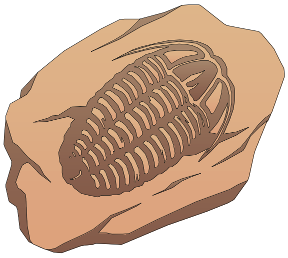


GEOLOGY

Geology: *The science of the Earth; how it was formed, what it is made of, its history and the changes that take place on it and in it.*

Unit Outline

In a State such as Western Australia, a significant part of our wealth and prosperity comes from rocks and minerals mined here and exported all over the world. In this unit you will be introduced to the important geological concepts; such as minerals, rocks, ores, crystals and earth processes.

Student Outcome Statement

Students understand how the physical environment on the Earth and its position in the Universe impact on the way we live.

Assessment

During this unit you will complete various assessments on the Unit Content below. You will be assessed on the **Earth and Space Science** and **Science Inquiry Skills** Outcomes.

Unit Content

Section 1: Structure of the Earth

1. Describe the layers that make up the Earth.
2. Explain the role of convection currents in moving the continental plates.
3. Link crustal movements to volcanic activity and earthquakes.
4. Folding and faulting of rocks is evidence of forces at work in the crust.
5. Distinguish between intrusions and extrusions.

Section 2: Weathering and erosion

1. Rocks are subject to physical and chemical weathering processes.
2. Erosion is the removal of matter from weathered rocks.
3. Wind and water are the agents of erosion.

Section 3: Minerals and Crystals

1. Define a mineral.
2. Describe and identify common minerals, such as quartz, mica and feldspar.
3. Distinguish between rocks and minerals.
4. Describe crystals.
5. Explain how the rate of cooling affects the size of crystals.
6. Describe the common properties used to identify minerals; colour, streak, hardness, lustre, cleavage and polarising light.

Section 2: Rocks

1. Define a rock.
2. Describe the features of common igneous, sedimentary and metamorphoric rocks.
3. List common examples of igneous, sedimentary and metamorphoric rocks.
4. Describe the formation of igneous, sedimentary and metamorphoric rocks.
5. Describe the formation and uses of fossils.

Section 3: Soils

1. Describe the nature and composition of soils.
2. Describe some properties of different soils.

Section 4: Environmental Issues

1. Describe some common materials which are obtained from the Earth's crust.
2. Critically evaluate the impact of human activity on the Earth and the environment.

Note to teachers: In addition to this resource, the Science Department owns a number of booklets of photocopiable blackline masters of worksheets. These include "Science from A - Z" Book 1 - 4 by H. Clark and J. Heaume and "A – Z of Science Book 4 by Z and R. Spry-Pol.

Australian Curriculum: Rocks

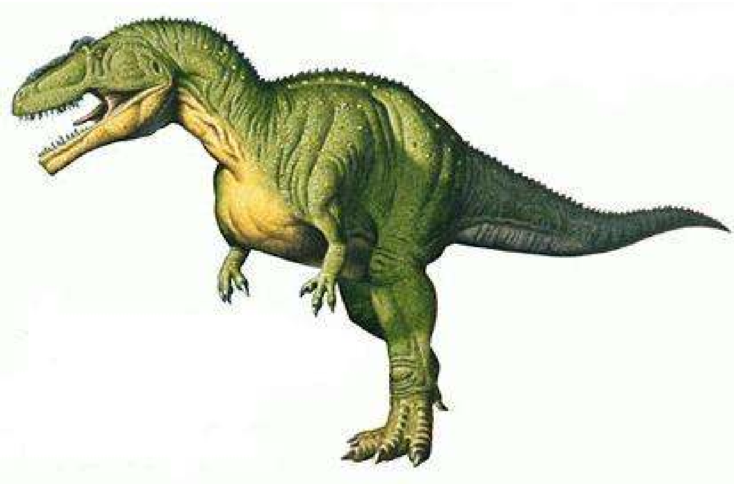
8.3A Sedimentary, igneous and metamorphic rocks contain minerals and are formed by processes that occur within Earth over a variety of timescales:

- representing the stages in the formation of igneous, metamorphic and sedimentary rocks, including indications of timescales involved
- identifying a range of common rock types using a key based on observable physical and chemical properties
- recognising that rocks are a collection of different minerals
- considering the role of forces and energy in the formation of different types of rocks and minerals
- recognising that some rocks and minerals, such as ores, provide valuable resources

9.3A The theory of plate tectonics explains global patterns of geological activity and continental movement:

- recognising the major plates on a world map
- modelling sea-floor spreading
- relating the occurrence of earthquakes and volcanic activity to constructive and destructive plate boundaries
- considering the role of heat energy and convection currents in the movement of tectonic plates
- relating the extreme age and stability of a large part of the Australian continent to its plate tectonic history

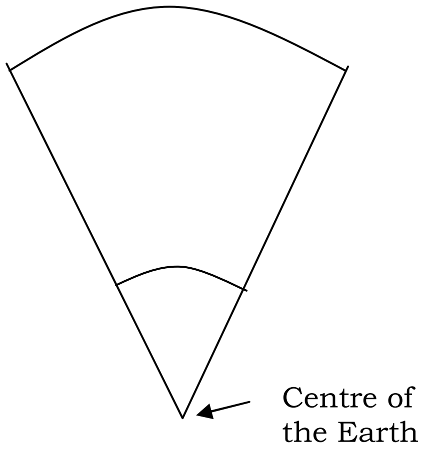
Geology Word List



- acidity
- chemical
- cleavage
- colour
- compounds
- conglomerates
- crust
- crystals
- deposition
- earth
- erosion
- faults
- feldspar
- folds
- fossils
- gravity
- hardness
- humus
- ice
- igneous
- light
- limestone
- lustre
- marble
- mechanical
- metamorphic
- mica
- mineral
- moisture
- polarising
- quartz
- radioactivity
- rocks
- sedimentary
- shale
- slate
- soils
- solidification
- streak
- water
- wave
- weathering
- wind

ACTIVITY 1: STRUCTURE OF THE EARTH

Using your text as a guide, and armed with a 20 metre tape measure and a piece of chalk, draw a scale diagram on a concrete or bitumen path near your science room to represent a segment of the Earth to show the layers. Use a scale of 1m = 1000 km.



Questions: Using your text book answer these questions in your notebook.

1. What is the mantle and how thick is it?
2. Where do you think that the Earth's crust would be about 35 km thick?
3. Where do you think that the Earth's crust would be about 6 km thick?
4. Is the inner core solid or liquid?

ACTIVITY 2: A MODEL OF THE EARTH

Aim: To draw a scale model of the Earth that shows the relative size of each of its layers.

Materials required:

- ruler
- calculator
- compass
- sheet of paper

Method:

1. Rule a horizontal line 15.75 cm at the bottom of one side of your page. This line represents the radius of the Earth.

2. Use a calculator to divide this distance into 60 units i.e. $\frac{15.75}{60} =$

3. From the left end of the line measure 13.33 units i.e. $\frac{15.75}{60} \times 13.33 =$

   Mark this point on the line. This represents the distance from the centre of the Earth to the outer boundary of the Inner Core.

4. Next measure a further 19 units i.e. $\frac{15.75}{60} \times 19 =$

   Mark this point as the limit of the Outer Core.

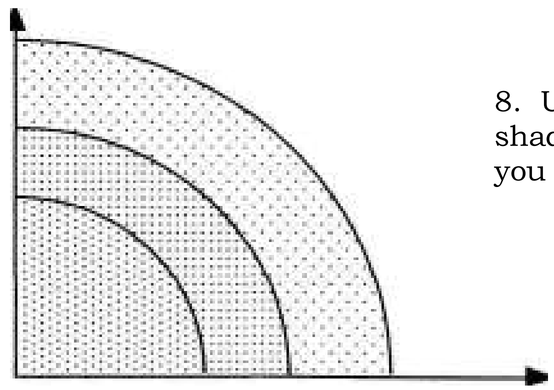
5. Measure a further 27.33 units i.e. $\frac{15.75}{60} \times 27.33 =$

   to represent the distance form the Outer Core to the boundary of the Mantle. Mark this point on your line.

6. The last 0.33 unit represents the thickness of the Crust, i.e. $\frac{15.75}{60} \times 0.33 =$

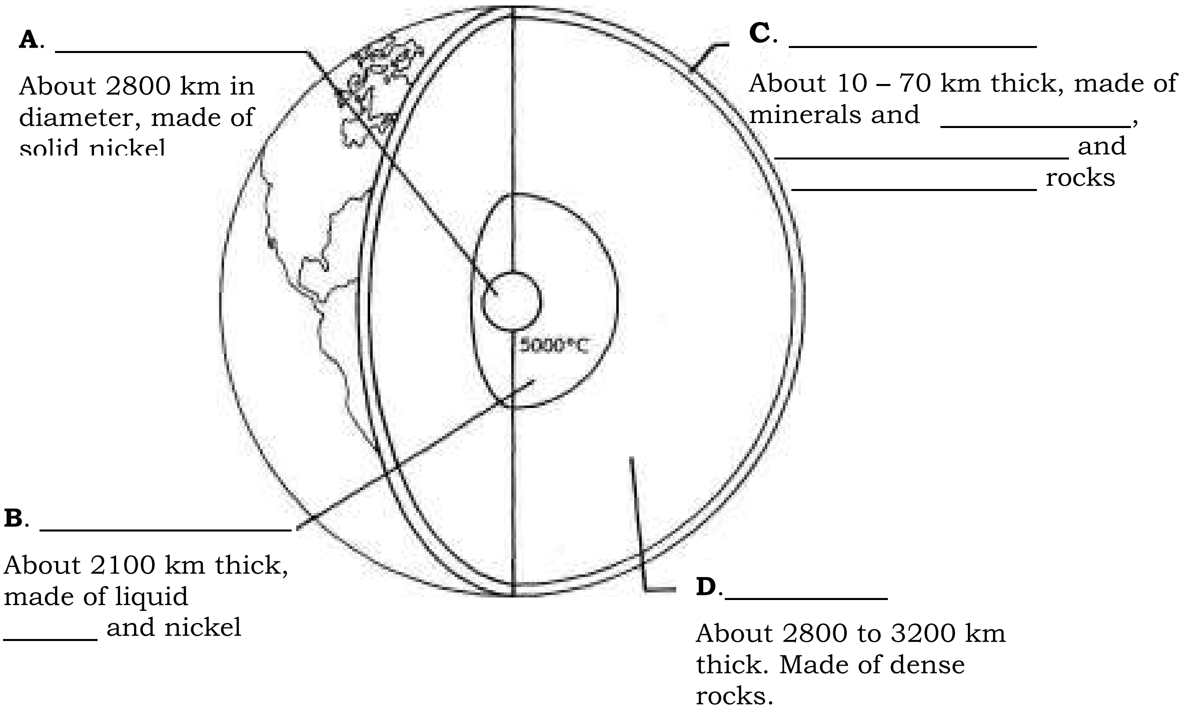
   Measure and mark this distance onto the line.

7. From the left end of the Earth's radius draw a vertical line towards the top of your page.
   Using your compass draw quarter circles to this vertical line using the distances you have marked as radii. Your diagram should look something like this:



8. Use different colours to shade the layers of the Earth you have now drawn.

WORKSHEET: THE EARTHS INTERIOR



1. Label the layers of the Earth on lines A—D.
2. Which layers can only be studied by indirect means?______________________________

   ____
3. Which layer contains the highest mountains and the deepest oceans?______________
4. What is the composition of:

   a. the outermost layer of the Earth?____

   b. the innermost layer?____
5. What happens to the temperature of the rocks as the layers go deeper into the Earth?

   ____
6. a. In which layer does erosion take place?____

   b. Why?____
7. a. In what areas is the outermost layer of the Earth the thinnest?________________

   b. Where is it the thickest?____
8. Which layer has the greatest mass?____

FORCES IN NATURE

The Earth beneath your feet – it's always there! So much so, that we forget about it most of the time. It is only when it does something that we remember that it is so important to us. Tremendous forces are at work in the Earth - building up, breaking down and carrying away material.

The Earth's crust can be altered by forces of nature that cause:

1. **VOLCANOES**
2. **EARTHQUAKES**
3. **FOLDING**
4. **FAULTING**
5. **INTRUSIONS**
6. **WEATHERING**
7. **EROSION**

> 1. *Are there any active volcanoes in Australia or in Australian Territories?*
> 2. *The Glasshouse Mountains of Queensland, Mount Gambier in South Australia and Cradle Mountain in Tasmania are all extinct volcanoes. Find out when one of these last erupted.*

ACTIVITY 3: VOLCANOES

Read the article below and use it to draw a cross-section of a typical volcano. Label your diagram with most of the terms in bold type.

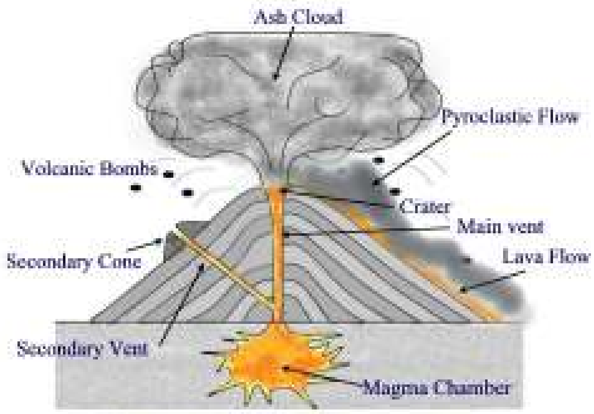
Along the plate boundaries there are massive forces at work in these areas of weakness in the Earth's crust.

There are no active volcanoes in Australia. A volcano which has not erupted for 25 000 years is said to be extinct. Volcanoes which are not erupting now but have done so in the last 25 000 years are said to be dormant. A volcano may remain dormant for 20 years or 5000 years between eruptions.

The liquid feeding a volcano is called **magma** – the material that makes up the mantle. Magma is a mixture of **lava** and **volcanic gases** and it pushes its way up the **vent** of the volcano to the surface. Volcanoes produce a lot of gas, which is ejected as the pressure inside the Earth is released at the surface often destroying part of the volcano as it erupts. In 1980 Mt St Helens in Washington State, USA blew out the side of the volcano and about 60 people are thought to have died.

Lava may be very runny or thick and pasty. Lava usually flows very slowly out of the **crater** of a volcano. Pasty lava may partly block the vent of a volcano, and if it contains large quantities of gas it can be very explosive. Some pasty lava is so full of bubbles that it is very light and can float. This lava when it solidifies to a rock is called **pumice**. If the lava has a lot of gas it begins to froth and results in a glowing cloud of **volcanic ash**. This ash can move out of the volcano at 200 km per hour. Solid fragments of rock vary in size from small pieces of ash up to giant boulders called **volcanic bombs**. These become solid in flight and if the pieces have lots of bubbles of gas in them they form a loose pile of rocks called **scoria**.

Any eruption where molten magma comes out of the earth and cools on the surface is called an **extrusion.**



Main Features of a Volcano

Webquest: Mount Merapi

On the 25th October, 2010, Mount Merapi near Yogyakarta in Indonesia exploded sending ash and debris high up into the sky to rain down on the surrounding villages.

1. How many casualties were there?

2. What were the major causes of deaths and injury?

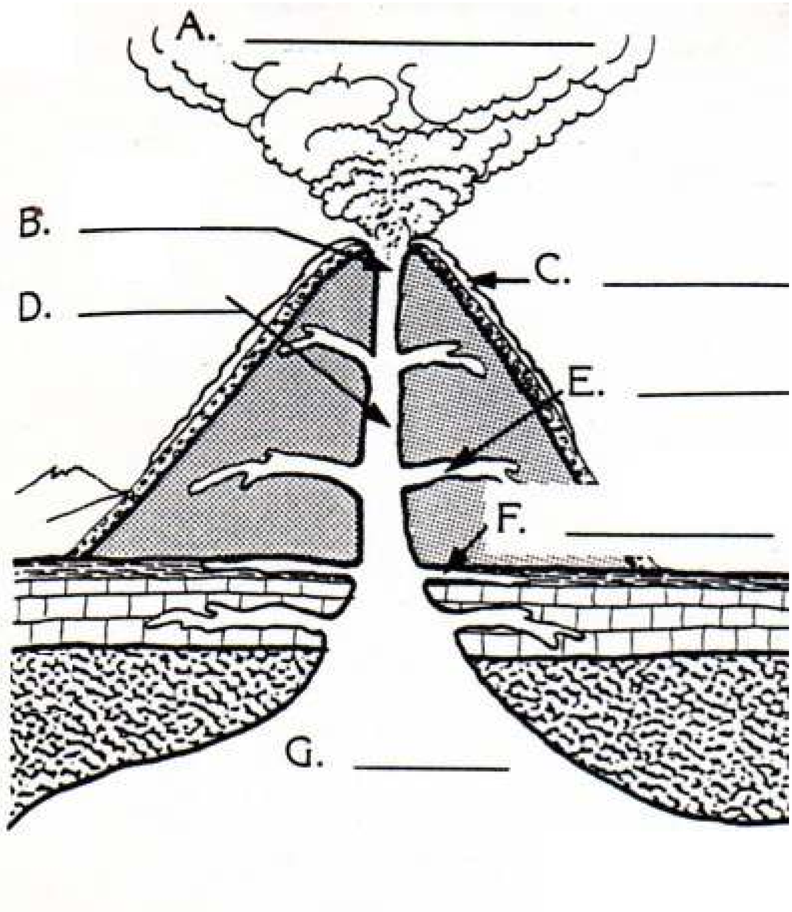
3. Had this volcano exploded before?

