Rocks & Minerals Package

Year 8
Australian Curriculum - Earth & Chemical Sciences
The WASP (Woodside Australian Science Project) is an initiative between Woodside and Earth Science Western Australia (ESWA). These activities are designed to provide support for the Earth Science part of the Earth & Space Science and part of the Chemical Sciences topic required by the Year 8 Australian Curriculum.

Copies of this and other supporting material can be obtained from the WASP website [http://www.wasp.edu.au](http://www.wasp.edu.au) or by contacting Julia Ferguson, julia@wasp.edu.au.

### Topic 1  Why Study Rocks?

### Topic 2  Rock Cycle

### Topic 3  Identifying Common Rock Types

### Topic 4  Rocks and Minerals as Resources

### Topic 5  Aboriginal Perspective

### Year 8 Australian Curriculum Science

#### Earth & Space Science

- 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.
  - Recognising that some rocks and minerals, such as ores, provide valuable resources.

#### Chemical Sciences

- The properties of the different states of matter can be explained in terms of the motion and arrangement of particles.
  - Using the particle model to explain observed phenomena linking the energy of particles to temperature changes.
- Differences between elements, compounds and mixtures can be described at a particle level.
  - Recognising that elements and simple compounds can be represented by symbols and formulas.
- Chemical change involves substances reacting to form new substances.
  - Identifying the differences between chemical and physical changes.
  - Identifying evidence that a chemical change has taken place.
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Why study rocks?
We Need Rocks for Breakfast! - Teacher Notes

Rock minerals → Soil → Corn → Breakfast cereal & toast

Pig → Bacon

Hen → Eggs

Cotton → Table cloth, dish cloth

Metals → Knives, forks & spoons

Clay → Plates and cups

Glass → Bottles and glasses

Rock hydrocarbons → Oil, gas, coal → Fuel for cooker, detergent, plastics

All of these end products hopefully return to the earth to be recycled.
We Need Rocks for Breakfast! – Student Activity

We all enjoy a hearty breakfast sometimes. But where does all this come from? Draw up a flow chart of what you need for breakfast and where it comes from.

E.G. TOAST

ROCK → SOIL → CORN → TOAST
These are a few questions students might like to consider before starting the “Rocks and Minerals” activities. It might be interesting if students revisit these answers at the end of the unit.

1. **Q.** Why study rocks at all?
   **A.** Rocks are important to the survival of this species. We even name human pre-history as the “Stone Age” followed by the Metal Ages (Bronze Age, Iron Age etc.). Studying and understanding rocks gave us the capacity to use them for art, architecture, cement, ceramics, currency, defence, energy for light/heat/cooking/moving/making (uranium, coal, gas, petroleum), farming (tools & fertilisers), fire (flint & pyrites), hunting (spears, bolas), jewellery, making metals, making monuments, metals, music (metals strings for some string instruments), painting (pigments), road surfaces, sport (curling), weapons. All living things depend on nutrients from soil which is weathered rock.

2. **Q.** Don’t rocks last forever?
   **A.** Most rocks last considerably longer than humans but in geological time they get weathered down and recycled by the earth to form new rocks.

3. **Q.** Have I ever eaten a rock?
   **A.** Oh yes! Try the “rocks for breakfast” worksheet for an answer to that.

4. **Q.** How is gold made? I’d like to find some.
   **A.** The gold we find on Earth was made by nuclear reactions in distant stars which exploded and the dust (including gold) spread out into space. Some of this dust stuck together to become our solar system including our own planet. It is that original amount of gold that we still have now. Earth processes move it about over geological time. Some places like Kalgoorlie have a relatively high concentration of gold whilst others like Albany have much less. You need to know what type of rocks to look in and how old they are.

5. **Q.** Will we use up all the gold and there will be no more?
   **A.** The gold we use will just be recycled geologically slowly by Earth processes. Matter can neither be created nor destroyed however if we are not careful in the future it may not be found in economically useful quantities.

6. **Q.** What use could I possibly have for learning to classify rocks?
   **A.** Rocks are classified according to their history. This history gives them certain useful characteristics. You will be able to know which rock suits which purpose. You won’t prospect for gold in coastal limestone or use it to make a doorstep or gravestone and you won’t buy shares in an oil company prospecting near Kalgoorlie!
7. Q. Why is it particularly important that people in Western Australia should know a bit about rocks?
A. A very large amount of this state’s income depends on agriculture and the minerals and resources industry. How development is managed will directly affect everyone either in their pocket or by access to local infrastructure (location of hospitals, schools, parks, beaches and roads). Knowledge supports intelligent decision making. We are responsible for helping plan our own futures.

8. Q. Most minerals such as gold, nickel and copper lie in igneous and metamorphic rocks. Why should we bother learning about sedimentary rocks?
A. Hydrocarbons (oil, gas and coal) are found in sedimentary rocks. Although our petroleum reserves are depleting, the five main sedimentary basins in Western Australia contain huge as yet undeveloped reserves of “tight gas”. This is a possible resource for this state’s future.

On the map below, indicate where you would find economic deposits of:

- Gold
- Diamonds
- Iron ore
- Karratha
- Port Hedland
- Kalgoorlie
Why Study Rocks? – Student Activity

These are a few questions you might like to consider before starting the “Rocks and Minerals” activities. It might be interesting to revisit your answers at the end of this topic.

1. Q. Why study rocks at all?
   A. ___________________________________________________________________

2. Q. Don’t rocks last forever?
   A. ___________________________________________________________________

3. Q. Have I ever eaten a rock?
   A. Oh yes! Try the “rocks for breakfast” worksheet for an answer to that.

4. Q. How is gold made? I’d like to find some.
   A. ___________________________________________________________________

5. Q. Will we use up all the gold and there will be no more?
   A. ___________________________________________________________________

6. Q. What reasons could I possibly have for learning to classify rocks?
   A. ___________________________________________________________________
7. Q. Why is it particularly important that people in Western Australia should know a bit about rocks?

A. _______________________________________________________________
   _______________________________________________________________

8. Q. Most minerals such as gold, nickel and copper lie in igneous and metamorphic rocks. Why should we bother learning about sedimentary rocks?

A. _______________________________________________________________
   _______________________________________________________________

On the map below, indicate where you would find economic deposits of:

- Gold
- Diamonds
- Copper
- Iron ore
- Oil & Gas
An initiative supported by Woodside and ESWA
The “Rock Cycle” describes how materials are cycled through our planet. The major driving force is heat which causes convection currents. As materials are heated they become less dense and rise. When they start to cool they become denser and sink down again.

At the surface of the planet heat from the Sun causes air to expand and winds are created. These winds can bring rain and snow. These quickly move materials and sculpt our planet’s surface.

Below the surface, residual heat from the formation of the planet and heat from the breakdown of radioactive materials also cause convection currents particularly at the crust mantle interface. These movements of partially melted rock are important in recycling material from within the Earth to the surface. These currents however take geological time in comparison with surface processes.

Although we traditionally start teaching the rock cycle at the “weathering” stage and follow all the processes round until rock is uplifted to the surface again, not all parts of the cycle need to be completed.

In a tectonically active area like the Pacific rim of fire, weathered material may be deposited as sediment and rapidly drawn down into the earth only to be erupted out of a volcano and be rock again in a relatively short period of geological time.

The inland of Western Australia has two large blocks of ancient rocks called the Pilbara and Yilgarn cratons (the pink masses on the geological map). These have been relatively unchanged for over two and a half billion years.
It is always important to know why you are studying something. Write down what you already know. I have given some pictures to help.

Have you ever wondered?

1. Why on earth would anyone choose to live on an island that has erupting volcanoes, suffers from earthquakes and perhaps even the occasional tsunami?
   Volcanic rock can be very rich in minerals which weather to produce fertile soils. In tropical areas it may only take two years before a farmer can have three crops a year. Living near a volcano has many economic advantages and several physical disadvantages.

   Sulphur fumaroles on White Island New Zealand

2. If there is gold to be found in Kalgoorlie, why isn’t it found in my back garden in Perth?
   Gold is found in rocks which either came up from very deep in the earth or were affected by fluids which did. These igneous and metamorphic rocks also have to be of a specific age, about 2.6 billion years old, to carry economic amounts of gold. Perth is built on very recent sedimentary rock. Very, very small amounts of gold (a few parts per billion) may be found in these rocks because they are made from weathered gold bearing rocks found further inland.

3. Why is our Hamersley and Pilbara region so important to Australia’s economy?
   Before there was significant oxygen in our atmosphere about 1.6 to 1.8 billion years ago, the Pilbara was a vast sea where weathered volcanic rock rich in iron was deposited in a silica rich sea. This created a massive pile of iron rich sedimentary rocks. Very much more recently (geologically) these rocks were uplifted and weathered during a climate period when silica was dissolved leaving rocks further enriched in iron. Modern life depends on steel. Developing second and third world countries are moving from agricultural economies to industrial ones. Steel is necessary for building infrastructure and transport. Iron ore from our Pilbara is particularly rich and relatively easy to mine. Australia is a politically stable and dependable exporter.

   Mt Whaleback in the Pilbara

4. Where do the molecules that make my body come from?
   Our bodies are made of chemicals. We get the ones we need to grow, repair and respire from the food we eat and the air we breathe. The plants and animals get their nutrients from soil. Soil is weathered rock. We get every molecule in our body from rocks. (The rocks that make our planet were formed of a mass of cosmic dust that coalesced about 4.5 billion years ago. We ARE truly “star stuff”).
5. We no longer bang stones together to make fire or use flints to hunt animals. Why should a present day Western Australian need to know about rocks and sediments? Since all we are and all we make is sourced from rocks knowledge of how to use these resources in a sustainable fashion is essential.

These questions are all explained by “The Rock Cycle”.
It is always important to know why you are studying something. Write down what you already know. I have given some pictures to help.

Have you ever wondered?

1. Why on earth would anyone choose to live on an island that has erupting volcanoes, suffers from earthquakes and perhaps even the occasional tsunami?

![Sulphur Fumaroles on White Island New Zealand](image)

2. If there is gold to be found in Kalgoorlie, why isn’t it found in my back garden in Perth?

![Mt Whaleback in the Pilbara](image)

3. Why is our Hamersley and Pilbara region so important to Australia’s economy?
4. Where do the molecules that make my body come from?

5. We no longer bang stones together to make fire or use flints to hunt animals. Why should a present day Western Australian need to know about rocks and sediments?

These questions are all explained by “The Rock Cycle”.

An initiative supported by Woodside and ESWA
Weathering is a destructive process

When rock is weathered it is broken down into smaller pieces called “CLASTS”. Weathering only involves the breakdown of the original rock, not the removal of clasts.

Various clasts

Weathering can be by:
PHYSICAL agents e.g. rain, heating and cooling, wind, ice, gravity.
CHEMICAL agents e.g. acid rain, humic acid in peat bogs, urine.
BIOLOGICAL agents e.g. mosses and lichens, animal feet, tree roots.

Although fresh volcanic basalts can be broken down in less than ten years in the tropics, most weathering takes geological time.
Visit: http://www.kineticcity.com/mindgames/warper/

Physical Weathering
These are physical changes as no new substance is produced.

1. Unloading
Most rocks have natural cracks. These can be the result of weakness due to bedding structures or to unloading as tectonic movements raise rock masses from depth. At depth rocks are subject to enormous pressure from overlying material and to increased temperature from within the Earth (25°C per kilometre). The buried rock becomes fairly plastic. When it is uplifted to the surface however it cools and cracks.

The geometry of the cracks depends on the minerals that make up the rock and any bedding or layering structures present. This is a sandy siltstone from the Hamersley Ranges near Tom Price in Western Australia. The geometry of the cracks relate to the geometry of the clay molecules from which it is made. The cracks fill with water and produce conditions which will allow plants to colonise and chemical weathering to begin.
Weathering - Teacher Background

When more homogenous rocks such as granites unload they develop rectangular joints and the rock mass weathers to form massive tors. During weathering some horizontal joints are also formed when load pressure is decreased causing sheets of granite to peel off. This is the beginning of “onion skin” weathering. The Bungle Bungles and Uluru are fine examples of this process.

“Onion skin” weathering at Walga Rock near Cue

2. **Freezing**
Most substances contract when they cool as a result of decreased kinetic energy of their molecules. Less molecule movement means less space is taken up and the material shrinks. Water is anomalous because it shrinks until about 4°C at which point its hydrogen atoms start to line up and bond. Water entering cracks and pore spaces will freeze and expand breaking rock.

In cold northern countries frost wedging was used to break up rocks in quarries. Thin groves would be cut into the rock and filled with water. Overnight expanding ice would widen and deepen the grooves. The process would be repeated until the crack was sufficiently large.

3. **Heating - Thermal expansion**
When a substance is heated it expands. Rocks heated during the day will cool at night. The rate of cooling is greater on the outside of a rock than at its core. This differential also contributes to onion skin weathering in homogenous rocks.

The outer layer of this granite tor in Lesmurdie has been peeled off by thermal expansion and contraction.
Chemical Weathering

1. Oxidation
The most common form of chemical weathering is oxidation. Oxygen makes up almost 21% of our atmosphere. It reacts with minerals and new products are created.

Oxidation reactions work faster if water is present, and faster still if salt and water are present. Sometimes the build up of weathering product can insulate the rock from further attack. Oxidation rates vary according to weather, exposure and rock type.

2. Acid rain
Acid rain is produced when carbon dioxide, sulphur trioxide or nitrogen dioxide are dissolved in water vapour in the atmosphere. It adversely affects plants, animals and buildings. Carbonate rich rocks such as limestone and marble are particularly sensitive to acid rain.

\[
\text{Water} + \text{Carbon dioxide} = \text{Carbonic acid} \\
\text{H}_2\text{O} + \text{CO}_2 = \text{H}_2\text{CO}_3
\]

\[
\text{Water} + \text{Sulphur trioxide} = \text{Sulphuric acid} \\
\text{H}_2\text{O} + \text{SO}_3 + \text{H}_2\text{SO}_4
\]

\[
\text{Water} + \text{Nitrogen dioxide} = \text{Nitric acid} \\
\text{H}_2\text{O} + \text{NO}_2 = \text{H}_3\text{NO}_3
\]

Prior to the advent of the Industrial Revolution people relied on energy from themselves and pack animals. Industrialisation depended on the use of fossil fuels such as coal, oil and gas. Large quantities of carbon dioxide, sulphur dioxide and nitrogen oxide have been released into the atmosphere where they are dissolved in water and fall as acid rain. Acid
Weathering - Teacher Background

Rain has badly affected vegetation downwind from factories. Rocks, houses and masonry have also been damaged.

