboriginal Perspective

Geologists have collected data and translated this into a map. The map is a scientific interpretation of the Mt Todd area. It tells a story of the events which have occurred to form the area. The Jawoyn Association has provided another interpretation of the Mt Todd area. The stories have been passed from generation to generation, leaving a record of how the Mt Todd area was formed. The stories tell of sacred sites and significant events which have formed this land.

## Traditional Areas around Edith Falls

Edith Falls is a popular tourist destination that is 60 km from Katherine. Jawoyn Traditional Owners of this area have sacred and significant sites located on and around Edith Falls.

> The *Edith Falls pool* is a significant place and stories from the Traditional Elders tell that the main pool was created and inhabited by 'Bolung' or the Rainbow Serpent Spirit. The name the Traditional Owners called this site is 'Djapurrdu': Back then it was an important place that young women were not allowed to go to. During ceremonies the young men were not allowed to drink from the pool for fear that 'Bolung' would be watching and waiting to take them away. Because of this the Elders had to collect water for them.
>
> In an area near the Edith Falls is a place called *Werenbun Outstation* and back then this was a camping site. In this area there is another dreaming site called 'Munjelk' in the form of a billabong. The Elders tell that a falling star landed here and turned into a Rainbow Serpent which inhabited this billabong.
>
> Five kilometres from Werenbun Outstation is the Mt Todd Gold Mine. In this area there are three sites. First there is *Mt Todd* or 'Djinbirrdi'. The story behind this place tells that the Plain Kangaroo or 'Gupu' who was a business man had rested here and before leaving gave Mt Todd this name.
>
> The second site near Mt Todd is the *Yinberrie Hills* which is inhabited by the Gouldian Finch or 'Unjmuygolo' In this area is a quarry where the men made spears and stone axes. The Traditional Owners named this place 'Louk'. Also near this area is a hill which inhabited 'Momnem' or Devil Devil Dreaming.

* All information gathered from Peter Jatbula - Senior Jawoyn Traditional Elder

* All information collected by Noel Hogan - Parks and Tourism Assistant

# Australian Geological Survey Organisation

The Australian Geological Survey Organisation (AGSO) was established in 1946 (as the Bureau of Mineral Resources) to provide a national geological survey focus during the post-war boom period. Since this time the Organisation has been instrumental in the discovery of numerous mineral and petroleum deposits and continues to provide the very best survey data and geological advice to government, industry and research institutions.

## Geological Map Sales

After using this book, why not obtain the geological map of your own area? Information on the current availability and prices of geological maps can be obtained from :

AGSO Sales Centre
Constitution Avenue
Parkes, ACT 2600
ph (02) 6249 9519
fax (02) 6249 9982

Email : sales@agso.gov.au
WWW: http://www.agso.gov.au

or

Reply Paid Service 538
AGSO Sales Centre
GPO Box 378
Canberra ACT 2601
(no stamp required)

# Australian Surveying & Land Information Group

The Australian Surveying and Land Information Group (AUSLIG) is the Australian Government's civilian surveying, mapping and land information agency. AUSLIG was established in 1987 from the amalgamation of the Australian Survey Office and the Division of National Mapping. Its responsibilities include the production and maintenance of national and regional spatial datasets in both digital and graphical form, and the reception and processing of remotely sensed satellite imagery of the Australian continent. A major part of this task involves the provision of topographic mapping information at the national scales of 1:100 000, 1:250 000 and smaller.

## Topographic Map Sales

Why not obtain the topographic map of your own area ? For copies of your map visit your local map retailer or contact AUSLIG:

AUSLIG Map Sales
PO Box 2
BELCONNEN ACT 2616
Free call : 1 800 800 173
Fax : 06 201 4381
WWW : http://www.auslig.gov.au
Email : mapsales@auslig.gov.au

# Glossary

**Aeolian** — wind-blown deposits, such as sand dunes

**Alluvium** — river sediment

**Amphibolite** — a type of dark metamorphic rock

**Basalt** — a dark-coloured fine-grained volcanic rock (see igneous rock classification diagram at the end of this glossary)

**Calcareous** — contains calcium carbonate, the material from which shells and coral are made

**Chert** — extremely fine-grained rock made up of silica. It is very hard and breaks with sharp edges and has therefore been prized by stone-tool making cultures

**Claystone** — a sedimentary rock made up of particles of clay

**Colluvium** — loose deposits of rocks and rubble found at the bottom of slopes or cliffs

**Conglomerate** — a sedimentary rock containing rounded pebbles cemented together

**Dacite** —a dense volcanic rock, rich in quartz (see igneous rock classification diagram at the end of this glossary)

**Dolerite** — a dark-coloured igneous rock with coarser crystals than basalt

**Dolomite** — a sedimentary rock like limestone, but which contains a large amount of the magnesium-bearing carbonate mineral, dolomite (the same name). This rock type is often called dolostone.

**Duricrust** — a hard crust of soil formed in semi-desert regions by the crystallisation of salts as water evaporates from the soil

**Dyke** — a sheet like igneous intrusion which cuts across the surrounding rocks

**Evaporite** — concentration of minerals which have crystallised due to the evaporation of high saline or alkaline water

**Evaporitic** — formed from the evaporation of water, such as sea salt (called halite)

**Feldspar** — a common rock-forming silicate mineral, less chemically stable than quartz

**Feldspathic** — containing the mineral feldspar

**Ferruginous** — containing lots of iron; these rocks often look 'rusty' in colour

**Fluvial** — produced by a river

**Gneiss** — a coarse-grained banded crystalline rock

**Granitic, granite** —coarse and medium-grained igneous rocks rich in quartz and feldspar (see igneous rock classification diagram at the end of this glossary)

**Greywacke** — a muddy sandstone

**Gypsum** — a white or colourless mineral; blackboard chalk is made from gypsum

**Halite** — rock salt, which has cube-shaped crystals

**Lacustrine** — produced by/or in a lake

**Lamproite** — a very unusual dark-coloured igneous rock which has formed from molten rocks being forced up from deep below the surface; these rocks can sometimes contain diamonds

**Limestone** — a bedded sedimentary rock composed mainly of calcium carbonate (calcite)

**Marine** — caused by the sea

**Marl** — a soft, unconsolidated rock, made up of a mixture of clay and calcium carbonate mud

**Metabasalt** — a metamorphosed basalt

**Mudstone** — consolidated mud, deposited in a sedimentary environment, especially in still water

**Phosphorite** — amorphous, grey, brown or black, thin-bedded, dense, powdery, or nodular calcium phosphate with phosphatised shelly fossils

**Phyllite** — an argillaceous (composed of clay) rock intermediate in metamorphic grade between slate and schist

**Plutonic** — used to describe rocks that have been formed beneath the surface of the Earth from the slow cooling of magma (see igneous rock classification diagram at the end of this glossary)

**Porphyry** — an igneous rock which contains large crystals in a groundmass of very fine crystals

**Pyroclastics** — pieces of rock ejected from a volcano

**Quartzite** — metamorphic rock consisting mostly of the mineral quartz

**Rhyolite** — a pale fine-grained volcanic igneous rock (see igneous rock classification diagram at the end of this glossary)

**Sandstone** — a bedded sedimentary rock composed of sand-sized grains, generally quartz

**Schist** — a medium-grained metamorphic rock with a wavy banding (schistosity)

**Shale**— layered sedimentary rock formed from fine muds and clays — it is usually soft and weathers rapidly

**Siliceous** — containing silica — which is the mineral quartz

**Sill** — an intrusive body of igneous rock of approximately uniform thickness and relatively thin which is squeezed between the layers of country rock

**Siltstone** — a fine-grained rock composed of particles of silt

**Tillite** — a sedimentary rock composed of cemented rock fragments deposited by a glacier

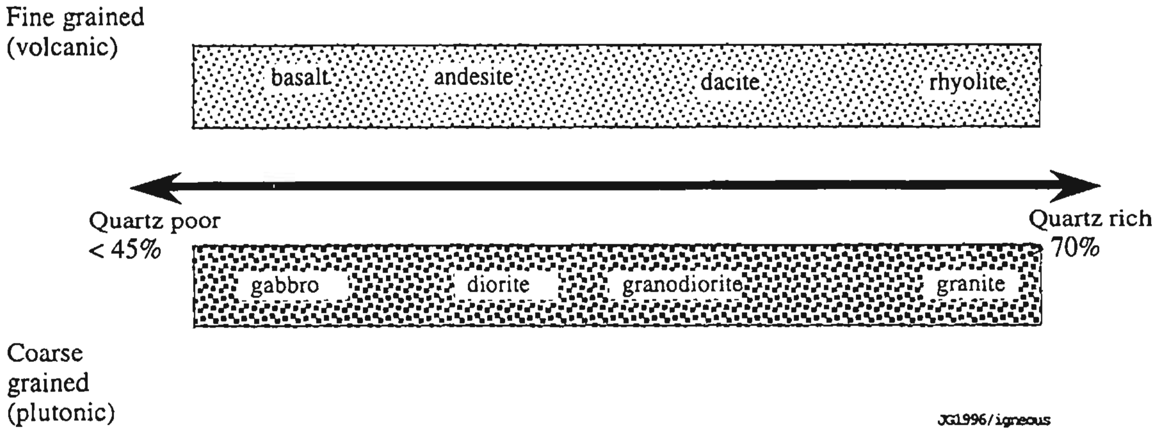
**Toscanite** — or rhyodacite, a volcanic rock, composition halfway between that of dacite and rhyolite

**Tuff**— a sedimentary rock, composed of fine particles of volcanic ash and dust

**Ultramafic** — an igneous rock which contains no quartz; the rock is very dark in colour; the molten rock which cools to form these rocks comes from within the Earth's mantle beneath the crust

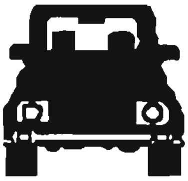
**Volcanic** — igneous rocks that have been poured out on to the Earth's surface

Igneous Rock Classification



INTRODUCTION TO GEOLOGICAL MAPS

# Activities



# THE GREAT OUTDOORS!

## 4 WHEEL DRIVING

You and your friends decide to go for a day trip around the Mt Todd area. You plan to depart from Katherine and have lunch and a swim with the freshwater crocodiles at Edith Falls. What supplies will you need to take? The 4 wheel drive uses 18 litres of petrol per 100km. How much petrol will you need in order to get there and back? Remember, your 4 wheel drive can't drive over cliffs! You will have to plan out a route which will get you there safely. Use the compass rose on the map card and refer to both the geological and topographical map to plan which way you will go once you reach the edge of the map (from Katherine).