4. Why would people choose to live so close to an active volcano?

5. Suppose you were to lead an emergency team sent in from Australia to assist these unfortunate people. What would be some of the challenges you and your team would have to face in meeting the immediate and long term needs of these people?

http://www.perthnow.com.au/news/top-stories/indonesian-volcano-erupts-20-hurt-by-hot-ash/story-e6frg12l-1225944122054

VOLCANO WORKSHEET



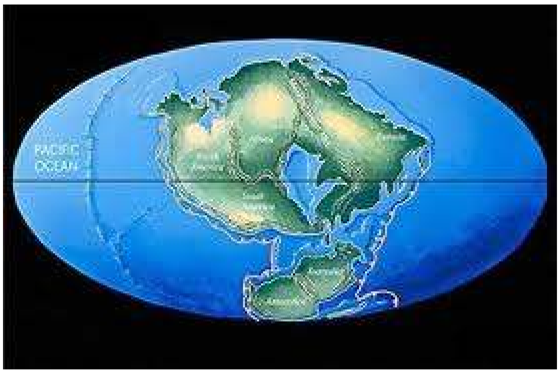
1. Locate and label on lines A-G these parts of a volcano:

   vent   sill   magma   dike   crater   gases, ashes and cinders   lava

2. Write the number of the item in Column B on the line before its description in Column A.

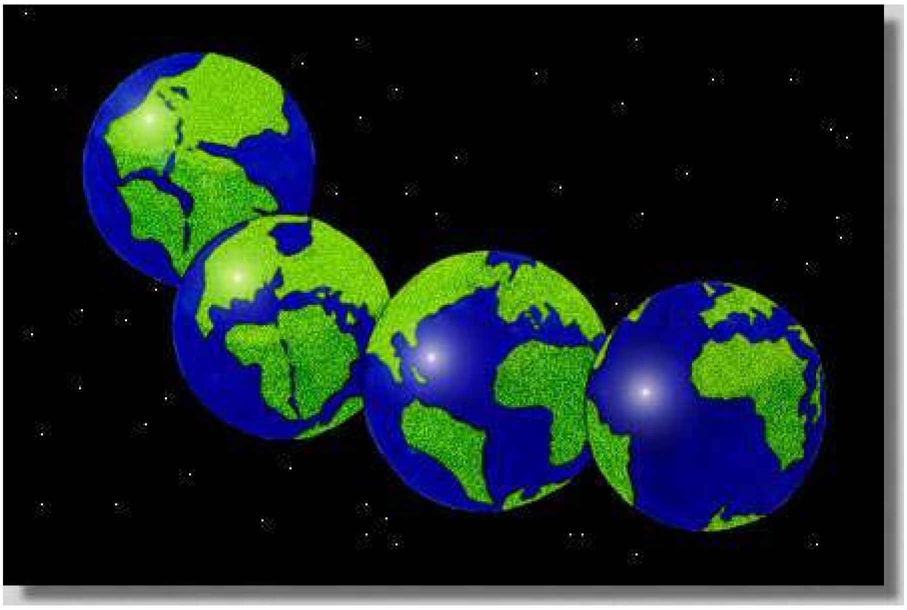
Column A	Column B
___a. molten rock deep within the earth	1. lava
___b. opening of a volcano	2. vent
___c. magma flow below surface of volcano	3. gases, ashes, cinders
___d. magma that reaches surface	4. magma
___e. connects pool of magma to crater	5. Mt. St. Helens
___f. spewed into atmosphere during volcanic eruption	6. sill
___g. an active American volcano	7. dike
___h. magma flow across layers of volcanic cone	8. crater

ACTIVITY 4: CRUSTAL MOVEMENTS



If you look at a map of the World you will probably notice that the coastlines on the two sides of the Atlantic Ocean look as if they fit together.

Scientists now believe that long ago all the continents were joined together in one huge landmass called Pangaea, surrounded by ocean.
They think that this land mass broke apart and pieces moved over millions of years to where they are today. These land masses continue to move, even as you read this page.



Obtain a copy of the World shown on the next page, cut out the land masses and try to reassemble them into the shape that was Pangaea on a new page in your notebook.
Glue them into place, then answer the questions which follow:

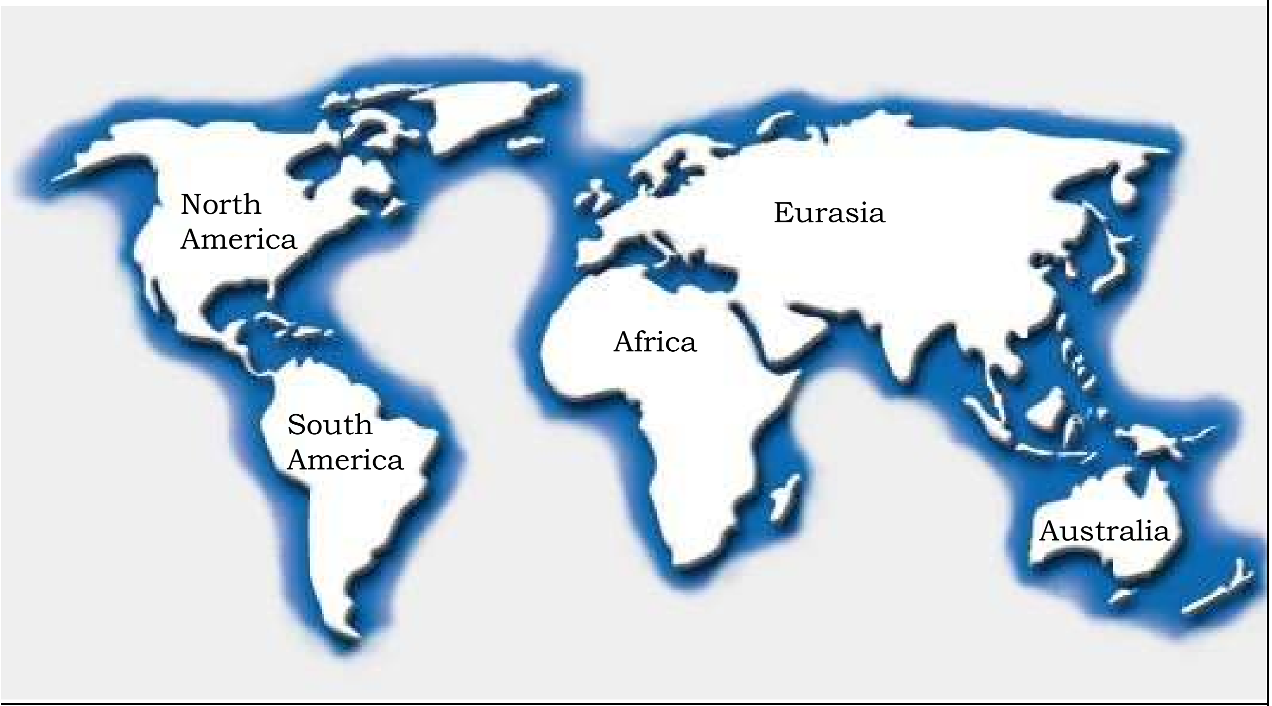
Questions:

1. What evidence might you put forward to support the Pangaea model?
2. Besides shape, what other evidence might scientists put forward to support this model?

Useful sites:

http://geomaps.wr.usgs.gov/parks/pltec/index.html
http://geomaps.wr.usgs.gov/parks/pltec/pangea.html for an animation of the break-up of Pangea
http://geomaps.wr.usgs.gov/parks/pltec/vigilim.html for a diagram of tectonic processes
http://pubs.usgs.gov/gip/dynamic/dynamic.html

WORLD MAPS

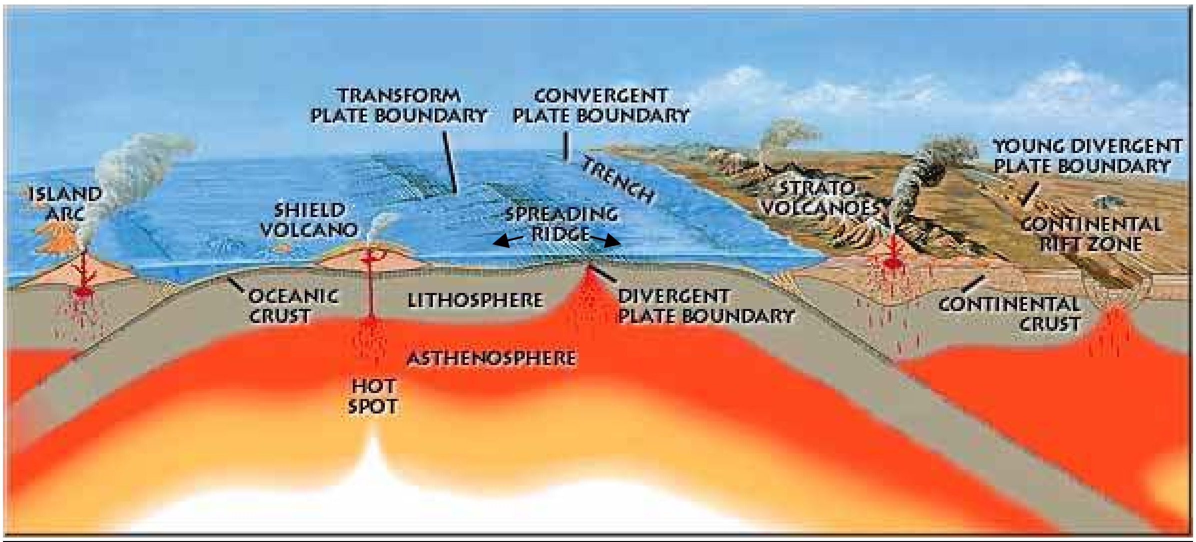

North America
Eurasia
Africa
South America
Australia


North America
Eurasia
Africa
South America
Australia


SOUTH AMERICA
AFRICA

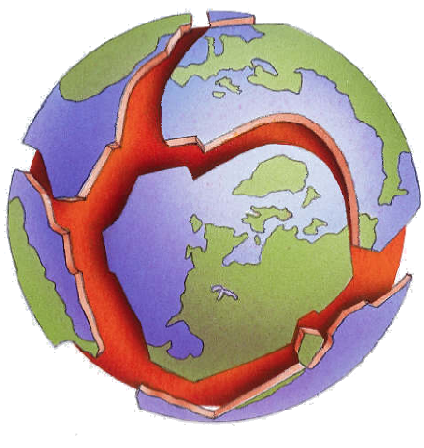
ACTIVITY 5: PLATE TECTONICS

Plates of the crust are always moving. Although the rate of movement is measured in centimetres per year, this movement causes stresses to build up in the Earth's crust as one plate is forced into an adjacent one. Where two plates collide land can be forced upwards to form mountains. The Himalayas have been formed in this way. One plate might be forced to move along another or alternatively, a crustal plate might be forced underneath another to form what is known as a **zone of subduction.** Deep ocean trenches form along these zones.



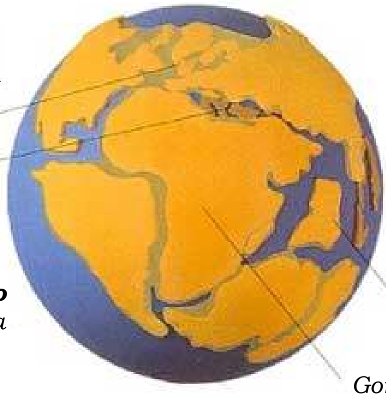
Questions

1. Where is the Marianas Trench? How deep is it?
2. Name another deep ocean trench and find out how deep it is.
3. What is meant by the words 'divergent' and 'convergent'?
4. In the diagram above is a 'divergent plate boundary'. What happens along such a boundary?
5. Find out the name of the kind of rock that forms the ocean crust and the name of the rock that forms the continental crust.
6. Explain why it is that the ocean crust moves underneath the continental crust at a convergent plate boundary.
7. Volcanoes are often found along convergent boundaries of crustal plates. Explain.
8. Find out what are 'black smokers'. What kinds of living things are able to survive in this hostile environment.

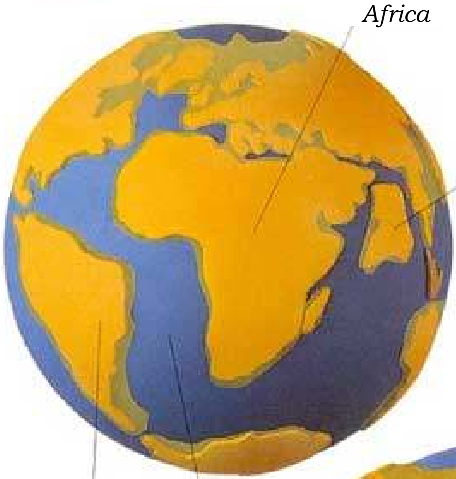


TECTONIC PLATES

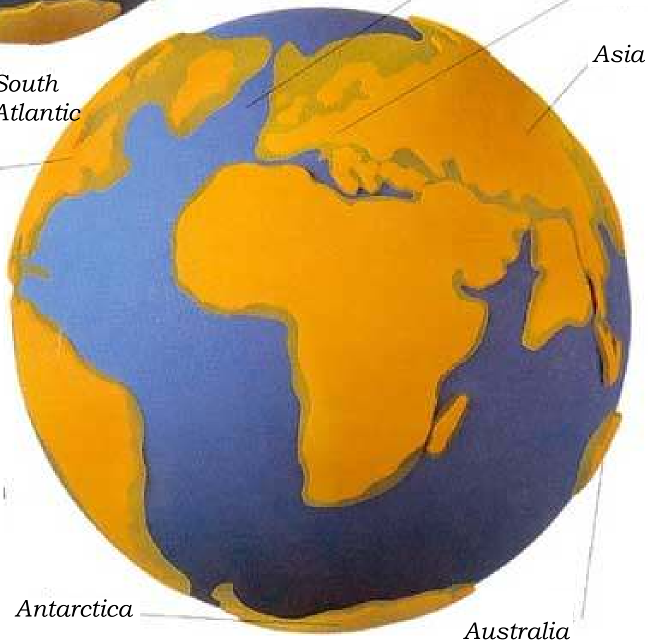
22o million years ago
There is only one land mass, Pangaea, in a vast ocean called Panthalassa



200 million years ago
The growing Tethys Sea splits Pangaea into Gondwanaland and Laurasia



135 million years ago
Gondwanaland splits into Africa and South America as the South Atlantic opens up. India drift towards Asia.



10 million years ago
Antarctica and Australia drift apart. Laurasia breaks up as the North Atlantic opens up, with North America moving away from Europe. The map of the world looks similar to the one we know today.

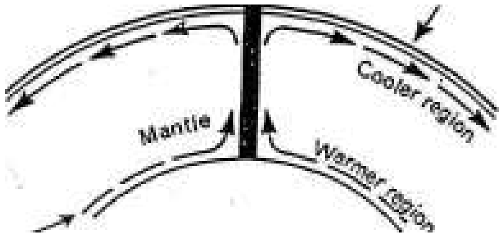
ACTIVITY 6: CONVECTION CURRENTS

In order to understand why the continents drift we need to realize that a large source of energy would be required to power the movement of land-masses weighing billions of tonnes. Finding the source of the energy that moves the crustal plates is a problem.

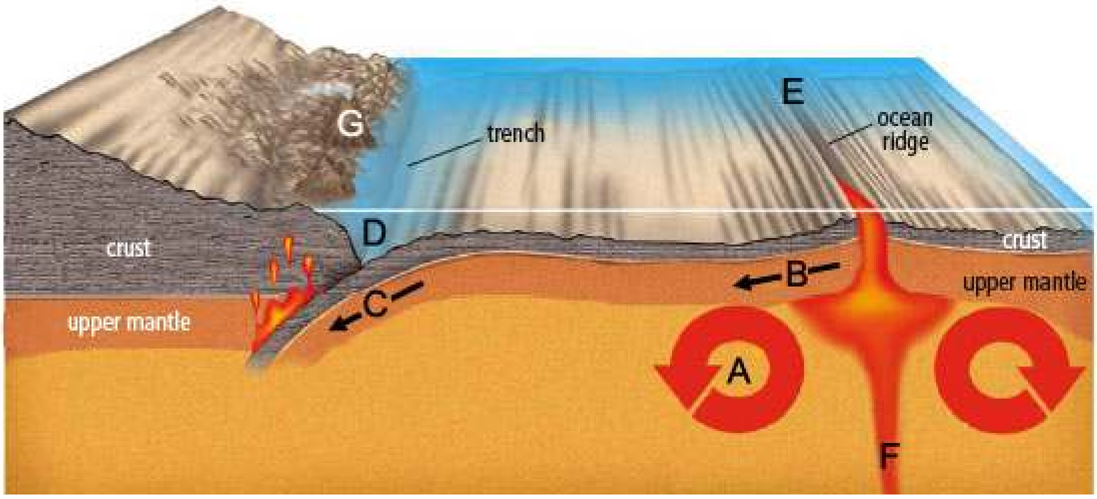
Let's explore a possible solution provided by an examination of the Mid-Atlantic Ridge.

Mid-ocean ridges are areas of crust where new material is being added to the Earth's surface from rocks deep in the mantle. This material is forced to the Earth's surface by convection currents. Convection currents are caused in the Earth's mantle by the heat that comes from the core of the Earth and this process scientists believe is the source of energy that moves the crustal plates.

The plate is pushed by the material spreading from the mid-ocean ridge.



Convection current in mantle



The diagrams above show how the plates may have been made to move. Plates that separate from each other allow lava from the mantle to rise to the ocean floor. As the lava cools, new crust forms at the mid-ocean ridge to fill the gap left by the separating plates.

Draw either of the above diagrams in your notes and below the diagram answer the following questions

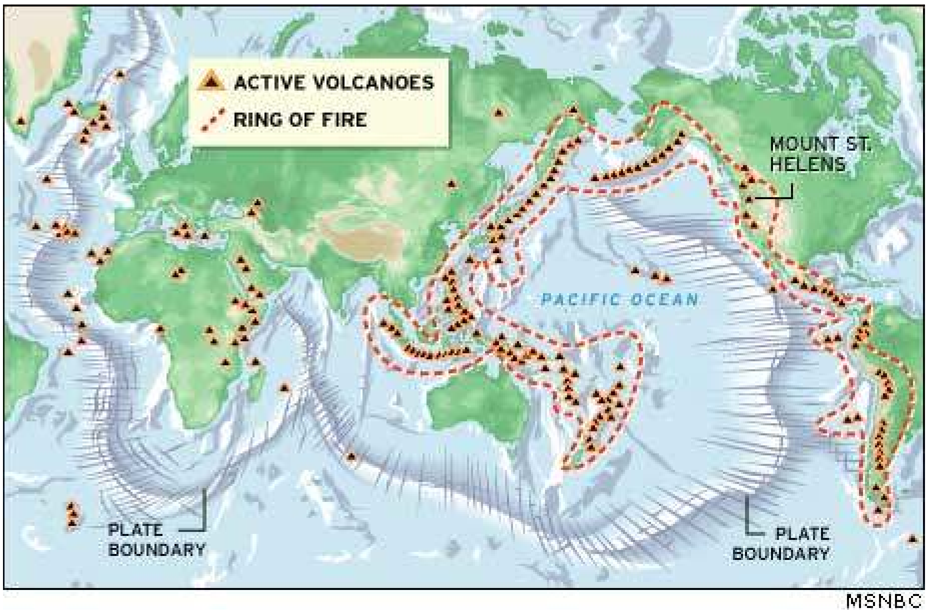
Required:

- Aluminium powder
- 250mL beaker
- Bunsen burner

1. Fill a 250mL beaker with cold water. Add a pinch of aluminium powder. Very gently heat the beaker over a Bunsen burner.
   - What happens to the particles of aluminium?
   - Explain their movement using terms like hot water, cold water, low density, high density and convection current in your answer.
2. Explain how the hot core could set up a convection current responsible for the plate movements.
3. What activities may occur at mid-ocean ridges as a result of the sea floor spreading occurring at the mid-ocean ridges?

ACTIVITY 7: THE RING OF FIRE

Examine the following map of the World then answer the questions that follow.



