AGSO

Geoscience Education

Australia : An Ancient Land

Teacher Notes and Student Activity Ideas

Gary B. Lewis

Record No. 1995/66

AUSTRALIAN GEOLOGICAL SURVEY ORGANISATION

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Primary Teaching Resource

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Curriculum Links

Australia : An Ancient Land has been specifically developed to provide an earth science component to the teaching of primary level Australian Studies. Listed below are the curriculum links for both the National Curriculum, NSW and Victorian Curricula.

National Curriculum

Science

Earth And Beyond
- Earth, sky and people (Level 2-3)
- The changing Earth (Level 2-3)

Working Scientifically
- Processing Data
- Evaluating Findings
- Using Science

NSW Science And Technology Syllabus (K-6)

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- Earth and its Surroundings (Stage 3)
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Suggested Units of Work
An Ancient Land (Stage 3)

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Science

Earth and Beyond
- The changing Earth (Level 3)

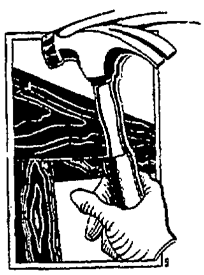
Life and Living
- Biodiversity, change and continuity (Level 2)

Australia : An Ancient Land

The recorded history of Australia did not begin with the arrival of Captain Cook in 1770. Nor did it begin with the discovery of the western coast of our continent by the Dutch in the century before, or by the Aboriginals over 50,000 years ago. The history of Australia started over 4,000,000,000 years ago and is recorded in our continents rocks and minerals.

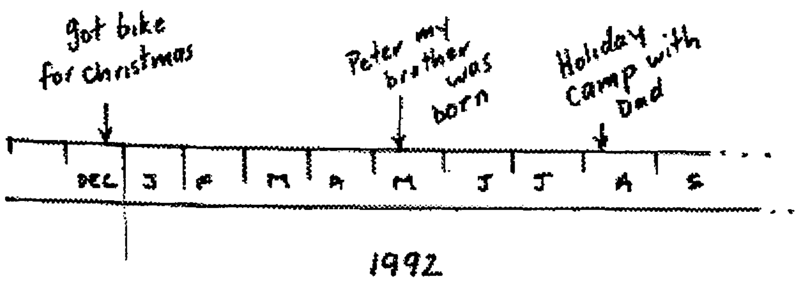
1. How Old is Old?

Geologists measure time in millions of years. They use a geological time scale or time line to show the age of the Earth from its "birth", some 4,600 million years ago, to the present day.



ACTIVITY
Make a time line of major events that students feel are important (their birth, brothers/sisters birthdays, sports grand final, death of someone famous?) Make a timeline out of a strip of cardboard using a scale of twelve centimetres equals one year. Record all the important dates on the timeline. Have students ask their parents what they feel are important dates to put on the time line? How do these differ?

If we used the same scale to represent the age of the Earth it would be 552,000km long - which is about one and a half times the distance to the Moon!



Extract from a student time-line

To make the geological time scale easier to use, geologists have divided the age of the Earth into units known as eras (Cainozoic to Palaeozoic) and periods (Quaternary to Precambrian). Each of these have been given a name.

The dinosaurs, for example, lived for about 130 million years before they became extinct 65 million years ago. Geologist call the era in which they lived the Mesozoic Era. Geologists have then divided the Mesozoic Era into three periods - the Triassic, Jurassic and the Cretaceous. Different types of dinosaurs lived in the different periods. Tyrannosaurus lived, for example, in the Cretaceous Period while Stegosaurus lived during the Jurassic period.

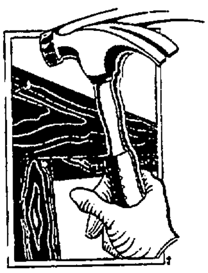
Tyrannosaurus

Stegosaurus

WARNING - most kids know more about dinosaurs than adults!

Dating rocks or fossils using the geological time scale, such as saying that Stegosaurus lived in the Jurassic, is known as relative dating. It is "relative" because one age is younger or older than another age rather than an absolute time in millions of years being given.

The Geological Time scale, used by Australian geologists, has been summarised on the next page.