Although carbon dioxide has been demonized as a greenhouse gas causing a change in global climate, it is necessary to support life. CO₂ in the atmosphere stops heat from the sun being instantly reflected back out into space leaving our planet a cold life-free place. Carbon dioxide is also one of the reactants in photosynthesis, which is the base of life’s energy.

Volcanoes are the major producers of carbon dioxide in our atmosphere. Many of Earth’s major extinction events have been preceded by unusually wide spreading volcanic outpourings called flood basalts. It is thought that the resultant dust clouds reduced photosynthesis whilst acid rain reduced available food for larger life forms.

**Interesting Facts**
- **Air has 0.039% carbon dioxide**
- **The air we breathe out contains 4.0% carbon dioxide**

*Tourists are only permitted to visit the cave paintings at Lascaux for a few days each year because their breath has made the damp cave air acidic and the paintings are becoming affected.*

3. Biological Weathering

At Ephesus in Greece, roads were carved from solid limestone. Over the last couple of thousand years the wheels of carts going to and from this ancient city have carved channels deeper than your hand. Many ancient Greek monuments are being reduced and damaged by tourists removing broken fragments as souvenirs. Humans are effective breakers of rock. Human feet have worn dips into the top of stone doorsteps in buildings raised by early settlers.

This photograph is of a human foot cut pathway in Karijini National Park. Tourists who do not stick to established paths and take shortcuts crush and kill the vegetation whose roots stabilises slope. The exposed soil is then subject to erosion carrying away more vegetation.

Our conservation and parks authorities are developing strategies to counter this behaviour. Car parks are solidly fenced and set back from areas of high tourist impact. This deters driving over sensitive scrub.

Dealing with the waste from large numbers of tourists is a challenge.
Weathering - Teacher Background

Composting toilets, dedicated camp sites and encouraging visitors to take their garbage away with them is also necessary.

Take only photographs – Leave only footprints

Any visitor to our Western Australian Goldfields will see enormous spoil heaps of rock broken underground and carried to the surface for processing. Guidelines for rehabilitation of these are now rigorous. A working gold mine north of Kalgoorlie was recently sold for $10.00. However the obligation to rehabilitate over one hundred years of damage by previous owners was part of the deal.

This Moreton Bay fig tree was planted 12 years ago and already it has wedged itself into concrete and asphalt.

Often mosses and lichens are the first plants to colonise fresh rock to be followed by more complex plants as soil develops. When plants and animals rot they produce a series of humic acids that chemically break down the rock. These further develop any established cracks and fissures.
Most substances contract when they cool as a result of decreased kinetic energy of their molecules. Less molecule movement means less space is taken up and the material shrinks. Water is anomalous because it shrinks until about 4°C at which point its hydrogen atoms start to line up and bond. Hydrogen bonding creates spaces in crystalline ice. Water expands 9% when it freezes to form ice. This explains why ice floats on water, has decreased density and why a bottle of wine hurriedly placed in the freezer to cool will expand and shatter if forgotten.

In some countries, teachers will take bricks, soak them in water and then freeze to demonstrate how frost wedging can break up rock. When the brick has thawed out it can be easily broken and crumbled because contained water has expanded causing internal cracks. Most WA bricks have very high clay content and are mechanically compressed before baking. As a result they have few pore spaces and will not allow water to penetrate. Unless you have access to hand thrown bricks or old bricks, this activity will not work.

In cold northern countries frost wedging was used to break up rocks in quarries. Thin groves would be cut into the rock and filled with water. Overnight expanding ice would widen and deepen the grooves. The process would be repeated until the crack was sufficiently large.

**Teacher demonstration or student activity**

This activity demonstrates how freezing water can break rock.

Scientific data for a “fair test” must be:

**OBSERVABLE**

**MEASURABLE**

**REPEATABLE**

Before it is **REPORTABLE**

**Materials required:**

- 2 clean and empty 1L milk cartons cut in half (only bottom half needed)
- 1 balloon
- A mixing bowl (plastic ice cream carton ideal)
- 1 spoon
- About 12 tablespoonsful of Plaster of Paris (A beautiful white outcrop of gypsum is near Monmatre in Paris – hence the common name).

1. Fill the balloon with water until it is about the size of a ping-pong ball. Tie it off.

**HINT** Make the water filled balloon just a little smaller than the carton. If it is too small the plaster will be thick enough to withstand the pressure of expansion. Make sure there is no air in the balloon, as it will not expand when cooled.

2. Place the water filled balloon into one carton
3. Place the Plaster of Paris (calcium sulphate, CaSO₄) in the bowl and mix in sufficient water until it has the thickness of custard or yoghurt.
Freezing (Plaster) – Teacher Notes

Word equation calcium sulphate + water = hydrated calcium sulphate.

Reactants Product

This is an exothermic (heat releasing) reaction. Since a new substance is created this is a chemical reaction.

4. Drop two tablespoons of plaster into the bottom of the carton. Place the balloon onto this and hold in position with two fingers. Add more plaster until the balloon is just covered. Keep fingers on the balloon until the plaster starts to firm (about 3 minutes) then remove fingers and smooth over with a little of the remaining plaster.

Hint Please do not empty the remaining scrapings down the sink as they will go solid and block the drain. If you wait until the plaster has set in the ice cream container, you can give the container a bit of a wiggle and the hard plaster will crackle off to be dropped into the bin.

5. Leave until the plaster has become hard. It may be necessary to hold down the balloon while the plaster sets

6. Place both half cartons in the freezer overnight. Water in the balloon will have expanded on freezing and have cracked the plaster.

7. Remove and observe

What happened to the plaster blocks? The block with the water filled balloon had cracked

Why was the other block included in the experiment? To act as a control against which change can be measured
Most substances contract when they cool. Water is different. It expands on cooling. Its particles are more spread out. The same volume (amount of space) contains less water. We call this a decrease of density.

In the diagrams below the dots represent particles of water.

**Space taken when frozen**

![Diagram showing space taken when frozen]

**Warm water**

![Diagram showing warm water]

**Frozen water**

![Diagram showing frozen water]

There is less water in the same volume when water freezes. This explains why ice floats on water.

In cold northern countries frost wedging is used to break up rocks in quarries. Thin groves would be cut into the rock and filled with water. Overnight expanding ice would widen and deepen the grooves. The process would be repeated until the crack was sufficiently large to break off a block of rock. We are going to test this idea.

Scientific data for a “fair test” must be:

O _________________________

M _________________________

R __________________________

Before it is

R__________________________
Freezing (Plaster) - Student Activity

Materials required per student or group:

- 2 clean and empty 1L milk cartons cut in half (only bottom half needed)
- 1 balloon
- A mixing bowl
- 1 spoon
- About 12 tablespoons of Plaster of Paris (A beautiful white outcrop of gypsum is near Montmartre in Paris – hence the common name).

1. Fill the balloon with water until it is about the size of a ping-pong ball. Tie it off.
2. Place the water filled balloon into one carton.
3. Place the Plaster of Paris (calcium sulphate, CaSO₄) in the bowl and mix in sufficient water until it has the thickness of custard or yoghurt.

Write the word equation for what has happened with the plaster of Paris and water. Label the reactants and product in the reaction.


Is this a chemical reaction or a physical reaction?

4. Drop two tablespoons of plaster into the bottom of the carton. Place the balloon onto this and hold in position with two fingers. Add more plaster until the balloon is just covered. Keep fingers on the balloon until the plaster starts to firm (about 3 minutes) then remove fingers and smooth over with a little of the remaining plaster.
5. Leave until the plaster has become hard. It may be necessary to hold down the balloon while the plaster sets.
6. Place both half cartons in the freezer overnight. Water in the balloon will have expanded on freezing and have cracked the plaster.
7. Remove and observe.

What happened to the blocks of plaster?


Why was the block without the balloon included in the experiment?

An initiative supported by Woodside and ESWA
In areas where the ground freezes and thaws during winter, expanding freezing ground water causes the land surface to rise and fall. After repeated freezing and thawing farmers go into the fields to pick up the large rocks which have been brought to the surface by frost heave.

Materials per student or group
- A disposable cup (paper or plastic)
- Half a cup of soil (preferably clay rich soil rather than sandy)
- Water
- 5 toothpicks, straight sticks
- Access to a freezer

1. Half fill a clear plastic drinking glass or small beaker with wet soil.
2. Mark the level of the soil on the outside of the container with a pen or piece of sticky tape.
3. Stick 5 toothpicks or broken skewers vertically into the wet soil.
4. Freeze and describe what happened.

What happened to the toothpicks? They were moved around as the expanding ice heaved the soil.

What do you think will happen to roads or houses constructed on soil which freezes and thaws? They will be tossed about and uprooted from their foundations. In permafrost areas roads have to be re-laid frequently and houses are built on wooden raft-like structures so they “float” on the surface of the heaving soil.

Where in Australia would people suffer from this problem? In the Australian Antarctic Territories. On the heights of the Dividing Range and mountain tops in Tasmania.

Can you suggest anything that might minimise this problem? Build houses on a raft of wood or concrete so that the framework can “float” as one unit and not be broken by conflicting stresses

During winter, air temperatures can be cooler than ground temperature. Soils can melt from below, reducing friction and causing avalanches on slopes.

Dissolved materials reduce the freezing temperature of water. This is why we put salt on mountain roads in winter and why pure juice icy poles are more difficult to freeze solid. It is possible however to freeze fresh water out of salt solution. This explains ice shelves and icebergs.
Frost Heave - Student Activity

In areas where the ground freezes and thaws during winter, expanding freezing ground water causes the land surface to rise and fall. After repeated freezing and thawing, farmers go into the fields to pick up the large rocks which have been brought to the surface by frost heave.

Materials per student or group
- A disposable cup (paper or plastic)
- Half a cup of soil (preferably clay rich soil rather than sandy)
- Water
- 5 toothpicks, straight sticks
- Access to a freezer

1. Half fill a clear plastic drinking glass or small beaker with wet soil.
2. Mark the level of the soil on the outside of the container with a pen or piece of sticky tape.
3. Stick 5 toothpicks or broken skewers vertically into the wet soil.
4. Freeze and describe what happened.

What happened to the toothpicks?
___________________________________________________________________________

What do you think will happen to roads or houses constructed on soil which freezes and thaws?
___________________________________________________________________________

Where in Australia would people suffer from this problem?
___________________________________________________________________________

Can you suggest anything that might help minimise this problem? ____________________
___________________________________________________________________________

Hooker Valley, New Zealand (photo courtesy of Lawrie Davidson)
Homework  Measuring the anomalous expansion of water

Scientific practise requires data which is measurable against international standards.

Explanation
Water expands 9% on freezing. This is because at temperatures under 40°C its hydrogen atoms start to line up and form hydrogen bonds. The bonding creates spaces in crystalline ice.

Materials per student
- A dictionary or access to the internet
- One empty clear clean cool drink bottle or glass
- Water
- Ruler
- Texta or sticky tape
- Permission to use the household freezer

1. Half fill a plastic cool drink bottle with water and place on a level surface
2. Mark the water level on the side of the bottle with a Texta or sticky tape
3. Measure the height of the water from the base of the bottle.
4. What units of measure will you use
5. Place upright in the freezer
6. Freeze overnight
7. Mark and measure the new level.
8. Calculate the percentage increase in volume

We are measuring the anomalous expansion of water. What does “ANOMALOUS” mean?

Unusual/not normal

Which units of measurement will you use to be scientifically accurate? mm

<table>
<thead>
<tr>
<th>Height of water before freezing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height of water after freezing</td>
</tr>
</tbody>
</table>

\[
\text{Percentage increase of water height after freezing} = \frac{\text{Height after freezing} - \text{Height before freezing}}{\text{Height before freezing}} \times 100
\]

My water increased ____________% on freezing
What would you have to do to make this data more accurate? Repeat many times and average. Use a more precise measuring device. Avoid parallax.

Ice is less dense than water because it has less mass per unit volume. This is why it floats on water.
Freezing - Student Homework

**Homework**  Measuring the *anomalous expansion of water*

You are going to find out what happens to water when it freezes. Most materials shrink or decrease in volume when they freeze.

**Materials per student**
- A dictionary or access to the internet
- One empty clear clean cool drink bottle or straight sided glass
- Water
- Ruler
- Texta or sticky tape
- Permission to use the household freezer

1. Half fill a plastic cool drink bottle or glass with water and place on a level surface
2. Mark the water level on the side of the bottle with a Texta or sticky tape
3. Measure the height of the water from the base of the bottle. (What units of measurement will you choose use? Scientific practise requires data that is **accurate** and **precise**)
4. Place bottle upright in the freezer
5. Freeze overnight
6. Mark and measure the new level of water/ice
7. Calculate the percentage increase in volume

We are measuring the anomalous expansion of water. What does “**ANOMALOUS**” mean?

___________________________________________________________________________

Which units of measurement will you use to be scientifically precise? ________________

Height of water before freezing  _________________

Height of water after freezing  _________________

Percentage increase of water  \[ \text{height after freezing} \times 100 \div \text{height before freezing} \] _________________

My water increased _________________% on freezing

An initiative supported by Woodside and ESWA
What would you have to do to make this data more accurate? _______________________

___________________________________________________________________________

___________________________________________________________________________

Explain why the freezing of water is described as “anomalous”

___________________________________________________________________________

**EXTRA for EXPERTS!**

How can you use the information you have collected to explain why ice floats on water?

Hint 500mL of water has a mass of 500g
Onion skin weathering develops in many homogenous rocks. As they were being uplifted from deep burial, the decrease in pressure caused cracks to form. Soil processes and uneven heating and cooling weathers them to rounded boulders and tors. The outside of the rock heats and cools faster than the inside. At night the outside can be contracting whilst the inside is still expanding. Stress produces curved cracks.

Expansion can be demonstrated by stretching a balloon and then pulling it over an empty cool drink bottle. The balloon will flop down. If the bottle is placed into hot water the air will heat and expand causing the balloon to rise.
Thermal Expansion (Heat) – Teacher Notes

Materials per student or group
- A large ball of plasticine (modeling clay) or potter’s clay
- A laboratory thermometer
- Access to outside the classroom (preferably on a sunny day)
- Graph paper

Experimental set up

1. Roll the plasticine into a round ball. With a pencil, make a hole into the center of the plasticine ball
2. Measure the ambient temperature (surrounding air temperature), the temperature on the surface of the plasticine and the temperature at the center of the plasticine ball. Enter these readings in the table provided. Care should be taken to avoid parallax by making sure the student’s eyes are level with the gradations of the thermometer.
3. Place the ball outside in the sunshine with the thermometer remaining within.
4. Take readings every 5 minutes and enter them into the table provided.
5. After 20 minutes bring the ball and thermometer inside and repeat as above.
6. Compare your readings with those of other students

<table>
<thead>
<tr>
<th>Time Mins.</th>
<th>Ambient temperature °C</th>
<th>Temperature of outside of ball °C</th>
<th>Temperature of center of ball °C</th>
<th>Location</th>
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<tbody>
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<tr>
<td>45</td>
<td>25</td>
<td>25</td>
<td>29</td>
<td>Inside</td>
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</table>
These readings were taken on a 35°C day in Perth. My readings have been provided if you have an excitable class or a rainy cold day. It took almost 90 minutes for the centre of the ball to return to 25°C. In our inland deserts temperatures can range from -6°C to 42°C over 24 hours.