Supplies✍ ____________________________________________

____________________________________________

Petrol✍ ____________________________________________

Route (you may draw a diagram using compass bearings showing direction and distance to illustrate your answer)

✍ ____________________________________________

____________________________________________

____________________________________________

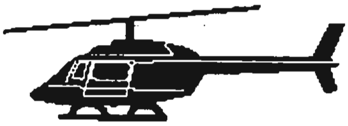
____________________________________________

You decide to collect a few rock samples from your trip. What samples do you think you might include? (ie. what *types* of rock, etc)

✍

____________________________________________

# TODD TOURS TRAVEL



Todd Tours Travel runs helicopter tourist flights around the Mt Todd area. Imagine you are the navigator on the flights. The helicopter has a GPS (Global Positioning System). By the push of a button, the pilot is able to find out the position of the aircraft in latitude and longitude. Your job is to provide the pilot with the correct latitude and longitude references in order to fly over the tourist attractions outlined in the flight itinerary. The pilot has requested that the lat/long references be converted to decimal.
Find the locations on the map and use the map card to work out the lat/long references.
Write these onto the itinerary then convert them to decimal.
To convert from degrees and minutes to a decimal figure, divide the minutes by 60.
Example:
132° 05' = 132° plus 5/60°

therefore 132° 05' = 132.0833°

Complete the information sheet for the pilot.

✍ **TODD TOURS TRAVEL** **HELICOPTER FLIGHT ITINERARY**

| Destination | Latitude | (decimal) | Longitude | (decimal) |
|---|---|---|---|---|
| Lucy's Camp | | | | |
| Mt Todd | | | | |
| Edith Falls | | | | |
| Emerald Creek Tin Field | | | | |
| Pegasus Gold Mine | | | | |
| Connell's Camp | | | | |

**uh oh.............** The GPS on the helicopter has gone down! The pilot can no longer use it to find out his whereabouts! This is where the skills of the navigator are essential! You must navigate your way back to Lucy's Camp using only the map and a compass. In what direction should the pilot fly to get there from Connell's Camp?

✍ ____________________________________________

# PIECING TIME, LIFE AND ROCKS TOGETHER

Have a look at the face of the geological map.

1. How could you work out an approximate area of each of the rock groups?

✍ ____________________________________________

____________________________________________

____________________________________________

2. Which rock group (Mullaman Beds, Katherine River Group, Cullen Granite or Finniss River Group) takes up the greatest area?

✍ ____________________________________________

3. Which rock category (igneous, sedimentary or metamorphic) takes up the greatest area?

✍ ____________________________________________

4. The Quaternary layers, pale yellow in colour, are made up of soil and unconsolidated sand and gravel known as alluvium. What topographical feature do these layers represent?

✍ ____________________________________________

5. Which rock group was being formed when Humans first evolved on Earth?

✍ ____________________________________________

6. Which rock groups were present when the dinosaurs were the dominating species on Earth?

✍ ____________________________________________

7. The Mt Todd Geological Map has its rock types summarised in a legend down the right-hand side of the sheet. Look at the fine print about the types of rocks found in each of the rock layers then write the major rock group (igneous, sedimentary or metamorphic) against each of the rock formations found on the map on the Mt Todd Legend Sheet.
Use the Student Activity Data Sheet for help.

8. ✂ Cut out the pictures of various life forms and fossils and stick them onto the Mt Todd Legend sheet in the space provided. To do this correctly, refer to the Geological Time Scale, and work out which forms of life would have been occurring at the time that the rock was deposited.

# FINDING YOUR WAY AROUND THE MAP

## Using the Map Card

The map card provided in the Map Kit includes tools to measure latitude and longitude, scale, and direction. Use the map card to help you to solve these problems.

✍

1. Use a thick felt tip pen to make a dot on a blank piece of paper. Measure the diameter of the dot.
Diameter of dot =________________mm

How big would this dot be if it was an area on the Mt Todd Map?______________km
Hint: 1 cm = 75,000 cm = 750 m = 0.75km

2. Stick a pin through a piece of paper. Measure the size of the hole.

size of hole = ________________mm

How big would this hole be if it represented a hole in the surface of the Earth on the Mt Todd map?

________________km

3. Using the map card, measure the distance between the following points:

a) Lucy's Camp and Connell's Camp?________________________

b) Emerald Creek Tin Field and the Pegasus Gold Mine?

________________________

4. Use a piece of string to help you measure the length of the Fergusson (string bends, rulers don't). First measure the distance in cm, then convert this to km.

Length of the Fergusson river = ____________km

5. How far is the summit of Mt Todd from the the Mt Todd Gold mine?_________km

6. The Mt Todd map uses a scale of 1: 75,000. Find out what is the most commonly used scale on geological maps produced in the 1990's.

____________________________________________________________

# MT TODD LEGEND SHEET

Life Forms

**ROCK GROUP**
**igneous, sedimentary, metamorphic**

**AGE**
**oldest possible age in millions of years**

CAINOZOIC

QUATERNARY

☐ - - - - - - - - - - - - - - ____________ ____________

MESOZOIC

LOWER CRETACEOUS

Mullaman Beds

☐ - - - - - - - - - - - - - - ____________ ____________

PRECAMBRIAN

UPPER PROTOZOIC

Katherine River Group

Kombolgie Formation

☐ - - - - - - - - - - - - - - ____________ ____________

Henwood Creek Volcanic Member

☐ - - - - - - - - - - - - - - ____________ ____________

McAddens Creek Volcanic Member

☐ - - - - - - - - - - - - - - ____________ ____________

Edith River Volcanics

☐ - - - - - - - - - - - - - - ____________ ____________

Phillips Creek Member

☐ - - - - - - - - - - - - - - ____________ ____________

LOWER PROTOZOIC

AGICONDIAN SYSTEM

Cullen Granite

☐
☐
☐
☐ - - - - - - - - - - - - - - ____________ ____________

Finniss River Group

Burrell Creek Formation

☐ - - - - - - - - - - - - - - ____________ ____________

✂ Cut these pictures out and stick them next to the relevant rock group

dinosaur

flowering plant

homo sapien

bacteria

# SPECIAL ASSIGNMENT: PROJECT PROSPECTOR

You are in a police forensics team. The police have found the body of a person in the area of Mt Todd. With the body they found a journal, samples of rocks and some gold nuggets. There does not *seem* to be any foul play but the journal indicates that the person was not alone in his journey, and the police would like to find out from where the gold ore was collected. Only one body has been found. Where was the other person at the time of death? Where are they now? Could they be at the place where the gold was found? There are many possible sites for gold mines on this map. Which site did the gold come from? You must use your special knowledge of geology and your geological map reading skills to crack the case.

The body was found at 132° 10' E and 14° 11' S. (In the Phillips Creek Member rock group)

The rock samples were found to be:
- basalt
- siltstone
- shale
- dacite
- sandstone
- rhyolite

The person was also carrying some samples of fossils and 5 small gold nuggets.

The journal was partly destroyed due to decomposition. You will need to use it together with the map and the map card to work out the route of the "prospector" and therefore where the gold has come from.
At some stages the journal is hard to read and you will have to fill in the gaps!

*10 March*
*The rangers dropped us off at the base of Edith Falls, with a warning to watch out for crocs! Our boots got their first taste of soil since Katherine. We collected a few samples of the local rock, which seemed to be a mixture of volcanics, including..............*

*........so then we set up camp. We needed a good night sleep to start our journey fresh in the morning.*

What types of volcanic rock did the prospector sample at this site?

✍ ______________________________

What was the person's approximate latitude and longitude when they made this journal entry?

✍ ______________________________

*11 March*

*We decided to climb up the cliff of the falls, and follow the river for about 2 km. At the top of Edith Falls the rock seemed to change. We collected some sandstone, which was very rich in quartz, then continued along the river.*

In what rock group are they located?

✍ ______________________________

*Walking upstream we found another type of volcanic rock.*

What type of volcanic rock is this?

✍ ______________________________

Is this rock older or younger than the volcanic rocks already collected?

✍ ______________________________

*We stopped for lunch here, a very pleasant spot near the water. There must have been heavy rainfall recently, as the river was overflowing. Further upstream we came across some rapids. Here we found some more sandstone. We walked a little further and found some more volcanics.*

What type of volcanic rock do you think this is?

✍ ______________________________

What rock group are they located in now?

✍ ______________________________

*We tried to cross the river at this point, when we were overcome by the rapids and started floating down stream. It was a rough ride, but we survived it. The scariest part was landing at the bottom of the falls amongst all the crocodiles! They didn't seem to be too disturbed by us, so they left us alone. Phew!* ..........

*12 March*

*We decided not to go back up the falls, but to walk along the base of the cliff on the border between the two rock types*...........

Which rock types are these?

✍ ______________________________

*We found some faults on the volcanic rock and a new rock type. This rock is slightly metamorphosed in some areas and seems to be folded. By my calculations our co-ordinates are 132° 12 'E latitude and 14° 10 ' S longitude.*

What types of rock are found in this area?

✍ ______________________________________________

What is the name of the rock group it is in?

✍ ______________________________________________

Compared to all the rocks on the map, how old are these rocks?

✍ ______________________________________________

What is the name of the metamorphosed rock?

✍ ______________________________________________

*13 March*

*Today we headed NE (at a bearing of 045° ) for about 4 km, where we found a huge fault.*

What are the latitude and longitude co-ordinates at this site?

✍ ______________________________________________

Which two rock units are being offset by this fault at this site?

✍ ______________________________________________

*We then continued for about 5km at a bearing of 67.5 'E. Here we collected fossils. — Some very rare and worth a lot of money. We will try to sell them when we get back to town!*

What is another way of describing this direction?

✍ ______________________________________________

What rock type are they at now?

✍ ______________________________________________

What type of fossils do you think they have found? (Think what animals and plants live in the environment in which these rocks have formed)

✍ ______________________________________________

*14 March*

*Today we trekked due north for about 6 km, collecting more fossil samples along the way. Of course Jess has her eye on the rare fossils, always trying to think of a get-rich-quick scheme......We kept walking towards north and stopped for the night when we reached the next geological boundary between the two sandstones.*

What is the name of the rock group containing the younger sandstone?

✍ ______________________________________________

*15 March*

*Today we changed direction and headed west for about 9 km. Jess stopped to get a drink and gave me a huge fright! I thought she'd been bitten by a snake by her loud shout. She'd found gold! She'd been dipping her hat in the water, and noticed the glitter. If there's gold in the river, there must be gold in the ground! We'll look tomorrow....*

What Latitude and longitude are they at now?