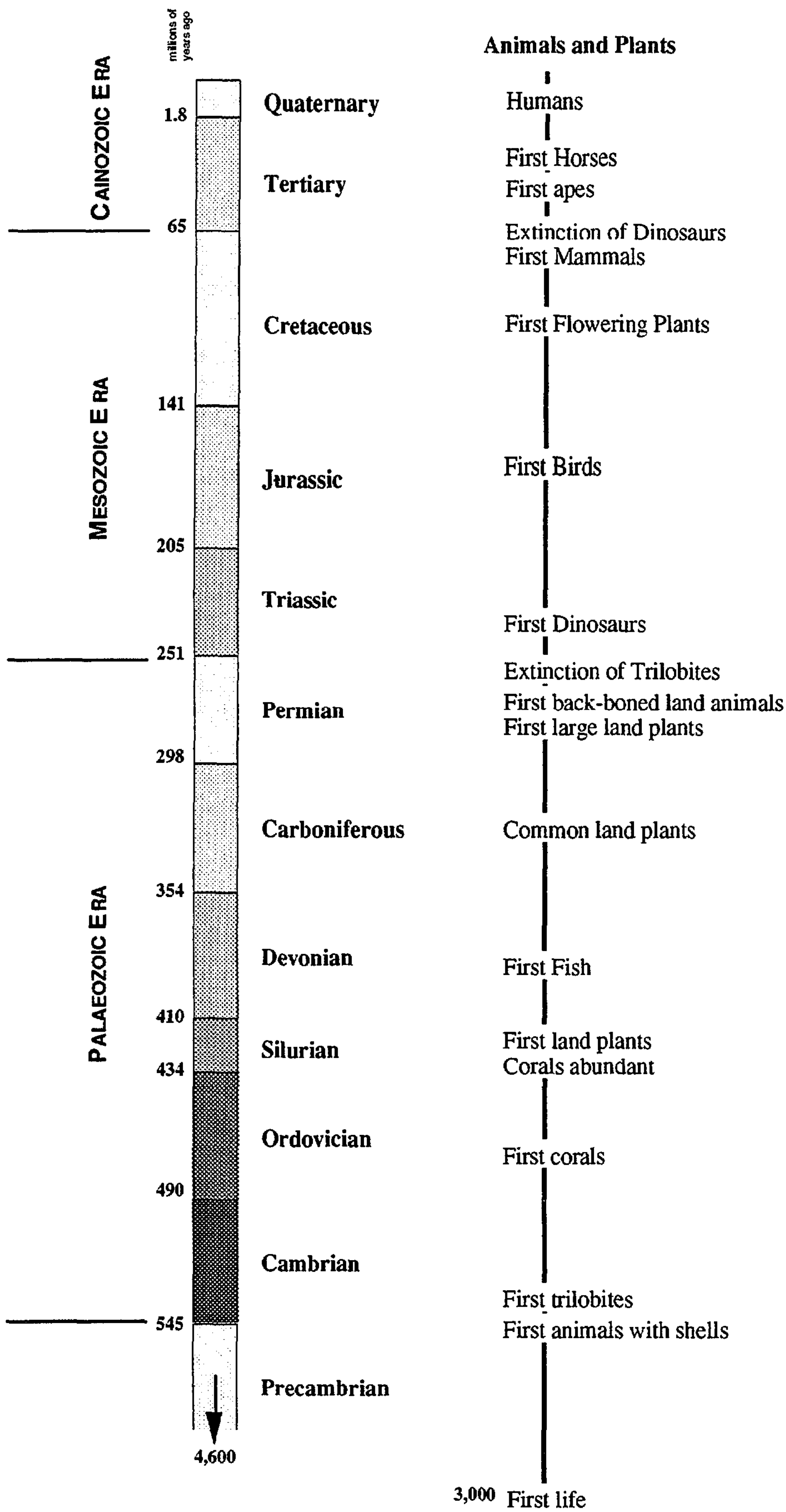


ACTIVITY
Have students "adopt" a geological period (Quaternary through to Precambrian) as ask them to find information about that period such as the length of time it lasted and what type of life existed on Earth during that period. Students could also find out the origins for each of the names (ie. Devonian from the area of Devon in England). Pick periods out of a hat or every student will want the "dinosaur periods". Have the students write their information on a page and use the pages to make up a geological time line.

1.1 Rock Clocks

Geologists can measure the age of many rocks by using the natural radioactive decay of certain mineral components. These components take a very long time to decay, but the rate at which they decay is known. By measuring the amount of decay, geologists can calculate the age of the rock.

Geological Time Line



Naturally occurring uranium, for example, decays over a very long period of time and turns into lead. Geologists can measure the tiny amounts of uranium and lead contained in some minerals and then use the proportions of each to calculate the age of the mineral.

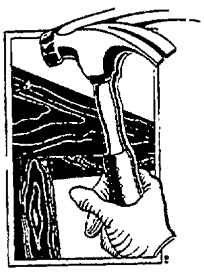
This type of dating allows geologists to put accurate ages on rocks (in millions of years). This is known as absolute dating.

The Oldest Rocks
The oldest rocks ever found on Earth are in Alaska in North America. These are 4,200 million years old. Some mineral grains found in younger rocks in Western Australia, which were once part of an older rock which was eroded, are even older.

Geologist believe that the oldest rocks in the universe are around 4,600 million years old. Meteorites, which formed at the birth of the universe, have been dated to be around this age.

1.2 Australian Places

Listed below are some well known Australian places with details of the rock types and ages found there. Some of these places are well known *because* of the rock formations! (State and approximate latitude and longitude are given)



ACTIVITY
Locate these places on a large map of Australia and have students find out more information about each place. Hang a large map of Australia up on the wall and mark the approximate ages of each of the places with a sticker.

NOTE : A primary science Australian Geology Map Kit is available from AGSO Geoscience Education. See contact details for the Sales Centre at the start of this booklet.

- **Uluru (Ayers Rocks) & Kata Tjuta (The Olgas)** N.T., (25.21S 131.02E)

The sandstones and conglomerates of Uluru and Kata Tjuta have been above sea level for some 300 million years. The rocks themselves were formed about 400 million years.

- **Warrumbungles**, NSW, (31.26S 149.36E)

The Warrumbungles are the eroded remnants of a large volcano. Minor volcanic activity probably began in the surrounding area about 17 million years ago. The volcano began to form about 16 million years ago when numerous explosive eruptions took place. Since then the volcano has been extinct.