When a rock in the desert is heated during the day it expands. At night it cools. The outside cools more rapidly than the inside which remains warmer longer.

7. Graph your results after deciding which type of graph to use
HINT If you are comparing one thing with another you use a line graph. If you compare different things you use a bar graph

8. Why did we keep taking the ambient temperature? To act as a control to make sure that we were only measuring the effect of heat or cold on the plasticine. If the ambient temperature had changed that would have added another variable and not made the experiment a “Fair Test”.

9. What measurements will you use for the vertical axis of your graph? Temperature
10. What measurements will you use for the horizontal axis of your graph? Time

The title of your graph should contain both the X axis label and the Y axis label e.g. A graph comparing the change of temperature of the core and surface of a ball of plasticine over time.

Marking Key
Title 1 mark
Labelled axes 2 marks
Units on axes 2 marks
Ruler used 1 mark
Sharp pencil used 1 mark
Accurate plotting 2 marks
Presented on time 1 mark
Onion skin weathering develops in many homogenous rocks. Homogenous means they are pretty uniform and don’t have layers or bedding. Soil processes and uneven heating and cooling turns them into the classic rounded boulders and hills we have in Western Australia, particularly in the desert. The outside of the rock heats and cools faster than the inside. At night the outside can be contracting whilst the inside is still expanding. Stress produces curved cracks.

Materials per student or group
- A large ball of plasticine (modeling clay) or potter’s clay
- A laboratory thermometer
- Access to outside the classroom (preferably on a sunny day)
- Graph paper

Experimental set up

1. Roll the plasticine into a round ball. With a pencil, make a hole into the center of the plasticine ball
2. Measure the ambient temperature (surrounding air temperature), the temperature on the surface of the plasticine and the temperature at the center of the plasticine
An initiative supported by Woodside and ESWA

Thermal Expansion (Heat) – Student Activity

ball. Enter these readings in the table provided. Care should be taken to avoid parallax by making sure your eyes are level with the gradations of the thermometer.

3. Place the ball outside in the sunshine with the thermometer remaining within.
4. Take readings every 5 minutes and enter them into the table provided.
5. After 20 minutes bring the ball and thermometer inside and repeat as above.
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7. Graph your results after deciding which type of graph to use
   HINT  If you are comparing one thing with another you use a line graph. If you compare different things you use a bar graph

8. Why did we keep taking the ambient temperature? __________________________

9. What measurements will you use for the vertical axis of your graph? __________

10. What measurements will you use for the horizontal axis of your graph? __________

The title of your graph should contain both the X axis label and the Y axis label e.g. A graph comparing the change of temperature of the core and surface of a ball of plasticine over time.
Oxidation

The most common form of chemical weathering is oxidation. Oxygen makes up almost 21% of our atmosphere. It reacts with minerals and new products are created.

This kangaroo petroglyph (Greek petros = stone, glyphein = to carve) is from the Burrup Peninsula (Murujuga) near Karratha on the Pilbara coast. Freshly broken rock is dark grey in colour because it contains some dark iron rich minerals. Weathering over millions of years has oxidised some of these surface minerals into a red rusty weathered crust. Aboriginal people have chipped through the crust to create images that relate to their cultural beliefs. The art dates back over a period of 30,000 years to the last Ice Age. The Dampier Archipelago contains the largest concentration of rock art in the world. Petroglyphs are more resistant to weathering than paintings which often have to be protected by overhangs or caves.

Oxidation rates vary according to weather, exposure and variation in rock type. This cannot be used as an accurate measurement of time to date the age of the art or to estimate relative age between different areas or rock types. Weathering of rock is a long slow process. This is why monuments, gravestones and important public buildings often use stone. The materials for construction last longer than the builders.

Over the last 30,000 years Aboriginal people have expended a lot of time and energy chipping through the red rusty crust of the rock to create these images. They must have been very important. If you had to spend weeks perched on a very hot rock in high temperatures, chipping away, what image would you create? Student answers will vary.
In the modern world, we also use symbols to represent complex messages. What would these symbols mean?

- road slippery when wet
- flammable
- radioactive
- riding of horses prohibited

Scientists also use symbols to represent elements. Elements are substances made with only one kind of atom. What elements do these symbols represent?

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Element</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>hydrogen</td>
</tr>
<tr>
<td>O</td>
<td>oxygen</td>
</tr>
<tr>
<td>C</td>
<td>carbon</td>
</tr>
<tr>
<td>Fe</td>
<td>iron</td>
</tr>
<tr>
<td>N</td>
<td>nitrogen</td>
</tr>
<tr>
<td>Mg</td>
<td>magnesium</td>
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<tr>
<td>Al</td>
<td>aluminium</td>
</tr>
<tr>
<td>Ca</td>
<td>calcium</td>
</tr>
<tr>
<td>Au</td>
<td>gold</td>
</tr>
<tr>
<td>Si</td>
<td>silicon</td>
</tr>
<tr>
<td>S</td>
<td>sulfur</td>
</tr>
</tbody>
</table>
Oxidation - Student Activity

Chemical Weathering

The most common form of chemical weathering is oxidation. Oxygen makes up almost 21% of our atmosphere. It reacts with minerals and new products are created.

This kangaroo petroglyph (Greek petros = stone, glyphein = to carve) is from the Burrup Peninsula (Murujuga) near Karratha on the Pilbara coast. Freshly broken rock is dark grey in colour because it contains some dark iron rich minerals. Weathering over millions of years has oxidised some of these surface minerals into a red rusty weathered crust. Aboriginal people have chipped through the crust to create images that relate to their cultural beliefs. The art dates back over a period of 30,000 years to the last Ice Age. Oxidation rates vary according to weather, exposure and variation in rock type. These cannot by themselves be used as an accurate measurement of time to date the age of the art or to estimate relative age between different areas or rock types.

Over the last 30,000 years Aboriginal people have expended a lot of time and energy chipping through the red rusty crust of the rock to create these images. They must have been very important. If you had to spend weeks perched on a very hot rock in high temperatures chipping away, what image would you create and why?

<table>
<thead>
<tr>
<th>Image</th>
<th>Reason</th>
</tr>
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<tbody>
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<td></td>
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</tbody>
</table>
In the modern world, we also use symbols to represent complex messages. What would these symbols mean?

Scientists also use symbols to represent elements. Elements are substances made with only one kind of atom. What elements do these symbols represent?

H  
Fe  
Al  
Si  
O  
N  
Ca  
S  
C  
Mg  
Au  
Na
Oxidation reactions work faster if water is present and faster still if both salt and water are present. Mafic igneous rocks such as basalt, gabbro and dolerite are made of iron rich minerals. Where these are exposed along a sea shoreline or to the hyper-saline waters of a salt lake, a dark band of oxidised rock will form rapidly. Much of the underground water in the goldfields is more saline than the sea.

We can test this by exposing steel wool (iron) to air, water and salty water. Steel wool represents iron rich minerals. The increased surface area of “wool” compared to a solid bar of steel or iron also increases the rate of reaction. In tropical areas rock will start to become oxidised within a year. The weathered skin of oxidised rock may in time protect the rock from further weathering.

Materials per student or group
- Three small pieces of steel wool
- Three half plastic Petri dishes
- A marking pen
- Water and salt water in a wash bottle

1. Mark one dish “Control”, another “Fresh water” and the third “salt water”.
2. Place equal sized pieces of steel wool onto each Petri dish
3. Flush steel wool in “fresh water” with fresh water and the wool in “salt water” with salt water
4. Leave for three days and observe results

Why did we not add anything to the control dish? This is the control dish. Any change resulting from testing one variable can be measured against this.
Describe any changes you notice in the other two dishes
The steel wool to which water had been added was becoming very rusty.
The steel wool to which had been added salty water was very rusty.
The petroglyph of the kangaroo above is from the Burrup Peninsula. The rocks stick out into the sea. A band of deep weathering extends 1m above high tide lines. Explain this. Spray from the sea contains salty water that increases the rate of oxidation/rusting to that height.

Oxidation rates vary according to variation in weather, exposure and variation in rock type. This cannot be used as an accurate measurement of time to date the age of the art.

Farmers and householders use metal “star” pickets to make fences. The pickets are driven into the ground and fence wire is strung through them. What part of the picket would be most affected by weathering and where in Western Australia would pickets last longest?

The part of the picket near the surface would be most impacted as it is exposed to air, water and possibly salt. Dry areas of WA with a low salt content would be best.
Weathering (salt & water) – Student Activity

Oxidation reactions work faster if water is present and faster still if both salt and water are present. Mafic igneous rocks such as basalt, gabbro and dolerite are made of dark iron rich minerals. Where these are exposed along a sea shoreline or to the hyper-saline waters of a salt lake, a dark band of oxidised rock will form rapidly.

We can test this by exposing steel wool (iron) to air, water and salty water. Steel wool represents iron rich minerals in the rock. The increased surface area of “wool” compared to a solid bar of steel or iron also increases the rate of reaction. In tropical areas rock will start to become oxidised within a year.

Materials per student or group
- Three small pieces of steel wool
- Three half plastic Petri dishes
- A marking pen
- Water and salt water in a wash bottle

1. Mark one Petri dish “Control”, another “Fresh water” and the third “salt water”.
2. Place equal sized pieces of steel wool onto each Petri dish
3. Flush steel wool in “fresh water” with fresh water and the wool in “salt water” with salt water
4. Leave for three days and observe results

Why did we not add anything to the control dish?
___________________________________________________________________________
___________________________________________________________________________

Describe any changes you notice in the other two dishes.
___________________________________________________________________________
___________________________________________________________________________

An initiative supported by Woodside and ESWA
The fish petroglyph above is from the Burrup Peninsula. These iron rich rocks stick out into the sea and have been weathered into a rusty orange colour. A band of deep dark weathering extends 1m above high tide lines. Explain why this has happened using the knowledge you have gained from your experiment.

Oxidation rates vary according to variation in weather, exposure and variation in rock type. This cannot be used as an accurate measurement of time to date the age of the art.

Farmers and householders use metal “star” pickets to make fences. The pickets are driven into the ground and fence wire is strung through them. What part of the picket would be most affected by weathering and where in Western Australia would pickets last longest?
Acid rain is produced when carbon dioxide, sulphur trioxide and nitrogen dioxide are dissolved in water vapour in the atmosphere.

Water + Carbon dioxide = Carbonic acid
\[ H_2O + CO_2 = H_2CO_3 \]

Water + Sulphur trioxide = Sulphuric acid
\[ H_2O + SO_3 + H_2SO_4 \]

Water + Nitrogen dioxide = Nitric acid
\[ H_2O + NO_2 = H_2NO_3 \]

**Interesting Geological Interpretation**

Many of Earth’s major extinction events have been preceded by unusually widespread and long lasting volcanic outpourings termed flood basalts. It is thought that the resultant dust clouds reduced photosynthesis whilst acid rain produced from the noxious gasses reduced available food for larger life forms.

At least two major extinctions have shown evidence to follow this pattern:
- K-T extinction (65.5my) 75% species became extinct. Dinosaurs disappear, mammals and birds emerge
- The Great Dying (251my) Earth’s greatest extinction. Over 90% of species die out.

These extinction events have three distinct sequential phases covering tens of millions of years
1. Massive volcanic outpourings
2. Warmer climate and acidification of the seas
3. Rapid temperature rise perhaps driven by methane release

**NB** Although carbon dioxide has been demonized as a greenhouse gas causing a negative change in global climate, it was necessary to create the conditions to support life. Carbon dioxide in the atmosphere stops heat from the sun being instantly reflected back out into space leaving our planet a cold life-free place. When living things respire (use carbohydrates to create energy) carbon dioxide is a by-product. Carbon dioxide has always been present and essential however the rate of recent increase is certainly problematic. Most life is dependant on enzymes as catalysts for effective functioning. Enzyme function is affected by both heat and acidity.

Since the Industrial Revolution when people stopped relying on energy from themselves and from pack animals and changed to using fossil fuels, large quantities of carbon dioxide, sulphur dioxide and nitrogen oxide have been released into the atmosphere where they are dissolved in water and fall as acid rain. Acid rain has badly affected vegetation down wind from factories. Rocks, houses and masonry have been also been damaged.
Acid Rain - Teacher Notes

Carbonic acid + carbonate (marble, limestone or chalk) = calcium salt + carbon dioxide + water
H$_2$CO$_3$ + CaCO$_3$ = CaCO$_3$ + CO$_2$ + H$_2$O

The following activities use carbonic acid because it is mild. Students need to know that:

An acid turns Universal indicator red
Neutral solutions turn Universal indicator green
Bases or alkalis turn Universal Indicator blue

Using CO$_2$ to create carbonic acid

I suggest that this activity is carried out as a competition between teams of 4 or 5 students. Each student has their own straw and can only blow for 1 minute before passing on to the next student (to prevent cases of hyperventilation) and overblowing. Splatter on the paper costs a 30 second handicap. The beakers of water are placed on white scrap paper or a light coloured bench top to more easily show colour change.

We can test that an acid is formed when we breathe out.

Materials required per student or group
- A small beaker or container with 100mL water
- A drinking straw for each student
- A dropper bottle with Universal Indicator
- One sheet of white paper

1. Place the beaker of water on a white sheet of paper and add a few drops of Universal indicator until it turns green
2. Students take turns to blow into the water for one minute. Any water splattered over the edge of the beaker incurs a penalty of waiting 30 seconds.
3. The process continues until the liquid turns red indicating an acid has been produced

By the end of one minute the liquid should be turning yellowish, by the end of five becoming orange and by ten minutes a reddish tinge should be discernable if the glass is held against a white background. Students who play bagpipes or didgeridoos need to rein in their reverse cycle breathing.