✍ ______________________________________________

*16 March*

*Yes! We've been able to confirm that there is a significant source of gold here! We'll have to leave it for a while though, while we return to Katherine for some more supplies and equipment....Jess is concerning me, she doesn't even want to leave his precious gold site....She doesn't seem keen to share it with anyone either.... I'd better watch my back on our return to Katherine! We hope to be at Edith Falls by tomorrow night. I've packed heaps of water...I hope its enough........*

This is the last known journal entry. The body of the "prospector" was found on the 28 March. Did he die of thirst? If so, why didn't Jess die too? Where is Jess? Maybe this fax message to the Katherine Police gives a clue....

Fax to: Katherine Police Dept.
From: Rochford's Camping and Mining Supplies
Date: 24 March

I would like to report that my jeep was stolen yesterday! My jeep is red, with licence plate number BOM 123.

A suspicious character was in here yesterday. She used a credit card to buy lots of supplies. After she left I checked the credit card imprint more thoroughly and noticed that the card was under the name of a Mr A. Mynor.

The jeep was my only mode of transport. Please find it!

The police need the following information from you to solve the crime....

Where is the gold site located (in lat/long)? Also, what is the name of the adjacent gold field. (so the police can look for Jess...)

✍ ______________________________________________

Well Done!
Thanks to your help, the police have located Jess at the gold site with the Rochford's jeep. She swears that she "never returned with Mr A Mynor" to his place of death. She says "He mustn't have taken enough water with him........"

What evidence have we already got which may suggest Jess's guilt?

✍ ______________________________________________

________________________________________________

________________________________________________

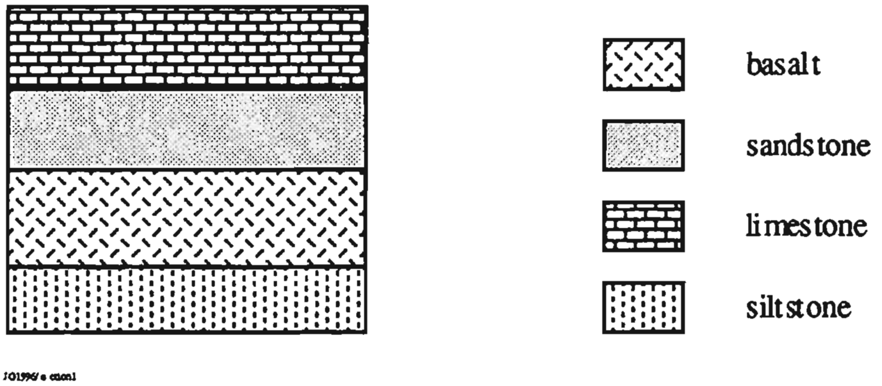
There is one crucial bit of evidence that can lock Jess away....It's all up to you.....
If Jess was with Mr A Mynor when he died, what type of rock sediments might you find on her shoes? (pick one which definitely PROVES she was there)
*Hint: Where was the body found?*

✍ ______________________________________________

# CROSS-SECTIONS TELL A STORY

Cross-sections are useful because they tell a story. They tell a story of which rocks have been deposited, and in what order. If you use a little of your imagination, a cross-section can even tell a story of what the Earth was like at the time the rock was deposited. (eg: if there is basalt , a volcano must have been there at some time; if there are fossils of marine life, there must have been an ocean present at some time; etc.) In this activity you are going to tell the stories of some cross-sections. You'll start off on some simple ones and work up to the Mt Todd cross-section. (which is also quite simple)

**Cross-section 1**



Which is the oldest rock layer in this cross section?

✍ ____________________________________________

Which is the youngest rock layer in this cross section?

✍ ____________________________________________

In which layer(s) might you find fossils? Why?

✍ ____________________________________________

Which layer might be slightly metamorphosed? Why?

✍ ____________________________________________

______________________________________________

Write a story about the sandstone layer. How do you think it was formed? What was the environment like at the time?

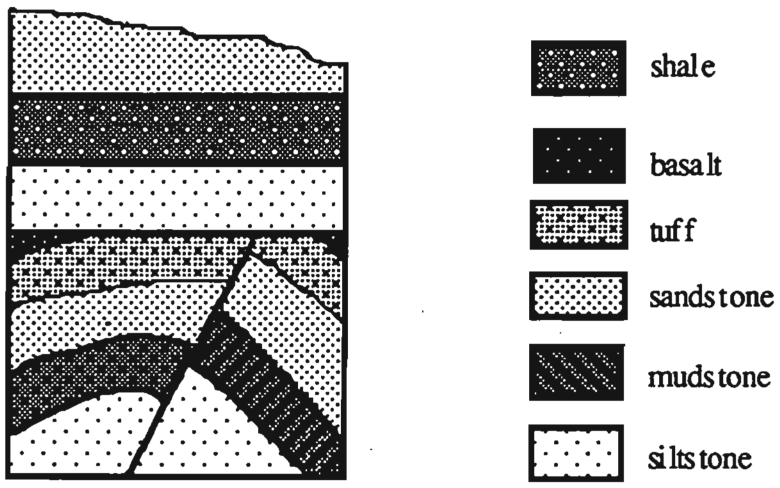
✍ ____________________________________________

______________________________________________

______________________________________________

**Cross-section 2**

*This cross-section shows that the rock layers have been folded and faulted. There is also an unconformity.*



There are two layers of siltstone. Which is the youngest layer?

✍ ______________________________________________

The bottom layers have been folded. Is this an anticline or a syncline?

✍ ______________________________________________

The bottom layers have also been faulted. Is this a normal or a reverse fault?

✍ ______________________________________________

Did the faulting occur before or after the folding? How do you know?

✍ ______________________________________________

Explain what is meant by an "unconformity".

✍ ______________________________________________

________________________________________________

________________________________________________

Draw an arrow on the diagram pointing to the unconformity.

List the order of events of the deposition, folding, faulting, etc, of the rock layers in this cross-section. (from first to last in chronological order)

✍ ______________________________________________

______________________________________________

______________________________________________

______________________________________________

______________________________________________

______________________________________________

______________________________________________

Finally, tell a brief story of how the following rock types might have occurred.

**tuff**

✍ ______________________________________________

______________________________________________

______________________________________________

______________________________________________

**mudstone**

✍ ______________________________________________

______________________________________________

______________________________________________

______________________________________________

______________________________________________

______________________________________________

## The Mt Todd Cross-section

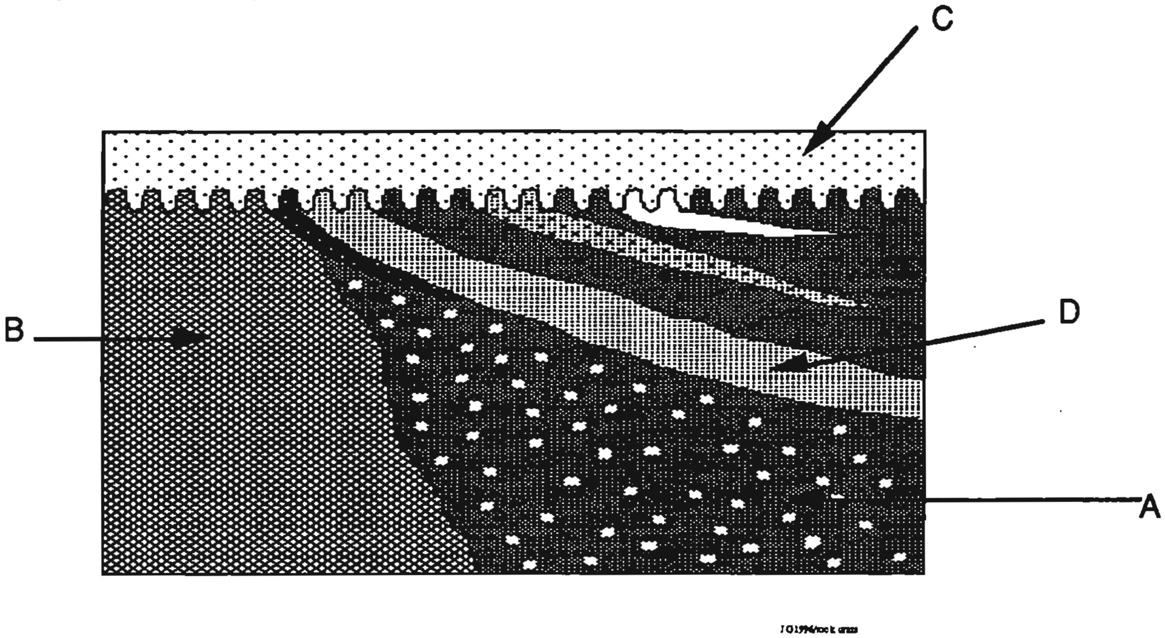
Now let's have a look at the Mt Todd Map cross-section. This section has been taken from the point A - B marked on the map.

### Diagram 1 - Cross-section A - B

Refer to the coloured cross-section on the bottom of the map as well as the legend for details about the rock types in this cross-section.

The diagrammatic relationship of the rock units is also a useful tool for telling the stories about the events which formed the rock layers in the Mt Todd area. The diagram below is a representation of the diagrammatic relationship of the rock units on the lower left side of the map.

### Diagram 2 - Diagrammatic relationship of the rock units



The first group of questions refers to Diagram 2.

Name the rock units labelled in the diagram.

A______________________________B______________________________

C______________________________D______________________________

What type of rock are each of these rock units made up of?
(ie metamorphic, igneous or sedimentary)

A______________________________B______________________________

C______________________________D______________________________

Write down the order in which those rock units were deposited. (be careful with A and B — Discuss this with your teacher first.)

(eg A then B then C then D)________________________________________

Which rock layer is the youngest?________________________________________

**Label** the major unconformity on the diagram of the relationship of rock units.

The next group of questions refers to Diagram 1, the cross-section.

In this cross-section, there is some folding shown. Label the folding, and indicate whether it is in the form of synclines or anticlines.

**Label** the fault.

Is this a normal or reverse fault?________________________________________

**Label** the oldest rock unit.
What is the name of this rock unit?________________________________________

**Label** the youngest rock unit.
What is the name of this rock unit?________________________________________

# FINDING YOUR WAY AROUND THE TOPOGRAPHICAL MAP

1. Where is the highest point on the map? 2. What is the spot elevation here?

✍ (lat/long)____________________ ✍ (lat/long)____________________

3. On what rock formation does this place occur?____________________

4. Where is the lowest point on the map? 5. What is the spot elevation here?

✍ (lat/long)____________________ ✍ (lat/long)____________________

6. Name 3 human made features shown on this map.

✍ ____________________________________________

7. What is the maximum height of Mt Todd? 8. Where would you find a swampy area?

✍ ____________________ ✍ (lat/long)____________________

9. What are the lat/long co-ordinates for Edith Falls?✍____________________

10. Give the lat/long co-ordinates for where Seventeen Mile Creek enters the National Park.

✍ ____________________________

11. In which direction does Seventeen Mile Creek flow? 12. Describe the *majority* of the vegetation.

✍ ________________________ ✍ ________________

13. What colours are the following features:

rivers✍____________________contours✍____________________

power lines✍____________________sealed roads✍____________________

unsealed roads ✍____________________

# ORIENTEERING EXERCISE

Imagine you are going on an orienteering exercise around the Mt Todd area. At the end of the exercise there is a greeting party waiting to welcome you and feed you a fantastic BBQ feast. You have only a compass to show you the way. Good luck!