- **Blue Mountains**, NSW

The Blue Mountains west of Sydney were formed about 40 million years ago when rocks of the Sydney area were uplifted. They are made up of thick sandstone layers with some thin shale bands. Some mountain tops in the Blue Mountains, such as Mt Tomah, are capped with a volcanic rock called basalt.

- **Gosses Bluff**, NT, (23.49S 132.17E)

A raised central structure of Gosses Bluff and its surrounding area of highly disturbed country rock was formed by a meteorite or comet impact about 130 million years ago.

- **Great Barrier Reef**, Qld

The Great Barrier Reef has grown on the Queensland continental shelf for around 18 million years. Around 19,000 years ago the sea level around the Earth was much lower due to an ice age and the reef was exposed to the air where it became eroded. When the sea level rose around 18,000 years the reef began to grow again.

- **Nullarbor Plain**, SA & WA

The Nullarbor Limestone, a hard dense, crystalline limestone is responsible for the low flat plateau of the Nullarbor Plain. It has been above sea level for 20 million years.

- **Wilpena Pound**, Flinders Ranges, SA, (31.31S 138.37E)

Wilpena Pound's massive quartzite formations are 600 million years old and are made up of seabed sand which have been folded and cooked by the Earth's heat over time.

- **Mt Wellington**, Tas, (42.54S 147.14E)

Mt Wellington is capped with an igneous rock which was extruded as lava from volcanoes around 200 million years ago. As the lava cooled large joints formed in the rock. These joints form the characteristic organ pipe features.

- **Wilsons Promontory**, Vic, (39.04S 146.22E)

Wilsons Promontory is made up of granitic rocks which cooled from a large molten mass of rock deep below the surface about 400 million years ago.

- **Ballarat**, Vic, (37.36S 143.58E)

Many areas around Ballarat are covered in black basalt lava flows which erupted from numerous small volcanoes about 3 million years ago. These basalt lava flows covered many gold bearing streams which were mined during the gold rushes. These basalt covered streams are known as "deep leads".

- **Mt Kosciusko**, NSW, (36.28S 148.17E)

Mt Kosciusko, the highest mountain in Australia (mainland & Tasmania), is made up from granitic rocks which cooled below the surface about 420 million years ago. These rocks were uplifted to form the mountains about 40 million years ago.

- **Mt Canobolas**, NSW, (33.17S 149.00E)

Mt Canobolas is the remnants of a volcano which last erupted 12 million years ago. The flanks of this volcano have been well preserved. Mt Canobolas is the highest point in a direct line between Sydney and the west coast of Australia.

- **Mt Warning,** NSW, (28.24S 153.16E)

Mt Warning is the central core of a volcano, known as the Tweed Volcano, which last erupted about 22 million years ago. The slopes of the volcano have been eroded away to form a valley through which the Tweed River flows. Mt Warning is the first place where sun shines (weather permitting) on the Australian mainland each day.

- **Sydney**, NSW, (33.55S 151.10E)

The rocks of the Sydney Region are sandstones and shales which were formed around 200 million years ago.

- **Hamelin Pool**, WA, (26.00S 114.00E)

Around 6,000 years ago the area now known as Hamelin Pool, which is inside Shark Bay, was flooded by the sea. About 4,000 years ago the waters of the pool had been partly blocked from the ocean by a sand barrier and that waters became very salty due to evaporation. In this unique environment a very ancient form of life, the stromatolites, started to grow. There are only a few places on Earth where these can be found. The oldest known fossils of stromatolites are found in the Pilbara region of Western Australia and are 3,500 million years old!

- **Cape Bougainville**, WA, (13.54S 126.06E)

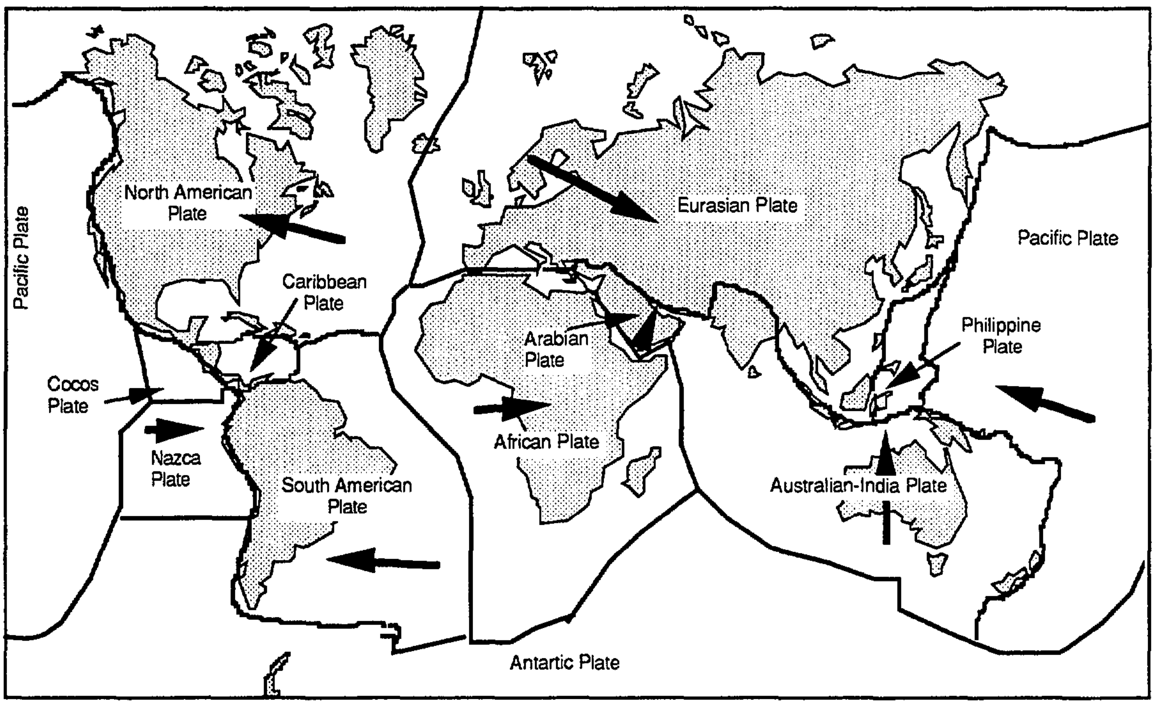
The rocks of Cape Bougainville are sandstone, siltstones, and volcanic rocks which were lain down in shallow water about 1,000 million years ago.