Questions:

1. Describe the distribution of volcanoes over the World.
2. What is the 'Ring of Fire'? Why is it located where it is?
3. Use the Internet to find out what happens at the boundaries of crustal plates.
4. What is a **mid-ocean ridge**? Describe how it forms.
5. Hawaii is located in the middle of the Pacific Plate, not at its boundary, yet it has many active volcanoes. Explain why this is so.
6. How would you use a hard boiled egg (you could try an unboiled one!) to illustrate **plate tectonics**?
7. Put the following words into a copy of the sentences below to describe the structure of the Earth's crust.

plates, moving, Earth's, forces, apart, slow, colliding, boundaries

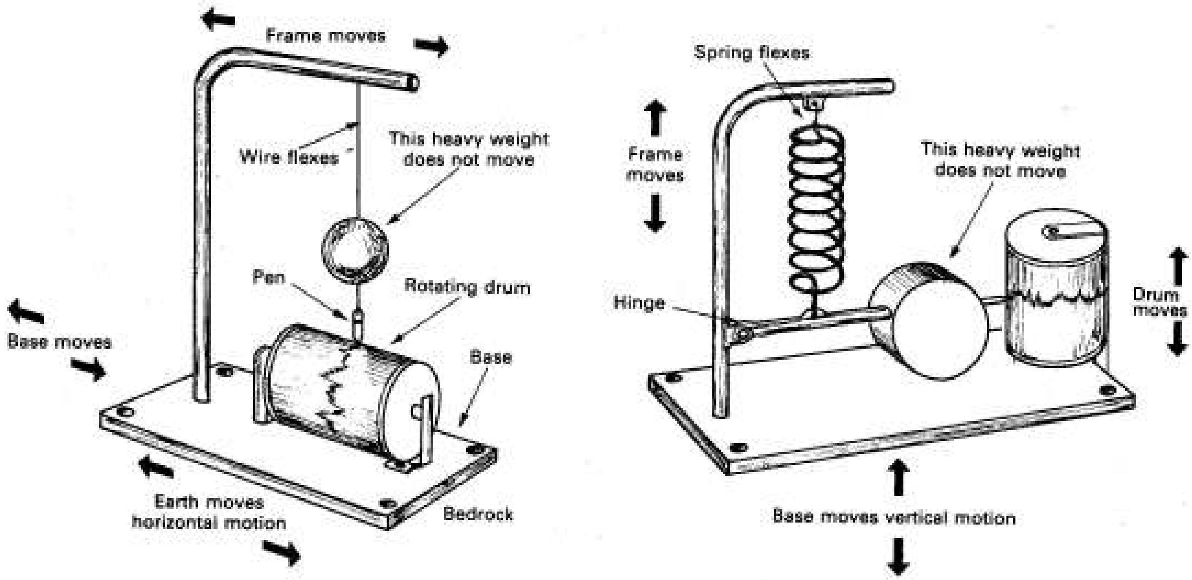
The _________ crust is composed of seven major and five minor ________ which float on the magma layer. These plates are ___________ but the movement is very _________. When the plates of the Earth's crust move, tremendous ________ are set up at the plate _____________. In some places the plates are moving ___________ and in other places the plates are _____________.

ACTIVITY 8: EARTHQUAKES

Earthquakes result from stresses built up in rocks due to earth movements. The energy is suddenly released when the rocks break. As stresses increase, the rocks usually bend and then when the deforming force exceeds the strength of the rocks, the crust breaks and snaps into a new position.

Most earthquakes take place at the boundaries between the crustal plates; although a small proportion (about 5%) occur within the plates. All the earthquakes in Australia occur within the plates. Of the million or more earthquakes that are detected by seismometers each year, most are not felt by people.

Examine the two seismometers shown below. Your teacher will give you one of the seismometers to examine. Discuss in your group how you think the device works. Then select one person from your group to visit another group and tell them how your device works. Somebody from another group will then come to your group to explain how the other seismometer works. (*Learning how to interpret and explain scientific diagrams to each other is a very important skill*).



Questions: Answer the following questions in your notebooks:

1. **List** the effects of earthquakes.

   Write down **one** place in WA that had an earthquake in 1968.
2. Earthquakes can be triggered by human activity. Can you **explain** the increase in earthquake activity after large dams have been built?
3. What is a **tsunami**?
4. On March 11th 2011, a tsunami struck and caused massive damage and loss of life in Japan. Find out more about the damage and loss of life in this disaster. Describe the cause of this tsunami.

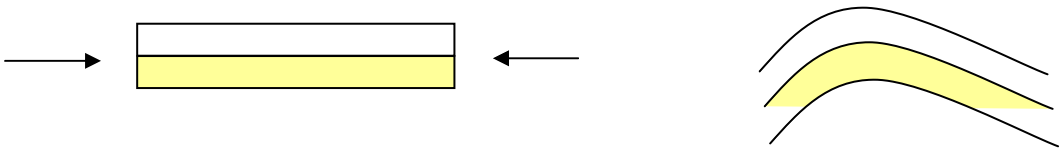
   http://www.abc.net.au/news/events/japan-quake-2011/beforeafter.htm

ACTIVITY 2: FOLDING

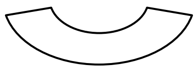
If rocks move gradually towards each other then the layers of rock can form folds.

DEMONSTRATIONS:

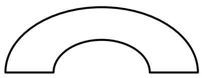
1. Get a piece of paper, hold it in both hands and then push the ends towards the middle. You have made a fold. Folds range from tiny crinkles in rocks to large mountains ranges more than 100 km across. Folds are formed by **compression** forces.
2. Get a sheet of newspaper. Fold the paper in half. Continue to fold the paper as many times as you can.
   The paper becomes more difficult to fold. With each folding the amount of paper doubles. After seven foldings there are _______?______ sheets. The Earth's crust, like the paper, requires a small amount of force to fold thin, lighter layers on the surface. Tremendous forces are required to fold over large, denser sections of rock.



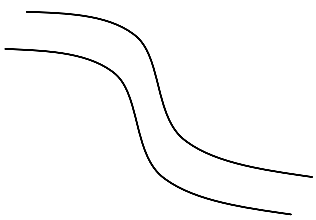
If a fold is ∪-shaped it is called a **syncline** (trough).



If a fold is ∩-shaped it is called an **anticline** (arch).

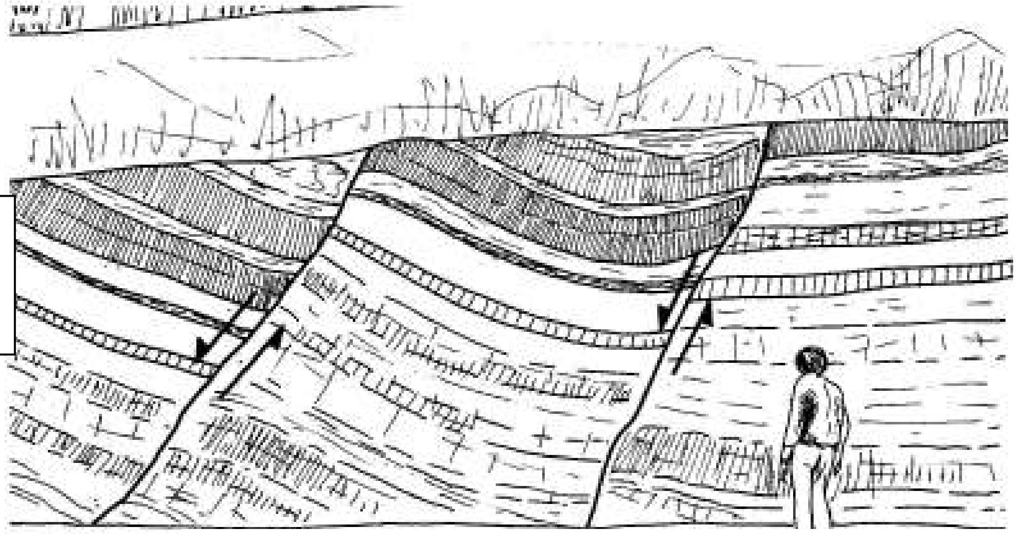


A single sided bend with a -shape is called a **monocline.**

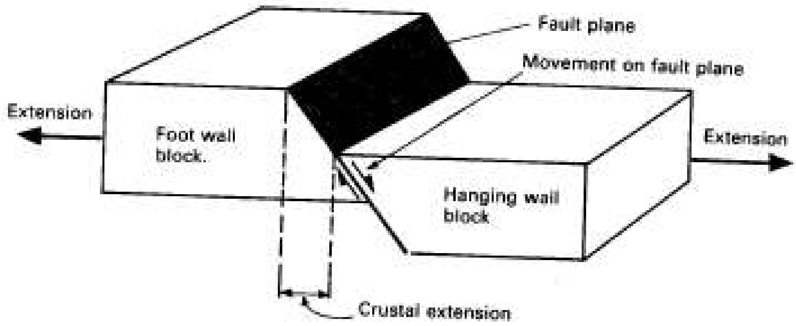


FAULTING

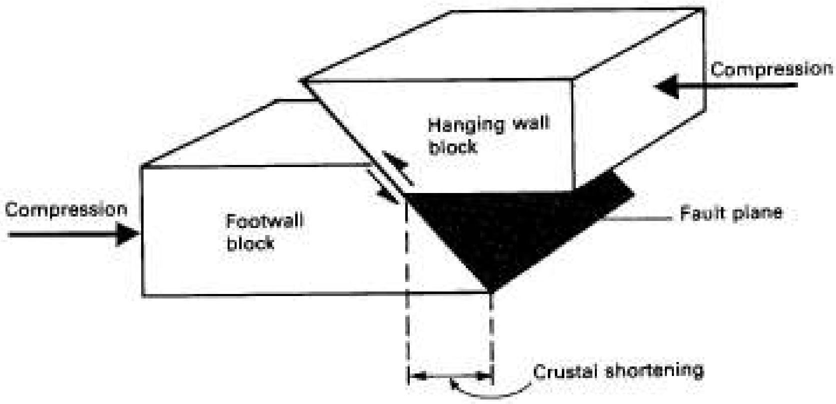
Sudden movements, such as earthquakes, can cause breaks or cracks in rocks called **faults.** They can be on a small scale or like the Darling Fault scarp can be hundreds of kilometres long.



The arrows indicate the movement either side of the fault line in a quarry.



Normal faults are produced by tension forces that result in crustal extension.
The formation of the Darling Scarp is an excellent example.



Reverse faults are produced by compression forces that result in crustal shortening

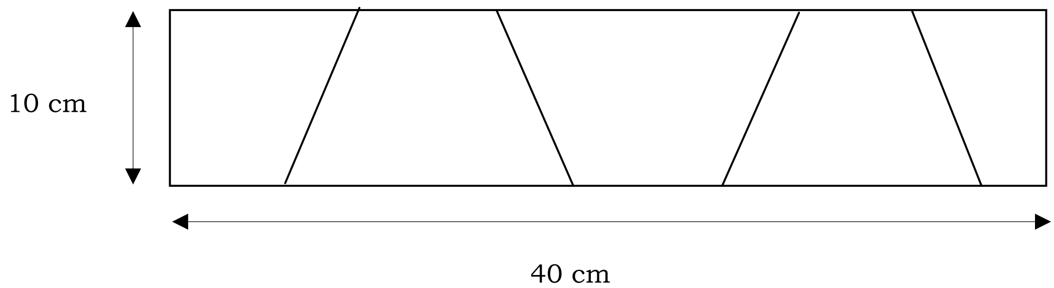
Challenge: Find out more about the Darling Scarp. How long is the Darling Scarp? When did the fault movement take place? How much movement took place? Where is the fault line now?

ACTIVITY 10: FAULTY CROSS-SECTIONS

HOW DO FAULTS RELIEVE STRESS IN THE EARTH'S CRUST?

What you will need:
Cardboard and scissors

There are several ways that the Earth's crust may be stressed. Two of them are tension (stretching, like a rubber band) and compression (squeezing). Rocks often break (fault) under these stresses. The type of fault can tell us the type of stress that was involved.



Procedure:

1. Take a piece of cardboard, and cut it carefully as shown in the diagram above. You may like to draw some rock layers on it.
2. Set up your cross-section so that it is a 40 x 10 rectangle. Now we fault it, by moving the ***even*** *numbered blocks* ***upwards***. Make sure there are no gaps between the blocks.
3. **Complete a table like that below:**

	Type of Fault	*Width before faulting*	*Width after faulting*	*Type of stress Tension/ compression*
Even numbered blocks pushed up	**Normal**			
Odd numbered blocks pushed up	**Reverse**			

4. Set up your cross-section so that it is a 40 x 10 rectangle again. Now we fault it, by moving the ***odd*** *numbered blocks* ***upwards***. Make sure there are no gaps between the blocks. Write your results in the table.

ACTIVITY 11: HOW HEAVY IS A TOR?

This is a challenge activity.

Your teacher will decide if they have time to do the activity in class time or set it for homework or omit the activity.

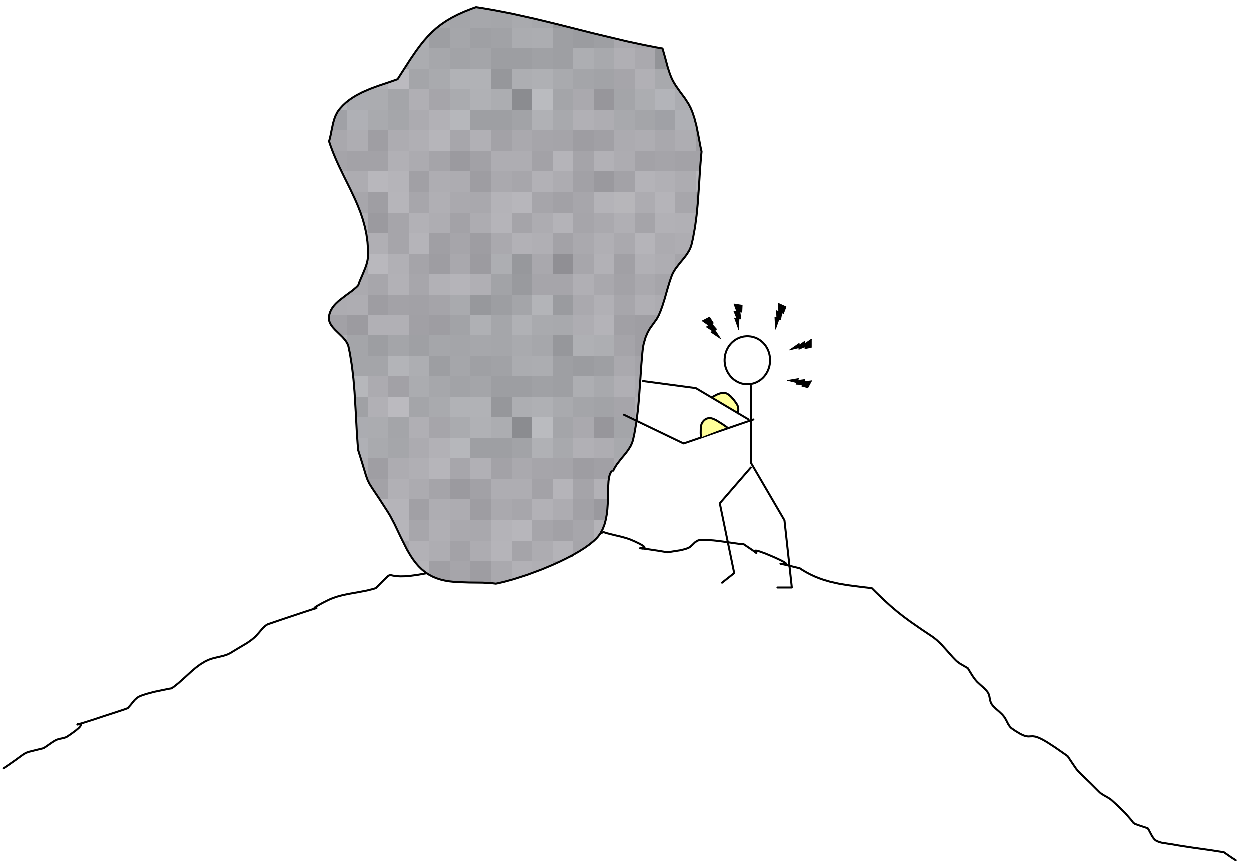
Looking at granite tors balanced on hillsides often causes us to wonder……..

………….What is their mass?

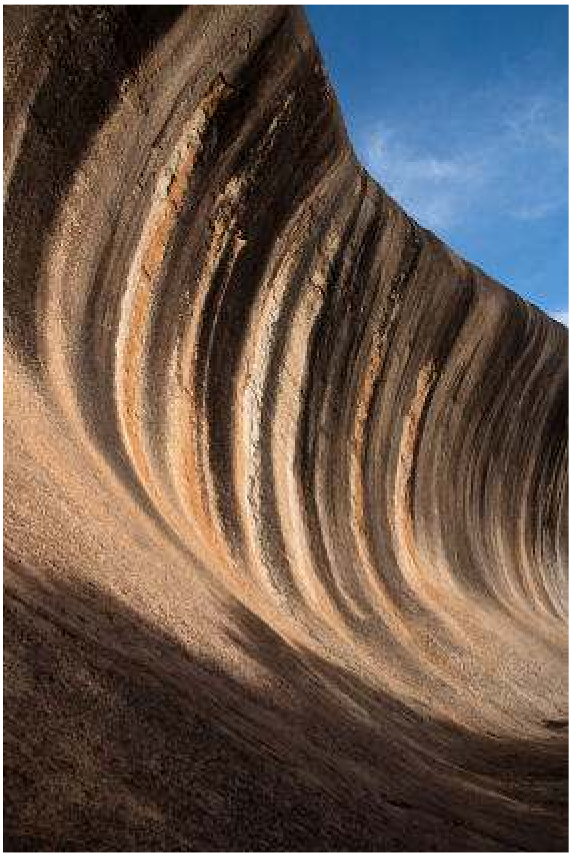
The Mission – should you choose to accept it!
Assume that a granite tor (boulder) is shaped like a cube with 4.5 m sides.
Using the equipment listed below find out the mass of the granite tor.

Equipment that could be useful:

- A piece of granite
- 1000 mL measuring cylinder
- water
- balance
- calculator
- someone who can tell you about density – not a



FUN GEOLOGY FACTS



By: Alice Langholt

It's fun to know some geology facts that you can share and use to amaze others. In the fields of mineral geology and petroleum geology, there is a wealth of knowledge and many fascinating pieces of information to be found. Here are some amazing geological places in the world that you and your friends may find worthy of studying.