**Start** at the Pinnacle. (there is only one on the map — see the legend for the symbol)

Walk for 13 km at a bearing of 310°.

What topographical feature do you find here? ✍ ______________________________

How will you cross it? ✍ ______________________________

Walk on a bearing of 63° for 8 km. What feature are you standing on now?

✍ ______________________________

What is the height of this feature? ✍ ______________________________

Walk for another 3.5 km on a bearing of 350° .

What metal might you find here? ✍ ______________________________

Walk WSW for 12.8 km. What human made feature to you find here?

✍ ______________________________

If the BBQ is at the bridge over the Edith River, in which direction will you have to walk now?

✍ ______________________________

For what distance? ✍ ____________________

# MT TODD ADVENTURE SPORTS LAND

You are an aspiring entrepreneur. You have decided to invest in a new adventure sports facility in the Mt Todd area. There are many natural features in this area which make the area an ideal adventure sports location. Part of your job will be to decide which sites are best suited to each adventure activity.

**Task 1**

Below is a list of the proposed activities and some suggestions for where they might be located. You will need to refer to the map and choose the best location for each activity. Make sure that you look carefully on the map, and check that there are no obstacles which may interfere with each activity.

| ACTIVITY | PROPOSED LOCATIONS | YOUR CHOICE |
|---|---|---|
| Abseiling | 132 ° 05’ 00” E 14° 10’ 00”S | |
| | 132° 12’ 00” E 14° 09’ 00” S | ✍ ____________ |
| | 132° 20’ 00” E 14° 10’ 00” S | |
| White water rafting | 132° 01’ 00” E 14° 03’ 00” S | |
| | 132° 11’ 00” E 14° 11’ 00” S | ✍ ____________ |
| | 132° 26’ 00” E 14° 10’ 00” S | |
| Airborne Rappelling | 132° 12’ 00” E 14° 04’ 00” S | |
| (jumping out of a helicopter on a rope) | 132° 03’ 20” E 14° 10’ 80” S | ✍ ____________ |
| | 132° 02’ 00” E 14° 10’ 00” S | |

**WHY** did you choose these particular sites for these activities?

Abseiling

✍ ________________________________________

________________________________________

White water rafting

✍ ________________________________________

________________________________________

Airborne rappelling

✍ ________________________________________

**Task 2**
Below is a list of some more proposed activities. Look on the map and choose the best site for each of them. (write this in lat/long) Give a reason for your choice.

Gold panning

✍ ____________________________________________

____________________________________________

What rock formation would the gold be coming from? ____________________

Camping "out bush" in dense vegetation

✍ ____________________________________________

____________________________________________

Bird watching (hint: you may find lots of birdlife in a swampy area)

✍ ____________________________________________

____________________________________________

Rock climbing

✍ ____________________________________________

____________________________________________

What rock formation would you be climbing on? ____________________

Flying fox

✍ ____________________________________________

____________________________________________

**Task 3**
Think of one more activity, and choose a location for it. Explain why you have chosen this location.

✍ ____________________________________________

____________________________________________

**Task 4**
Choose a location for the main office for this Adventure Park.
Explain why you have chosen this location.

✍ ____________________________________________

____________________________________________

# LINKING GEOLOGY WITH TOPOGRAPHY

Geology is not just the study of rocks. It goes further than that. *Geology* means "the study of the Earth". Geological processes may take millions of years to complete the formation of sandstone layers, or they may only take a few seconds such as volcanic explosions. It is important to understand that these geological processes shape the surface of the Earth. In turn these rocks and structures themselves influence the other processes (ie biological) occurring on the the Earth's surface.

eg— a volcanic eruption can form a mountain — the soil on this mountain will be very rich in minerals — and therefore a fertile area to grow crops.

eg— limestone forms over millions of years from the remains of dead marine animals — the limestone will weather very easily because it is made of calcium carbonate, which deteriorates in acidic rain — this process will form caves — caves provide a good home for bats.

Can you think of any other examples where geology has influenced other processes on the Earth's surface?

✍ ____________________________________________

____________________________________________

____________________________________________

During this activity you will find out how the geology which has formed the Mt Todd area has influenced the topography.

A diagram highlighting the spot elevations for the area has been provided. You will be using this to work out which areas form topographic highs and lows.

**Step 1**
Look at the geology map. Compare it with the spot elevation diagram which shows geological boundaries. Try to locate the different rock units on the diagram. You may want to write the symbol for each rock unit on the spot elevation diagram.

**Step 2**
Find the Cullen Granite on the spot elevation diagram. Find the *average* height of the rock group. (to do this, find all the spot elevations, add them together then divide by the number of spot elevations you added together.)

Average height of Cullen Granite ✍ ______________(a)

### Step 3

Find the average height of each rock group by following step 2.

Average height of Finniss River Group ✍ ____________ (b)

Average height of the Edith River Volcanics ✍ ____________ (c)

Average height of_Phillips Creek Member ✍ ____________ (d)

Average height of
Mc Addens Creek Volcanic Member ✍ ____________ (e)

Average height of
Henwood Creek Volcanic Member ✍ ____________ (f)

Average height of Kombolgie Formation ✍ ____________ (g)

Average height of Mullaman Beds ✍ ____________ (h)

### Step 4

Find the average height of *all* the rock groups (to do this, add (a) - (h), then divide by 8.)

Average height of
all the rock groups in the Mt Todd area ✍ ____________ (i)

### Step 5

Look at the geology map again. Look carefully at the cross section. Two folds are shown. From left to right, there is a syncline, then an anticline.

The **syncline** is formed mainly from the following rock groups:

The Kombolgie Formation
The Mc Addens Creek Volcanic Member
The Henwood Creek Volcanic Member

Would you expect a syncline to form a topographic high, or a topographic low?

✍ ______________________________

Why?
✍ ______________________________________________

______________________________________________

Now let's find out....

## Step 6

Find the average height of the rock groups which form this syncline.

use this simple formula: $\frac{(e)+(f)+(g)}{3}$

Average height of syncline ✍ ____________________

Compare this figure with the average height of all the rock groups in the Mt Todd area. (i)

Is this syncline higher or lower than the average height of the area? ✍ ________________

Has the syncline formed a topographic high, or a topographic low? ✍ ________________

Why do you think this is so?

✍ ____________________________________________________________

____________________________________________________________

____________________________________________________________

## Step 7

The rock groups which form the **anticline** are:

The Finniss River group
The Edith River Volcanics

Would you expect this anticline to form a topographic high, or a topographic low?

✍ ______________________________

Why?

✍ ____________________________________________________________

____________________________________________________________

____________________________________________________________

____________________________________________________________

Now let's find out....

**Step 8**
Find the average height of the rock groups which form this anticline.

use this simple formula: $\frac{(b) + (c)}{2}$

average height of the anticline ____________________

Compare this figure with the average height of the rock groups in the Mt Todd area. (i)

Are the rocks in this anticline higher or lower than the rocks in the Mt Todd area?

✍ ________________________________________

Does the anticline form a topographic high, or a topographic low?

✍ ________________________________________

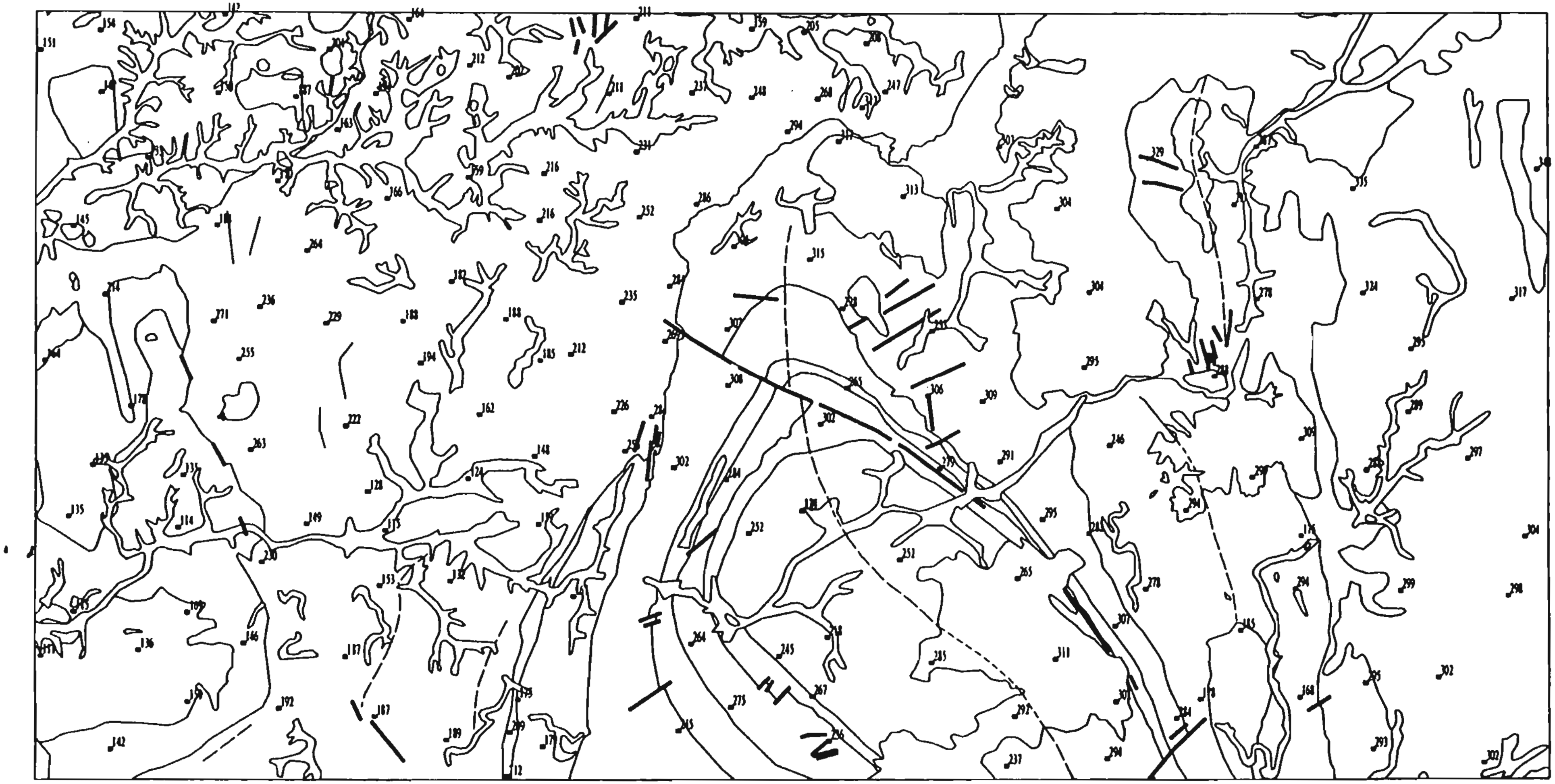
Why do you think this is so? Use the space below to daw a diagram to help explain your answer.