Interesting Facts
- The air we breathe in contains 0.39% carbon dioxide
- The air we breathe out contains 4.0% carbon dioxide

Tourists are only permitted to visit the cave paintings at Lascaux for a few days each year because their breath has made the damp cave air acidic and the paintings are becoming affected

NOTE in a chemical change reactants are mixed together to form a product
Answer the questions below

Which are the **reactants** (original materials)? **Water and carbon dioxide**

What is the **product**? **Carbonic acid**

What is the purpose of Universal Indicator? **To indicate if the liquid has changed from being neutral to being an acid**

What colour was the water in the beaker immediately after adding Universal Indicator? **Green**

What happened to the colour of the water after blowing into it for ten minutes? **The water became pink or red.**

What did this change in colour indicate? **The water had changed from neutral to an acid**

Is this a chemical or physical change? Explain your answer. **A change of colour indicated that a new substance had been created, an acid. This is a chemical change.**
Extra for experts
The major contributors to carbon dioxide in the atmosphere prior to the industrial revolution were volcanoes. When fossil fuels are burned, large amounts of sulphur dioxide and nitrogen oxide are released. These dissolve in water to form highly active sulphuric acid and nitric acid.

Extension: Kitchen Science
Students can create their own vegetable indicators by crushing colourful plants such as purple cabbage, nasturtium leaves and flowers and rose petals with a mortar and pestle with a little sand. Alternatively vegetable material can be placed into a blender with a little water and processed until liquid. Crushed purple cabbage can also be boiled. The spice turmeric can be boiled in water.

The liquid produced can then be passed through kitchen cloth (Chux?) to remove lumps. The filtrate can be reserved in a bottle or jam jar for experiments.

Small amounts of foods, drinks, household cleaners and toiletries can be placed in a clean saucer and tested using these indicators.
Acid Rain – Student Activity

Acid rain is produced when carbon dioxide, sulphur trioxide and nitrogen dioxide are dissolved in water vapour in the atmosphere.

1. \( \text{Water} + \text{Carbon dioxide} = \text{Carbonic acid} \)
2. \( \text{Water} + \text{Sulphur trioxide} = \text{Sulphuric acid} \)
3. \( \text{Water} + \text{Nitrogen dioxide} = \text{Nitric acid} \)

What is/are the reactant/s in the first equation? ____________________________________________

What is/are the product/s in the second equation? ____________________________________________

What is common to all the products? ______________________________________________________

Volcanoes are the major contributors to the gasses that form acid rain.

Since the Industrial Revolution when people stopped relying on energy from themselves and from pack animals and changed to using fossil fuels, large quantities of carbon dioxide, sulphur dioxide and nitrogen oxide have been released into the atmosphere where they are dissolved in water and fall as acid rain. Acid rain has badly affected vegetation down wind from factories. Rocks, houses and masonry have been also been damaged.

Indicators
We often cannot see what has happened in a chemical reaction. Indicators such as litmus paper and Universal Indicator solution allow us to infer a change has taken place because they change colour.

An aciD turns Universal indicator reD

Vinegar and lemon juice are acids

Neutral solutions turn Universal indicator green

Water is a neutral solution

Bases or alkalis turn Universal Indicator Blue

Toothpaste is an alkali
Acid Rain – Student Activity

Using Carbon dioxide to create carbonic acid

Materials required per student or group
- A small beaker or container with 100mL water
- A drinking straw for each student
- A dropper bottle with Universal Indicator
- One sheet of white paper

1. Place the beaker of water on a white sheet of paper and add a few drops of Universal indicator until it turns green
2. Students take turns to blow into the water for one minute. Any water splattered over the edge of the beaker incurs a penalty of waiting 30 seconds.
3. The process continues until the liquid turns red indicating an acid (carbonic acid) has been produced

Interesting Facts
The air we breathe in contains 0.39% carbon dioxide
The air we breathe out contains 4.0% carbon dioxide
Tourists are only permitted to visit the cave paintings at Lascaux for a few days each year because their breath has made the damp cave air acidic and the paintings are becoming affected

NOTE in a chemical change reactants are mixed together to form a product

Answer the questions below using the results of this experiment

Which are the reactants (original materials)? ________________________________

What is the product? ________________________________

What is the purpose of Universal Indicator? ________________________________

What colour was the water in the beaker immediately after adding Universal Indicator? ___

What happened to the colour of the water after blowing into it for ten minutes? ______

What did this change in colour indicate? ________________________________

Is this a chemical or physical change? Explain your answer. ________________________________

An initiative supported by Woodside and ESWA
Acid Rain – Student Activity

Extension     Kitchen Science

Students can create their own vegetable indicators by crushing colourful plants such as purple cabbage, nasturtium leaves and flowers and rose petals with a mortar and pestle with a little sand. Alternatively vegetable material can be placed into a blender with a little water and processed into liquid. Crushed purple cabbage can also be boiled. The spice turmeric can be boiled in water.

The liquid produced can then be passed through kitchen cloth (Chux?) to remove lumps. The filtrate can be reserved in a bottle or jam jar for experiments.

Small amounts of foods, drinks, household cleaners and toiletries can be placed in a clean saucer and tested using these indicators.
Acid Weathering – Teacher Notes

Measured dissolution of limestone - Fair test

Materials per student or group
- A small lump of limestone, chalk or soft carbonate rock
- A nail to scrape a depression or hollow into the rock
- Triple beam balance
- One half of a plastic Petri dish
- Sand, soil or plasticine to support the rock so that the hollow will hold acid (see picture above)
- A small beaker of weak acid.
- A Pasteur or transfer pipette.
- A camera (optional)

1. With the nail, scrape a small depression into one side of the limestone rock
2. Using sand or plasticine, set the rock upright onto the Petri dish so that the depression will hold liquid
3. Take a picture of the rock
4. Compress the bulb of the pipette and suck in exactly 5mL of acid
5. Little by little drip acid into the depression on the rock. Be careful not to overfill and spill
6. Observe what happens
7. Continue refilling until either all the acid has been used up or 35 minutes have passed.
8. Review your activity to see if this used good scientific practice.

When you added the acid to the limestone, what did you observe? A gas evolved – fizzing. The acid cut into/dissolved the limestone.

At the end of the experiment, had the limestone changed. Yes

Was this a chemical change or physical change? Chemical change – new substance produced
Write a word equation for this chemical reaction
Calcium carbonate + hydrochloric acid = carbon dioxide + calcium chloride + water
Limestone + vinegar = carbon dioxide + calcium acetate + water
Calcium carbonate + vinegar = carbon dioxide + calcium acetate + di-hydrogen oxide

Why had this change occurred? The acid reacted with limestone to produce a gas.

Did you CONTROL the experiment? NO! We should have left a piece of limestone to compare with the piece affected by the acid. We didn’t all use the same volume/amount of acid.

What things did you keep the same? We all used the same acid & carbonate at the same time in the same place etc.

What things were not kept the same? Size of limestone lump, volume of acid.

What could you have done to improve control? Keep everything the same and have an untouched piece of limestone for comparison.

Explain your answers. Was your data:
Observable? Yes We could see a change
Measurable? No We should have measured the mass/volume of limestone before and after
Repeatable? Yes All the groups did the same thing
Reportable? No It needs to be improved
Was this a “fair test” NO
Acid Weathering - Student Activity

Measured dissolution of limestone - Fair test

Materials per student or group
- A small lump of limestone, chalk or soft carbonate rock
- A nail to scrape a depression or hollow into the rock
- Triple beam balance
- One half of a plastic Petri dish
- Sand, soil or plasticine to support the rock so that the hollow will hold acid (see picture above)
- A small beaker of weak acid.
- A Pasteur or transfer pipette.
- A camera (optional)

1. With the nail, scrape a small depression into one side of the limestone rock
2. Using sand or plasticine, set the rock upright onto the Petri dish so that the depression will hold liquid
3. Take a picture of the rock
4. Compress the bulb of the pipette and suck in exactly 5mL of acid
5. Little by little drip acid into the depression on the rock. Be careful not to overfill and spill
6. Observe what happens
7. Continue refilling until either all the acid has been used up or 35 minutes have passed.
8. Review your activity to see if this used good scientific practice.

When you added the acid to the limestone, what did you observe? ____________________
___________________________________________________________________________
Acid Weathering - Student Activity

At the end of the experiment, had the limestone changed? ____________________________

Was this a chemical change or physical change? ________________________________

Write a word equation for this chemical reaction
___________________________________________________________________________

Why had this change occurred?
___________________________________________________________________________

Did you CONTROL the experiment? _____________________________________________

What things did you keep the same? ____________________________________________

What things were not kept the same? ____________________________________________

What could you have done to improve control? __________________________________

___________________________________________________________________________

Explain your answers. Was your data:
Observable? _______________________________________________________________

Measurable? _______________________________________________________________

Repeatable? __________________________________________________________________

Reportable? __________________________________________________________________

Was this a “fair test”? ______________________________________________________
Acid Weathering – Teacher Answers

Students will compare the effect of acid on rocks that are used as building materials such as granite, limestone, brick (baked clay), sandstone, dolerite and marble. Good scientists share materials and compare data to discover inconsistencies. This can be done in the school laboratory or in the kitchen at home.

Materials per student or group

- Four similar sized small specimens of different rocks. Suggestions would be brick (metamorphosed clay), granite, road metal, limestone. See what you have in the garden and on your way to school. Good scientists co-operate. Exchange specimens with friends. Some garden centers or soil sources will let students have broken or damaged rocks to share. Kitchen and bathroom shops can be sources for broken tiles of marble and slate.
- Four plastic drinking cups, beakers or containers big enough to place a rock in each
- A weighing machine (kitchen or bathroom?)
- About 1 liter of acetic acid (vinegar)

1. Weigh each rock and enter its mass in the table provided
2. Place the rocks into the beakers
3. Pour 250mL of vinegar over each rock
4. Leave the rocks in the vinegar for about one week. Remove and stand to dry for a day
5. Reweigh the rocks and enter their masses into the table provided
6. Calculate the percentage loss using: (Initial mass minus final mass) divided by 100

<table>
<thead>
<tr>
<th>Rock name</th>
<th>Description</th>
<th>Initial mass (g)</th>
<th>Final mass (g)</th>
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Were you measuring data from a physical reaction or a chemical reaction? Chemical reaction as a new substance was produced.

Can anyone use this data to decide which rock to create a national monument in a coal burning-area? Explain your answer. Yea as the data produced is observable, measurable, repeatable and is therefore reportable.
Acid Weathering – Student Homework

You will compare the effect of acid on rocks that are used as building materials such as granite, limestone, brick (baked clay), sandstone, dolerite and marble. Good scientists share materials and compare data to discover inconsistencies. This can be done in the school laboratory or in the kitchen at home.

Materials per student or group
- Four similar sized small specimens of different rocks. Suggestions would be brick (metamorphosed clay), granite, road metal, limestone. See what you have in the garden and on your way to school. Good scientists co-operate. Exchange specimens with friends. Some garden centers or soil sources will let students have broken or damaged rocks to share. Kitchen and bathroom shops can be sources for broken tiles of marble and slate.
- Four plastic drinking cups, beakers or containers big enough to place a rock in each
- A weighing machine (kitchen or bathroom scales?)
- About 1 liter of acetic acid (vinegar)

1. Weigh each rock and enter its mass in the table provided
2. Place the rocks into the beakers
3. Pour 250mL of vinegar over each rock
4. Leave the rocks in the vinegar for about one week. Remove and stand to dry for a day
5. Reweigh the rocks and enter their masses into the table provided
6. Calculate the percentage loss using: (Initial mass minus final mass) divided by 100

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Were you measuring data from a physical reaction or a chemical reaction? ____________

___________________________________________________________________________
Could this data be used to decide which rock to use to create a national monument in a coal-burning area? Explain your answer. __________________________________________
___________________________________________________________________________
___________________________________________________________________________
Grave Concern – Teacher Notes

It is hard to measure the rate of weathering. Against our human life scale it appears to work very slowly. Gravestones and their inscriptions can be used to gain an estimation of relative age.

Gravestones have to be beautiful and yet soft enough to carve inscriptions into them. They also have to be able to withstand weathering. These three gravestones below are from Fremantle Cemetery. I have obscured the names of those interred. All stones three were erected between 1876 and 1887 face the same direction and are in the same part of the graveyard.

1. How old are these gravestones now? Present date minus 1876 to 1889

2. Which has stood the test of time best? Explain your answer. The sandstone gravestone is most affected by weathering. Its shape and lettering are badly affected even though it is not the oldest. It has had to be set in cement to stay upright. The slate gravestone has kept its shape but the engraved lettering has become difficult to read because parts of the rock have flaked off along bedding planes. The marble gravestone has kept its shape and most of its lettering well but has superficial colour change due to moss and lichens.

3. Why did I make sure all three gravestones are about the same age, are from the same part of the cemetery and are facing in the same direction? To ensure a “Fair Test”. All would be equally affected by the same kind of weather. Same sun, rain, wind direction. The only variable which changed was the type of rock.
4. What do you think the main agents of weathering in this graveyard were? There are at least three. Sun (heating and cooling), oxidation, rain & acid rain, moss and lichens. Elsewhere acid soil from decomposing leaves eats away at the stones at ground level.

5. Can you tell which gravestone is the oldest? Explain your answer. No because the rocks are different - OR - Only by reading the dates engraved in the stone.

In the twentieth century diamond coated saws were used to cut and polish gravestones. This meant that very hard rock such as granite could be used. Engraving granite is difficult because it chips easily so monumental masons used softer, but more expensive marble to carve the inscriptions.

In this family grave, which memorial tablet is the oldest? Explain your answer. The left tablet is oldest because there is more evidence of colonisation by mosses and lichens.
In other parts of the world there are different agents of weathering. Use your library or internet and find out about “The Elgin Marbles”. They were “rescued” from the Parthenon in Greece by Lord Elgin and held by the British Museum. What extra factors were these marble sculptures affected?

1. Longer exposure to weathering – 447BC to present
2. People directly damaging them by breaking them up for building stone
3. Explosions when the Turkish gunpowder store exploded
4. Removal and travel by archaeologists and their workers
5. Acid rain
6. Politics/greed

The source of this information should be cited by students.
Grave Concern – Student Activity

Gravestones have to be beautiful and yet soft enough to carve inscriptions into them. They also have to be able to withstand weathering. These three gravestones below are from Fremantle Cemetery. I have obscured the names of those interred. All stones three were erected between 1876 and 1889 face the same direction and are in the same part of the graveyard.

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2. Which has stood the test of time best? Explain your answer. _________________
   __________________________________________________________________________
   __________________________________________________________________________

3. Why did I make sure all three gravestones are about the same age, are from the same part of the cemetery and are facing in the same direction?
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   __________________________________________________________________________
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In the twentieth century diamond coated saws were used to cut and polish gravestones. This meant that very hard rock such as granite could be used. Engraving granite is difficult because it chips easily so monumental masons used softer, but more expensive marble to carve the inscriptions.

Marble dedication slabs on granite

In this family grave, which memorial tablet is the oldest? Explain your answer.

______________________________________________________________

______________________________________________________________

______________________________________________________________

An initiative supported by Woodside and ESWA
Grave Concern – Student Activity

In other parts of the world there are different agents of weathering. Use your library or the internet to find out about “The Elgin Marbles”. They were “rescued” from the Parthenon in Greece by Lord Elgin and held by the British Museum. What extra factors were these marble sculptures affected by?