2. Australia is Moving!

The rocks which make up the surface or crust of the Earth are divided into a number of slabs known as plates. These plates are not stationary, but move slowly past, over or under each other. The boundaries of these plates are dotted with active volcanoes and numerous earthquakes.

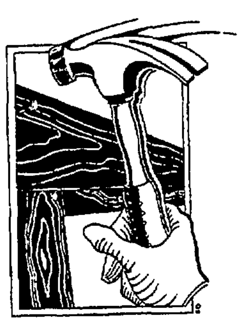
Australia lies in the middle of one of these huge crustal plates, known as the Australian - India Plate. The nearest edge of the Australian-Indian plate is many hundreds of kilometres away from the Australian coast and so the Australian mainland has no active volcanoes and does not suffer from many major earthquakes.

The Earth's Major Crustal Plates



Approximate Plate movement

Our plate is moving very slowly northwards. Each year Australia moves about 7cm closer to the equator.



ACTIVITY
If Australia continues to move northwards at 7cm a year, how long will it take your school to reach the equator?

CITY	Approximate current Distance from Equator
Sydney	3740km
Melbourne	4152km
Brisbane	3025km
Perth	3630km

Adelaide	3842km
Hobart	4719km
Darwin	1361km
Canberra	3883km

* To calculate the approximate distance your city or town is from the equator you need to know the latitude and multiply it by 111km. For example, Mt Kosciusko (NSW) has a latitude of 36°28'. First convert the minutes (28') to a decimal by dividing it by 60 (as there are 60 minutes in a degree of latitude):

$$28 \div 60 = 0.46$$

Then multiply the degrees plus this decimal by 111km:

$$36.46 \times 111\text{km} = 4047\text{km (approximately)}$$

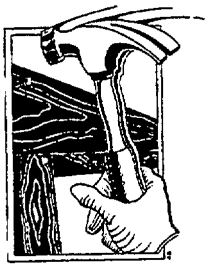
3. Australian Volcanoes

Australia has one active volcano known as "Big Ben"- it is not on the Australian mainland but on a small island called Heard Island which lies between Australia and Antarctica. Big Ben is also the highest mountain on any Australian Territory (2745m). There are no active volcanoes on the Australian mainland (including Tasmania).

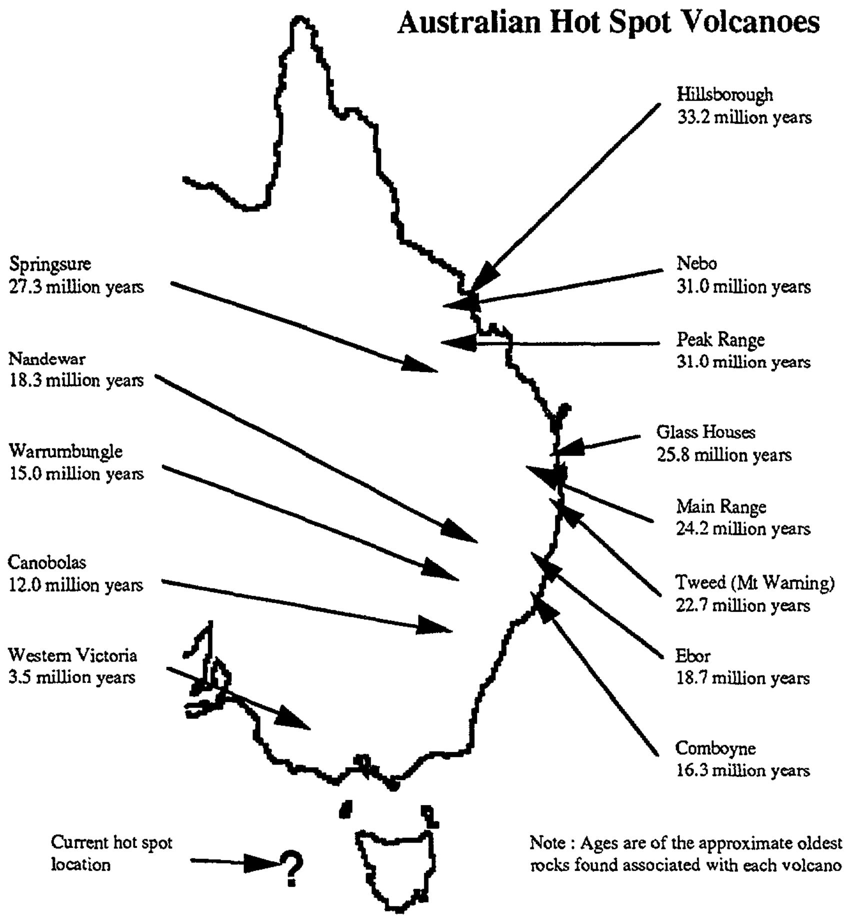
This has not always been the case. Australia has had many active volcanoes over geological time. The eruptions of the most recent ones were most probably witnessed by Aboriginal tribes in Victoria!