✍ ____________________________________________________________

______________________________________________________________

______________________________________________________________

# Mt Todd - Geological Boundaries and Spot Elevations



AGSO

AUSTRALIAN GEOLOGICAL SURVEY ORGANISATION

INTRODUCTION TO GEOLOGICAL MAPS

# Answers

## TODD TOURS TRAVEL

Todd Tours Travel runs helicopter tourist flights around the Mt Todd area. Imagine you are the navigator on the flights. The helicopter has a GPS (Global Positioning System). By the push of a button, the pilot is able to find out the position of the aircraft in latitude and longitude. Your job is to provide the pilot with the correct latitude and longitude references in order to fly over the tourist attractions outlined in the flight itinerary. The pilot has requested that the lat/long references be converted to decimal.

Find the locations on the map and use the map card to work out the lat/long references. Round the co-ordinates off to the nearest minute.
Example:
132° 10' 20" = 132° 10'

Write these onto the itinerary then convert them to decimal.
To convert from degrees and minutes to a decimal figure, divide the minutes by 60.
Example:
132° 05' = 132° plus 5/60°

therefore 132° 05' = 132.0833°

**TODD TOURS TRAVEL HELICOPTER FLIGHT ITINERARY**

| Destination | Latitude | (decimal) | Longitude | (decimal) |
|---|---|---|---|---|
| Lucy's Camp | 14°07' S | 14·1167°S | 132° 04'E | 132·0667°E |
| Mt Todd | 14°08' S | 14·1333°S | 132° 08'E | 132·1333°E |
| Edith Falls | 14° 11' S | 14·1833°S | 132° 11'E | 132·1833°E |
| Emerald Creek Tin Field | 14° 01' S | 14·0167°S | 132° 10'E | 132·1667°E |
| Mt Todd Gold Mine | 14° 08' S | 14·1333°S | 132°06'E | 132·1000°E |
| Connell's Camp | 14° 05' S | 14·0833°S | 132°07'E | 132·1167°E |

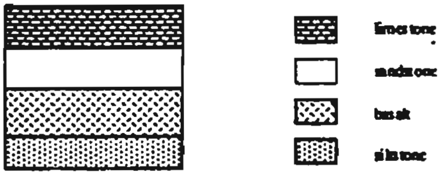
**uh oh**............The GPS on the helicopter has gone down! The pilot can no longer use it to find out his whereabouts! You must navigate your way back to Lucy's Camp using only the map and a compass. In what direction should the pilot fly to get there from Connell's Camp?
Bearing of 230° (approximately SW)

---

## CROSS-SECTIONS TELL A STORY

Cross-sections are useful because they tell a story. They tell a story of which rocks have been deposited, and in what order. If you use a little of your imagination, a cross-section can even tell a story of what the Earth was like at the time the rock was deposited. (eg: if there is basalt, a volcano must have been there at some time; if there are fossils of marine life, there must have been an ocean present at some time; etc.) In this activity you are going to tell the stories of some cross-sections. You'll start off on some simple ones and work up to the Mt Todd cross-section. (which is also quite simple)

**Cross-section 1**



Which is the oldest rock layer in this cross section?
siltstone

Which is the youngest rock layer in this cross section?
limestone

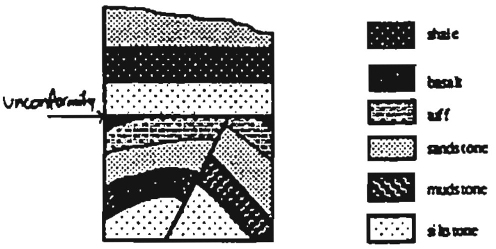
In which layer(s) might you find fossils? Why?
limestone, sandstone - formed in marine environments

Which layer might be slightly metamorphosed? Why?
sandstone or siltstone - basalt intrusion/flow would have heated the surrounding rocks, 'cooking' them

Write a story about the sandstone layer. How do you think it was formed? What was the environment like at the time? *Hint : Where is sand found today?*
Sandstone is formed from the deposition of sand sediments, which have settled out of water or wind. These sediments have been compressed and cemented together to form rock.

---

**Cross-section 2**
*This cross-section shows that the rock layers have been folded and faulted. There is also an unconformity.*



There are two layers of siltstone. Which is the youngest layer?
The one closest to the top.

The bottom layers have been folded. Is this an anticline or a syncline?
Anticline

The bottom layers have also been faulted. Is this a normal or a reverse fault?
Normal

*Extension Question* : Did the faulting occur before or after the folding? How do you know?
After, because the fault is not bent or broken

*Extension Question* : Explain what is meant by an "unconformity".
A geological boundary which indicates that a large amount of time has elapsed between the erosion of the older layers of rock and the deposition of younger rocks.

Draw an arrow on the diagram pointing to the unconformity.

---

List the order of events of the deposition, folding, faulting, etc. of the rock layers in this cross-section. (from first to last in chronological order)
Deposition of siltstone, deposition of mudstone, deposition of sandstone, deposition of tuff, eruption of basalt, folding, faulting, erosion, deposition of siltstone, deposition of shale, deposition of sandstone, erosion to present day landscape.

*Research Question* : Finally, tell a brief story of how the following rock types might have occurred.

**tuff**
A volcano erupts, exploding ash and other materials into the air. The fine ash settles over the countryside and may eventually solidify to form tuff.

**mudstone**
(similar to sandstone, but with finer sediments)
Mud has been compressed and cemented together to form rock.

### The Mt Todd Cross-section

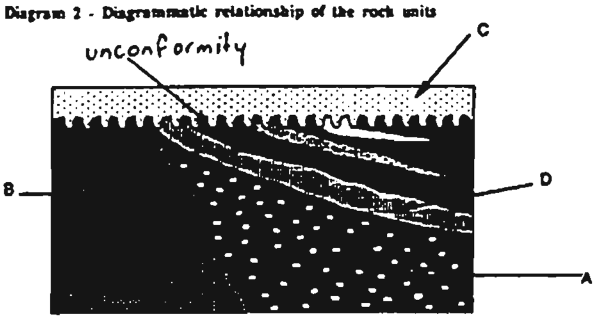
Now let's have a look at the Mt Todd Map cross-section. This section has been taken from the point A - B marked on the map.

**Diagram 1 - Cross-section A - B**

Refer to the coloured cross-section on the bottom of the map as well as the legend for details about the rock types in this cross-section.

The diagrammatic relationship of the rock units is also a useful tool for telling the stories about the events which formed the rock layers in the Mt Todd area. The diagram below is a representation of the diagrammatic relationship of the rock units on the lower left side of the map.

**Diagram 2 - Diagrammatic relationship of the rock units**



The first group of questions refers to Diagram 2.

Name the rock units labelled in the diagram.

A Burrell Creek Formation B Cullen Granite

C Quarternary D Edith River Volcanics

What type of rock are each of these rock units made up of?
(ie metamorphic, igneous or sedimentary)

A Mainly sedimentary (some meta) B Igneous

C sedimentary D mainly igneous (some sedimentary)

---

Write down the order in which those rock units were deposited. (be careful with A and B — Discuss this with your teacher first.)

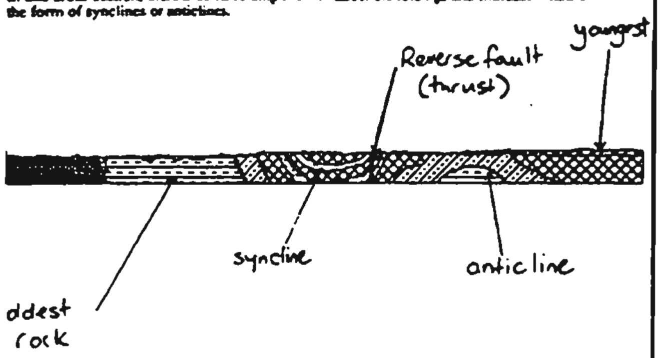
(eg A then B then C then D) A, B, D.C.

Which rock layer is the youngest? C

Label the major unconformity on Diagram 2. (Where does it appear that the rocks have been abruptly cut?)

The next group of questions refers to Diagram 1, the cross-section.

In this cross-section, there is some folding shown. Label the folding, and indicate whether it is in the form of synclines or anticlines.



Label the fault.

Is this a normal or reverse fault? Reverse (thrust)

Label the oldest rock unit.
What is the name of this rock unit? Burrell Creek Formation

Label the youngest rock unit.
What is the name of this rock unit? Quarternary

---

## SPECIAL ASSIGNMENT: PROJECT PROSPECTOR

You are in a police forensics team. The police have found the body of a person in the area of Mt Todd. With the body they found a journal, samples of rocks and some gold nuggets. There does not *seem* to be any foul play but the journal indicates that the person was not alone in his journey, and the police would like to find out from where the gold ore was collected. Only one body has been found. Where was the other person at the time of death? Where are they now? Could they be at the place where the gold was found? There are many possible sites for gold mines on this map. Which site did the gold come from? You must use your special knowledge of geology and your geological map reading skills to crack the case.

The body was found at 14° 11' S 132° 10' E. (In the Phillips Creek Member rock group)
The rock samples included:

basalt
siltstone
shale
dacite
sandstone
rhyolite

The person was also carrying some samples of fossils and 5 small gold nuggets.

The journal was partly destroyed due to decomposition. You will need to use the remains of the journal together with the map and the map card to work out the route of the "prospector" and therefore where the gold has come from.

Note: An example of a rock *unit* is the Henwood Creek Volcanic Member.
The rock *types* observed in the Henwood Creek Volcanic Creek Member are basalt, dacite and pyroclastics.
Do not confuse rock *units* with rock *types!*
Also - IGNORE the Quarternary unit (yellow) for this activity - it is not considered to be a rock, because it is made up of soil and alluvial sediments.

*10 March*
*The rangers dropped us off at the base of Edith Falls, with a warning to watch out for crocs! Our boots got their first taste of soil since Katherine. We collected a few samples of the local rock, which seemed to be a mixture of volcanics, including..............*

*.......so then we set up camp. We needed a good night's sleep to start our journey fresh in the morning.*

Hint: Check the topography map for the location of the rapids, and to find out the direction of the river flow.