___________________________________________________________________________

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___________________________________________________________________________

Source _____________________________________________________________________
Weathering is a *destructive* process.

The number of people visiting Karijini National Park in the Hamersley Range has increased dramatically over the last ten years. Australian native animals are soft footed and their impact is minimal. Humans are more destructive. Not only do they dislodge rocks exposing underlying strata to weathering but their impact kills vegetation making the area more prone to erosion.

Which biological weathering agent caused the development of the path? **Humans – tourists to Karijini**

What can be done to stop this damage? Exclude people. Move paths elsewhere. Stabilise path with concrete or wood to reduce impact.

What will happen if this weathering is allowed to continue? *Erosion by wind and rain will expand the pathway.* There are already signs asking visitors to stay on the paths. These are not always followed.

Which biological agent is causing the break-up of the path?
**The invasive root of the Moreton Bay fig tree which was planted twelve years previously**

What can be done to stop this damage? **Remove the tree. Redirect the pathway.**

What will happen if this weathering is allowed to continue? **The expanding root system will further crack the concrete and tarmac exposing the underlying material to weathering by wind and water**

Weathering in this cave is caused by bats.

**This cave is in a breakaway east of Geraldton**

How could bats cause the breakdown of rock? Bats (*Chiroptera*) roost in this cave. Being living things, bats urinate and defecate. Although most of their droppings are the hard exoskeleton of their insect diet the urine and faeces combine to stain and chemically break down rock over time.
Is biological weathering always damaging to rock? **No.**

Are there any positive results from biological weathering? Biological weathering is an essential part of the production of soil. Soil is essential for the maintenance of life on Earth. It is the basis of the food chain on land.

Over the 70,000 years since the end of the last Ice Age the number of humans on our planet has expanded from possibly 20,000 people to 7.089 billion in mid 2013 (US Census figure).

Describe four ways human activities can cause changes in weathering patterns. Agriculture changing soils and hooved creatures impacting it. Salinity changes due to agriculture.

Acid rain from burning fossil fuels.

Mining breaking and moving rocks.

Runoff from roads.

Building using rocks, sand and bricks (baked clay).

Roads & railways exposing rock, moving rock and changing waterways.

Global climate change increasing rate of chemical breakdown and weather pattern change.

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**Biological weathering of limestone in coastal Tamala Limestone near Fremantle**

This picture demonstrates how grass root systems and dead grass can break down solid limestone and turn it into soil. Humic acid is created from rotting vegetable matter. The acid reacts with the limestone. The blue arrows lie to the right of major roots. Since living things are based on the element carbon, dead material appears darker. A lighter zone lies under the left root where humic acid has penetrated and reacted with the limestone. Once this has broken down it will be colonised by extensions of the root.
Biological Weathering – Student Activity

Weathering is a **destructive** process

Which biological weathering agent caused the development of the path?

_________________________________________________________________________________

What can be done to stop this damage?

_________________________________________________________________________________

What will happen if this weathering is allowed to continue?

_________________________________________________________________________________

Which biological agent is causing the break-up of the path?

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In this cave weathering is caused by bats.

How could bats cause the breakdown of rock?

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_________________________________________________________________________________

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Biological Weathering – Student Activity

Is biological weathering always damaging to rock? ____________________________

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Over the 70,000 years since the end of the last Ice Age the number of humans on our planet has expanded from possibly 20,000 people to 7.089 billion in mid 2013 (US Census figure).

Describe four ways human activities can cause changes to weathering patterns.

1. _____________________________________________________________

2. _____________________________________________________________

3. _____________________________________________________________

4. _____________________________________________________________

Biological weathering of limestone in coastal Tamala Limestone near Fremantle
This picture demonstrates how grass root systems and dead grass can break down solid limestone and turn it into soil. Humic acid is created from rotting vegetable matter. The acid reacts with the limestone. The blue arrows lie to the right of major roots. Since living things are based on the element carbon, dead material appears darker. A lighter zone lies under the left root where humic acid has penetrated and reacted with the limestone. Once this has broken down it will be colonised by extensions of the root.
Erosion is the process of removal and transport. During this process clasts may be further broken down into smaller and rounder pieces. The products of weathering are removed by erosion (Latin e=away from, rodos=to gnaw)

The Fortescue River cut this and many other gorges through the Hamersley Ranges after their uplift that started about 160 million years ago.

Moving water carries clasts which abrade the underlying rocks. The country rock consists of lightly metamorphosed ancient Banded Iron Formations (BIF). Hard silica rich red layers (jasper) are inter-bedded with softer ironstone and asbestos. Differential weathering and erosion of these produces the characteristic layered effect seen in this photograph.

Weathering during the last 60 million years has removed silica and asbestos resulting in iron rich zones. The original rock averaged 30% iron ore whereas the weathered material can rise to 60% and more forming the iron ore deposits presently being mined near Newman and Tom Price.

Photograph by Amber Atkins

With the exception of glaciers, anything that moves mixtures of materials will sort them by size and by density. This can be demonstrated by “yandying” a mixture of materials in a shallow dish such as a laboratory tray, meat tray or yandy as seen below. Dried materials separate fairly quickly.

**ASIDE:** The old university story of professors grading student theses by grabbing a pile and throwing them across the lecture theatre is based on this process. The heaviest would land near the professor’s feet and be given a “first” whilst those that hit the far wall were given a “third”.

The major forces for erosion are gravity, wind and water. Biological agents play a minor role.

1. **Wind**

Wind is produced by the Sun heating the atmosphere and the ground. Close to the surface of the Earth it blows strongly but its strength and its carrying power decreases with height. Walking along the beach or out on a sand flat sand carried by the wind stings your ankles but rarely has little effect at head height. Dunes along our coast and at the side of inland salt lakes are formed by wind power. At Cervantes near the Pinnacles, roads have to be kept clear of wind blown sand. Dunes can move a hundred metres in one year.
2. Water

Running fresh water moves downhill. The clast size it can carry depends on the force of the flow. Clast shape is also affected by collisions within the flow. In mountainous regions where the grade of the riverbed is high a mixture of clast sizes will be carried. When rivers enter the sea their flow is rapidly slowed and large amounts of medium grained sediments will be deposited in alluvial fans such as those at the mouth of the Swan and Gascoyne rivers. Only fine silts and muds will be carried far out to sea.

Seawater has maximum erosive power at wave level. This erosive force cuts platforms on reefs and rocks and wave cut notches at the base of cliff. They can be used to indicate historic sea levels.

This small cliff near Rockingham has notches cut at present day sea level and at much higher sea level during the Ice Age.

3. ICE

Glaciers cover 10% of our planet. Although we do not have glaciers scouring the surface of mainland Australia at present, during the great Permian Ice Age approximately 300 million years ago it was covered by ice to a depth of 5km. Ice freezes around weathered fragments and plucks rock from the sides of the valleys it passes down. Clasts are unsorted unless reworked by glacial rivers. Glaciation leaves classic U-shaped valleys. Boulders dropped from Permian glaciers can be found near Mingenew in the Central Midlands of WA.
4. **GRAVITY (Soil Creep and landslides)** movement due to gravity

Weathered material on slopes slowly moves downhill due to gravity. The rate of movement depends on the size of the clasts, presence or absence of water and the angle of slope. Weathered material from Wiluna is moving very slowly down towards the Eucla Basin and will eventually end up in the Great Australian Bight. This process may take millions of years. Landslides that occur when water moves unstable soil slopes, can take only minutes.
Water
Like wind, the greatest erosive energy of a current of water is at its base. This is why water often undercuts structures during floods. The wave cut notches on this cliff near Rockingham are evidence of changing sea levels in recent post-glacial (Ice Age) times.

The size of materials a river can erode and carry varies with the strength of its flow and the distance from its source. Strength of flow decreases with distance because of friction with the riverbed.

Vegetation and the erosive power of water – Activity
Erosive power is decreased if materials are damp or well vegetated. A simple demonstration of this can be carried out in the school sand pit or long jump pit. Students make pairs of damp sand castles by hand or using large empty yoghurt or ice cream containers. Range these in a line to represent houses along a shoreline. Students can use leaves, twigs and flowers to create gardens, hedges and lawns in front of one of their castles. Moats and roads can be added too. Each student or group half fills a bucket with water and sluices it up the “beach” towards their own pair of castles. Comparison is made of water erosion on vegetated and un-vegetated castles.
Erosion by Water – Teacher Notes

When you collect scientific data, what criteria are necessary? Data has to be:

- Observable
- Measurable
- Repeatable

Has only variable been used? Yes

What is that variable? Vegetation

Is this a “FAIR TEST”? Yes the data is observable, measurable and repeatable and only one variable was tested.

Examine the effect/s vegetation has on erosion in your experiment. What conclusion can you draw from your results? Vegetation decreases the effects of erosion

Compare your results with those of other students. What conclusion can you draw from this experiment? Vegetation decreases erosion

As a result of what you have observed, what advice would you give to a person living by the seaside when sea level is rising? Vegetate the area between the sea and your house

An initiative supported by Woodside and ESWA
Erosion by Water – Student Activity

Water
Like wind, the greatest erosive energy of a current of water is at its base. This is why water often undercuts structures during floods. The wave cut notches on this cliff near Rockingham are evidence of changing sea levels in recent post-glacial (Ice Age) times.

Vegetation and the erosive power of water - Activity

Materials per student or group
- Access to a sand pit
- Empty ice cream or large yoghurt containers
- Pieces of vegetation (twigs, flowers, leaves, grass, weeds and flowers).
- A bucket half filled with water

1. Decide on a “shoreline”.
2. Make two sand castles
3. Vegetate the garden of one.
4. When directed by your teacher sluice the two castles with the half bucket of water
5. Compare your results with those of other groups
Erosion by Water – Student Activity

When you collect scientific data, what criteria are necessary? Data has to be:

O _________________________________________________________________________

M _________________________________________________________________________

R _________________________________________________________________________

Has only variable been used?___________________________________________________

What is that variable? _________________________________________________________________________

Is this a “FAIR TEST”? __________________________________________________________

Examine the effect/s vegetation has on erosion in your experiment. What conclusion can you draw from your results?

___________________________________________________________________________

___________________________________________________________________________

Compare your results with those of other students. What conclusion can you draw from this experiment?

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As a result of what you have observed, what advice would you give to a person living by the seaside when sea level is rising?

___________________________________________________________________________

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An initiative supported by Woodside and ESWA
With the exception of glacial ice anything which moves materials sorts them by size and by density. The “Yandy” activities demonstrate how humans can sort mixed materials by movement.

**Both wind and water act in the same way.**
1. The greatest energy is near the base of the current.
2. The greater the distance travelled the less the carrying power of the current due to friction.

**Wind**

Winds are not caused by direct radiation from the sun heating the atmosphere but from heat increasing the temperature of the Earth’s surface. Heat is conducted into the atmosphere where expansion creates convection currents. As the air heats it becomes less dense and rises. This allows colder heavier air to flow in and replace it. View [http://www.weatherwizkids.com/weather-wind.htm](http://www.weatherwizkids.com/weather-wind.htm)

Most students have walked across a windy beach or sand plain. They may remember that blown sand stings around their ankles but is not noticeable higher on their bodies. The greatest energy is near the base of the current. This is why it can be difficult taking small dogs for walks on the beach on a windy day.

In the inland, uneven heating over clay pans and surrounding scrub can create “willy willies” or “cockeyed bobs” which tear up vegetation and occasionally damage homes. Since the earth moves under the atmosphere the current is twisted. Some Aboriginal parents tell their children that if they don’t behave an evil spirit will come down through a willy willy and chastise them. The legend of the creation of the brolga, a large native bird found in the tropics involves a young girl taken away in a willy willy. She preferred dancing to working.

**Teacher demonstration the sorting effect of a wind current**
- A weekend newspaper
- A hairdryer or fan
- A pile of dry mixed sediment (if you don’t have sediment a packet of dry soup mix and sand will work to a degree)

Covering part of a corridor or side of the classroom with overlapping sheets of newspaper. Spray air from a hairdryer or fan onto a pile of dry mixed size sediments. Fine clay particles will travel the farthest grading to pebbles near the wind source.

**HINT: Do not let the students stand at the other end of the line of overlapping newspaper. They will get dust in their eyes.** The paper overlap should point away from the hairdryer.
Erosion by Wind – Teacher Notes

Wave Rock near in Western Australia

The profile of Wave Rock demonstrates a decrease in erosive power of wind with height. Sand grains carried by wind have worn away this rock and carried away the debris. Here at Wave Rock in the wheat belt of W.A., humic acid (rotted vegetation) has chemically started the breakdown of granite at ground level. Wind blown sand erosion has started at this weakened level and worked upwards creating the cave like curve.

EXTRA for EXPERTS: Perched pebbles
Since the maximum erosive effect is at the base of a wind current consistent streams of air can undercut pebbles lying on the top of sand or dirt.

To demonstrate the effect of wind
Materials per student
- 1 Petri dish
- A little water
- Dry sand or dirt
- A few pebbles
- A drinking straw
- A sheet of newspaper

An initiative supported by Woodside and ESWA
Erosion by Wind – Teacher Notes

1. Spread the newspaper out and place the Petri dish near the edge
2. Moisten the bottom of the Petri dish with a little water
3. Fill with sand
4. Place the pebbles on top of the sand
5. Gently blow through the straw to move the sand from between the pebbles

Constant abrasion by wind blown sand and deposition of iron and manganese from evaporating groundwater causes “desert varnish” on exposed rock in our interior.

Pebbles from the plains south of the Pilbara

Students might reflect on:
- Car “Duco” or paintwork being rendered dull by inland dust and wind
- Ankle sting from wind blown sand
- Sand blasting waterside restaurant windows rendering them opaque
- A hand lens or magnifying glass can be used to see that the surface of individual grains of desert sands (silica), have been rendered opaque. The yellow sands behind the coast also demonstrate this sand blasted opaque surface
Erosion by Wind – Student Activity

With the exception of glaciation, anything that moves materials sorts them by size and by density. The “Yandy” activities demonstrate how humans can sort mixed materials by movement.

Both wind and water act in the same way.
1. The greatest energy is near the base of the current.
2. The greater the distance travelled the less the carrying power of the current due to friction.

Wind
Winds are not caused by direct radiation from the sun heating the atmosphere but from heat increasing the temperature of the Earth’s surface. Heat is conducted into the atmosphere where expansion creates convection currents. As the air heats it becomes less dense and rises. This allows colder heavier air to flow in and replace it. View http://www.weatherwizkids.com/weather-wind.htm

If you walk along a beach on a windy way, which part of your body stings most from wind action?