3.1 Australia's Hot Spot Volcanoes

As the Australian-Indian plate moves northwards it has travelled over a "hot spot" in the underlying layer of the Earth known as the mantle. This hot spot has caused a number of volcanoes to form above it over the last 33 million years. The remnants of the oldest hot spot volcano during this time is found in far northern Queensland and the youngest in western Victoria. The ages of the volcanoes decrease as you travel from Queensland to Victoria. (see diagram).



ACTIVITY
Make a volcano out of clay, plasticine or paper mache around a plastic or foam cup. Get your students to find some pictures of volcanoes so they make a realistic shape. Place some bicarbonate of soda into the cup. Add a few drops of red food colouring to the cup then tip in some vinegar. The vinegar reacts with the bicarbonate to foam up and pour "lava" down the slopes of the cone.



The current position of the hot spot is thought to be off the west coast of Tasmania. It is not producing any volcanic activity at this time.

4. Australian during the Ice Ages

An ice age is a period of time in which the Earth experiences colder climatic conditions, normally characterised by an increase in glaciers (ice rivers) and ice-caps.

4.1 Ancient Ice Ages

The Earth has gone through many ice age periods. The first known ice age was during the middle Precambrian, around 2,300 million years ago. Rocks deposited by glaciers of this ice age have been found in Western Australia. This ice age lasted several tens of millions of years.

A great deal of evidence exists in Australia for a later ice age in the late Precambrian. Rocks deposited by glaciers can be found in a band across Western Australia, Northern Territory and South Australia. In some locations the glacial material is more than 5,500m thick! This ice age started around 950 million years ago and lasted for around 400 million years.

Near the end of the Ordovician, around 450 million years ago, another ice age commenced and lasted about 50 million years. Australia has no rocks providing evidence for this ice age, however evidence can be found on other continents.

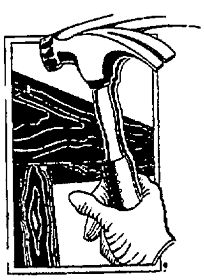
The Late Palaeozoic Ice Age, starting 330 million years ago and lasting 90 million years, left geological evidence on all the continents which once made up the supercontinent of Gondwana. This ice age probably was characterised by ice caps that waxed and waned over the 90 million years. In Australia there is evidence for six or more ice cap centres that formed during this ice age.

4.2 The Last Ice Age

More is known about the last Ice Age than any other. The Late Cainozoic Ice Age was originally referred to as the "Great Ice Age". It started about 2,600,000 years ago and went through at least 10 cycles of growing and shrinking glaciers.

During this ice age an ice cap developed over the central highlands of Tasmania with glaciers forming on the edges such as in the Cradle Mountain area. Mainland Australia had weaker affects due to its low altitude. Some small glaciers developed in the Kosciusko region and snow and ice reached 1000m below the current snowline. The major affect of the ice age on Australia was caused by the resulting sea level drop of around 150m.

The last major glacial period reached its maximum around 19,000 years ago and since then the glaciers and ice sheets have contracted. The temperature during this glacial maximum is estimated to have been 5°C lower in Australia than the present average temperatures.



ACTIVITY
Have students find out the different temperature scales used around the world by scientists (Celsius, Fahrenheit, Kelvin). What is the freezing point of water on each of these scales.
(. . . which are : Celsius = 0°C, Fahrenheit = 32°F, Kelvin = 273K)
Set up two containers with water with a 5°C temperature difference. Ask students if they can guess the temperature difference between the water in the two containers.

4.3 And the sea was lower

During the last ice age the Earth's oceans were lowered due to the amount of snow and ice forming on land in the Northern Hemisphere. The 150m drop in sea level around Australia opened up "land bridges" between Australia and New Guinea, Tasmania and many islands. These land bridges allowed humans as well as many animals to travel from island to island. When the sea level rose at the end of the ice age these land bridges again were flooded by the ocean trapping humans and animals on islands.

5. Life in Ancient Australia - Fossils!

Fossils are the remains or traces of plants and animals that have been preserved in rocks. For example the bones of dinosaurs are fossils. So too are the footprints made by dinosaurs!

The great variety of organisms that have been preserved in this way includes corals, sea shells, fish, reptiles, amphibians, ferns, trees and even pollen and bacteria. Fossils range in size from the skeletons of massive animals such as mammoths and dinosaurs to the remains of microscopic plants and animals. The science involved with the study of fossils is called palaeontology.

Fossils are almost exclusively found in sedimentary rocks such as limestones, mudstone, and sandstones which formed in ancient seas, lakes, deltas and floodplains. The most likely rocks to contain fossils are those formed in relatively shallow seas.

Fossils are found in rocks formed as far back as about 540 million years ago. Beyond that age fossils are extremely rare. This point in time represents when animals started to develop hard parts (shells and bones) which have been easily preserved. Animals before this time were soft bodied, like jelly fish.