---

What types of volcanic rock did the prospector observe at this site?
✍ Rhyolite, dacite, trachyandesite, pyroclastics.
some basalt, tuffaceous sediments

What was the person's approximate latitude and longitude when they made this journal entry?
✍ 14° 11' S 132° 11' (12') E

*11 March*
*We decided to climb up the cliff of the falls, and follow the river east wards for about 2 km. At the top of Edith Falls the rock seemed to change. We collected some sandstone, which was very rich in quartz, then continued along the river.*

In what rock unit are they located?
✍ Kombolgie Formation

*Walking upstream we found more types of volcanic rock.*

What types of volcanic rock are these?
✍ Basalt, pyroclastics

Are these rocks older or younger than the volcanic rocks already observed?
✍ Younger

*We stopped for lunch here, a very pleasant spot near the water. There must have been heavy rainfall recently, as the river was overflowing. Further upstream we came across some rapids. Here we found some more sandstone. We walked a little further and found some more volcanics.*

What types of volcanic rock do you think these are?
✍ Basalt, dacite, pyroclastics

What rock unit are they located in now?
✍ Henwood Creek Volcanic Member

*We tried to cross the river at this point, when we were overcome by the rapids and started floating down stream. It was a rough ride, but we survived it. The scariest part was landing at the bottom of the Edith falls amongst all the crocodiles! They didn't seem to be too disturbed by us, so they left us alone. Phew! ..........*

*12 March*
*We decided not to go back up the falls, but to walk along the base of the cliff on the border between the two rock units.........*

Which rock units are these?
✍ Edith River Volcanics and Kombolgie Formatio

*We found some faults on the volcanic rock and a new rock unit. This rock is slightly metamorphosed in some areas and seems to be folded. By my calculations our co-ordinates are 14° 8' S latitude and 132° 12' E longitude.*

What types of rock are found in this area?
✍ Siltstone greywacke phyllite
What is the name of the rock unit it is in?
✍ Burrell Creek Formation
Compared to all the rocks on the map, how old are these rocks?
✍ Oldest
What is the name of the metamorphosed rock?
✍ Phyllite

*13 March*
*Today we headed NE (at a bearing of 045°) for about 3.7 km, where we found a huge fault.*

What are the latitude and longitude co-ordinates at this site?
✍ 14° 06' 42" S 132°13' 24" E
Which two rock units are being offset by this fault at this site?
✍ Kombolgie Formation and McAdden's Creek Volcanic Member

*We then continued for about 5.5 km at a bearing of 67.5. Here we collected fossils. — Some very rare and worth a lot of money. We will try to sell them when we get back to town!*

What is another way of describing this direction?
✍ ENE
What rock unit are they at now?
✍ Mullamen Beds
What type of fossils do you think they have found? (Think what animals and plants live in the environment in which these rocks have formed)
✍ Marine fossils

---

*14 March*
*Today we trekked due north for about 6 km, collecting more fossil samples along the way. Of course Jess has her eye on the rare fossils, always trying to think of a get-rich-quick scheme......We kept walking towards north and stopped for the night when we reached the next geological boundary between the two sandstones.*

What is the name of the rock unit containing the younger sandstone?
✍ Mullomen Beds

*15 March*
*Today we changed direction and headed west for about 9 km. Jess stopped to get a drink and gave me a huge fright! I thought she'd been bitten by a snake by her loud shout. She'd found gold! She'd been dipping her hat in the water, and noticed the glitter. If there's gold in the river, there must be gold in the ground! We'll look tomorrow....*

What latitude and longitude are they at now?
✍ 14° 02' 30" S 132° 11' 12" E

*16 March*
*Yes! We've been able to confirm that there is a significant source of gold here! We'll have to leave it for a while though, while we return to Katherine for some more supplies and equipment....Jess is concerning me, she doesn't even want to leave her precious gold site....She doesn't seem keen to share it with anyone either.... I'd better watch my back on our return to Katherine! We hope to be at Edith Falls by tomorrow night. I've packed heaps of water...I hope its enough.......*

This is the last known journal entry. The body of the "prospector" was found on the 28 March. Did he die of thirst? If so, why didn't Jess die too? Where is Jess? Maybe this fax message to the Katherine Police gives a clue....

Fax to: Katherine Police Dept.
From: Rochford's Camping and Mining Supplies
Date: 24 March

I would like to report that my jeep was stolen yesterday! My jeep is red, with licence plate number BOM 123.

A suspicious character was in here yesterday. She used a credit card to buy lots of supplies. After she left I checked the credit card imprint more thoroughly and noticed that the card was under the name of a Mr A. Mynor.

The jeep was my only mode of transport. Please find it!

---

The police need the following information from you to solve the crime....

Where is the gold site located (in lat/long)? Also, what is the name of the adjacent gold field. (so the police can look for Jess...)
✍ 14° 02' 30" S 132° 11' 12" E
Driffield Gold Field

Well Done!
Thanks to your help, the police have located Jess at the gold site with the Rochford's jeep. She swears that she "never returned with Mr A Mynor" to his place of death. She says "He mustn't have taken enough water with him......"

What evidence have we already got which may suggest Jess's guilt?
✍ The prospector's journal - they did take enough water, he was suspicious of Jess' motives
Eye witness - stolen credit card and jeep

There is one crucial bit of evidence that can lock Jess away....It's all up to you....
If Jess was with Mr A Mynor when he died, what type of rock sediments might you find on her shoes? (pick one which definitely PROVES she was there)
*Hint: Where was the body found?*
✍ Red and purple shale. (only in the Phillips Creek Member)

---

# FINDING YOUR WAY AROUND THE TOPOGRAPHICAL MAP

1. Where is the highest point on the map? 2. What is the spot elevation here?

✍ (lat/long) 14°03'24"S 132°21'E ✍ (lat/long) 335m

3. On what rock unit does this place occur? Mullaman Beds

4. Where is the lowest point on the map? 5. What is the spot elevation here?

✍ (lat/long) 14°10'06"S 132°02'42"E ✍ (lat/long) 114m

6. Name 3 human made features shown on this map.

✍ Power lines, Flying fox, roads, gas pipeline

7. What is the maximum height of Mt Todd? 8. Where would you find a flying fox?

✍ 230m ✍ (lat/long) 14°10'S 132°04'E

9. What are the lat/long co-ordinates for Edith Falls? ✍ 14°01'S 132°10'E

10. Give the lat/long co-ordinates for where Seventeen Mile Creek enters the National Park.

✍ 14°09'50"S 132°21'06"E

11. In which direction does Seventeen Mile Creek flow? 12. Describe the majority of the vegetation.

✍ South ✍ Medium

13. What colours are the following features:

rivers ✍ blue contours ✍ brown

power lines ✍ black sealed roads ✍ red

unsealed roads ✍ red (lighter, thinner)

## ORIENTEERING EXERCISE

Imagine you are going on an orienteering exercise around the Mt Todd area. At the end of the exercise there is a greeting party waiting to welcome you and feed you a fantastic BBQ feast. You have only a compass to show you the way. Good luck!

14° 09' 36"S 132° 29' 18"E

Start at the Pinnacle. (there is only one on the map — see the legend for the symbol)

Walk for 13 km at a bearing of 310°.

What topographical feature do you find here? ✍ Edith River

How will you cross it? ✍ Flying fox

Walk on a bearing of 63° for 8 km. What feature are you standing on now?

✍ Mt Todd

What is the height of this feature? ✍ 230m

Walk for another 3.5 km on a bearing of 350°.

What metal might you find here? ✍ Tin

Walk WSW for 12.8 km. What human made feature do you find here?

✍ power lines

If the BBQ is at the bridge over the Edith River, in which direction will you have to walk now?

✍ a bearing of 170°

For what distance? ✍ 4km

---

## MT TODD ADVENTURE SPORTS LAND

You are an aspiring entrepreneur. You have decided to invest in a new adventure sports facility in the Mt Todd area. There are many natural features in this area which make the it an ideal adventure sports location. Part of your job will be to decide which sites are best suited to each adventure activity.

**Task 1**
Below is a list of the proposed activities and some suggestions (co-ordinates) for where they might be located. You will need to refer to the map and choose the best location for each activity. Make sure that you look carefully on the topography map, and check that there are no obstacles which may interfere with each activity. Circle the preferred co-ordinates for each activity.

| | |
|---|---|
| **Abseiling** | 14° 10' 00" S 132° 05' 00" E |
| | [✓ 14° 09' 00" S 132° 12' 00" E] |
| | 14° 10' 00" S 132° 15' 00" E |

WHY did you choose this particular site for this activity?

✍ It is near some cliffs.

| | |
|---|---|
| **White water rafting** | 14° 03' 00" S 132° 01' 00" E |
| | 14° 11' 00" S 132° 11' 00" E |
| | [✓ 14° 10' 00" S 132° 26' 00" E] |

WHY did you choose this particular site for this activity?

✍ It is close to rapids.

| | |
|---|---|
| **Airborne Rappelling** (jumping out of a helicopter on a rope) | 14° 04' 00" S 132° 12' 00" E |
| | [✓ 14° 10' 36" S 132° 03' 00" E] |
| | 14° 10' 00" S 132° 02' 00" E |

WHY did you choose this particular site for this activity?

✍ It is in a clearing, far enough away from power lines, vegetation etc...

---

**Task 2**
Below is a list of some more proposed activities. Look on the map and choose the best site for each of them. (write this in lat/long) Give a reason for your choice.

Gold panning (check for alluvial gold on the geology map)
✍ 14° 02' S 132° 11' E
(Near Driffield Gold Field)

What rock unit would the gold be coming from? Burrell Creek Formation also from Quarternary, soil and sediments

Camping "out bush" in dense vegetation
✍

Bird watching (hint: you may find lots of birdlife in a very wet area)
✍

Rock climbing
✍

What rock unit would you be climbing on?

Flying fox 14° 10' S 132° 04' E
✍ There is already a flying fox at this site

**Task 3**
Think of one more activity, and choose a location for it. Explain why you have chosen this location.
✍

**Task 4**
Choose a location for the main office for this Adventure Park.
Explain why you have chosen this location.
✍

---

## LINKING GEOLOGY WITH TOPOGRAPHY

Geology is not just the study of rocks. It goes further than that. *Geology* means "the study of the Earth". Geological processes may take millions of years to complete the formation of sandstone layers, or they may only take a few seconds such as volcanic explosions. It is important to understand that these geological processes shape the surface of the Earth. In turn these rocks and structures themselves influence the other processes (ie biological) occurring on the the Earth's surface.

eg— a volcanic eruption can form a mountain — the soil on this mountain will be very rich in minerals — and therefore a fertile area to grow crops.

eg— limestone forms over millions of years from the remains of dead marine animals — the limestone will weather very easily because it is made of calcium carbonate, which deteriorates in acidic rain — this process will form caves — caves provide a good home for bats.