Interesting information: Western Australia loses the equivalent of two football pitches of topsoil every day due to wind blowing it out to sea. Our broad acre farming methods and history of clearing the scrub leave no roots to hold the soil in place.

Your teacher will demonstrate the sorting effect of wind

Wave Rock Western Australia
Erosion by Wind – Student Activity

How does this photograph demonstrate the erosive power of wind?

EXTRA for EXPERTS: Perched pebbles

Since the maximum erosive effect is at the base of a wind current consistent streams of air can undercut pebbles lying on the top of sand or dirt.

These pillars are the result of wind and water erosion. Small pebbles protect underlying sand from rain erosion. Later wind erosion removes lower sand creating pillars.

To demonstrate the effect of wind

Materials per student

- 1 Petri dish
- A little water
- Dry sand or dirt
- A few pebbles
- A drinking straw
- A sheet of newspaper

1. Spread the newspaper out and place the Petri dish near the edge
2. Fill the Petri dish with sand
3. Place the pebbles on top of the sand
4. Gently blow through the straw to move the sand from between the pebbles
5. Repeat the experiment with damp sand

What difference did dampening the sand make?
Erosion by Wind – Student Activity

Constant abrasion by wind blown sand and deposition of iron and manganese from evaporating groundwater causes “desert varnish” on exposed rock in our interior.
Weathered clasts carried along by a current of wind or water will collide and abrade. The longer they are carried the rounder and smaller they become.

- Rock such as talc, limestone and chalk are made of soft minerals and therefore reduce and round rapidly. Please note classroom chalk is often reconstituted and cemented. It is often harder than natural chalk rock and the outer compacted edge resists abrasion.
- Igneous rocks such as dolerite (often used as road metal) and granite will take much longer to abrade.
- Heterogeneous rocks such as schists and fossiliferous mudstone will have some parts wearing down before the others.

Shaking relatively soft materials in jam jars or tins for varying periods of time can demonstrate this. Lumps of chalk or crayon can be shaken for varying periods of time and the results compared. If marbles are added to the clasts then rounding will occur faster. This is the principle used in ball mills on mine sites where large lumps of rock are reduced in size to increase surface area for later chemical treatments.

**NOTES**

1. Internet sites may recommend shaking sweets such as M&Ms or Smarties. Their round shape and hardened exterior mean that it can take hours before noticeable change occurs.
2. Standard commercial chalk may be hardened by adding cement and compressed. Larger chalk sticks are softer. Break them to provide “rough edges”.

---

An initiative supported by Woodside and ESWA
3. If no rocks are available locally, halve or quarter calcium (Caltrate) tablets, available from the medicine section of the supermarket or from a chemist. Enthusiastic shaking for 10 minutes produces noticeable results.
4. This activity is very noisy but good fun.

A homogeneous rock: (Greek homo = same, genus = kind).

Materials per group
- Jam jar with lid, transparent take-away container or tin with lid
- Even sized pieces of blackboard chalk, crayon or limestone
- Six marbles
- Timer
- Hand lens

Students may need to be shown how to use a hand lens/magnifying glass before starting. Many students mistakenly move the lens back and forward between the object and their eye. More correctly the lens is kept close to the eye and the object is brought towards it until it comes into focus. Students may test by looking at their thumbnail, then at scars or sores on exposed parts of their bodies. Teachers with my sense of humour often then tell them that the final test is to look at the back of their elbows – IMPOSSIBLE!

1. Estimate the percentage of coarse, medium and fine clasts that are present after each shaking interval
2. Select a typical clast for each interval and sketch it into the space provided in the worksheet. Add a scale.
3. Estimate the percentage of angular particles at the end of each interval

<table>
<thead>
<tr>
<th>Time</th>
<th>Shape</th>
<th>Scale</th>
<th>% coarse</th>
<th>% medium</th>
<th>% fine</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td>1:1</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5 minutes</td>
<td></td>
<td></td>
<td>95</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>10 minutes</td>
<td></td>
<td></td>
<td>80</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>15 minutes</td>
<td></td>
<td></td>
<td>70</td>
<td>0</td>
<td>30</td>
</tr>
<tr>
<td>20 minutes</td>
<td></td>
<td></td>
<td>65</td>
<td>0</td>
<td>35</td>
</tr>
<tr>
<td>25 minutes</td>
<td></td>
<td></td>
<td>60</td>
<td>0</td>
<td>40</td>
</tr>
</tbody>
</table>
Knocking Off the Rough Edges – Teacher Notes

Explain the change in the rate of breakdown Rate of breakdown decreases because broken fines cushion the impact of larger clasts on the walls of the container.

Option: Heterogeneous rock
Most weathered material is not homogeneous (Clasts would have come from a variety of sources and be weathered to different degrees). Some rocks also contain different minerals which weather at different rates and have different hardness.

Biscuits/cookies can represent heterogeneous rock. Chop chip cookies and sultana cookies can be shaken to demonstrate that some components break down faster than others.

Heavy minerals in Western Australia
Our ancient granites and gneisses only contain a very small amount of “rare earth” minerals such as ilmenite and monzanite. Some gneiss also contain garnets. These minerals are very resistant to weathering and are quite heavy. Rock is weathered releasing these hard resistant minerals and they are carried down to the sea by rivers.

In the sea they become concentrated by currents and are thrown up onto the beach. Wind can further concentrate deposits of heavy minerals. Many of our rare earth mineral deposits echo ancient beach lines.

Ball Mills
If rocks need to be finely ground then ball mills are used. Gold is often found finely distributed through other rocks. Crushing allows more surface area of gold bearing rock to be exposed for chemical treatment. Hard ceramic or steel balls are added to tumbling mills. They increase the rate of breakup. The balls are sent away for recycling regularly as they wear away and become less effective.

If the first activity is repeated with 5 glass marbles to represent the steel balls. The chalk pieces will be reduced to fine dust in five minutes.

Ball mills also produce flour, cement, pigments, ceramics, pyrotechnics and crush coal for coal fired power stations.
Clasts are bits of broken rock and are the product of weathering. When clasts are transported (eroded) they will collide and abrade (break and become rounder). The longer they are carried the rounder and smaller clasts become. Transport is usually by wind or water.

**An homogeneous rock:** (Greek homo = same, genus = kind)

Materials per group
- A container with lid
- Even sized pieces of rock or rock like material
- Timer
- Six marbles (optional)
- Hand lens

You will be shaking materials in a jar and observing what happens.

1. Discuss which strategy would result in the most effective breakdown of material. (Either take 5 minute turns to shake the jar or 1 minute turns).
2. Estimate the percentage of coarse, medium and fine clasts that are present after each shaking interval
3. Shake in a rolling fashion
4. Select a typical clast for each interval and sketch it into the space provided in the worksheet.
5. Add a scale.

<table>
<thead>
<tr>
<th>Time</th>
<th>Shape</th>
<th>Scale</th>
<th>% coarse</th>
<th>% medium</th>
<th>% fine</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 minutes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 minutes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Knocking Off the Rough Edges – Student Activity

<table>
<thead>
<tr>
<th>Time</th>
<th>Shape</th>
<th>Scale</th>
<th>% coarse</th>
<th>% medium</th>
<th>% fine</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 minutes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 minutes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25 minutes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Which strategy did you use? __________________________________________________

Why did you decide on this strategy? _______________________________________
___________________________________________________________________________

Explain the change in the rate of breakdown.____________________________________
___________________________________________________________________________

Was your strategy effective? __________________________________________________

**Ball Mills**

If rocks need to be finely ground then ball mills are used. Gold is often found finely distributed through other rocks. Crushing allows more surface area of gold bearing rock to be exposed for chemical treatment. Hard ceramic or steel balls are added to tumbling mills.

Repeat the previous experiment adding 6 marbles.

How long does it take to reduce the rock fragments to fine dust? ___________________

**Homework option: Heterogeneous rock** (Greek hetero = other, genus = kind).

Most weathered material is not homogeneous. Clasts would have come from a variety of sources and be weathered to different degrees. Some rocks also contain different minerals which weather at different rates and have different hardness.

Biscuits/cookies can represent heterogeneous rocks. Chop chip cookies and sultana cookies can be shaken to demonstrate that some components break down faster than others.
Our Western Australian granites only contain a very small amount of rare earth minerals such as ilmenite and monzanite. Some granite gneisses also contain garnets. These minerals are very resistant to weathering and are quite heavy. They remain and become concentrated by currents of wind and movement by water in the sea.

Dark mineral rich layers of sand on the beach near Cape Leeuwin Southwest WA
The photograph shows ridged lines running across the slopes leading down to the valley. These are caused by soil creep which is exacerbated by sheep farming removing the bushes and trees whose long roots would have held the soil in place. Sheep make their paths along these ridges of slumping soil making them more outstanding. The loss of topsoil and decrease in fertility led the farm to be abandoned.

The angle of slope necessary to promote soil creep can be estimated by placing soil or sand in a laboratory tray, using bricks or books to raise one. The increase of depth of soil at the bottom can also be measured. The angle of repose is the angle between the base of the tray and the flat bench or table. On the edges of the Stirling Ranges where the slopes are sharp and there is rain, the soil will creep down the slope in just tens or hundreds of years.

**Testing soil creep**

Materials per student or group
- 1 laboratory tray
- Dry soil or sand (from sand pit or long jump pit)
- Bricks or books
- A protractor
- A ruler
- Water and a measuring cylinder

**Part 1**
1. Fill your tray to an even depth of 1 cm. Use a ruler to produce a level surface.
2. Use bricks or books to raise one end of the tray until it slopes at the angle your teacher will suggest for your group.
3. Leave the tray in this position for 5 minutes.
4. Return your tray to level.
5. Measure the height of soil or sand at the bottom of the tray.
6. Repeat twice more and average your three readings.
7. Enter your data into the sheet provided.
Part 2
1. Add 500mL of water to the sand or soil in your level tray and mix well
2. Return your tray to the slope you used previously
3. Leave for 5 minutes
4. Measure the height of the sand at the bottom of the tray three times and average the readings
5. Enter your data on the sheet provided.
6. Add other group’s data to fill the table

Part 3
Graph the results and answer the questions.

<table>
<thead>
<tr>
<th>Slope</th>
<th>Increase in depth of dry material (mm)</th>
<th>Increase in depth of wet material (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>15°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20°</td>
<td></td>
<td></td>
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<tr>
<td>25°</td>
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<td>30°</td>
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<td>35°</td>
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</tr>
<tr>
<td>40°</td>
<td></td>
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</tr>
</tbody>
</table>

Students often confuse accuracy and precision. If you only choose to take slope readings at 5° intervals your readings will be accurate. If you take readings at 1° around where the slope became unstable you will be more able to measure the slope precisely. Accuracy is a matter of reading technique whereas precision is a matter of choice of tools.

Why did we take three readings and then average them? To provide a more accurate result and decrease the effect of any outlying results.

When the slope increased what happened to the soil? More soil moved down slope.

What could be done to make the readings more precise? Take readings at a closer interval.

When you added water, what happened? The slope became unstable at a lower angle.

To the north of Australia lie many mountainous volcanic islands. Weathering in the tropics is rapid and deep rich soils are produced which are excellent for farming. Mudslides are a common hazard at certain times of the year. What would be the main triggers for mudslides? Steep slopes, deep soils and rain. Earthquakes can also trigger mudslides. They often occur in the Monsoon season.
Testing soil creep

Materials per student or group
- 1 laboratory tray
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- Bricks or books
- A protractor
- A ruler
- Water and a measuring cylinder

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6. Repeat twice more and average your three readings
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1  2  3 Ave.</td>
<td>1  2  3 Ave.</td>
</tr>
<tr>
<td>15°</td>
<td></td>
<td></td>
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<tr>
<td>20°</td>
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<tr>
<td>25°</td>
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<td></td>
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Why did we take three readings and then average them? _____________________________
___________________________________________________________________________

When the slope increased what happened to the soil? _____________________________

What could be done to make the readings more precise? _____________________________
___________________________________________________________________________

When you added water, what happened? _________________________________________
___________________________________________________________________________

To the north of Australia lie many mountainous volcanic islands. Weathering in the tropics is rapid and deep rich soils are produced which are excellent for farming. Mudslides are a common hazard at certain times of the year. What would be the main triggers for mudslides?
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

An initiative supported by Woodside and ESWA
In the Great Dividing Range snow falls in the high mountains. Avalanches can threaten skiers. What might trigger an avalanche? Rain. Snow melt. Skiers or climbers clambering across the slope destabilising it. People rolling rocks down the slopes.

**SAFETY:** What would you do if you were in charge of safety at a granite mountain climbing resort?

**HINT** In the oil and gas industry, personnel are trained to use the “Bow tie” approach:

1. Spot the HAZARD.
2. Take measures both physical and behavioural to prevent the event that the hazard might have caused (TRAINING).
3. MITIGATE effects of the event if it occurs.
4. Have a successful outcome

(The third step is necessary because humans can make serious mistakes when distracted).

- Test different rocks for their signature angles of repose
- Monitor slopes and inform people when they may be unstable
- Place notices to make people aware of landslip dangers and what to do if one occurs
- Train climbers to be aware of landslip danger
- Have a landslip plan prepared and accessible
- Regularly train rescue groups
- Keep up to date with the latest information
- Take out personal insurance
Landslide Preparation – Student Activity

In the Great Dividing Range snow falls in the high mountains. Avalanches can threaten skiers. What might trigger an avalanche?

SAFETY: What would you do if you were in charge of safety at a granite mountain climbing resort?

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1. Spot the HAZARD.
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3. MITIGATE effects of the event if it occurs.
4. Have a successful outcome

(The third step is necessary because humans can make serious mistakes when distracted).
If you were standing where Mingenew is located in the Central Midlands of Western Australia between 280 and 320 million years you would be under an ice cap five kilometres thick. We know this because there are “drop rocks” found in local fields. They are many kilometres from their outcrop and were deposited when the glacier melted. They have classic plucked ends, polished scored soles and lie in classically unsorted sediments. Indeed glacial erosion helped create the flattened shield like surface of much of this state.

Glaciers are rivers of ice that move slowly downhill plucking rocks from the surrounding landscape grinding them into flour. Glaciers flow because pressure from overlying ice melts the ice at the bottom. Rivers flow at the bottom of glaciers.

Glaciers presently cover ten per cent of the Earth’s surface. In the distant past however it is suggested that almost the entire planet was covered in ice during the late Proterozoic. This was one of the earliest mass extinctions and is known as “Snowball Earth”.

Glaciers freeze around rock debris and employ these to grind their way over the land leaving characteristic U shaped valleys. Scratches or striations are left in country rock indicating the direction of movement. These scratches have been used as evidence to support the theory that the continents of Australia, South Africa, South America, India and Antarctica were once part of a supercontinent called Gondwana. Striations cut into rock in all these continents can be traced back to movement out from a common ice sheet when they were joined together.