- **Moving Rocks in Death Valley, California:** The flat clay surface of this area in California has trails left by rocks, with the rocks sitting at the end of them. Wiggly, zigzag trails have been made when these large rocks have mysteriously moved on their own across the flat surface. Scientists still don't know exactly what causes these rocks to move. Some ideas include ice crystals forming beneath the rocks or the wind blowing them.
- **Hawaii's Curtain of Fire:** In January, 1983, the eruption of a volcano fissure on Mount Kilauea caused the Puu Oo eruption. This lava fountain shot liquid magma as high as 160 feet into the air through the fissure, making a wall of lava that could be seen for miles.
- **Southwest China's Stone Forest:** What looks like limestone trees towering for miles can be found in Southwest China in Shilin, a town whose name translates to "stone forest." Water bubbling along the surface of the ground eroded everything but these massive limestone structures, which tower over the trees and hills. Centuries of wind and rain erosion have weathered the peaks into jagged edges, creating a unique natural landscape.
- **Western Australia's Wave Rock**: In the town of Hyden in Western Australia, there is a large rock that looks like a big ocean wave. It is an amazing 50 feet tall and 360 feet long. A granite rock was striped by algae and eroded over time, created a shape resembling an ocean wave frozen just as it begins to crest. Tourists travel from all corners of the world to get pictures of themselves "surfing" on this impressive structure.
- **Uzbekistan's Hell Gate**: In Darvaz, Uzbekistan, geologists were drilling for gas. A cavern was penetrated by drilling equipment, causing a massive hole to form in the ground. Natural gas started to seep from the hole. To keep the gas from spreading, the geologists ignited it. It has now burned for more than 35 years, with no sign of stopping. It now looks like a big hole of fire and has become a popular tourist attraction.

http://www.life123.com/parenting/education/geology/geology-facts.shtml

WEATHERING

After they have formed, rocks far below the surface of the Earth do not change much. It is only when they are at or near the surface that weathering of rocks can begin. There are two types of weathering:

1. **PHYSICAL WEATHERING. (or MECHANICAL WEATHERING)**

This is the breakdown of large pieces of rock into smaller pieces and then eventually soil particles.

2. **CHEMICAL WEATHERING.**

This is the breakdown of rock by chemicals such as acids to form new substances.

In the next two activities you should discover some ways in which rocks can be broken down.

ACTIVITY 12: PHYSICAL WEATHERING BY TEMPERATURE CHANGE

Equipment:

- Safety glasses
- Bunsen burner and matches
- Two pieces of glass rod
- Ice water
- Tongs
- Metal can
- Bench protective board

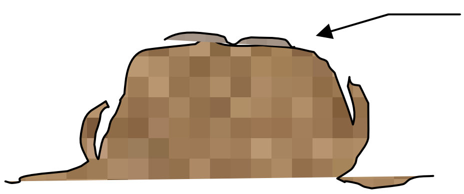
DO NOT REHEAT A CRACKED GLASS ROD!!!!

PROCEDURE:

1. Put on your safety glasses and follow your teacher's safety instructions.
2. Heat a piece of glass rod for about one minute then drop it into a can filled with water from the tap.
3. Heat another piece of glass rod for the same time and *carefully* drop the glass into a can filled with ice water.
4. Closely examine the pieces of glass that were cooled. Observe how the heating and rapid cooling affected the glass rod.

QUESTIONS: Write the answers in your notebooks

1. What happens when brittle materials, like glass, are heated and then cooled rapidly?
2. What happened to the hot glass rod when it was put into water at room temperature?
3. What happened to the glass rod when it was put into the ice water?
4. Talk this question over with your group as it will show your understanding of science. Explain how continuous heating and cooling of rocks help to break them down. Use science terms in your answer. Hint: What happens to the length of a material when you heat it and cool it?
5. In what areas of Western Australia might **temperature changes** be important in the weathering of rocks.



Exfoliation is the scientific term for the formation of these sheets of rock that split from the surface - a good place to find centipedes, lizards and millipedes.

ACTIVITY 13: PHYSICAL WEATHERING BY FREEZING WATER

You might be surprised to learn that very cold weather can sometimes cause rocks to crack open.
AIM: To determine if freezing water causes rocks to break up.

Equipment:

- Drinking straw
- Plasticine
- Freezer
- Beaker of water

PROCEDURE:

1. Place one end of the straw in a beaker of water.
2. Fill the straw with water by sucking the water up.
3. Hold your tongue over one end to prevent the water from escaping while you insert a plasticine plug into the other end of the straw.
4. Remove your tongue and plug that end with another piece of plasticine.
5. Lay the straw in the freezer overnight.
6. Remove the straw and observe the ends.

QUESTIONS:

1. What happens to water when it freezes? This is very queer or anomalous behaviour!
2. Explain how freezing water can break down rocks. Talk it over with your group.
3. Have you accidentally put a glass bottle of drink in the freezer and left it there. What happens and why?

ACTIVITY 14: CHEMICAL WEATHERING

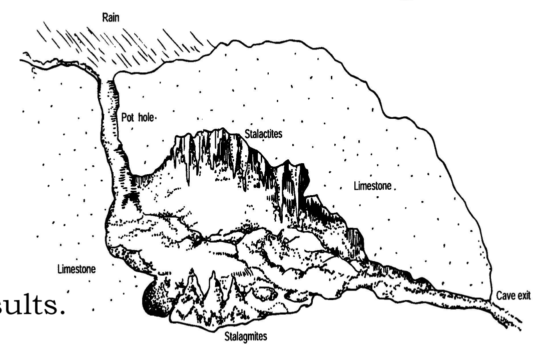
WHAT WILL HAPPEN IF ACID SOLUTION IS POURED ONTO A ROCK SAMPLE?
(Copy this question into your notebook as a heading)

HYPOTHESIS: Write an answer to the above question. Your answer is a **hypothesis** you will test.

THE TEST: Design your own investigation using the following equipment.

Equipment:
- Six test tubes
- Test tube rack
- Two pieces of granite
- Two pieces of limestone
- Two pieces of sandstone
- Water
- 2 mol per litre hydrochloric acid ($HCl_{(aq)}$)

Chemical weathering



RESULTS: Prepare a suitable table for your results.

CONCLUSION: Was your hypothesis rejected or supported? Do you have to modify or change your hypothesis? Write a conclusion about what type of rock will be weathered by acid solutions.

EROSION

Rocks broken down by the weathering processes can be moved to other areas by the forces of wind and water. This process is known as EROSION.

DEMONSTRATION 15: EROSION BY WATER

AIM: To investigate what size rock particles a stream of water can move.

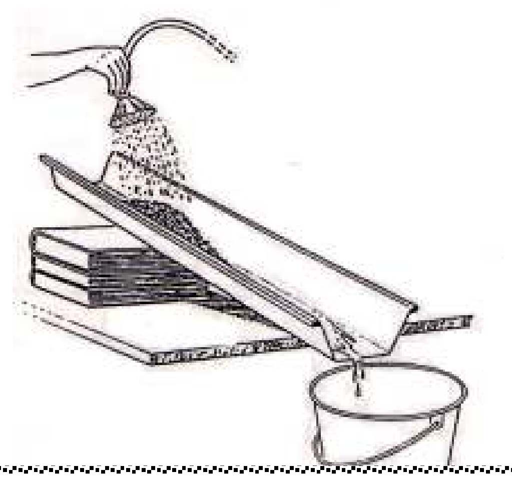
Your teacher will demonstrate how to set up a *river or stream model.*
What do you think will happen when a stream of water is passed over a mound of loose rock fragments?

The soil mixture contains most of these different sized particles:

- Fine powdered clay
- Fine beach sand
- Coarse river sand
- Small gravel pebbles
- Road making blue metal

Here is a list of some of the things you should try to observe during the demonstration:

- The different sizes and masses of the rock particles.
- The slope of the stream trough (the slope will be changed in the investigation)
- The amount of water flowing (this will be changed also)
- How far the different particles are carried by the water.



Here are three questions to discuss in your groups before writing your answers.

1. *How does the slope of the stream affect the type of rock particles the water can carry?*
2. *How does the amount or speed of water affect the type of rock particles the stream can carry?*

WORKSHEET FOR EROSION DEMONSTRATION:

(Your teacher will give you a copy)

STEEPNESS OF THE SLOPE	STRENGTH OF WATER SPRAY	OBSERVATIONS ABOUT THE PARTICLES CARRIED (type, size, distance carried)
Gradual slope	Fine spray	
	Medium spray	
	Heavy spray	
Medium slope	Fine spray	
	Medium spray	
	Heavy spray	
Steep slope	Fine spray	
	Medium spray	
	Heavy spray	

Your teacher might take you down to the creek to see how water is an agent of erosion.

ACTIVITY 16: SANDS AIN'T SANDS

Equipment:

- *Microscope*
- *microscope slides*
- *sand samples*

Focus using the LARGE knobs at the bottom REAR of the microscope.
Change the magnification by rotating the revolving nosepiece to a different objective.

The samples come from four different beaches.

Copy then fill in the table for the four samples. If you don't want to put %, just put ticks, 'yes' or 'no' or jot down some notes as to what you see.

	% quartz grains	% coloured minerals	% shell bits	% tiny shells	% other
A					
B					
C					
D					

NB look out for tiny, cream-coloured, rounded cylinders – these are CORALLINE ALGAE.

Read the descriptions of the beaches over the page and match the samples:

ROTTNEST is sample ☐ YALLINGUP is sample ☐
BROOME is sample ☐ COTTESLOE is sample ☐

ROTTNEST: Here the sea teems with tiny marine life forms and the warm shallow water supports seagrass and other plants including coralline algae. The limy skeletons of these plants and animals make up much of the beach sand.

COTTESLOE: The sandy limestone making up the cliffs is being broken down and eroded continually, and the beach sands are being washed and winnowed by the wind and waves. As a result mainly the hard quartz (a glassy or translucent colourless mineral) grains survive, while other materials are dissolved or broken into powder. There is a little shelly material.

YALLINGUP: Ancient granite and gneiss rocks fringe the coast here. They have a speckled appearance due to dark iron-rich minerals as well as quartz and feldspar. Some even contain garnet.

BROOME: In the tropical waters of Broome marine organisms are abundant. Some tiny shells are the "baby" forms of snails and bivalves; there are fragments of glassy sponge skeletons, and (like at Rottnest) the shells of many kinds of single-celled creatures called foraminifera. However, the cliffs along Cable Beach are formed of quartz-rich sandstone of Cretaceous age which are being eroded.

Look at the samples laid out for you to see of the rocks along the coasts where these sands come from.

ACTIVITY 17: PROPERTIES OF MINERALS

Aim: To use tests employed by geologists to identify minerals within a rock sample.

Equipment:

- set of hardness test minerals
- coin
- nail
- piece of glass
- minerals kits
- streak plate
- Geiger counter
- U.V. light source

Procedure:

A. Moh's Scale of Hardness.

1. Use the Internet to find a definition for "Moh's Scale of Hardness". Record this in your notebooks.

2. Copy the following table into your notebook. Then test the hardness of the materials across the top of the table against that of the samples in the box. Place a √ or X next to each sample to indicate whether or not the sample gets scratched or not.

Name		**Finger nail**	**Coin**	**Nail**	**Glass**
Talc	1				
Gypsum	2				
Calcite	3				
Fluorite	4				
Apatite	5				
Orthoclase	6				
Quartz	7				
Topaz	8				
Corundum	9				

Using this table, record the hardness of finger nail, coin, nail and glass

B. Streak and Colour.

3. Distinguish between 'colour' and 'streak' as used to describe a mineral.

   Write definitions in your notebook.

4. Select 4 mineral samples and describe the colour of the mineral and its streak in a table like this one drawn in your notebook.

Name	Colour	Streak

ACTIVITY 18: MINERALS

MINERALS

Minerals are ______________ ______________- which are found in the Earth's surface. They are formed when there is a chemical reaction between two or more ________________. There are about ___________ different minerals though only ________ are common in the Earths crust.

Two broad groupings of minerals:

1. Rock forming minerals: found in all rock types.
2. Ore Minerals: sources of metal.i.e.

   Haematite → Iron
   Bauxite → ____________________
   Azurite → ____________________

Minerals are basically grouped according to their chemical composition. There are eight groups

Element →	Mineral →	Rock
Silicon Oxygen Potassium Calcium Magnesium Iron Sodium Aluminium Hydrogen	**Quartz** (Si, O) **Feldspar** (K, Ca, Na, Al Si, O) **Mica** (K, Fe, Mg, Al Si, O, H)	Granite

Physical Characteristics o f Minerals

These are determined by the arrangement of atoms within the molecules and the way in which molecules are linked together.

Aim: To use tests employed by geologists to identify minerals within a rock sample.

Equipment:

- set of hardness test minerals
- coin
- nail
- piece of glass
- minerals kits
- streak plate
- Geiger counter
- U.V. light source

A. Moh's Scale of Hardness.

1. Use the Internet to find a definition for "Moh's Scale of Hardness". Record this in your notebooks.

2. Copy the following table into your notebook. Then test the hardness of the materials across the top of the table against that of the samples in the box. Place a √ or X next to each sample to indicate whether or not the sample gets scratched or not.

Name		**Finger nail**	**Coin**	**Nail**	**Glass**
Talc	1				
Gypsum	2				
Calcite	3				
Fluorite	4				
Apatite	5				
Orthoclase	6				
Quartz	7				
Topaz	8				
Corundum	9				

Using this table, record the hardness of finger nail, coin, nail and glass

B. Streak and Colour.

When minerals are rubbed on rough surfaces a mark of a special colour is produced. This is called the mineral's STREAK.

1. Distinguish between 'colour' and 'streak' as used to describe a mineral.Write definitions in your notebook.

2. Select 4 mineral samples and describe the colour of the mineral and its streak in a table like this one drawn in your notebook.

Name	Colour	Streak

C. Cleavage.

1. Record a definition for cleavage in your notebook.

   Select 4 samples to sketch.

Name	Name
Name	Name

COPY AND COMPLETE IN YOUR NOTEBOOK

D. Radioactivity.

Select 4 samples from the kit and describe the level of radioactivity for each. For the last two rows compare the radioactivity of two samples from another kit (e.g. quartz).

Name	**High activity**	**Medium activity**	**Low activity**

E. Fluorescence.

Describe the appearance of 4 mineral samples under normal light and under ultraviolet light (U.V.)

Name	**Under normal light**	**Under U.V. light**

F. Magnetic properties:

A few minerals are attracted to magnets.

ACTIVITY: Move the magnet near the supplied sample.
Record your observation in your notes.

What is the name of this mineral? ________________________

What is significant about this name? ______________________

Some special characteristics of some minerals:

a. DOUBLE REFRACTION:

Some minerals do strange things to light as it passes through them. e.g. calcite.

ACTIVITY:
1. Place the calcite specimen on the CROSS below and rotate it SLOWLY.
Observe what happens to the cross as the calcite rotates.

+

2. Place the crystal over some writing on this page.

Record your observation in your notes.

b. POLARISING EFFECT:

Certain minerals produce interesting colour patterns when placed between materials called POLAROIDS.

ACTIVITY: Place the supplied MICA sample between the two polaroids and slowly rotate one of polaroids.

Record your observation in your notes.

Muscovite mica

Biotite mica

4. Tests

Select several samples from Kit B and do various test on them. Record the results of the tests you carry out in a table similar to the one below:

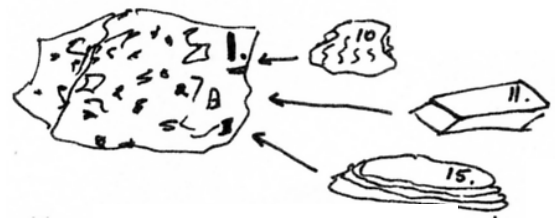
Name of sample	Hardness	Streak	Colour	Cleavage	Radioactivity	Fluorescence

ACTIVITY 12: MINERALS THAT FORM ROCKS

Aim: To examine samples of quartz, mica and feldspar, minerals common in rocks.

1. In your group brainstorm how you think these minerals were formed. Write some of your group's ideas in your notebook.
2. Examine a sample of granite. Identify and describe similarities and differences between the minerals and the sample of granite rock. Record your ideas.
3. Collect a mineral kit (Selby's Commercial Kit). This kit contains rocks (1 - 9) and minerals (10 - 21).

   Select a rock. From the information in the kit, determine the minerals that make up the rock. Find these minerals in the kit. Look carefully at the rock and see if you can detect the minerals that make up the rock. Draw a table similar to the one below in your notebook, and then record your observations and conclusions. The first rock has been done for you.

Rock	**Minerals present**
1. Granite 	10. Quartz 11. Orthoclase feldspar 15. Biotite mica

COPY AND COMPLETE IN YOUR NOTEBOOK

4. Now it's your turn. Select two different rocks (2 - 9) and repeat the above steps, recording your results in the table you have drawn.

MINERALS FACT SHEET

YOUR TASK: Produce an interesting information fact sheet on a mineral of your choice for the rest of the class.

Be sure to include the following information:

- Mineral name
- Elements it is made up of
- A description of where it is found
- Description (colour, crystal shape, streak, hardness, density)
- Picture of your mineral
- Interesting facts
- References

Some minerals you might like to choose from are: Quartz, Mica, Feldspar, Magnetite, Calcite, Pyrite, Diamond etc.

Here are some websites to help you find information for your fact sheet!

http://www.mii.org/commonminerals.php

http://www.mii.org/mineralphotos.php

http://www.uky.edu/AS/Geology/webdogs/rocks/main.htm

http://www.mine-engineer.com/mining/mineral/mineralindx.htm

http://www.rocksandminerals.com/uses.htm

http://www.minsocam.org/MSA/K12/properties/minpropindex.html

http://www.johnbetts-fineminerals.com/jhbnyc/bestgall.htm

TYPES OF ROCKS

There are thousands of different rocks that make up the Earth's crust. Geologists divide all the rocks into **three main groups according to how the rocks are formed**.

1. **IGNEOUS ROCKS**
2. **SEDIMENTARY ROCKS**
3. **METAMORPHIC ROCKS**

All rocks are made up of one or more chemicals called **minerals.**
Minerals are chemicals that are found in the Earth's crust e.g. quartz, asbestos, calcite.

Minerals that contain valuable elements used by man are given the special name **ores** e.g. bauxite (contains aluminium), iron ore (contains iron).

Minerals that are usually clear, with beautiful colours and are rare are called **gemstones** e.g. rubies, diamonds, amethysts, sapphires, opals.

IGNEOUS ROCKS

Igneous rocks are formed when molten magma cools and solidifies.

If the cooling takes place **out on top** of the Earth's surface we call them **extrusive igneous rocks.**

If the cooling takes place **inside** the Earth's surface we call them **intrusive igneous rocks.**

Whether the magma cools slowly or quickly controls the size of the mineral crystals.
Crystals are chemicals with special shapes.

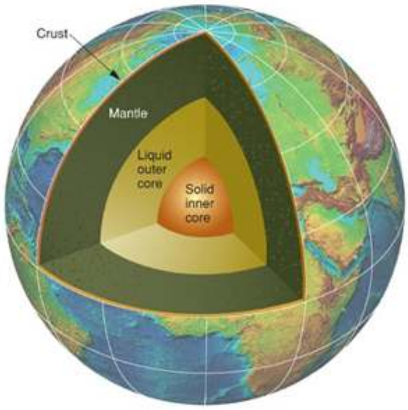
IGNEOUS ROCKS

INTRUSIVE IGNEOUS ROCKS	**EXTRUSIVE IGNEOUS ROCKS**
GRANITE	BASALT
DOLERITE	OBSIDIAN (Volcanic Glass)
GABBRO	PUMICE

Challenge:

Find out about the remarkable Giant's Causeway in Ireland and the Andara Lava Tubes of Queensland.