5.1 Fossil Formation

For a fossil to be formed from a dead plant or animal the remains must undergo rapid burial. This stops scavengers eating the remains , slows down decay and to protects the remains from being broken down by wind or wave action. The most favourable conditions for preservation occur on the floors of shallow seas and lakes.

Commonly fossils are found in which all the soft parts have decayed but the hard parts such as shell and bone, have been preserved.

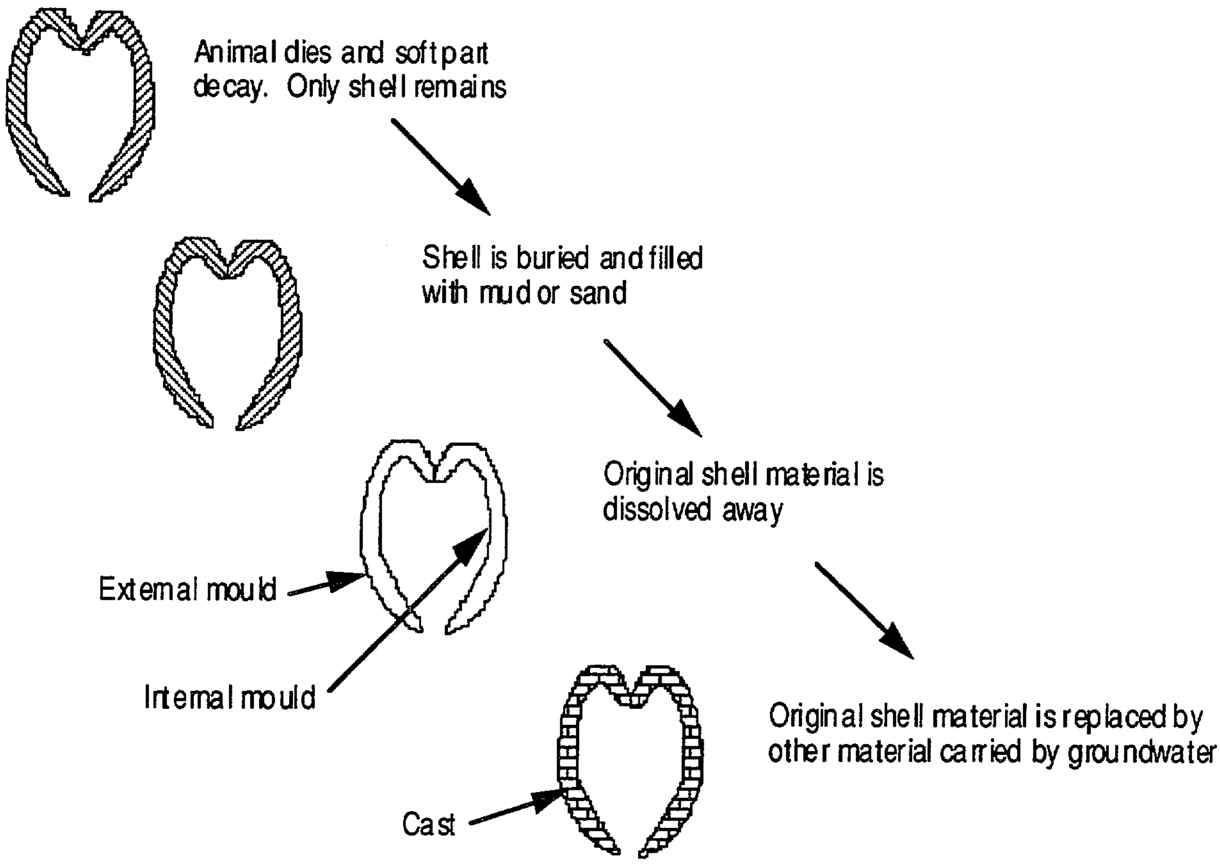
In other fossils the mineral content of the hard parts has been replaced with other minerals. This is usually caused by the replacement of the hard parts by minerals deposited from water percolating through the rocks. Common replacement minerals are calcite, silica, haematite and limonite. Examples of fossils in which replacement has occurred are petrified wood, opalised bones and shells.

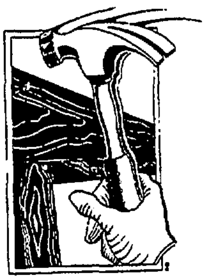
Often the original shell or bone materials is dissolved and completely removed leaving "spaces" in the rock. The "space" is a mould of the fossil, showing the imprint of the surface features of the original shell or bone.

Occasionally fossils are found in which some of the organic matter remains. Examples of these are insects in amber, bones preserved in tar pits, mummified animals in arid climates, and carbonised fossils in black shale.

Perhaps the most spectacular examples of preserved prehistoric animals are the mammoths and other mammals found frozen in the Siberian tundra. These were exceptional as the animals were perfectly preserved, even hair, skin and flesh!