Pressure from a great weight of ice above causes the base ice to melt which aids movement. Teachers can demonstrate this by cutting an ice block and pulling a length of wire across it using gloves. Sneaky teachers can place 5c pieces in the cuts and let them freeze over again!

This activity is easiest to be carried out as homework.

Materials per student or group
- Plastic or paper cup
- Cling wrap or equivalent
- Water
- Gravel or road metal
- Access to freezer
- Soft wooden boards, pine offcuts or pallet wood (cardboard will suffice but becomes soggy very quickly).
- Camera or sketch pad

1. Half fill the cup with water and add the gravel
2. Tightly cover and seal the cup with cling wrap
3. Up-end the cup onto a saucer or plate and place in the freezer
4. Next day remove the plastic wrap and drag your glacier over the soft wood surface. Remember to only move it in one direction.
5. Take a photograph or sketch what has changed.
Glaciation (Ice Erosion) - Student Homework

If you were standing where Mingenew is located in the Central Midlands of Western Australia between 280 and 320 million years you would be under an ice cap five kilometres thick. We know this because there are exotic “drop rocks”, found in local fields many kilometres from their outcrop, that were deposited when the glacier melted.

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2. Tightly cover and seal the cup with cling wrap
3. Up-end the cup onto a saucer or plate and place in the freezer
4. Next day remove the plastic wrap and drag your glacier over the soft wood surface. Remember to only move it in one direction.
5. Take a photograph or sketch what has changed.
6. Bring your findings to share with your fellow students.

An initiative supported by Woodside and ESWA
Erosion involves movement or transport of materials. Anything that moves mixed materials will separate them by size and density.

Aboriginal people used a yandy or coolomon to separate out seed from sand. It had many other uses which are explained in another section.

Moving a mix of materials in a yandy or equivalent will demonstrate this.

Materials per student
- A yandy, laboratory tray, panning dish or meat tray.
- A mixture of materials to represent weathered clasts (bits of rock).

1. Place the materials in the yandy and mix until homogenous
2. Hold the yandy lightly with one end slightly raised
3. Gently swirl the materials within the yandy. It really doesn’t matter which movement you use as long as you are consistent so the forces are in a uniform direction. Keep the movement constant.

Because girls have wider hips than boys they are often better at this activity.

In the goldfields the diggers couldn’t use water to pan for gold. Water was brought in on camel back and was almost as expensive as gold itself. The miners sometimes used Aboriginal girls to “dry pan”. They would yandy the dirt and then toss it up into the air and catch most of it again as it fell down. Here and in America, men would also toss gold bearing dust on a blanket up into a breeze. Fine flakes were supposed to stick in the blanket fibres and denser pieces of gold fall directly back down onto it. Lighter clay rich dirt would blow away in the wind.

The Wilfley table is a modern development of this simple machine. It can be used to separate gold and tin from gangue (crushed ore) and coal from mullock (uneconomic country rock). It employs water to move crushed ore over a riffled slanting surface and improve separation.

http://www.youtube.com/watch?v=qYvXrAfK6i
Visit [http://www.kineticcity.com/mindgames/warper/](http://www.kineticcity.com/mindgames/warper/) there is a fun game students can play to estimate timescales and forces for erosion and weathering.

You may also like to ask students to create an essay, diary or cartoon telling the story of the weathering and erosion experiences of a clast on its way to the sea.

**Suggested marking key**

- Title, heading or name on presentation 1 mark
- Clear stages of process given 3 marks
- Elaboration within stages 6 marks
- Well sequenced 2 marks
- Concepts well understood and demonstrated 6 marks
- X factor (humour, imagination, vocabulary etc) 5 marks
- On time 4 marks
- Rough notes attached 2 marks
- References properly attributed 5 marks

Name of student 1 mark

/35 marks
A river and its sediments

As rivers carry sediments down from the mountains to the sea overall grain size deposited on the stream bottom decreases. This is due to friction decreasing the carrying power of the river. The heaviest material is dropped out first. On the Swan River, boulders are found at Toodyay, coarse sand at Midland and fine sandy silt at the river mouth.

Hydrologists took specimens from five locations five kilometres apart along a riverbed. So they could calculate the proportions of coarse, medium and fine materials on the riverbed.

<table>
<thead>
<tr>
<th>Location</th>
<th>Specimen size</th>
<th>Coarse</th>
<th>Medium</th>
<th>Fine</th>
<th>From Mountain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bob’s Bridge</td>
<td>10kg</td>
<td>4kg (40%)</td>
<td>4.5Kg (45%)</td>
<td>1.5kg (15%)</td>
<td>first</td>
</tr>
<tr>
<td>Lazy bend</td>
<td>30kg</td>
<td>6kg (20%)</td>
<td>9kg (30%)</td>
<td>15kg (50%)</td>
<td>fourth</td>
</tr>
<tr>
<td>The crossing</td>
<td>10kg</td>
<td>3kg (30%)</td>
<td>3kg (30%)</td>
<td>4kg (40%)</td>
<td>third</td>
</tr>
<tr>
<td>The lump</td>
<td>20Kg</td>
<td>7kg (35%)</td>
<td>7kg (35%)</td>
<td>6kg (30%)</td>
<td>second</td>
</tr>
<tr>
<td>Mann Road</td>
<td>5 kg</td>
<td>1kg (20%)</td>
<td>1kg (20%)</td>
<td>3kg (80%)</td>
<td>fifth</td>
</tr>
</tbody>
</table>

Can you work out the sequence in which the specimens were taken? Specimen size varies so students have to adjust to be equivalent. Fractions or percentages can be used.

Draw a graph comparing their findings at the highest and lowest point of the river valley their findings at the highest and lowest point of the river valley. A bar graph is required because results are not continuous.

Graph must have a title, have both axes labelled and be in pencil.
A river and its sediments

As rivers carry sediments down from the mountains to the sea overall grain size deposited on the stream bottom decreases. This is due to friction decreasing the carrying power of the river. The heaviest material is dropped out first. Hydrologists (people who study water) took sediment specimens from five locations five kilometres apart along a riverbed, so they could calculate the proportions of coarse, medium and fine materials on the riverbed.

Your Task

1. Can you use the evidence below to work out in which sequence the specimens were taken? In the table write in the sequence in which the sediments were taken from number one in the mountains to number five at the river mouth.

2. Draw a graph comparing their findings at the highest and lowest point of the river valley.

<table>
<thead>
<tr>
<th>Location</th>
<th>Specimen size</th>
<th>Coarse</th>
<th>Medium</th>
<th>Fine</th>
<th>From Mountain</th>
</tr>
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<td>4.5Kg</td>
<td>1.5kg</td>
<td></td>
</tr>
<tr>
<td>Lazy Bend</td>
<td>30kg</td>
<td>6kg</td>
<td>9kg</td>
<td>15kg</td>
<td></td>
</tr>
<tr>
<td>The Crossing</td>
<td>10kg</td>
<td>3 kg</td>
<td>3kg</td>
<td>4kg</td>
<td></td>
</tr>
<tr>
<td>The Lump</td>
<td>20Kg</td>
<td>7kg</td>
<td>7kg</td>
<td>6kg</td>
<td></td>
</tr>
<tr>
<td>Mann Road</td>
<td>5 kg</td>
<td>1kg</td>
<td>1kg</td>
<td>3kg</td>
<td></td>
</tr>
</tbody>
</table>
Graded bedding – Teacher Notes

Currents of wind and water will carry clasts. The faster a stream flows the larger the clasts it can carry. Fast flowing currents carry medium and fine particles in suspension whilst heavier and larger particles bounce along the base of the current in a process known as saltation. Wading through rivers or in the wave surge near the shore we can feel these larger particles around our ankles but not at our knees.

Examining long rivers such as the Swan or Murchison two things become evident:

1. **Decrease in clast size from source to sea**
   Clast size decreases from the source to the sea because friction with the riverbed reduces the carrying energy of the current.
   - Near the source large clasts with some medium and small clasts will be deposited (boulders, gravel, sands and a little silt)
   - On the plains mostly medium clasts with some fine clasts will be deposited (sands and silt)
   - When the river enters the sea its flow is rapidly slowed permitting most of the sand to be deposited as wedge shaped deltas.
   - Fine silts and muds are deposited as the current eventually is slowed down to a stop.

   A crude version of this can be demonstrated using a downpipe from the school’s gutters. The flow decreases away from the base of the down pipe as does clast size.

   **ASIDE:** information on making a student-friendly grain size indicator and acquiring specimens of different grain sizes is on the accompanying “Grain size indicator Teacher” sheet

2. **Graded bedding**

   Each rain or wind driven current surge will also create vertical variation within beds. Beds are coarser at the base and decrease in clast size upwards as rain or wind current power ceases. This is termed graded bedding. During a wet or windy season the current will pulse many times gradually decreasing in carrying power towards the end.

   The rock here is Devonian sandstone showing classic graded bedding patterns. It demonstrates sandy sediments deposited by water during a wet season about 360 million years ago. Overall the grain size decreases from the base upwards. We can use this classic reduction in grain size to tell if rock beds are lying right way up or have been
Graded bedding – Teacher Notes

turned upside down. When a fresh surge of water carries new material it can cut into the underlying beds. The rock represents deposition during a single wet season.

Teacher demonstration

Teachers can demonstrate graded bedding by:

1. Placing mixed clast sizes into a large transparent glass jar until it is half full
2. Add water and secure the lid or cap
3. Ask your most energetic student to vigorously shake it for 5 minutes
4. Leave the jar to settle.

Ask the students to formulate an hypothesis as to what they think will happen when the shaken jar is left to settle. The larger heavier clasts will settle first to form the bottom layer, to be followed by medium clasts and the fine. Graded bedding is demonstrated

Humus layer floating on water

Fine layer

Medium layer

Coarse layer

In a riverbed this also can be seen.

This photograph is of the side of the Swan River near Bell’s Rapids.

The bands of larger pebbles indicate the end of rainfall when flow energy starts to decrease.

Grainsize decreases upwards until the next flush of rainfall causes the river to begin to deposit again.
Graded bedding activity

Students can create their own representation of graded bedding. They may need reminding that the youngest beds lie at the top. A rubbish bin has its most recent rubbish deposited on top of older material. When drawing geological sections we always draw the oldest rocks at the bottom to mirror Nature. The history of deposition of their rock will start at the bottom and progress upward. Students will write the history on the right side of the worksheet and either draw or stick materials to the left side. This activity encourages students to learn verbally and visually.

Materials per student or group

- Glue sticks or glue
- Containers of coarse, medium and fine material. If you have coarse sand, medium sandy soil and silt to hand, please ensure it is dry. Silt can be sieved from potting mix, mixed sand and soil can be used for medium grained sediment and coarse sand can be accessed from building sites and river bends. Lentils or split peas can represent coarse grained sediment, breadcrumbs for medium grained and cocoa or flour for fine grains.
- Old newspaper to cover work areas.

1. Please remember that the bedding grades upward so no sharp boundaries or gaps should be apparent.
2. First write up the deposition history of your stream in the right hand column starting at the bottom.
3. Coat the left hand column with glue and sprinkle grains onto it to represent the story described in your history column. Larger fragments that do not stick to the paper can be drawn.
4. Draw in an arrow pointing to the younger beds and write “WAY UP”.

An initiative supported by Woodside and ESWA
Graded Bedding - Student Activity

Currents of wind and water will carry clasts. The faster a stream flows the larger the clasts it can carry. Examining long rivers such as the Swan or Murchison two things become evident:

1. Clast size decreases from the source to the sea.
2. Each rain or wind driven current surge will also create vertical variation within beds. Beds will be coarser at the base and decrease in clast size upwards as rain or wind current power ceases. This is termed graded bedding.

Your teacher will demonstrate how clast size decreases as the current flow decreases

Materials per student or group
- Glue sticks or glue
- Containers of coarse, medium and fine material.
- Old newspaper to cover work areas.

1. Please remember that the bedding grades upward so no sharp boundaries or gaps should be apparent. Each layer grades into the next.
2. First write up the deposition history of your stream in the right hand column starting at the bottom. There can be several wet seasons or storms.
3. Coat the left hand column with glue and sprinkle grains onto it to represent the story described in your history column. Larger fragments that do not stick to the paper can be drawn.
4. Draw in an arrow pointing to the younger beds and write “WAY UP”

<table>
<thead>
<tr>
<th>Rock</th>
<th>Descriptive history</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Grain size reference
In the field or laboratory, it can be difficult for students to come to a decision about the grain size/sizes of soil or rocks. For general reference this tool makes decisions (at year 8 level) easier.
For more advanced classwork visit: http://www4.uwm.edu/course/geosci697/sections/grainsize%20comp.jpg

Our cerebellum unconsciously compares information from different parts of our body to control balance and maintain general homoeostasis. In this case information from our left hand is compared with that from our right. Students might like to place one hand on the table and another on their cheek. Their brain will instantly tell them which is warmer, smoother and moister. No conscious decision making is required.

A board (or a plastic paint scraper) with three or more grades of sandpaper or garnet paper stuck on makes a simple reference tool. The reverse side of paper states the grade or coarseness of the grains of quartz. (40 for coarse, 120 for medium and 240 for fine) I prefer garnet paper as the red colour covers subsequent stains more easily.

Students feel the rock or soil specimen with one hand and rub the sandpaper portions with the other. Their cerebellum will tell them if the clasts are coarser or finer than their reference square.

Ideally, nests of sieves will reduce any soil specimen to its different size fractions but these can be expensive and cumbersome. Where soil specimens have many different sizes of grains, lightly moving the specimen in your dry hand or Petri dish, will separate them somewhat. The different portions can be size estimated by comparison to the grain size indicator.
Acquiring different clast sized specimens.

Dry samples of potting mix, soil, builder’s sand, beach sand, aquarium grit and river sand are good. Ideally these can be passed through soil sieves to separate them into different sized fractions.

If you do not have these sieves:
- Pass through a kitchen sieve to separate the coarse fraction and then pass the remainder through a tea strainer to separate medium and fine.
- Use a yandy/coolomon, laboratory tray or flat dish to separate the fractions. See notes on the yandy in the erosion section.
- Even a dustpan can be used to separate grain sizes as long as it is consistently moved only back and forth in one direction.

School canteens and Domestic Science area often use cardboard shaker boxes of herbs, spices and bicarbonate of soda. Filling the empties with soils of graded sizes makes useful dispensers for the “Graded Bedding” activity.
The size of clasts a river can erode and carry varies with the strength of its flow and the distance from its source. Large heavy fragments are deposited first and grain size decreases with distance. After rain, river flow strength decreases and sediments become increasingly finer.