ACTIVITY 20: IGNEOUS ROCKS...A FIERY BEGINNING



1. Describe how igneous rocks form.
2. Examine some of the sample from Kit H. List some different igneous rocks.
3. Compare the colour of 8 different igneous rocks. Write the names of the rocks under these headings.

LIGHT	GREY	DARK

COPY AND COMPLETE IN YOUR NOTEBOOK

4. Why do different rocks have different sized crystals?
5. Compare the grain size of 8 different igneous rocks. Write the names of the rocks under these headings.
6.

GLASS-LIKE	SMALL CRYSTALS	LARGE CRYSTALS

COPY AND COMPLETE IN YOUR NOTEBOOK

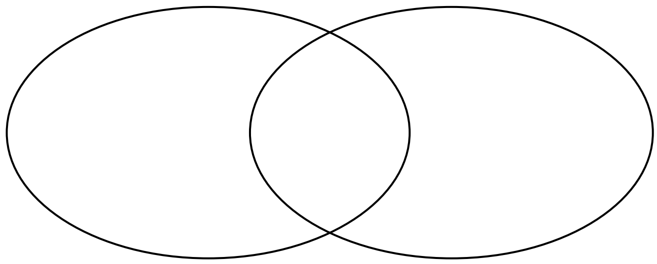
ACTIVITY 21: METAMORPHIC ROCKS

1. Describe how metamorphic rocks form.

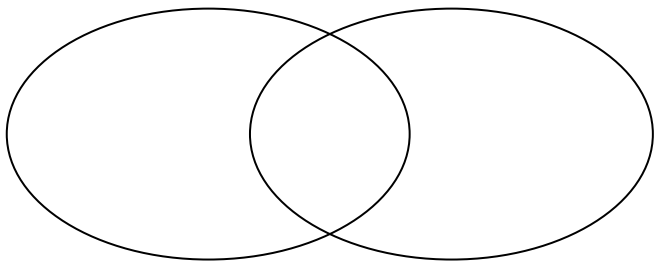
2. Examine a rock from Kit M. Name then describe the rock. A diagram will help your description.

3. Below are three examples of rocks that are formed from other rocks by metamorphic action. For each example compare the original rock to the metamorphic rock. In your notebook draw similar ovals. In each oval, describe properties that relate only to that rock and in the intersection describe how they are similar.

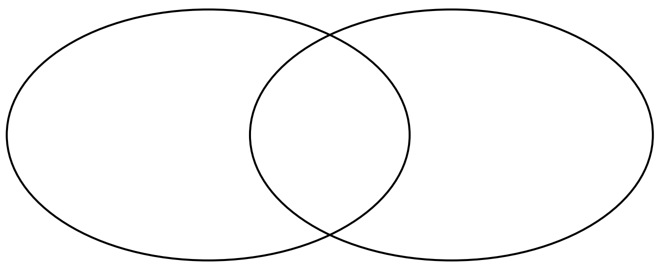
Limestone → Marble



Granite → Gneiss



Shale → Slate



ACTIVITY 22: DESCRIBING ROCKS

This activity is made up of three parts:

1. Looking at crystals.
2. Observing a "Red Label" collection of rocks.
3. Investigating how the rate of cooling controls the size of mineral crystals.

EQUIPMENT for Part A

- 1 Stereomicroscope
- Hand lens.
- Three samples of different crystals that are easy to identify with a hand lens e.g. $CuSO_4$, NaCl, fertiliser.

EQUIPMENT for Part B

- "Red Label" rock collection
- Hand lens
- Mounted needle
- 1 Stereomicroscope

EQUIPMENT for Part C

- 3 large test tubes
- 3 beakers - 250 mL
- cotton wool
- ice
- hot supersaturated KNO_3 solution (must be retained – do not pour down sink)

PROCEDURE for Part A: (Do not spend too much time on this section)

1. Use your hand lens to look at the various crystals that you have been given. Move a single crystal away from the others so that you can observe it more closely.
2. Your teacher has a stereomicroscope that you can look through to observe crystals in greater magnification.
3. In your notebook, draw a diagram of the shape of the different crystals.

PROCEDURE for Part B:

Geologists must train themselves to be careful observers. By observing special features of rocks, such as grain size, colour, lustre, feel, amount of weathering, they can determine the useful minerals that are in the rock.

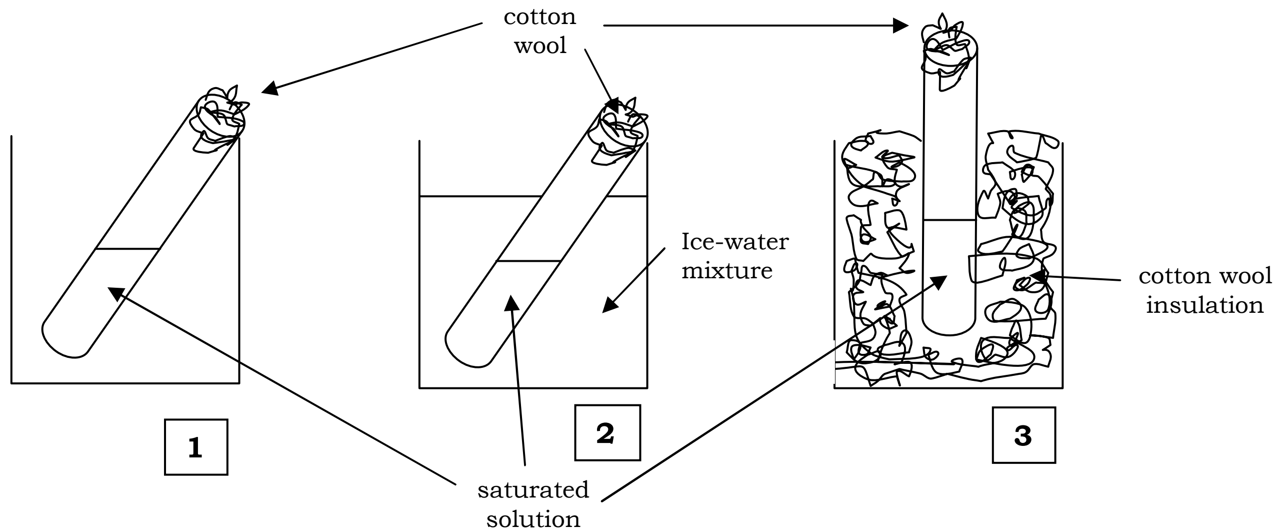
1. Closely examine the rocks from the "Red Label" collection. What can you observe? Are the rocks grainy or smooth? Do they have jagged edges or are they rounded and smooth?
2. If you can break off small pieces of rock, you can use the mounted needle to pick out some of the smallest pieces. Use a hand lens to look at these pieces.
3. Draw up a table similar to the one below, leaving space to describe four different igneous rock samples. (Your teacher will tell you which four rock samples to examine)

ROCK SAMPLE	OBSERVATIONS	CORRECT NAME
1		
2		
3	**COPY AND COMPLETE IN YOUR NOTEBOOK**	
4		

PROCEDURE for Part C:

In observing rocks you may have seen that the size of their crystals and grains varies. Some have coarse grains and others are fine grained.

1. Collect your equipment and label test tubes 1, 2 and 3.
2. Set up the equipment as shown in the diagram below and place about 25 mL of hot supersaturated KNO_3 (potassium nitrate) in each test tube.



3. Store the beakers in a suitable place until the next science lesson.
4. What do you think this investigation is trying to show?
5. <u>Next period</u>: Observe the changes which have occurred in your test tubes. Write down your observations using the heading: **RESULTS:**

CONCLUSION for Part C:

Discuss in your group and write down how the rate of cooling affects the size of the crystals that formed.

ACTIVITY 23: EXAMINING GRANITE, AN IGNEOUS ROCK

AIM: To find out how many different minerals make up the rock called granite.

EQUIPMENT:
- Small vial of pre-crushed pink granite.
- 3 Tooth picks
- Hand lens

NOTE: Please return crushed pink granite to the vial.

PROCEDURE:

1. Use the tooth picks to separate the grains into groups of similar looking minerals. You should be able to make at least three different piles.
2. Now make a close examination of the grains in each pile and record your observations of **colour, surface texture** (dull or shiny) and **crystal shape** in your notebook.

QUESTIONS:

Granite often consists of combinations of the following minerals:

QUARTZ	*TRANSPARENT, GLOSSY, BREAKS IRREGULARLY*
FELDSPAR	*PINK, MILKY or COLOURLESS, TRANSLUCENT, CHUNKY, BREAKS ANGULARLY*
BIOTITE	*BLACK, SHINY, FLAKY OR PLATELIKE CRYSTALS (BLACK MICA)*
MUSCOVITE	*TRANSPARENT OR YELLOWISH, SHINY AND FLAKY (WHITE MICA)*
HORNBLENDE	*BLACK TO DARK GREEN, ELONGATED CRYSTALS, BREAKS IRREGULARLY*

1. What are the names of the three minerals in your piece of granite?

2. Explain why a rock such as granite, which is formed deep within the Earth's crust, contains large crystals.

Did you know………….

Sometimes very large crystals are found in rocks. The picture shows giant crystals of the Cave of Crystal in Mexico. You might like to find out more about this cave and its crystals.

- Of what are they made?
- How did they grow to be so large?
- Why could a human live for only 30 minutes in this cave?

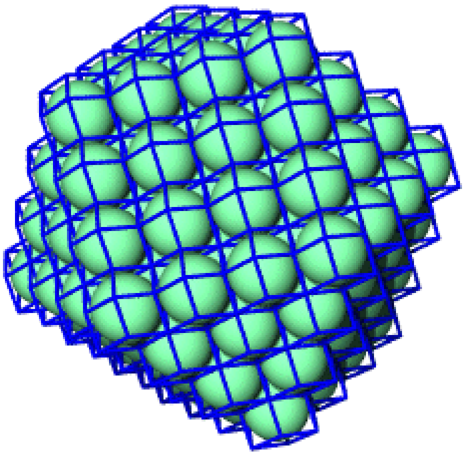
CRYSTALS

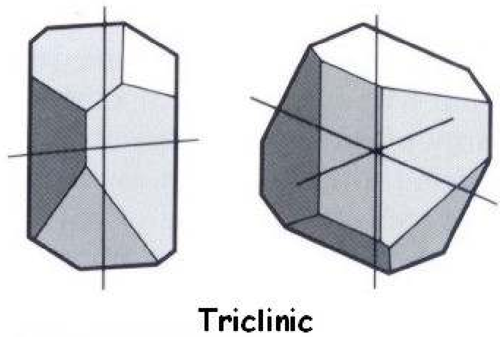
Your teacher will give you a sheet showing an outline of a crystal. Carefully cut out the crystal shape then assemble it, using glue to hold it together.

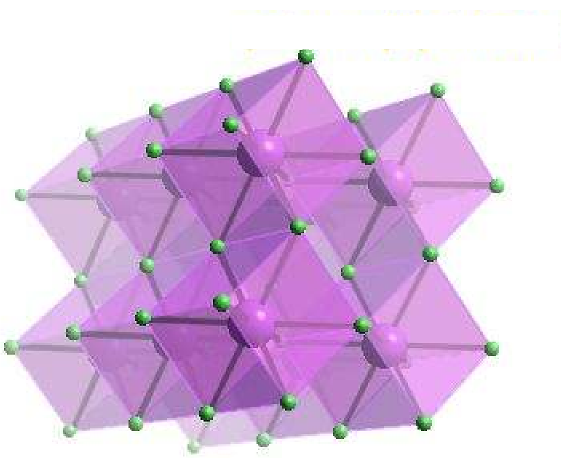
Your crystal may be a:

- Cube
- Prism
- Monocline
- Octahedron
- Hexagonon
- Hexagonal trapezohedron
- Marco Bachypyramid

Teachers: see file: S/Learning Area/Science/Science Resources/8324 Geology/Crystals/8324 Crystal shapes







ACTIVITY 24: CRYSTAL SYSTEMS

Activity idea
In this activity, students investigate crystal shapes and crystal systems. Traditional ceramics are clay-based – clays have a mineral composition and minerals have a crystalline structure.

By the end of this activity, students should be able to:
- describe the main points of difference between a crystalline solid and an amorphous solid
- recognise and identify at least 3 of the 7 crystal systems
- use models to point out the angular and side length differences that characterise the cubic, triclinic and rhombohedral crystal systems
- effectively use optical aids such as hand lenses and simple microscopes to view crystalline solids.

Introduction/background

Traditional ceramics are clay-based. Clays have a mineral composition and minerals have a crystalline structure. A mineral is defined as a naturally occurring inorganic substance with a certain chemical composition and set of physical properties. Many minerals occur in characteristic crystal shapes.

A crystalline solid is made up of an orderly repeating pattern of constituent atoms, molecules or ions extending in all 3 spatial dimensions.

A limited number of crystal shapes have been found in nature. There are only 7 groups, or crystal systems, into which all naturally occurring crystals can be placed. Careful observation of crystal shapes is one of the best ways to classify and distinguish between different minerals. This activity focuses on three of these crystal systems – cubic, triclinic and rhombohedral.

What you need

- Crystal systems diagram
- Copies of the student worksheet
- Small dropper bottles of 1 $molL^{-1}$ solutions of sodium chloride (NaCl) and copper sulfate ($CuSO_4$)
- Clean 'golden' beach sand
- Simple light microscope plus microscope slides
- Electric hot plate
- Templates to construct models of cubic, triclinic and rhombohedral crystal systems
- Paper glue

What to do

1. Hand out copies of the crystal systems diagram and discuss with the class. Explain that they will be investigating 3 of these crystal systems – cubic, triclinic and rhombohedral.

2. Make sure each student has the necessary materials and equipment and a copy of the student worksheet and templates.

Student Worksheet – Studying Crystal Systems

1. Cubic crystals:
   - Place a drop of the sodium chloride solution supplied in the centre of a microscope slide.
   - Gently heat the slide by placing it on a hot plate (low setting).
   - When all the water has evaporated, view the sodium chloride crystals that remain under the low power of a microscope.
   - Note the shape of the crystals and sketch what you see.

2. Triclinic crystals:
   - Place a drop of the copper sulfate solution supplied in the centre of a microscope slide.
   - Gently heat the slide by placing it on a hot plate (low setting).
   - When all the water has evaporated, view the copper sulfate crystals that remain under the low power of a microscope.
   - Note the shape of the crystals and sketch what you see.

3. Rhombohedral crystals:
   - Place a small sample of beach sand in the centre of a microscope slide and spread out the grains.
   - View under the low power of a microscope.
   - Note the shape of the grains with a clear or whitish appearance – these are grains of the mineral quartz. Sketch what you see.

4. Compare the sketches you have drawn to the crystal systems diagram.

5. The mineral halite, a naturally occurring form of sodium chloride, has a cubic crystal structure. Use the cubic crystal template to construct a model of a halite crystal. Fold all edges. Glue the tabs and stick together.

6. The feldspar minerals plagioclase and orthoclase have a triclinic crystal structure. Copper sulfate crystallises out of solution as triclinic crystals just like the feldspars. Use the triclinic crystal template to construct a model of a feldspar mineral crystal. Fold all edges. Glue the tabs and stick together.

7. Quartz minerals are commonly found in beach sand. These tiny grains have a rhombohedral shape (cubic system stretched along a body diagonal). Use the rhombohedral crystal template to construct a model of a quartz crystal.

Galena crystal

Tourmaline crystal

SEDIMENTARY ROCKS

Sedimentary rocks are formed when insoluble particles settle on the bottom of oceans lakes and rivers. The sediments which make up these rocks can be of almost any type of material.

Here are the names of three sedimentary rocks and the type of sediments they are made from.:

- **LIMESTONE** Made from skeletons or shells of tiny sea animals.
- **CONGLOMERATE** Made from pebbles of gravel
- **SANDSTONE** Made from grains of sand

ACTIVITY 25: MAKING SEDIMENTARY ROCKS

Equipment:
- Fine sand
- Coarse sand
- Small pebbles and shells
- Plaster of Paris (cement)
- 4 Yoghurt containers
- Beaker of water

Note:
This activity is to be done outside the laboratory as it is very messy.

PROCEDURE:

1. Mix the fine sand and the Plaster of Paris cement then add plenty of water in a yoghurt container. The amount of cement will determine the hardness of the rock..
2. Apply pressure with your fingers to compress the ‘rock’. This models the real sedimentation process.
3. Repeat steps 1 and 2 with the other soil samples.
4. In the fourth plastic yoghurt container you might like to make a multi layered sedimentary rock.
5. Leave the plastic containers to stand on the windowsill for a few days.
6. You can then pour off any water and leave until it dries out completely.
7. When the rock has dried out you can remove it, cut it in half with an old hacksaw blade and examine its appearance.
8. In your notebook draw a diagram showing a cross section of the ‘rock’ formed in the plastic container.

Extension:

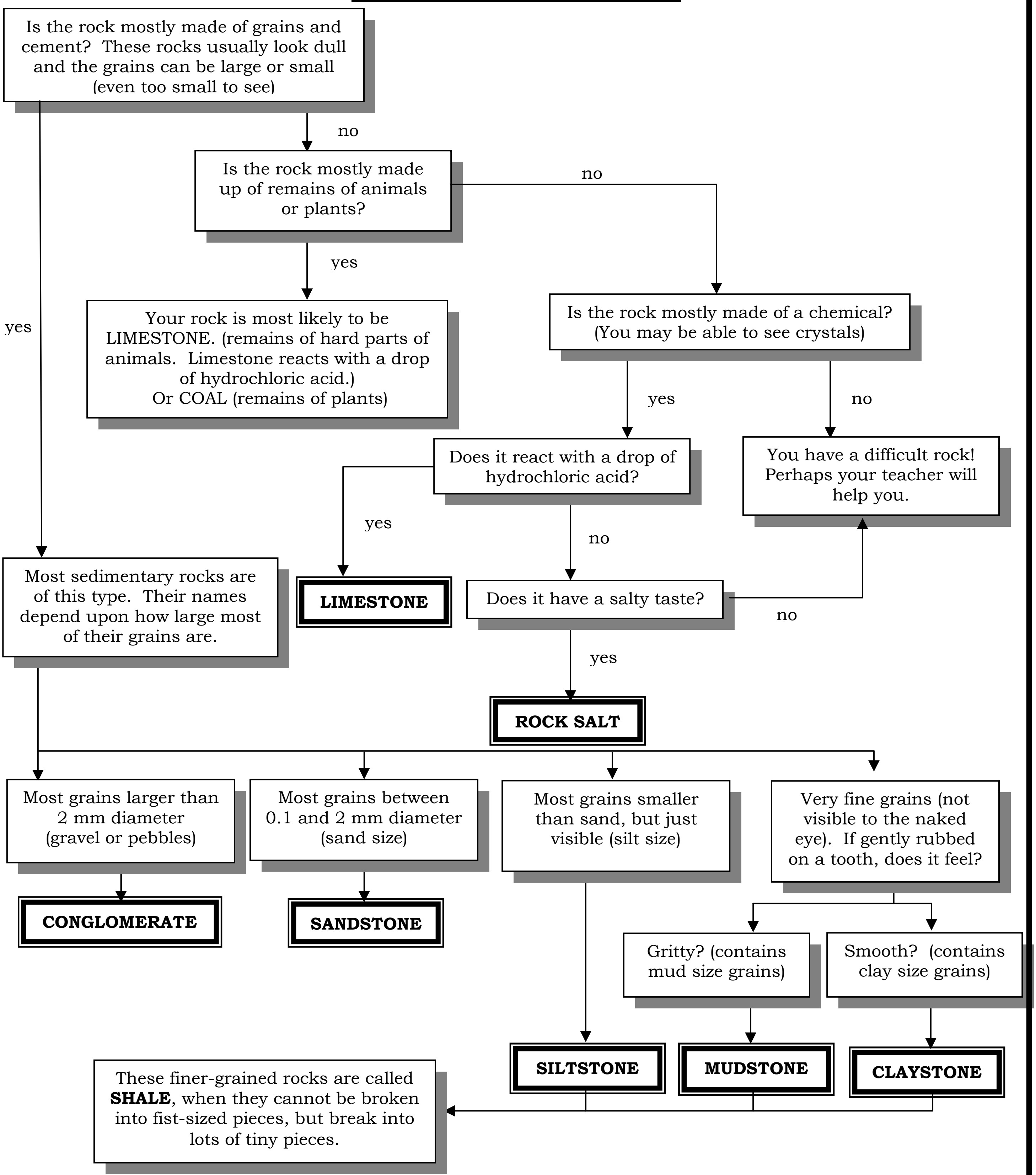
Sedimentary rocks form by either mechanical deposition of sediments or by the precipitation of minerals from a solution. Which of the following rocks are formed by mechanical deposition and which are formed by precipitation from a solution? A table would be a good way of presenting your answers.

a. Sandstone
b. Laterite
c. Mudstone
d. Guano
e. Halite
f. Gypsum
g. Conglomerate
h. Diatomite
i. Calcite
j. Chalk
k. Tuff
l. Chert

ACTIVITY 26: IDENTIFYING SOME SEDIMENTARY ROCKS

Examine some sedimentary rock samples from the Red Label Collection. See if you can name them and describe the characteristics of each sample. Draw up your own table. You can use the key below to assist in naming the sedimentary rock type.