Can you think of any other examples where geology has influenced other processes on the Earth's surface?

✍ Rivers may cut through rocks, forming valleys, the layers of rock weathering at different rates. Where a layer of rock resists weathering, a cliff may form, causing a waterfall — ferns will grow near waterfall

During this activity you will find out how the geology which has formed the Mt Todd area has influenced the topography.

A diagram highlighting the spot elevations for the area has been provided. You will be using this to work out which areas form topographic highs and lows.

**Step 1**
Look at the geology map. Compare it with the spot elevation diagram which shows geological boundaries. Try to locate the different rock units on the diagram. You may want to write the symbol for each rock unit on the spot elevation diagram.

**Step 2**
Find the Cullen Granite on the spot elevation diagram. Find the *average* height of the rock unit. (to do this, find all the spot elevations, add them together then divide by the number of spot elevations you added together.)

Average height of Cullen Granite ✍ 151m (a)

**Step 3**
Find the average height of each rock unit by following step 2.

Average height of Finniss River Group 214m (b)

Average height of the Edith River Volcanics 173m (c)

Average height of Phillips Creek Member 199m (d)

Average height of
Mc Adders Creek Volcanic Member 268m (e)

Average height of
Henwood Creek Volcanic Member 283m (f)

Average height of Kombolgie Formation 281m (g)

Average height of Mullaman Beds 303m (h)

**Step 4**

Find the average height *of all* the rock units (to do this, add (a) - (h), then divide by 8.)

Average height of
all the rock units in the Mt Todd area 215m (i)

**Step 5**

Look at the geology map again. Look carefully at the cross section. Two folds are shown. From left to right, there is a syncline, then an anticline.

The syncline is formed mainly from the following rock units:

The Kombolgie Formation
The Mc Adders Creek Volcanic Member
The Henwood Creek Volcanic Member

Would you expect a syncline to form a topographic high, or a topographic low?

(Student's opinion)

Why?

---

Now let's find out....

**Step 6**

Find the average height of the rock units which form this syncline.

use this simple formula: $\frac{(e)+(f)+(g)}{3}$

Average height of syncline 277 m

Compare this figure with the average height of all the rock units in the Mt Todd area. (i)

Is this syncline higher or lower than the average height of the area? higher

Has the syncline formed a topographic high, or a topographic low? High

Why do you think this is so?

The more resistant rocks in the core of the syncline weather and erode less than the rocks in the flanks making a syncline a topographic high. (see teacher notes)

**Step 7**

The rock units which form the anticline are:

The Finniss River group
The Edith River Volcanics

Would you expect this anticline to form a topographic high, or a topographic low?

(student's opinion)

Why?

---

Now let's find out....

**Step 8**
Find the average height of the rock units which form this anticline.

use this simple formula: $\frac{(b)+(c)}{2}$

average height of the anticline 193 m

Compare this figure with the average height of the rock units in the Mt Todd area. (i)

Are the rocks in this anticline higher or lower than the rocks in the Mt Todd area?

lower

Does the anticline form a topographic high, or a topographic low?

Topographic low

Why do you think this is so? Use the space below to draw a diagram to help explain your answer.

Preferential weathering and erosion of fractured zones makes the anticline a topographic low (see teacher notes)

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# MT TODD MINING

The Mt Todd area has been mined sporadically for gold since the 1870's. As well as the knowing the location of the gold deposits, for a mine to operate a company must be able to sell the gold it mines for more than cost of extracting the gold from the ground.

The first major gold mine in the Mt Todd area was at Driffield (latitude 14°3'S longitude 132°12'E). During the life of the mine it extracted 15,000 imperial tons of gold ore from which the miners recovered 5,500 troy ounces of gold.

How much gold was there in each imperial ton of ore extracted ?

0·36 troy ounces

If one imperial ton contains 35,840 ounces, what was the percentage concentration of gold in the Driffield deposit ?

0·00102 %

The Batman deposit, currently being worked at the Mt Todd Gold Mine (latitude 14°8'S longitude 132°6'E) by Pegasus Gold Australia, was 104,800,000 tonnes with each tonne having 1.05 grams of gold.

How much gold in total will be extracted from the Batman deposit?

109,500,000 grams

What is the percentage concentration of gold in the Driffield deposit ? (1 tonne = 1000kg)

0·000001 %

If the current gold price is $16 for a gram of gold ($540 for an ounce), how much is/was the gold worth in:

Driffield deposit : $ 2,970,000
Batman deposit : $ 1,752,000,000

If it is estimated that it will cost $1,095,000,000 to extract the gold from the Batman deposit, what is the lowest possible price the mine can sell their gold per gram to cover the costs of extraction?

$10 per gram

1 2 3 4 5 6 7 8 9

Distance in kilometres

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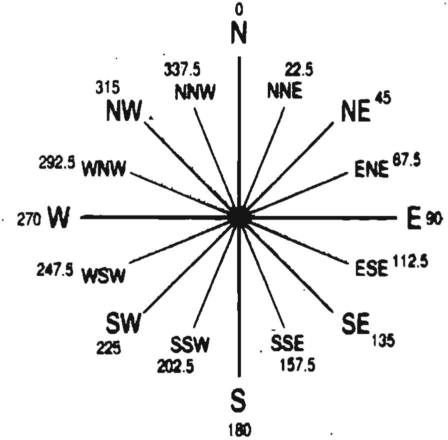
# 1:75 000 MAP CARD

Latitude



Longitude

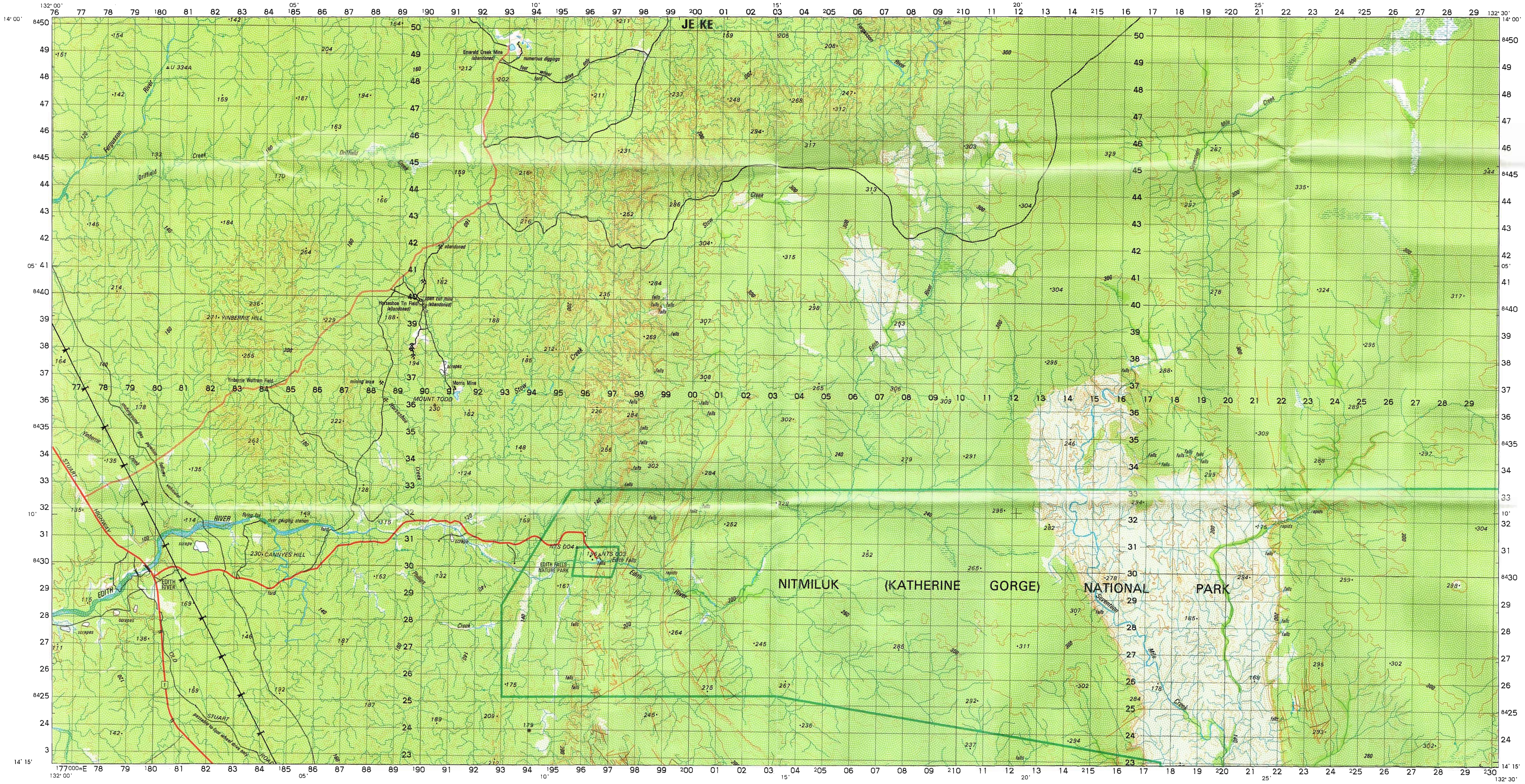
1 2 3 4 5

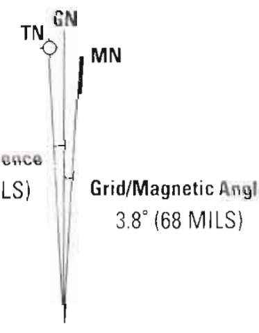
30-2/61

# MT TODD TOPOGRAPHICAL SPECIAL

NORTHERN TERRITORY

MAP RELIABILITY: Map information has been determined from 1988 aerial photography and verified by 1991 field inspection. Every effort has been made to show all features necessary to make the map a useful general reference.





True North (TN), Grid North (GN), and Magnetic North (MN) are shown diagrammatically for the centre of the map.

Magnetic North is correct for 1991 and moves Easterly by 0.1° (2 MILS) in about five years.