Formation of Moulds and Casts





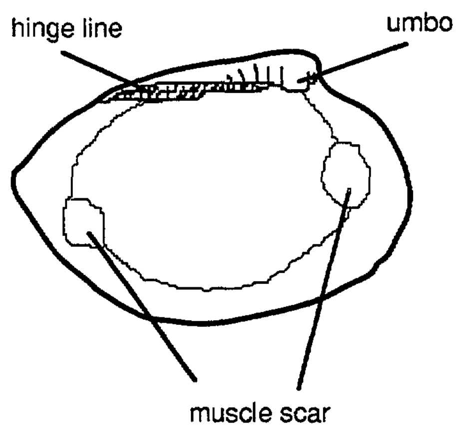
ACTIVITY
Make your own fossils using plaster of paris (casting plaster) and plasticine. Take a shell or similar item and push it into a bed of plasticine to make an impression. Remove the shell then build a wall of plasticine around the impression to form a well. Mix up some plaster in water so it is the consistency of thick cream and pour into the well. Tap the plasticine well on the desk a few time to release any air bubbles and then leave to set (it will take a few hours). When set, pull the plasticine away from the plaster to leave the plaster "fossil". Paint the fossil brown to make them look realistic!

Note : This process is actually used to make casts of fossils found in the bush rather than taking the fossil home. In this way fossils are preserved as part of the environment. Some important fossil sites have been destroyed by people collecting fossils (many ending up in boxes under beds!).

5.2 Some Common Australian Fossils

Bivalves

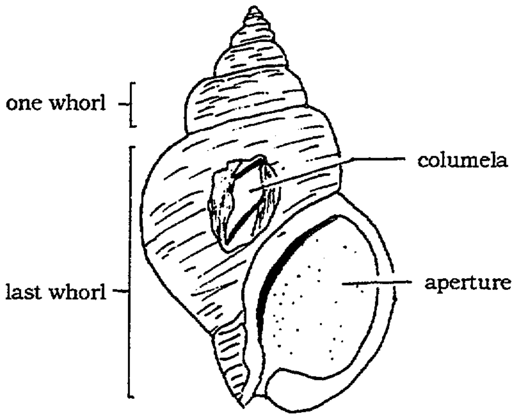
The bivalves are shellfish (e.g. pipis, scallops, clams) whose shells, or valves, are virtually mirror images of each other. The two shells are joined together by a hinge and each shell has a hinge line. This hinge line is a surface on which small bumps or teeth and corresponding sockets occur so when the valves are placed together they lock into each other. The shell material above the outside of the hinge line forms a small hook, known as the umbo. The animal holds its shells together using strong muscles. These muscles attach to the shells in two places, leaving a "scar" on the shell.
The size and position of the muscle scars, hinge line and umbo is important for bivalve classification.



Gastropods

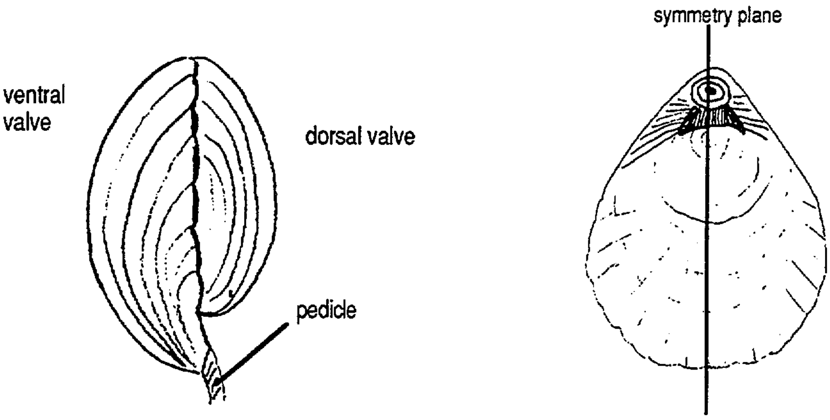
Gastropods are a group of animals characterised by a coiled shell. Common garden snails are examples of gastropods. They are found in marine and fresh water environments as well as on land. They first appeared in the early Cambrian.

As many fossil gastropods are broken, they show the internal column, known as the columella. Each full turn of a gastropod is known as a whorl. Some gastropods have many whorls; others only a few.

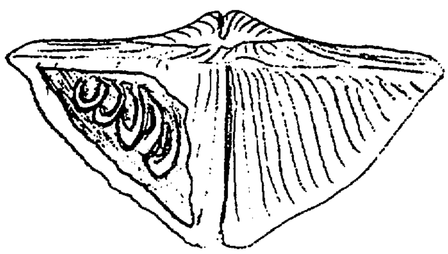


Brachiopods

Brachiopods are shelled animals similar to bivalves. In brachiopods the two shells (or valves) are not the same size (i.e. not mirror images). The shells are however symmetrical along a central plane. The brachiopods first evolved in the Cambrian and some forms still exist today.



One interesting form of brachiopod, the spiriferids, are "bat" shaped, and have a spiral internal skeleton which supported the internal feeding organ.



Spiriferid brachiopod

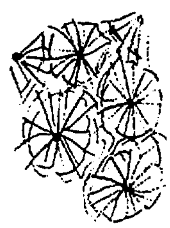
Corals

The corals belong to a family of animals which also includes jelly fish and sea anemones. They are almost entirely marine animals.

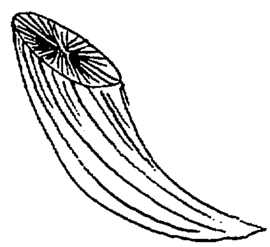
Two extinct coral forms are important in the fossil record, the rugose and the tabulate corals. Both forms lived only during the Palaeozoic Era.

Rugose Corals

The rugose corals occurred as either solitary or colonial forms. The solitary corals are usually horn shaped and lived in muddy sediment.