SEDIMENTARY ROCK KEY



ACTIVITY 27: SANDWICH GEOLOGY

In some construction sites, you can see a cross-section of the layers of rock underground. Build a sandwich and explore how natural forces create rock layers.

MATERIALS: Slices of white, dark rye, and brown bread (cut off all the crusts); jam; chunky peanut butter; raisins; plate; knife; spoons.

DOING IT:

1. An empty plate represents **igneous** bedrock.

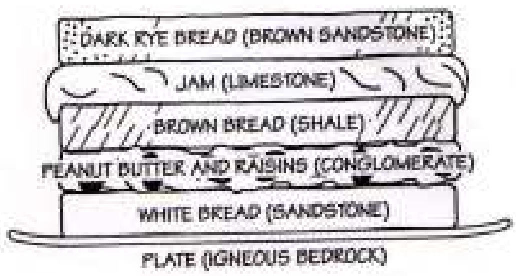
2. Pretend there's a river flowing over the bedrock. White sand -- from rocks eroded by the river -- is being carried along in the water. Where the water flows more slowly, the sand is deposited on the river bottom. Over many years, the sand is pressed and cemented together to form white **sandstone**. Put down a slice of white bread for the sandstone.

3. One year, there's a major flood. Tonnes of mud and rocks are swept over the sandstone. Spread chunky peanut butter over the white bread to represent the mud and rocks. Throw on several raisins for big boulders that have been caught up by the rushing water. This mud, rock, and boulder mixture becomes a sedimentary rock layer called a **conglomerate**.

4. As time passes, the flow of the water slows. The water now carries small bits of rock called silt. The silt accumulates and forms another layer. Over many years, the silt turns into **shale** rock. A slice of brown bread is the shale.

5. Around this time, the Ice Age ends. Glaciers start melting. The oceans rise and cover the existing layers of rock. As time goes on, living creatures in the salt water die and their shells and skeletons line the ocean floor. Over many years, this calcium-rich layer becomes **limestone**. Spread a thick layer of jam on the brown bread to represent the limestone.

6. Finally, pretend there's a bad drought. Strong winds pick up particles of eroded rock. The particles swirl against a mountainside and you get a layer of brown sand. Over many years, this layer becomes brown **sandstone**. Finish your sandwich with a slice of dark rye bread to represent the brown sandstone.



7. Review what each part of the sandwich represents (keep the white bread on the bottom). What's the oldest part of the sandwich? Why? Is the middle part of the sandwich younger or older than the oldest part? Why? How do geologists tell the age of rocks?

7. Geologists studying rocks rarely find level layers. Rock layers are often bent or broken. Bend the sandwich to form a mountain, and then a valley. Watch how the layers bend.

8. Munch away at your geological creation!

Over many, many years, sediments compact together to form layers of sedimentary rock. The "**Law Of Superposition**" says that, in general, before the topmost layer (stratum) of rock can be formed, the layer beneath it must already be formed. Thus, in any sequence of layered rock in the Earth's crust, a given layer will be older than the layer above it and younger than the layer below. For example, lava may cover an area around a volcano, cool to form igneous rock, and later be covered by a layer of sedimentary rock. The sedimentary rock would be younger than the igneous rock. **However, there are exceptions to this guide.** Magma may not come up through a volcano; instead, it may squeeze in between layers of existing rock in the Earth's crust. The igneous rock formed as the magma cools would then be younger than the layer of rock above it. One way to tell this is by looking for evidence of heat effects on the layers above and below the igneous rock; igneous rock from volcanic lava would create a heat effect only on the layer beneath it (because the layer above it doesn't exist yet).

ACTIVITY 28: METAMORPHIC ROCKS

Metamorphic rocks are formed by heat and/or pressure on igneous or sedimentary rocks. What does and/or mean?

Equipment:
70 mL clay; 10 mL sand; Plastic beaker; Stirring rod; 250 mL beaker
Samples of limestone, sandstone, granite, marble, quartzite (Toodyay stone), gneiss
Hand lens

PROCEDURE:

PART A: PREPARING A SEDIMENTARY ROCK – SHALE

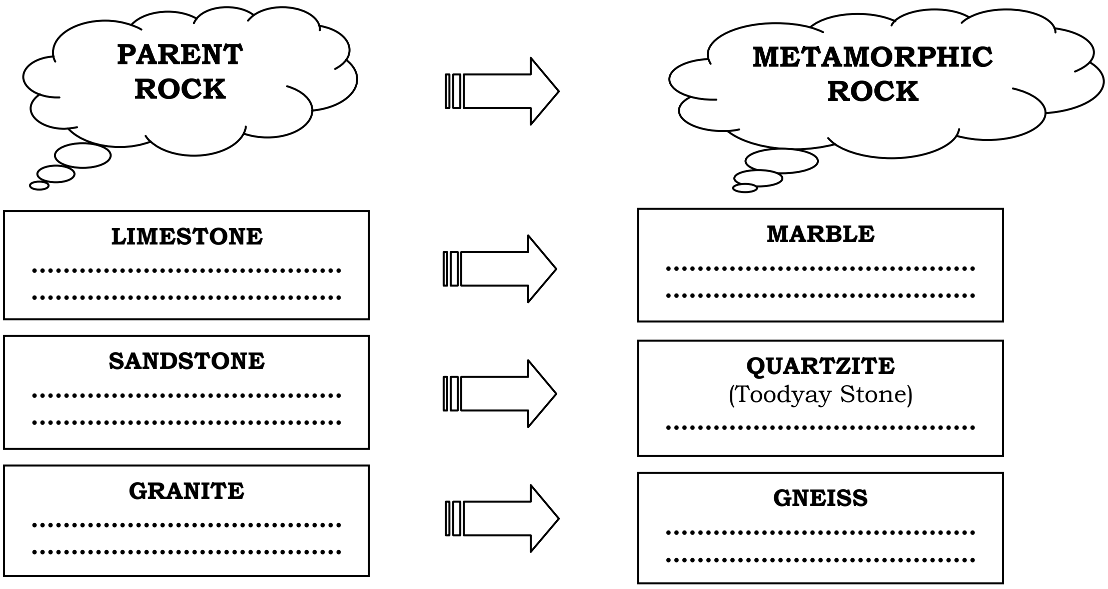
1. Take 70 mL of clay and 10 mL of sand and mix them in a plastic beaker.
2. To the mixture add a small amount of water.
3. Pour off any excess water and leave it to dry.

PART B: WHAT HAPPENS TO THE SHALE WHEN IT IS HEATED?

1. Take the sample of dry shale that you have made and carefully break it into two pieces.
2. Place a small mark on both pieces of shale so that you can identify them later.
3. Store one piece of shale in a safe place. Your teacher will tell you where.
4. Give the other sample to your teacher. This sample will be intensely heated in a kiln.
5. After the shale sample has been fired, examine it closely and compare it to the unfired sample.

PART C: OBSERVING THREE METAMORPHIC ROCKS

Examine with a hand lens, a parent rock and the *metamorphic rock* from which it is formed. **Copy the chart below into your notebook.**
Describe each pair of rocks in the spaces provided.



QUESTIONS: Write the answers in your notebook.

1. In what ways are the samples similar?
2. In what ways are the samples different?
3. What does the word metamorphic mean?
4. How are metamorphic rocks formed?
5. How is the metamorphic rock known as marble formed?
6. Is diamond a metamorphic rock? Explain.

ACTIVITY 22: WHICH ROCK IS THAT?

You will be given a range of unidentified rocks. Using your knowledge, classify each as igneous, sedimentary or metamorphic.

Use the chart below to help you decide which type of rock your samples are.

Equipment:

6. Rock samples

- Hand lens
- 1 mol L^{-1} hydrochloric acid

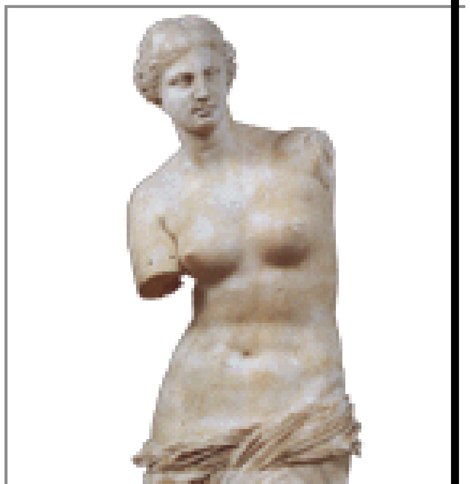
	ROCK TYPE		
OBSERVATIONS	**IGNEOUS**	**SEDIMENTARY**	**METAMORPHIC**
Large, separate crystals	✓	✗	✗
Heavy for its size	✓	✗	✗
Fizzes when acid is poured on	✗	✓	✗
Layers present	✗	sometimes	mostly
Minerals lined up in one direction	✗	sometimes	✓

The identification charts on page 45 and page 49 could be helpful.

A ROCK DESCRIPTION SCHEME

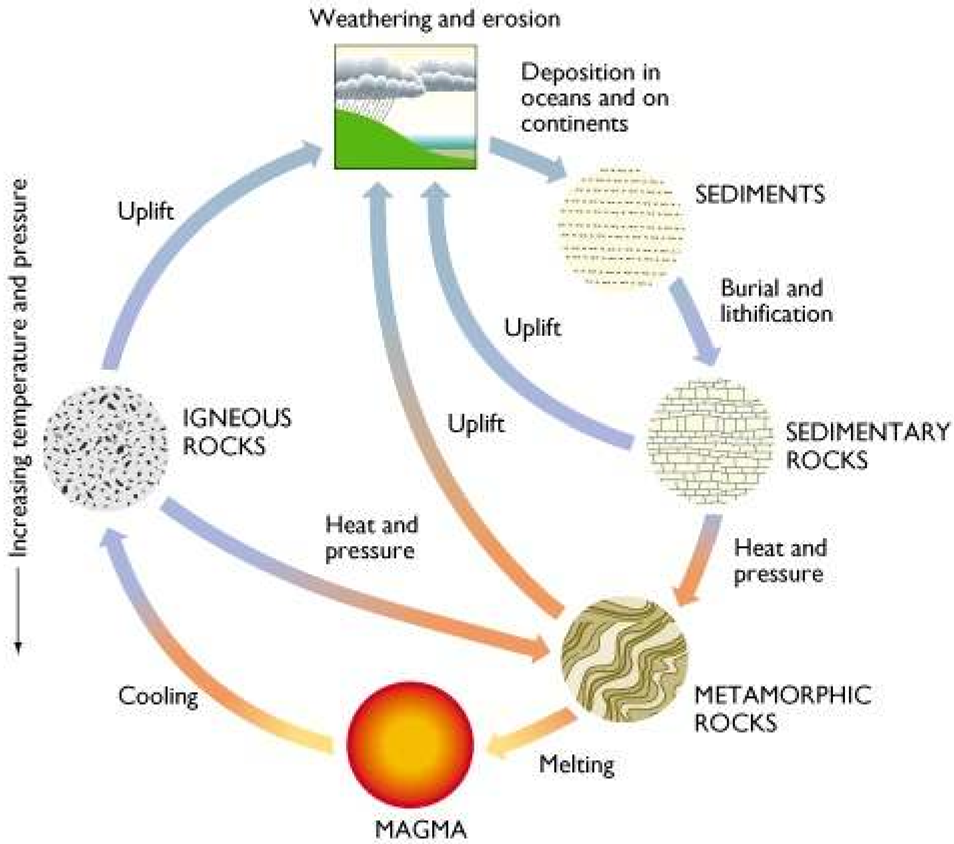
TEXTURE

- glassy — **OBSIDIAN (I)**
- Rock made up of rock and mineral fragments, fossils may be possible
  - Made up of round pebbles — **CONGLOMERATE (S)**
  - Made up of angular pebbles — **BRECCIA (S)**
  - Fizzes with acid
    - white — **CHALK (S)**
    - grey — **LIMESTONE (S)**
  - Fine grained does not react with acid
    - No obvious layering — **MUDSTONE (S)**
    - Obvious layering — **SHALE (S)**
  - Medium or coarse grained, does not react with acid
    - Made up of rock fragments in muddy matrix — **GREYWACKE (S)**
    - Made up of sand grains — **SANDSTONE (S)**
- Rocks made up of crystals locked together
  - Grains lined up in the same direction
    - Reacts with acid — **MARBLE (M)**
    - Coloured white or grey, does not react with acid — **QUARTZITE (M)**
    - Fine grained splits into thin slabs — **SLATE (M)**
    - Medium or coarse grained
      - Not banded — **SCHIST (M)**
      - banded — **GNEISS (M)**
  - Grains not lined up in the same direction
    - Pale colour
      - Coarse grained — **GRANITE (I)**
      - Medium grained — **MICRO GRANITE (I)**
      - Fine grained — **RHYOLITE (I)**
    - Dark colour
      - Coarse grained
        - Dark mineral – mainly hornblende — **DIORITE (I)**
        - Dark mineral mainly augite — **GABBRO (I)**
      - Medium grained
        - Dark mineral mainly augite — **DOLERITE (I)**
        - Dark mineral mainly hornblende — **MICRO DOLERITE (I)**
      - Fine grained
        - Grey or brown — **ANDESITE (I)**
        - black — **BASALT (I)**



THE ROCK CYCLE

Rocks are continuously recycled through burial, compaction, cementation, remelting and uplift. In geological time today's coral reef is tomorrow's limestone and in a few million years it might be marble. The marble might be pushed further down into the mantle and be mixed with more molten material which could then be pushed to the surface to form volcanic mountains erupting new lava onto the Earth's surface. This is known as the 'Rock cycle'



CHALLENGE: GEOLOGICAL TIME

It is very difficult to understand the time period over which our Earth has been in existence.

You might like to enter the "Paleotraveller" and time travel through the development of Australia from the Cambrian to the present and view changes in landforms, life forms, sea levels and temperature.

- There are challenges which require you to:
- Construct a geological time scale for Australia
- Graph sea level changes
- And more!

National Geographic has an excellent interactive *Prehistoric Timeline* for you to use to extend your understanding of geological time.

http://science.nationalgeographic.com/science/prehistoric-world/prehistoric-time-line.html

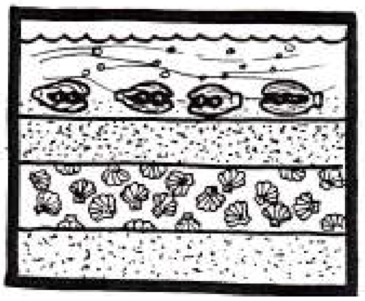
SUMMARY: TYPES OF ROCKS

There are three main types of rocks:

1. Igneous (fire rocks)

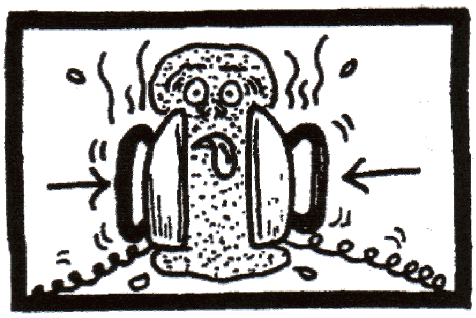
- formed from hot magma from inside the Earth.
- the magma cools to form rock.
- volcanoes produce igneous rocks which means 'fire rocks'.
- granite, volcanic glass and basalt are examples.

2. Sedimentary (layered rocks)



- rocks that are made up of particles that form layers.
- sand from a beach can harden to form a rock called sandstone.
- mud in a stream can harden to form mudstone
- the shells of little animals that live in the ocean pile up to form layers of rock and form limestone.
- chalk is a special kind of limestone made up of millions of tiny seashells too small to see.

3. Metamorphic (changed rocks)



- rocks that are changed by heat and pressure (squeezing).
- when limestone is heated and squeezed it becomes marble.
- when mudstone is squeezed it becomes slate used for old-style blackboards and floors.
- these rocks sometimes have some layering in them similar to sedimentary rocks.

ROCK QUIZ: Your teacher will give you a copy. See how much you can remember about the different kinds of rocks!

ACTIVITY 30: FOSSILS

Fossils are preserved plant or animal impressions that are found usually in sedimentary rocks.

HOW FOSSILS ARE FORMED

The following diagrams show how fossils are formed.

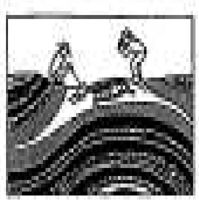
A living organism. In this case a marine animal swimming.

The organism dies, sinks to the ocean floor and starts to *decay*.

Muddy conditions usually ensure that the organism is quickly buried. This gives the best chance for fossilisation. Mostly only bones are left.