SCALE 1:75 000

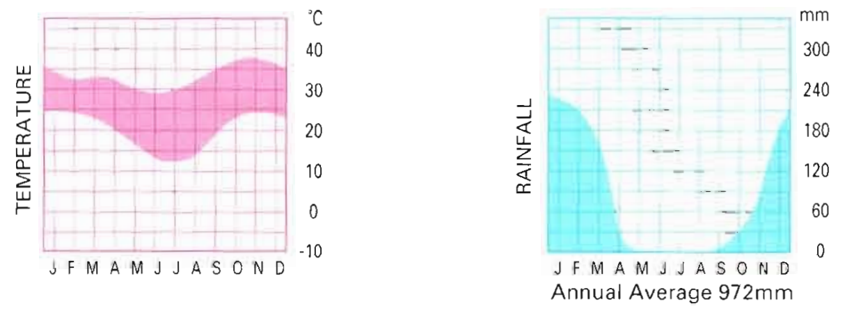
0 1 2 3 4 5 6 7 8 9 10

kilometres

## WORLD GEODETIC SYSTEM (WGS)

To convert from WGS (84) to this map co-ordinate system (AGD 66):
DECREASE Eastings by 129 metres
DECREASE Northings by 157 metres
DECREASE Longitudes by 4.3 seconds
INCREASE absolute value of Latitudes by 5.1 seconds

## CLIMATIC GRAPHS: KATHERINE



Annual Average 972mm

AUSLIG

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TRANSVERSE MERCATOR PROJECTION
AUSTRALIAN MAP GRID
HEIGHTS IN METRES 20 METRE CONTOUR INTERVAL

HORIZONTAL ACCURACY ............... ±50 metres
HORIZONTAL DATUM .................. Australian Geoditic Datum (AGD), 1966
VERTICAL ACCURACY .................. ±10 metres
VERTICAL DATUM ..................... Australian Height Datum (AHD)

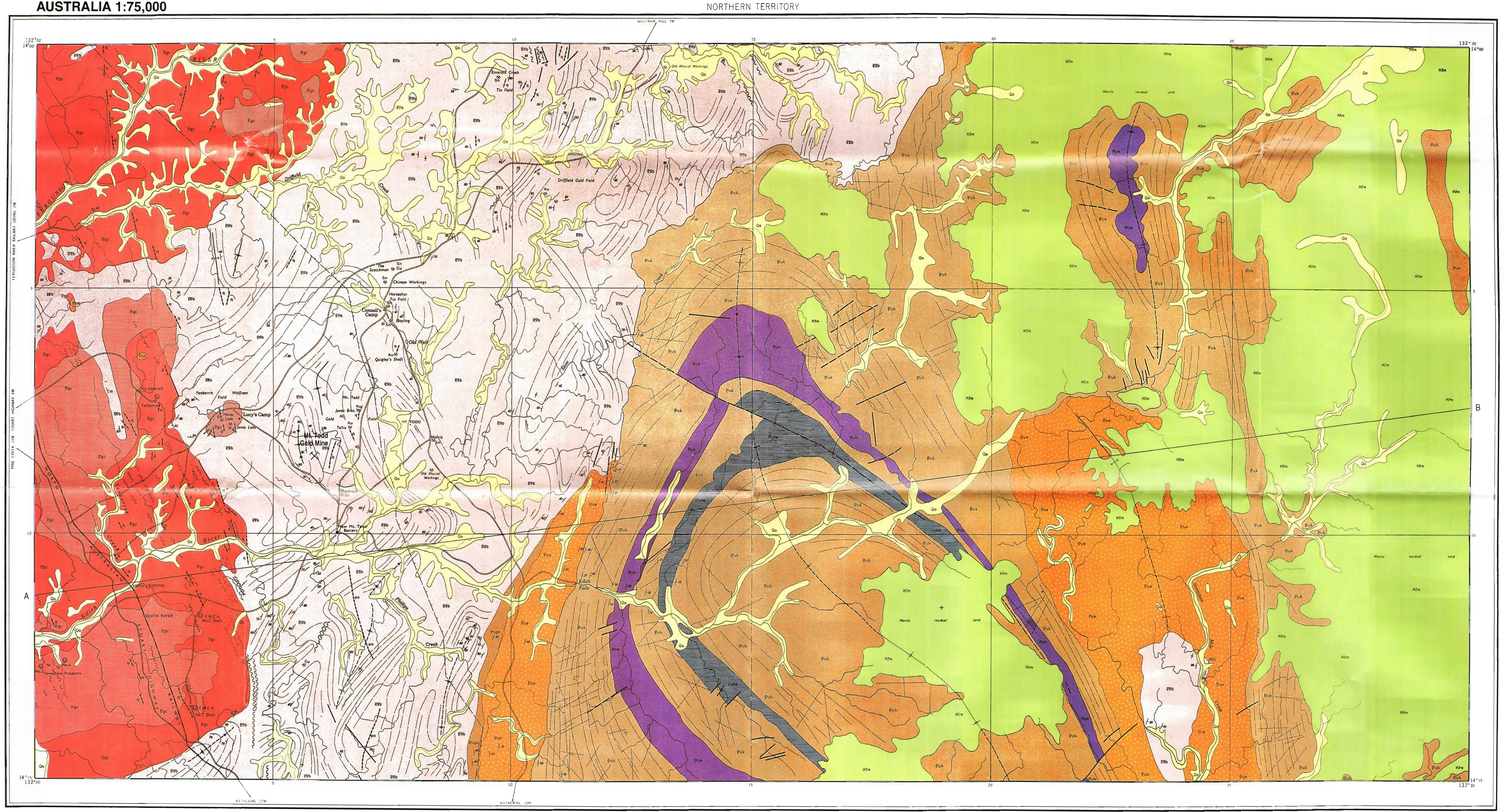
## LEGEND

Built-up area; Heliport; Divided highway
Metropolitan route marker
Recreation reserve; Drive-in theatre; Underpass
Sealed road two or more lanes; National route marker
Sealed road one lane; Cutting; Embankment
Unsealed road two or more lanes; Culvert; Causeway
Unsealed road one lane; Approximate position
Vehicle track; Road bridge; Gate; Stock grid
Foot track; Footbridge
Multiple track railway; Siding; Station
Single track railway; Light railway
Railway tunnel; Bridge; Underpass
Power transmission line
Administrative boundary
Homestead; Building; Ruin; Church
Mine; Windpump; Yard; Fence
Horizontal point control; Bench mark; Spot elevation ▲ BM·282 ·132

Contour with value; Cliff; Pinnacle
Depression contour; Sand; Distorted surface
Levee bank; Sandridge
Razorback ridgeline; Faultine
Vegetation; Dense, Medium, Scattered
Rainforest; Pine plantation
Orchard or vineyard; Line of trees or windbreak
Watercourse; Flow direction
Swamp; Area subject to inundation
Lake; Perennial, Intermittent, Mainly dry
Watercourse; Perennial, Intermittent, Mainly dry
Tank or small dam; Bore, Well, Spring or Waterhole
Saline coastal flat; Intertidal flat; Rock bare or awash
Lighthouse or navigation light; Intertidal ledge or reef
Exposed wreck; Submerged wreck
Submerged reef; Submerged rock
Mangrove swamp; Indefinite coastline

**AUSTRALIA 1:75,000**

# MT TODD
NORTHERN TERRITORY



## LEGEND

CAINOZOIC

QUATERNARY

Qa — *Alluvium, soil*

MESOZOIC

LOWER CRETACEOUS

Kℓm — Mullaman Beds
*Ferruginous sandstone, conglomerate, quartz sandstone and residual sand. Undifferentiated marine and freshwater sediments*

PRECAMBRIAN

UPPER PROTEROZOIC

Katherine River Group
Kombolgie Formation

Ꝑuk — *Quartz sandstone, greywacke, conglomerate Tuffaceous and feldspathic sandstone*

Ꝑuhe — Henwood Creek Volcanic Member
*Basalt, dacite and pyroclastics*

Ꝑum — Mc Addens Creek Volcanic Member
*Basalt and pyroclastics*

Ꝑue — Edith River Volcanics
*Rhyolite, dacite, toscanite, pyroclastics and tuffaceous sediments. Minor basic flows*

Ꝑupc — Phillips Creek Member
*Medium-grained purple greywacke, red and purple shale, conglomerate, tuffaceous in places*

LOWER PROTEROZOIC

AGICONDIAN SYSTEM

Cullen Granite

Ꝑgc — *Fine-grained granite*

Ꝑgc — *Fine-grained hybrid granite*

Ꝑgc — *Coarse-grained porphyritic hornblende granite*

Ꝑgc — *Coarse-grained granite*

Finniss River Group
Burrell Creek Formation

Ꝑℓb — *Siltstone and greywacke, phyllite in places.*

*Geological boundary*

*Anticline, showing plunge*

*Syncline*

*Fault*

*Where location of boundaries, faults and fold axes is approximate, lines are broken, where inferred, queried, where concealed, boundaries and fold axes are dotted*

*Strike and dip of strata*

*Vertical strata*

*Horizontal bedding*

*Trend lines*
*Dip < 15°*
*Dip 15 – 45°*
*Joints*
} *Air-photo interpretation*

*Shear zone*

*Dyke* q – *quartz*, po – *acid porphyry*, g – *greisen*, d – *dolerite*

*Prospect, little or no production*

*Mine or prospect*

Au — *Gold*
Cu — *Copper*
Sn — *Tin*
U — *Uranium*
W — *Wolfram*
} *Encircled mineral symbol indicates unexploited deposit*

Geology, 1953, by: J.H. Rattigan and A.B. Clarke. Compiled 1959, by M.A. Randal, Bureau of Mineral Resources, Geology and Geophysics
Drawn by Adastra Aerial Surveys.

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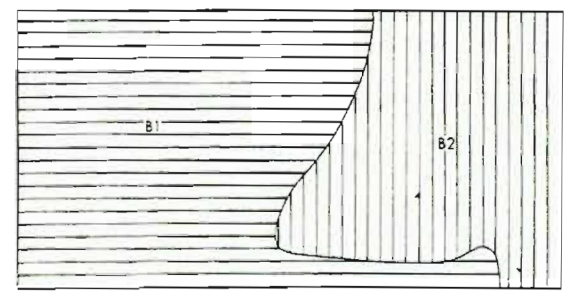
Australia Pty Ltd

NORTHERN TERRITORY — DEPARTMENT OF MINES AND ENERGY —

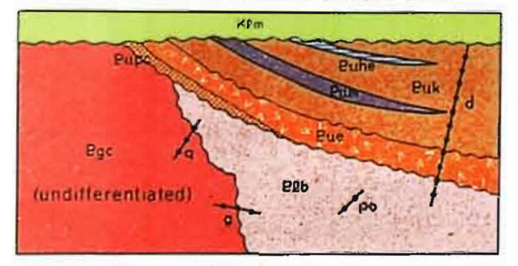
SCALE 1:75 000
0 1 2 3 4 5
kilometres

GEOLOGICAL RELIABILITY DIAGRAM



B1 Detailed reconnaissance — numerous traverses
B2 Air-photo interpretation and traverses

DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS



Unconformity
Local unconformity

## Section A - B
(Folding partly diagrammatic)