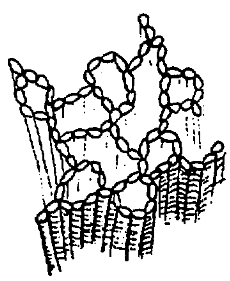
Colonial rugose



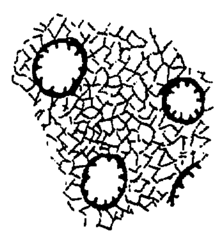
Solitary rugose

Tabulate corals

The tabulate corals were entirely colonial. The coralites were smaller than the rugose corals and each coralite was connected to other coralites via small pores.



Halysites

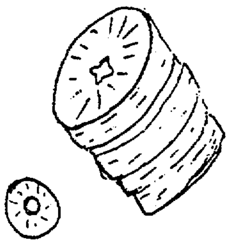


Heliolites

Echinoderms

The echinoderm family includes animals such as star fish, sea urchins and sea lilies. All echinoderms have an external skeleton.

One form of echinoderm, the crinoid or sealilly, is very common in the fossil record. These evolved in the Ordovician and while still in existence, were most prolific in the Palaeozoic Era. Crinoids consisted of a stem made up of many ring-like plates, called ossicles, at the top of which was a cup-shaped structure made up of plates. From the cup grew long feeding arms.

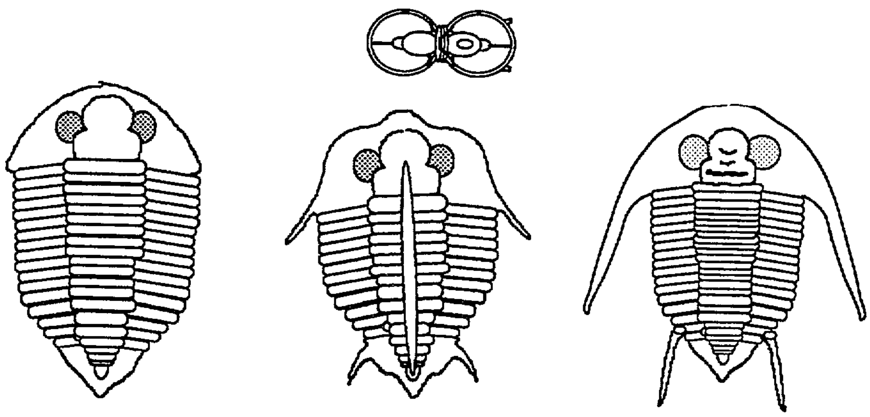


Crinoid ossicles

Trilobites

Trilobites belong to the group of animals which have segmented bodies and legs known as Arthropods. The trilobites are one of the earliest members of the arthropods with the first trilobites evolving in the early Cambrian. They became extinct in the late Permian some 300 million years later.

Trilobites were marine animals ranging in size from a few millimetres to up to 60cm long. They can be found preserved as whole specimens or as parts of specimens, such as a tail or cheek. It is known that the trilobites shed their shells as they grew like modern day crabs.



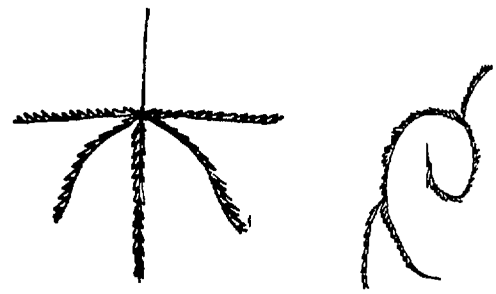
Some trilobite forms

Around 2000 different types of trilobites have been described by geologists. The changing form of the trilobites over their time on Earth allows geologists to use them as "index fossils" for dating specific periods in the Earth's history.

Graptolites

Graptolites are stick-like fossils that are found in shales and slates. Graptolites floated in the ocean currents and probably fed on plankton.

They are found in rocks of the Palaeozoic Era and evolved rapidly during this time, making them good index fossils for the relative dating of rock beds.



Some graptoloid forms

Plants

Fossils of land plants can be found in sedimentary rocks from the late Silurian to the Recent. Coal seams - coal being made up of massive accumulations of plant material - contain some distinctive fossils which are used to date the layers. Petrified wood is quite common, especially in the sediment layers between coal seams.

One interesting fossil plant is Glossopteris, which is only found in rocks of Permian age and is restricted to the southern continents. (India, South Africa, Australia)

Glossopteris leaf

Other common Australian plant fossils:

Stem fragment of Lepidodendron (Carboniferous)

Gangamopteris leaf (Permian)

Rhacopteris frond (Jurassic)

6. Australian Geological Survey Organisation

The Australian Geological Survey Organisation (AGSO) is a government scientific organisation which provides geological and related information to all sectors of Australia (government, industry, environmental agencies etc). Much of what is known about Australia's ancient past has come from the study and research of geologists (scientists who study rocks, minerals and their relationships), geophysicists (scientists who study the Earth's physical properties such as gravity), geochemists (scientists who study the Earth's chemistry), palaeontologists (scientists who study fossils) and other professionals who work at AGSO or other geoscientific institutions.

Scientists at AGSO are currently undertaking further study into our continent. This includes details geological mapping both onshore and offshore, studies into groundwater and salinity of major drainage basins, such as the Murray Darling Basin and studies of Australia's earthquake hazards.

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