Bones are removed cell by cell by water action forming a *mould*, which is then filled by rock minerals. Replacement is a *casting* process.
Replacement minerals are usually:
(a) silica (SiO_2)
(b) calcium carbonate ($CaCO_3$)
We say the fossil has become petrified

Mountain building processes over a long period of time cause *uplift* and some *folding.*

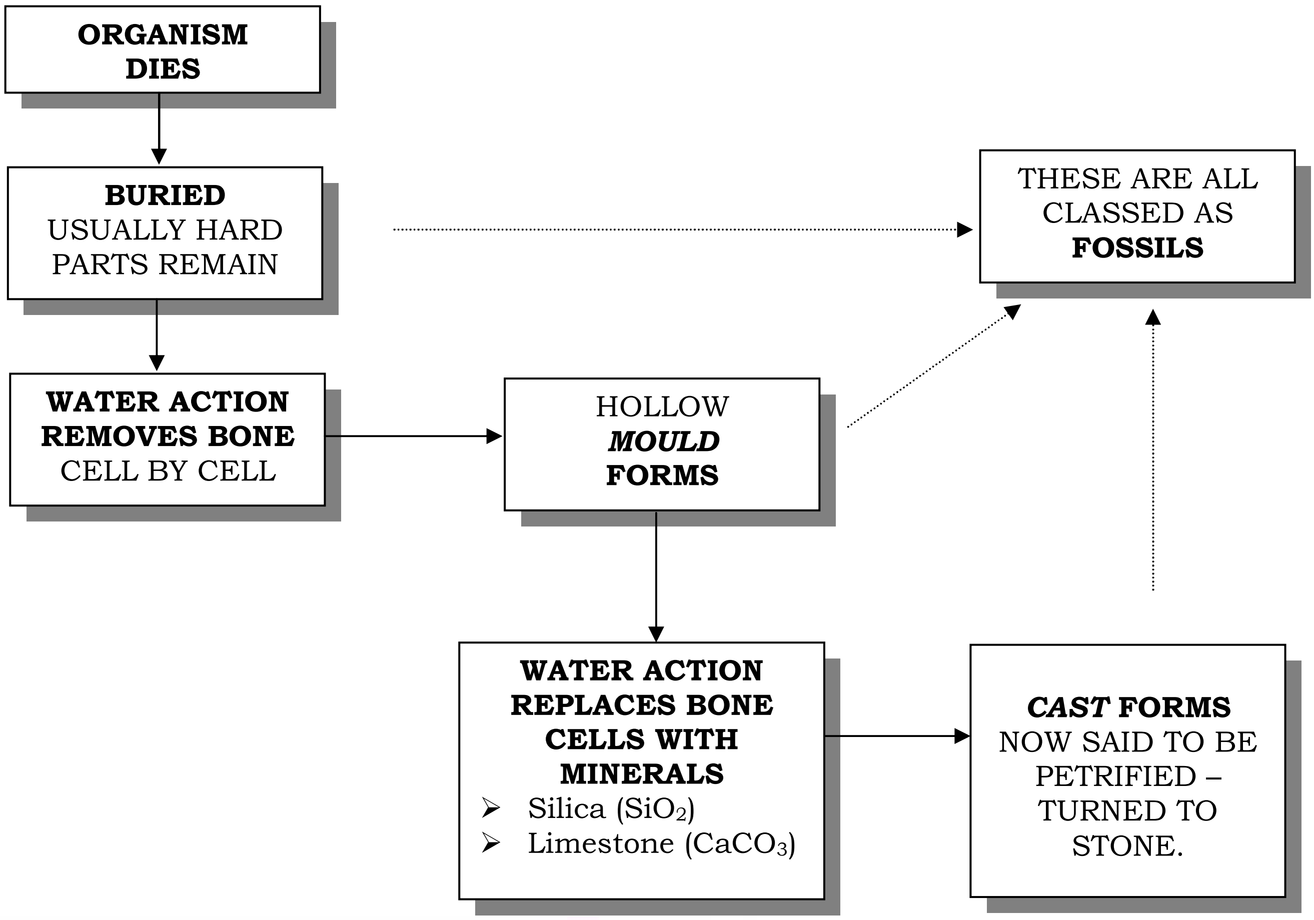


Weathering and *erosion* expose the *petrified remains*. The study of fossils is carried out by scientists called *palaeontologists*.

Questions:

1. Why are fossils important to geologists?
2. What is an index fossil and why are these important?

FOSSIL SUMMARY



RESEARCH

There are some very significant fossil sites in Australia. Research one of these:

- Ediacara in South Australia
- Winton and Riversleigh in Queensland
- Canowindra in South Australia
- North Pole in Western Australia

ACTIVITY 31: FOSSILS

1. Examining different kinds of fossils

Equipment:

Fossil specimens including
- Casts
- Moulds
- Traces
- True form fossils

Pass specimens around the classroom classifying each fossil into a table drawn in your notebooks similar to the one below:

Name of fossil	Cast	Mould	Trace	True form

Enter the name or number of each specimen in the first column, then classify the specimen by placing a tick in the table in the appropriate column.

2. Making a fossil

1. Obtain a copy of a model trilobite or nautiloid from your teacher.
2. Follow the instructions to complete the model.
3. Suspend your model with other models to make a class mobile.

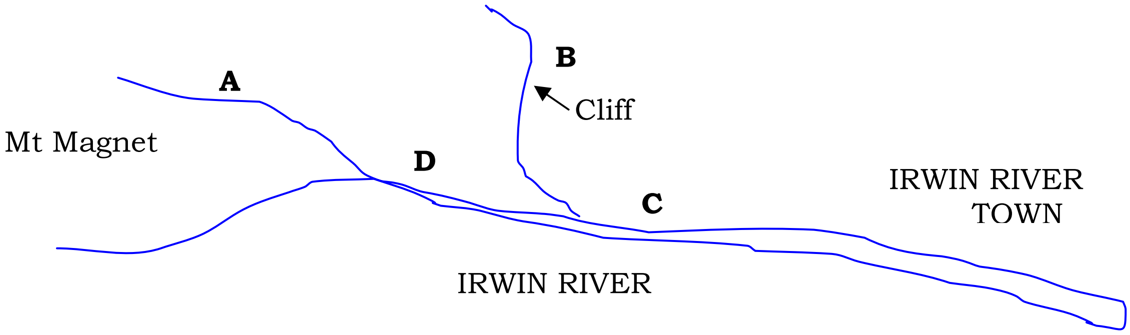
Note to the teacher:
Templates for this activity can be found at:
S/Learning Areas/Science/Science Resources/8324 Geology/8324 Fossil Templates

1.
- Make a plasticine mould of a 'fossil' specimen
- Fill the mould with Plaster of Paris
- Use water colour paints to colour the fossil.

2. Visit a virtual fossil museum at
http://3dmuseum.geology.ucdavis.edu/frame.html

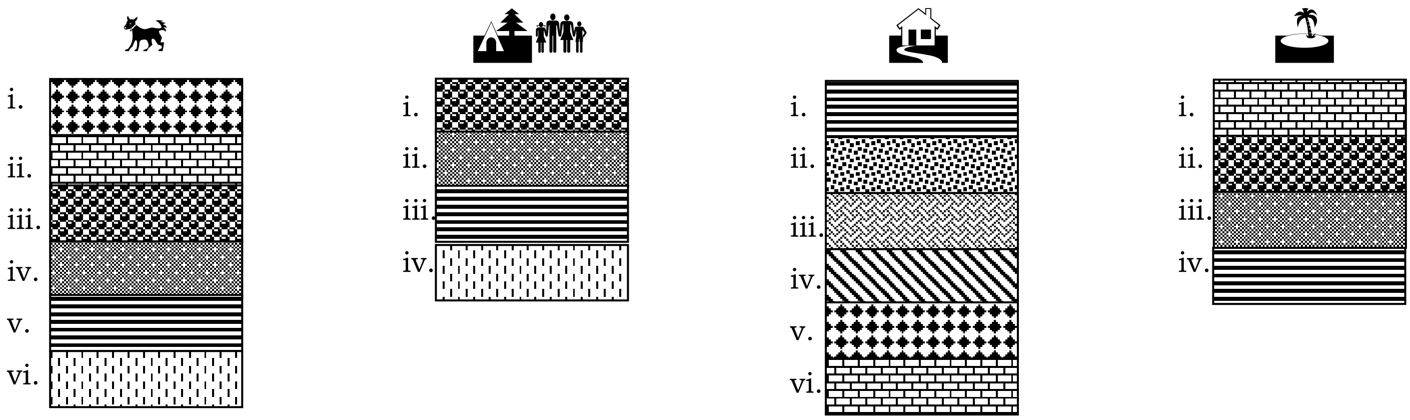
ACTIVITY 32: MATCHING ROCK LAYERS

AIM: To match the layers of a sedimentary rock formation from profile information gathered at four related sites.



PROCEDURE: You are to compare each of the rock profiles below to find out which profile contains the oldest sedimentary rock formation and which is the youngest. Refer to a layer by its site followed by the layer e.g. Site 1, Layer iv.

Site 1 Core Sample 1	Site 2 Core Sample 2	Site 3 Core Sample 3	Site 4 Core Sample 4



To compare the sedimentary rock formations you will have to assume three things:

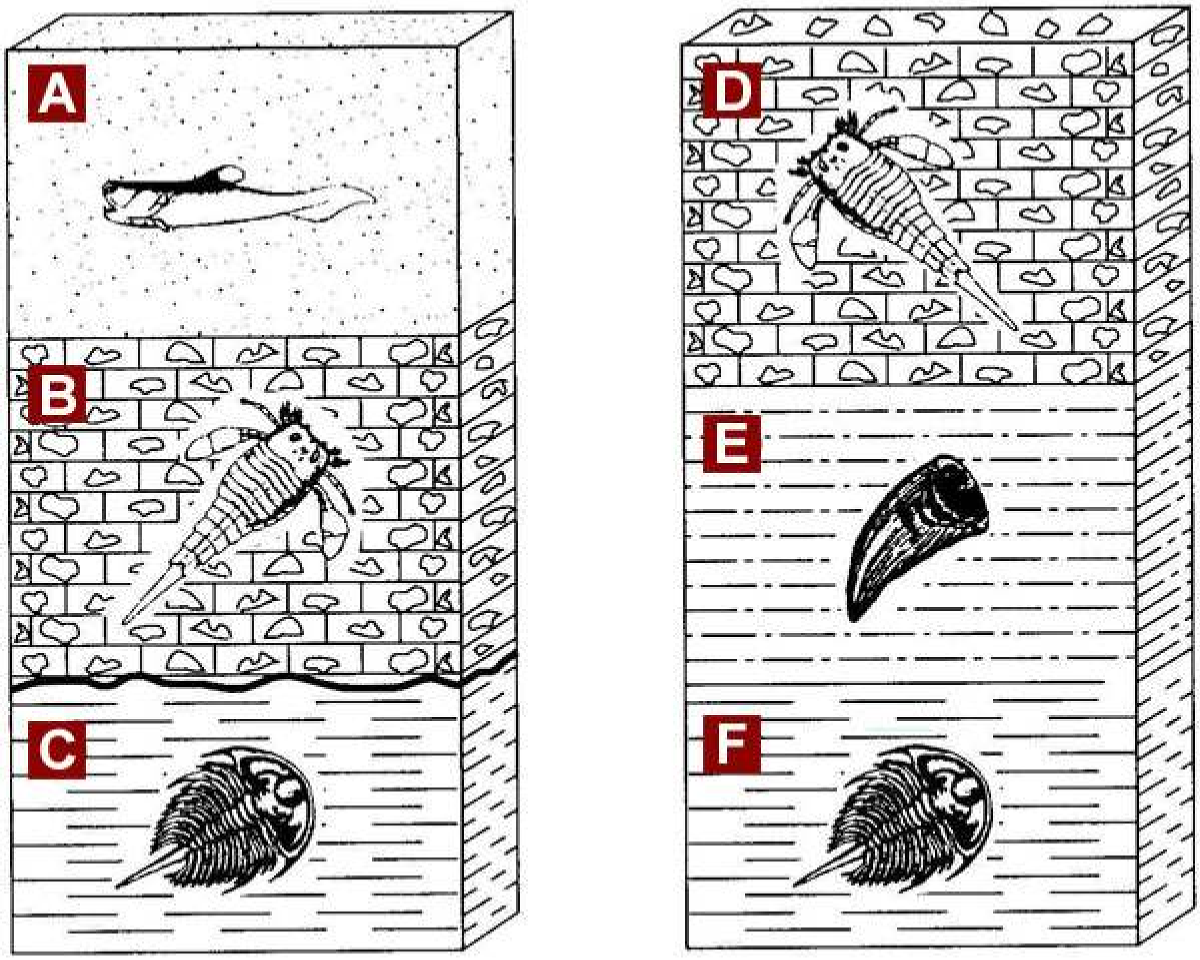
1. Successive layers are laid down on top of the preceding layers. The reverse order of deposition can never occur unless the earlier layers are inverted by folding.
2. When deposition takes place, it produces horizontal layers only. If layers are observed to be inclined, then the rocks have been moved since deposition.
3. Naturally formed layers do not have abrupt ends, or have gaps within them. Gaps and abrupt ends indicate movement of the original deposits after formation e.g. by faulting.

Before starting, consider the following:

1. The ground levels do not have to be the same for each rock formation.
2. You should try to compare the layers in the separate sedimentary formations, two at a time.
3. You should assume that there has been no faulting.
4. You should assume that the more strata a sedimentary rock has the older it is.

CORRELATION OF ROCK LAYERS

The diagrams below represent two rock outcrops found several kilometres apart. A geologist will match layers in the two sites by the fossils found in the layers. This matching process is called 'correlating'.



Use the geologic profiles above to answer the following questions.

1. Which layers are the same?

2. Of the rock layers E and F, which is the oldest?

3. What is the correct sequence of rock layer from oldest to youngest?

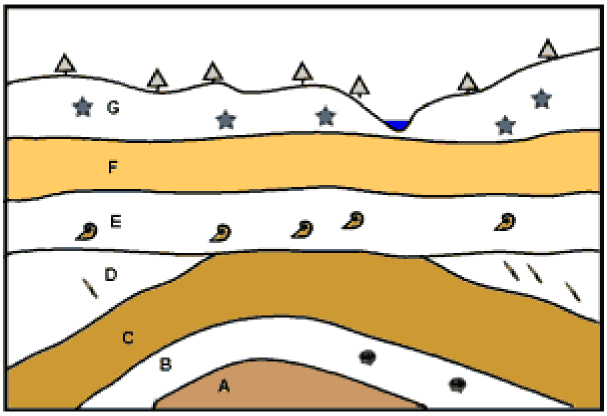
4. An unconformity (buried erosional surface) is represented by the interface between which two layers?

5. What type of rock is layer A?

CORRELATION ACTIVITY

PROBLEM: How can the principles of stratigraphy be used to do relative age dating?

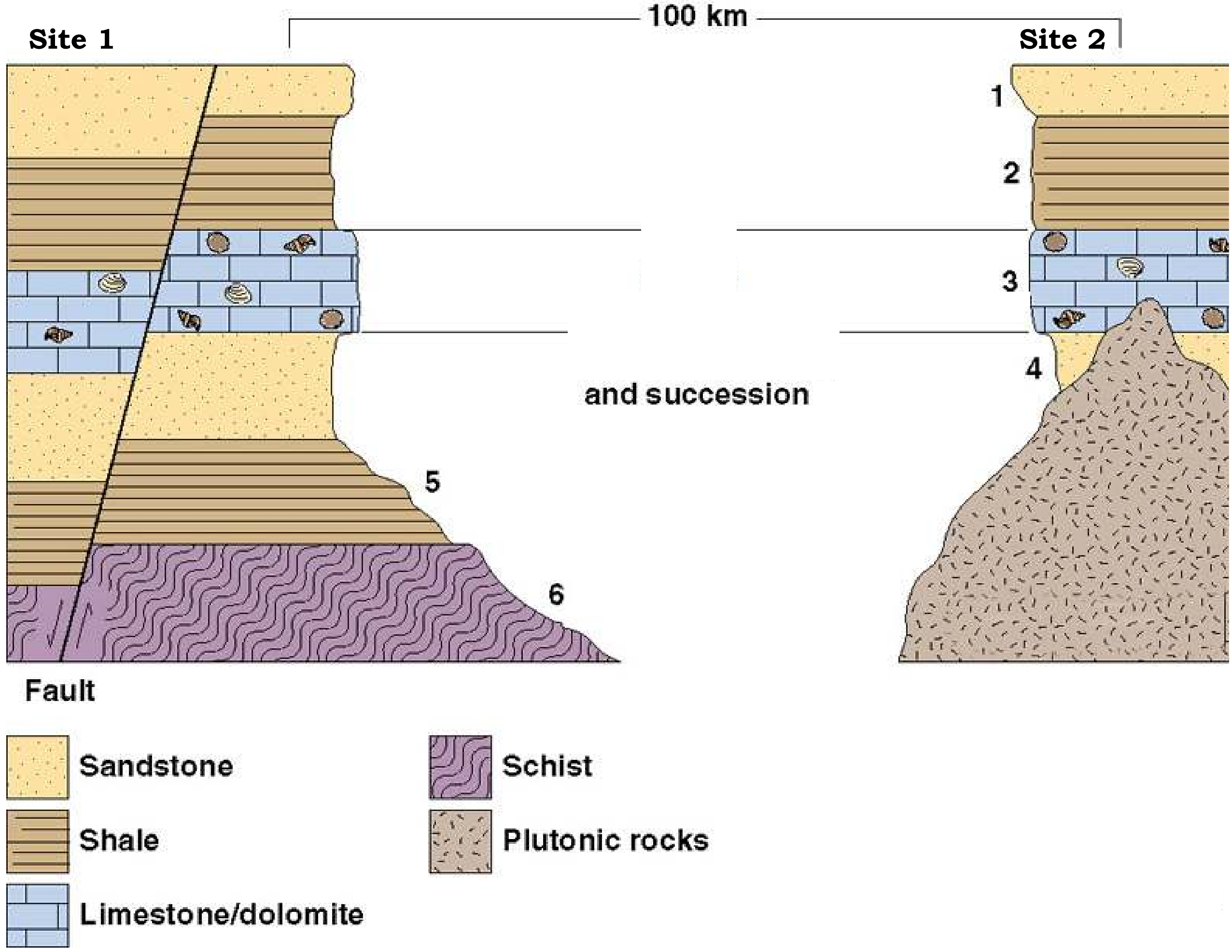
Exercise I. This drawing shows a cross-section, or a side view, of the rock layers below the Earth's surface. The trees and water show where the surface is. Each rock layer is identified by a letter. Some of the rock layers contain fossils. Using the principles of stratigraphy, answer the following questions about the cross section.



1. Which rock layer is the oldest?
2. Which rock is the youngest?
3. Which principle helped you determine your answer?
4. Between what two layers has erosion occurred? How can you tell?
5. Which rock units have been affected by mountain building? How can you tell?
6. Which type of fossil is the oldest?
7. Which stratigraphic principles helped you answer this question?

Exercise 2

Consider the rock strata exposed in cliff faces at Site 1 and 2 shown in the diagram below



1. Is the fault shown older or younger than Layer 1?
2. Is the intrusion of plutonic rock older or younger than Layer 3?
3. The fossils shown in the Layer 3 are the same in both sites. What can be concluded about the age of this fossil layer at Site 1 and 2?
4. What must have happened to the sediments between Site 1 and Site 2?

ACTIVITY 33: GEOLOGISTS CASEBOOK

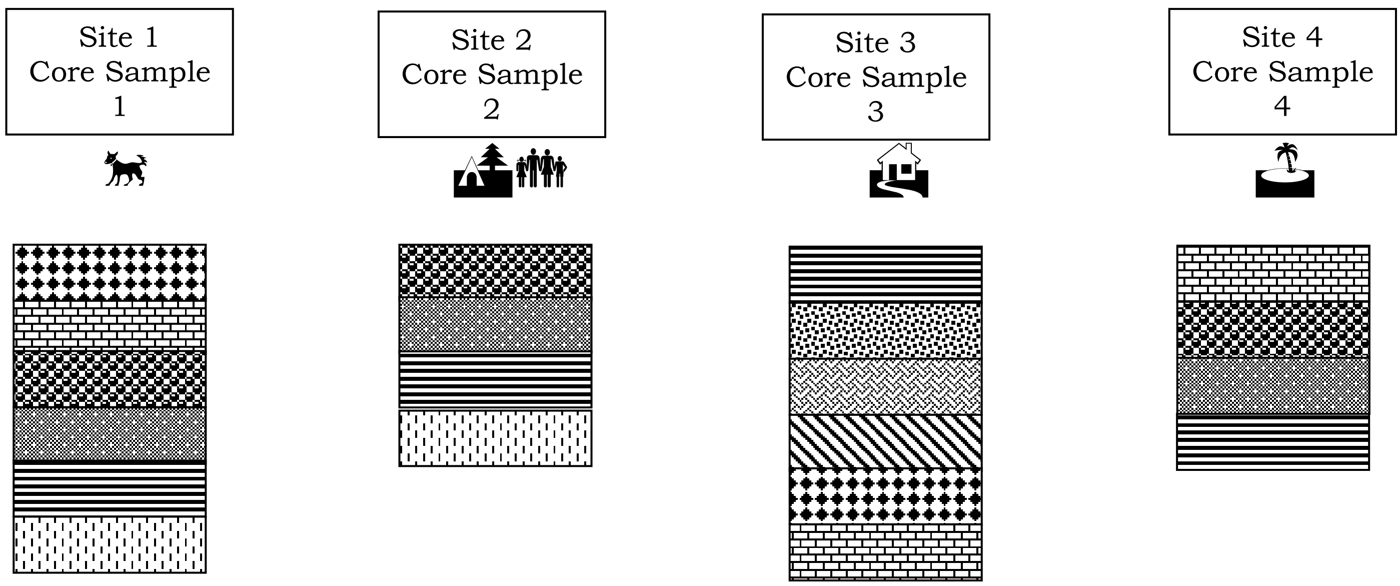
Valuable minerals can be located in sedimentary rocks – for example coal and oil. Some are also useful building materials – limestone and sandstone are two. Occasionally a sedimentary rock can be built up of fragments of precious or semi-precious minerals. Part of the work of the geologist involves:

1. *Recognising layers of sedimentary rock where they outcrop in hills and on plains.*
2. *Being able to match the layers found in drill cores in one area with layers of rock from another area.*

A PROBLEM TO SOLVE:

Rocks Sandstone (a gritty chap) and Beryl Amethyst (a little green but very keen) are two up and coming geologists. They have studied four sets of sedimentary rocks from core samples taken at different places on the Poseidon Plains. Rocks has located a semi-precious mineral in layer (iv) of core sample 4. He has placed a miner's claim on the site of core sample 3 so he can open-cut mine this sedimentary layer. But Beryl cautions him saying that, although the layers are similar, they were laid down at different times. Beryl is also studying the amount of surface erosion. Rocks tells her it is obvious that most erosion has occurred at the site of core sample 3.
Was he correct in the decisions he has made?

DRILLING DATA – POSEIDON PLAIN

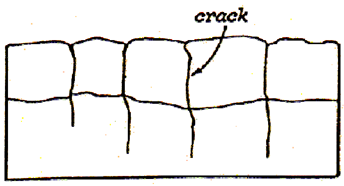


ACTIVITY 34: FORMATION OF SOILS

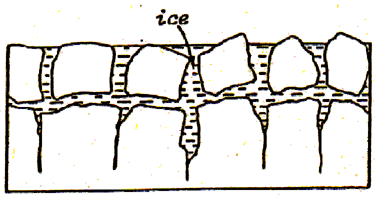
Soils are complex mixtures of different materials — mainly sand, silt, clay mineral salts, metallic oxides, and humus. They are formed by the action of weather and living organisms on rocks.

The process of soil formation is extremely slow and takes place in three stages of fragmentation, softening, and darkening.

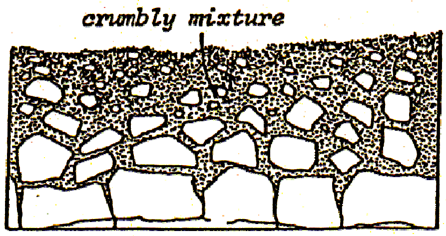
1. **FRAGMENTATION**. Daily temperature changes cause the outer parts of rocks to expand and shrink repeatedly, resulting in the development of cracks. (This occurs because rocks are poor conductors of heat.)



   The cracks soon become filled with rainwater. If this freezes on a cold night, it expands and widens the cracks.

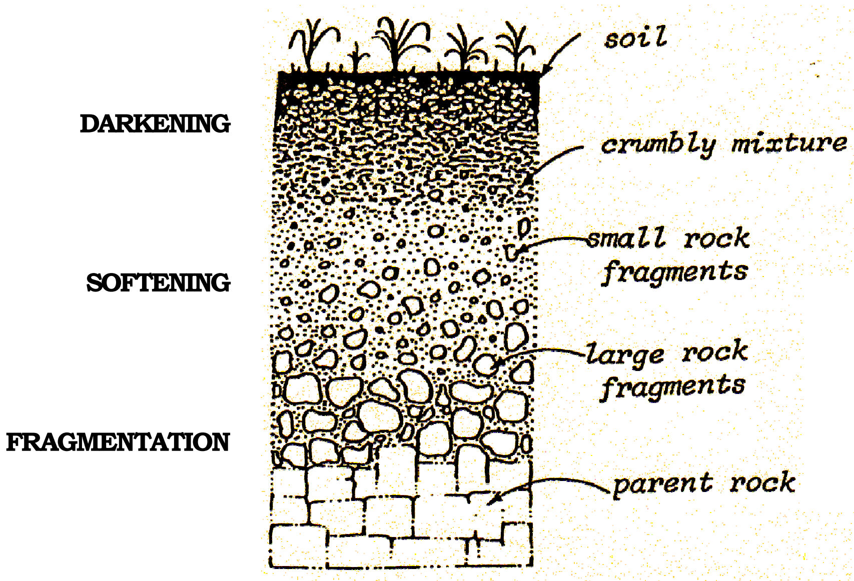


2. **SOFTENING**. Air and water in cracks have a slow chemical action on some of the minerals in igneous rocks, such as granite and basalt, changing these minerals into clay. In most sedimentary rocks, such as sandstone and conglomerate, clay is already present as a cementing material. When clay becomes wet it expands and widens cracks.



These processes increase fragmentation and gradually change the hard rock into a crumbly mixture.

3. **DARKENING** Further exposure to air and water, and the addition of humus from the remains of living organisms, finally gives the mixture a dark colour.



The three stages of soil formation can often be seen in a fresh road cutting. A diagram of a section of such a cutting is called a soil profile.

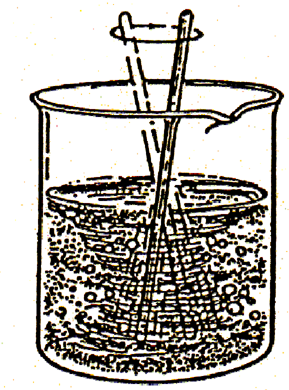
ACTIVITY 35: WHICH SOIL CONTAINS THE MOST HUMUS?

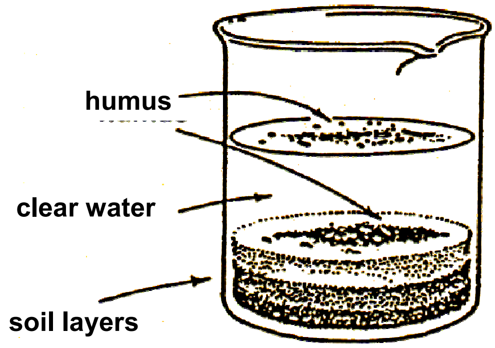
All good soils contain humus. Humus is made up of tiny pieces of decaying plants and animals.

If you examine humus closely, you might recognize some of the pieces in it. You might find tiny pieces of leaves, twigs or roots of plants. You might also find the dry skeletons of dead insects.

Here is an activity which shows you how to estimate the amount of humus in a soil.

- *Collect two or more samples of soil.*
    - *Sample 1 - rich topsoil.*
    - *Sample 2 - poor subsoil.*
- *Place the soil samples into separate glass beakers.*
- *Cover the soils with water. Add enough to make the beakers about 2/3 full.*
- *Stir- the water and soil vigorously until you are sure they have mixed thoroughly.*
- *Let the beakers stand for a few minutes until all the particles have settled.*





Some of the humus may have floated to the surface. Some of it may have settled on top of the rest of the soil.

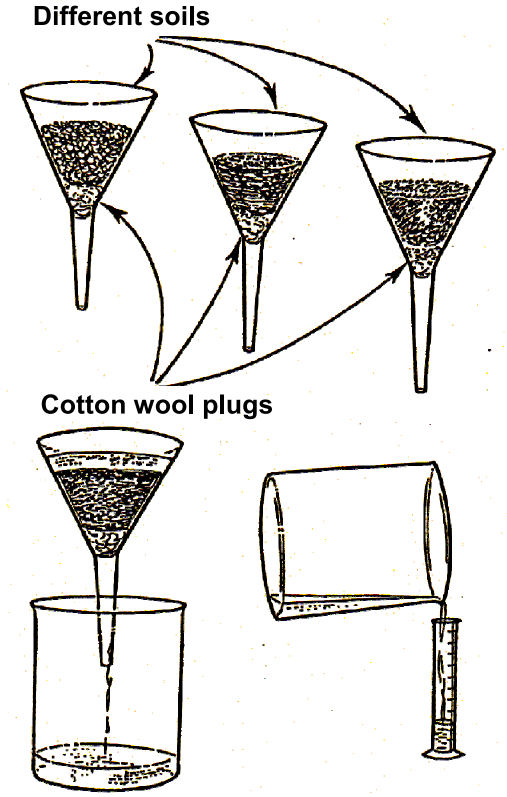
BRAINSTORM THESE QUESTIONS, THEN WRITE ANSWERS TO THEM:

1. In what ways are the soil samples similar?
2. In what ways are the soil samples different?
3. Can you recognize any parts in the humus? Perhaps a hand-lens will help.
4. Why do you think humus is a valuable soil substance?
5. Why does humus float to the surface of the water?
6. Which soil contains the most humus?

ACTIVITY 36: WHICH SOIL HAS THE BEST HOLDING CAPACITY?

All our important food crops need a good soil if they are to grow properly. A good soil has three important features

- *It must hold water for the roots to absorb.*
- *It must have air in it to allow the roots to respire.*
- *It must have minerals for the plants to use*



Half-fill the first funnel with clean dry sand. Half-fill the second funnel with some good loam or topsoil.

Half-fill the third funnel with any other type of soil you can find.

Pour a small test-tube full of water into each of the funnels.

Collect the water that runs through each soil.

Use a measuring cylinder to compare the amount of water which runs through the three types of soil.

Questions:

1. Use a table like the one below to record your measurements:

	Type of Soil Tested	Amount of Water Added	Amount of Water Collected
1			
2			
3			

2. What can you say about the water holding capacity of the soil samples?
3. Which soil is the most permeable?

EXTRA FOR EXPERTS

How can you measure the *rate* at which the water *permeates* through each of the samples? Try your idea.

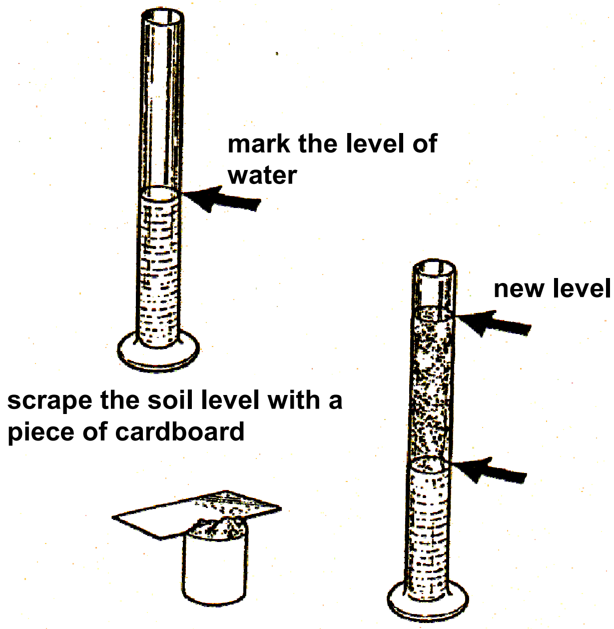
ACTIVITY 37: WHICH SOIL CONTAINS THE MOST AIR?

Read this information:

The roots of plants must be able to breathe air. The air is usually found in the spaces between the soil particles.

Some soils contain more air space than others. Here is an interesting way for you to measure the amount of air in a soil.

1. Fill a small beaker with water.
2. Pour the water into a long measuring cylinder.
3. Measure the volume of water you used. Record it in the table below.
4. Fill the same beaker to the brim with the soil you are going to test. Add this to the water in the cylinder and stir it.
5. Let the soil settle. Measure the volume of water and soil in the cylinder.
6. Record your measurements in the table.
7. Repeat the measurements for other soils.



Copy the following table.

	Soil A	Soil B	Soil C
First level (water only)			
Second level (water + soil)			

Questions:

1. How do these measurements show you here was some air in the soil?
2. Which type of soil contains the most air?

MIND BENDERS!!!

3. a) How would you work out the fraction of soil that was air space?

   (b) Calculate the percentage of air space in each of the soil samples.

SOME IMPORTANT GEOLOGICAL MATERIALS...

Choose one of the materials listed below and find out:

- How it is obtained.
- What it is used for.
- Some advantages and disadvantages of making and using the material.

Submit your information as a poster or Presentation.

Choose from:

- Aluminium
- Coal
- Gold
- Silver
- Copper
- Diamonds
- Iron & steel
- Lead
- Titanium
- Rocks and soil
- Zinc
- Tin
- Oil & gas
- Magnesium
- Mercury
- Salt

ACTIVITY 38: TREASURING OUR EARTH

Humans for thousands of years have exploited the Earth for its minerals. One of the earliest minerals to be used was copper. Although rarely native copper could be found, just like nuggets of gold, large scale use of copper began with the mining of ores of copper and their smelting to obtain the copper they held. The earliest mining was in the Fertile Crescent of Western Asia, and in South America. Copper could be beaten into shape, melted and poured into moulds to form useful shapes.

Ötzi the Iceman, who was found in the Ötztal Alps between Austria and Italy and whose remains were dated to about 3300 BC, was found with a copper axe, which indicates that copper mining existed in Europe at least 5,300 years ago (500 years earlier than previously believed).

The South Asian inhabitants of Mehrgarh fashioned tools with local copper ore between 7700–3300 BC.

However, copper is a very soft metal. The so-called Copper Age was quickly replaced when a new technology, that of combining copper with tin to form a much harder metal **alloy** called bronze, became common. So began the Bronze Age. Bronze however, was not as hard or strong as iron. By heating iron ore with charcoal the iron could be extracted and used to make strong axes, weapons and other tools. So began the Iron Age and eventually industrial cities using iron and steel to make an enormous number of tools, machines and other implements.

Steel-making needed enormous amounts of coal to provide the energy to extract the iron from its ore and to drive steam engines needed for industry. Mining of these resources has made some countries including our own very rich. It has also created enormous problems for our World. The burning of fossil fuels has led to the Greenhouse Effect (Global Warming) and acid rain. There has also been the loss of habitat for native animals and plants due to mining operations, road making, clearing for cities and towns and for agriculture to feed us.

Questions:

1. Apart from the metals mentioned in the passage above, list five other metals we extract from the ground.
2. What other substances that are *not* metals are mined. List five of these.
3. What are the two main types of ways these resources are mined?
4. Where in this State is the 'Super Pit"? Use Google Earth to examine this enormous hole in the ground.

In our everyday lives almost every item we touch can be linked to mining operations of some kind. The enormous population of humans and their demand for consumer goods has meant huge pressures have been put on 'Mother Earth'. Some of these are listed on the next page…..

ACTIVITY 38: HUMAN IMPACT ON THE EARTH

Research one of the following and draw a poster to show your findings.

Deforestation

Acid Rain

Algal Blooms

Photochemical Smog

Habitat Loss

Greenhouse Effect

Desertification

Species Extinction

Acid Sulfate Soils

Oil Spills

Contamination of Waterways

Atmospheric Pollution

Coral Bleaching

Geology Revision Worksheet

TYPES OF ROCKS

1. ___________rock is made from molten Earth materials. An example of this type of rock is______________.
2. Rocks are broken down into smaller particles by the action of changes in temperature, rain, ice and wind. This is called .These small particles of rock are compacted and cemented together and form____________rocks. An example of this type of rock is_________________.
3. _______________ rocks are formed by other rocks being changed by the action of heat and/or pressure on other rocks. An example of this type of rock is___________.

MINERALS

4. ___________ are made of minerals.
5. Minerals are_______________occurring are made up of ______________.

CHARACTERISTICS OF MINERALS

6. The crystals of many minerals have their own ___________. For example halite and pyrite crystals are cubes and mica crystals are flat sheets.
7. ________________ is the measure of how difficult it is to scratch the surface of a mineral. Hardness is measured using __________________scale.
   The softest on the scale is the number____and the mineral that is the softest is_______.
   The hardest on the scale is the number___and the mineral that is the hardest is ___________________.
8. If you rub a mineral on a white tile the colour left behind on the tile is called the __________________. The colour of the mark is not always the same as the colour of the mineral.
9. Many minerals split easily in certain directions, this splitting is called_____________. For example mica splits easily into flat sheets.
10. Some minerals glow a different colour when placed under a U.V. light. This characteristic is called________________.

SPECIFIC MINERALS

11. The three minerals that make up the rock Granite are:

a) ___________ which is black and flaky
b) ___________ which is pink in colour.
c) ___________ which is white and has long thin crystals.
d] Minerals that cool slowly will form___________crystals.

Word Bank (2 words will be left over)

Metamorphic	Hardness	Streak	Igneous	Quartz	Sedimentary	Compounds
Weathering	Limestone	Feldspar	Shape	Diamond	Naturally	Crystals
Fluorescence	Marble	Rocks	1	Mica	Cleavage	Talc
Granite	Mohs	10	Halite	Bigger	Smaller	Pumice