To copy a river’s course to the sea, a flume tube can be created from a length of guttering. One end is raised and the other rests on the ground or in a trough to collect water and debris. Mixed coarse debris (gravel, road metal, and pebbles), medium (sands) and fine (silts) form a “sandcastle” at the top of the slope.

**Erosion and deposition by water.**
A watering can with rose can pour “rain” down onto the sandcastle for a short while. Students can observe which sediments drop out earliest. This is best carried out outside or with the end of the tube over a bucket or sink.

**Erosion and deposition by wind.**
A hair dryer can be used to blow on the sandcastle. Ask students not to stand towards the end of the tube as they may get dust in their eyes. Students can be asked to explain how they can limit variables to make their observations scientific.

If neither flume tube or guttering is possible, lay a long line of newspaper along the floor. Make sure the sheets overlap away from the direction of airflow.

An initiative supported by Woodside and ESWA
It can be critical to know which way up your rocks lie. We assume that they were originally deposited as flat lying beds (The Principle of Original Horizontality). Later they may have been faulted, folded or even overturned. Under pressure at depth, rocks fold like plasticine. If you wish to drill down to a gold bearing bed or an oil bearing bed you need to know which “WAY UP” your sediments lie or you could be drilling (very expensively) in the wrong direction.

How would graded bedding tell you “WAY UP”? The larger grains lie below the finer grains. Beds decrease in grain size towards the top.

Some fossils can also indicate age. These are known as index fossils. Index fossils are useful if:

- They existed for a short period of time.
- They existed over a wide geographic range.

By matching up these index fossils across the country you can find rocks of similar ages and work out quickly if your rock sequence is the right “WAY UP”. In this activity slices of bread will be used as layers or beds of sediment and thin cross slices of red snake indicate the oldest index fossil, yellow slices the middle fossils and green the youngest. The orange fossils can be found at any level as they are not index fossils.

Bread  
GREEN Youngest Last fossils deposited  
Bread  
YELLOW Middle Middle fossils  
Bread  
RED Oldest First fossils deposited  
Bread  

Materials per student or group

- Four slices of bread with the crusts removed (ask the school canteen or local supermarket for old sliced loaves). One loaf is usually enough for five sedimentary piles. Crusts impair compaction.
- Scissors
- Three thin slices of green, red and yellow snake and 9 orange (1 packet should do for 1 class). Excitable classes may need the cut snake sections prepared earlier. Scissors work better than knives. These colourful slices represent fossils.
- 1 plastic sandwich bag
Sedimentary Sandwiches – Teacher Notes

- 1 drinking straw. These will drill through the sedimentary sandwiches/beds to see if they hit target and tell which way is up. Some fast food venues have great transparent drinking straws.
- Old newspaper to cover bench or table

I have found it easier to direct students step by step through this exercise.

1. Lay a sheet of newspaper onto the bench
2. Direct the students to slice the snakes so that you have 3 slices of 3 different colours (index fossils) and 9 orange slices (fossils which do not indicate any specific age).
3. Place the first layer of sediment (slice of bread) onto the newspaper
4. Place three red “fossils” on the bread and add three orange ones. This is the oldest bed.
5. Cover with another slice of bread/layer of sediment
6. Place three yellow “fossils” on this slice and add 3 orange ones. This is the middle bed.
7. Cover with a slice of bread/layer of sediment
8. Place 3 red “fossils” on this slice along with any orange ones that remain
9. Cover with a slice of bread/layer of sediment
10. Since sediment needs to be cemented and compacted before it becomes rock, students should slip the pile into the sandwich bag, without sealing it and then sit on it for a count of twenty.
11. Then pick up the bag and turn it in your hands several times until they cannot remember which is the correct way up
12. Pass this bag on to another group without speaking
13. Students collect their new bag and gently slip the pile of bread/sediment onto their newspaper. The sedimentary pile cannot be moved after this.
14. They will be using the straw to drill down into the pile to see if you can find any fossils and work out way up

Each drill hole will cost you half a million dollars. You only have a budget of three million dollars.

You should consider these ideas before you start:

What does finding an orange fossil tell you? Nothing. They are not index fossils

What does finding a yellow fossil tell you? Nothing. They are in the middle of the pile
If gold is found in the beds with the green fossils will you have a short way to drill or a long way? That depends on which way up the sedimentary pile lies.

Before we think of drilling, which is expensive, we use geophysics or remote sensing to guess what might lie below the surface. Without moving your sedimentary pile, run your fingers gently over the surface. Are there any clues which might help you to site your drill holes? Some students might feel bumps which indicate fossils below the top layer.

Have a good look at your sedimentary pile. Can you see any indications of which way up it lies? Some students might see fossils pushed to the edge during compaction. If the chairs students compressed the sandwiches on have a pattern, then the bread with an impression of that pattern might indicate the base of the pile.

Decide whether to concentrate drilling over any indications in a square grid or radiate outwards. These are questions that exploration geologists, geochemists and geophysicists have to consider.

Drill core in the straw can be removed by squeezing or gentle blowing.

15. Drill your first three holes. How many holes did you have to drill until you knew “Way Up”.

An initiative supported by Woodside and ESWA
It can be critical to know which way up your rocks lie. We assume that they were originally deposited as flat lying beds (The Principle of Original Horizontality). Later they may have been faulted, folded or even overturned. Under pressure at depth, rocks fold like plasticine. If you wish to drill down to a gold bearing bed or an oil bearing bed you need to know which “WAY UP” your sediments lie or you could be drilling (very expensively) in the wrong direction.

How would graded bedding tell you “WAY UP”?

Some fossils can also indicate age. These are known as index fossils. Index fossils are useful if:

- They existed for a short period of time.
- They existed over a wide geographic range.

By matching up these index fossils across the country you can find rocks of similar ages and work out quickly if a rock sequence is the right “WAY UP”.

Materials per student or group

- Four slices of bread with the crusts removed
- Scissors
- Three thin slices of green, red and yellow snake and 9 orange. (Scissors work better than knives). These colourful slices represent fossils.
- 1 plastic sandwich bag
- 1 drinking straw.
- Old newspaper to cover bench or table
1. Lay a sheet of newspaper onto the bench
2. Slice the snakes so that you have 3 slices of 3 different colours (index fossils) and 9 orange slices (fossils which do not indicate any specific age).
3. Place the first layer of sediment (slice of bread) onto the newspaper
4. Place three red “fossils” on the bread and add three orange ones. This is the oldest bed.
5. Cover with another slice of bread/layer of sediment
6. Place three yellow “fossils” on this slice and add 3 orange ones. This is the middle bed.
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8. Place 3 red “fossils” on this slice along with any orange ones that remain
9. Cover with a slice of bread/layer of sediment
10. Since sediment needs to be cemented and compacted before it becomes rock, slip the pile into the sandwich bag, do not seal it and then sit on it for a count of twenty.
11. Pick up the bag and turn it in your hands several times
12. Pass this bag on to another group without speaking
13. Collect your new bag and gently slip the pile of bread/sediment onto your newspaper. The sedimentary pile cannot be moved after this.
14. You will be using the straw to drill down into the pile to see if you can find any fossils and work out way up

Each drill hole will cost you half a million dollars. You only have a budget of three million dollars.
You should consider these ideas before you start:

What does finding an orange fossil tell you? ________________________________

What does finding a yellow fossil tell you? ________________________________

If gold is found in the beds with the green fossils will you have a short way to drill or a long way?

_____________________________________________________________________

Before we think of drilling, which is expensive, we use geophysics or remote sensing to guess what might lie below the surface. Without moving your sedimentary pile, run your fingers gently over the surface. Are there any clues which might help you to site your drill holes?

_____________________________________________________________________

Have a good look at your sedimentary pile. Can you see any indications of which way up it lies?
Sedimentary Sandwiches – Student Activity

Decide whether to concentrate drilling over any indications in a square grid or radiate outwards. These are questions that exploration geologists, geochemists and geophysicists have to consider.

Drill core in the straw can be removed by squeezing or gentle blowing

15. Drill your first three holes
   How many holes did you have to drill until you knew “Way Up”?
   ____________________________
De-watering Of Sediments – Teacher Notes

**A host rock must contain hydrocarbons (organic material).** The organics are rarely in high concentration. Source rocks form as sedimentary layers within basins. When marine sediments are compacted they de-water, become cemented and form sedimentary rocks such as sandstone, limestone, and shale. The organic material is changed chemically at the same time.

**Layered deposition of sediments - Teacher demonstration**

When mixed sized sediments and water are shaken, it will differentiate into layers. This is how bedding (sedimentary layers) is formed during deposition.

Place a mixture of pebbles, sand, clay or potting mix and water in a large screw topped jar. Close the lid and ask your most energetic student to give it a vigorous shake for two minutes. Leave the jar for five minutes and you will be able to see that the sediments separate according to size and density.

![Layered deposition of sediments](image)

What is the difference between sediment and sedimentary rock? **Sediments are materials which have been laid down by wind or water.** Sedimentary rock is sediment that has been buried, compacted and cemented. During this process the rock becomes dewatered.

**Student activity De-watering sediment**

![De-watering sediment](image)

**Materials required per person or group:**

- 1 plastic container or tray larger than a student’s foot. Laboratory or student desk trays are excellent
- Sufficient dry sand to fill tray to a depth of between 2 and 3cm.
- 1 jug of water
- 1 plastic ruler
- 1 well shod student

An initiative supported by Woodside and ESWA
De-watering Of Sediments – Teacher Notes

1. Place a layer of dry sand in the bottom of a plastic container.
2. Place the ruler into the sand and measure the height of the sand. **2.5cm**
3. Add water to the sand until it is very damp (about 1 litre).
4. Measure the height of the damp sand. **2.5cm**
5. Explain any changes or lack of changes in the height of sand after water has been added. *Water has seeped into the empty pore spaces between the grains so the level of sand has not risen. NOTE if the tray is moved, the level of the top of the sand may even drop as liquid may allow sand grains to slip about and fit together better.*
6. Firmly step onto the sand with one foot. Keep your weight on the wet sand for 1 minute before stepping off.
7. Wait for 1 minute and record what has happened to the level of the wet sand. *The area under the foot has become compacted under pressure forcing water out from between the sand particles. When the foot was removed, water flowed into the depression.*

When sediments are overlain by younger deposits water is squeezed upwards towards an area of lower pressure. Students may have noticed this when walking at the edge of the sea or across clay pans. Students can also stand on wet kitchen sponges and see how pressure dewateres the sponge. In both cases water was held in the holes or pores.

8. What happens to any fragments of dead living things in the sediment during this compression? *They become compressed and converted into kerogen. Kerogen is the precursor to oil and gas*

9. Draw what will happen to this sediment when it is overlain by more sediment.

<table>
<thead>
<tr>
<th>Before compaction</th>
<th>After compaction</th>
</tr>
</thead>
</table>

An initiative supported by Woodside and ESWA
**De-watering Of Sediments - Student Activity**

What is the difference between sediment and sedimentary rock?

______________________________

______________________________

**Materials required per person or group:**
- 1 plastic container or tray
- Sufficient dry sand to fill tray to a depth of between 2 and 3cm.
- 1 jug of water
- 1 plastic ruler
- 1 well shod student

Place a layer of dry sand in the bottom of a plastic container. Place the ruler into the sand and measure the height of the sand. (HINT Remember to write the unit e.g. cm or mm)

The height of the sand is _________________________________________________

Add water to the sand until it is very damp (about 1 litre).

Measure the height of the damp sand. ________________________________

Explain any changes or lack of changes in the height of sand after water has been added.

______________________________

______________________________
De-watering Of Sediments - Student Activity

Firmly step onto the sand with one foot. Keep your weight on the wet sand for 1 minute before stepping off.

Wait for 1 minute and record what has happened to the level of wet sand.

__________________________________________________________________________

__________________________________________________________________________

What happens to any fragments of dead living things in the sediment during compression?

__________________________________________________________________________

__________________________________________________________________________

Draw what will happen to this sediment when it is overlain by more sediment.

<table>
<thead>
<tr>
<th>Before compaction</th>
<th>After compaction</th>
</tr>
</thead>
</table>

Interesting Fact  
By one kilometre depth 90% of water has been squeezed out of the sediments. Almost all is gone by the next 6 or seven kilometres.
Sedimentary Pile – Teacher Notes

Sediments are **compacted and cemented** to become rocks. Mineralising groundwater cements the clasts together and overlying beds provide pressure that compacts and dewater the sediments.

Students can create their own rock columns by layering coarse to fine sediments into plastic cups and pressing them down firmly. Cementing groundwater can be made from a supersaturated solution of Epsom salts. Keep adding Epsom salts to hot water and stir until no more can be dissolved. Soak the sediments and leave for a couple of weeks to dry. Plastic containers may be left or can be removed by a Stanley knife. Students can challenge each other to guess “Way up” by looking at graded bedding indications in the beds.

Materials per student or group
- Containers with different sediments e.g. builder’s sand, garden sand, beach sand, potting mix, pea gravel, pindan. The more varied the colours the better
- Clear plastic drinking glasses or the bottom half of clear plastic drink bottles
- A super-saturated Epsom salt solution or plaster of Paris
- Water
- Stanley or craft knife

If the activity has to be completed more rapidly, dry Plaster of Paris can be mixed weight for weight with the sediments. Layer the sediments into the container, press down and add water. Cement powder can also be used but a whitish blurred rock results.

**OPTION** Index fossils can be made from buttons, cutting out shapes from plastic ice cream containers or buying plastic dinosaurs. If plastic dinosaurs are placed into only one bed they can be used as index fossils. Since the dinosaurs represent the same period of time, students can arrange their columns to line up the dinosaur beds and find who has the oldest beds and who has the youngest.
Sedimentary Pile – Student Activity

Sediments are compactioned and cemented to become rocks. Mineralising groundwater cements the clasts together and overlying beds provide pressure that compacts and dewateres the sediments.

Create your own rocks by compacting and cementing sediments.

Materials per student or group

- Containers with different sediments e.g. builder’s sand, garden sand, beach sand, potting mix, pea gravel, pindan. The more varied the colours the better.
- Clear plastic drinking glasses or the bottom half of clear plastic drink bottles
- A cementing solution in a small beaker
- A container for excess cementing solution
- Stanley or craft knife (option)
- Fossil replica (option)

Sediments grade upwards from coarse to fine.

1. Lay down layers of sediment
2. If you are using an index fossil agree with the rest of the class which type of sediment it would be found in. These fossils are “index fossils”. They indicate a particular short period of time.
3. Compact your sediment by pressing firmly down on it
4. Pour in some cementing agent and make sure your sediment is thoroughly saturated.
5. Pour off any excess cementing agent into the container provided
6. Place your wet sediment pile as directed by your teacher
7. When they are dry exchange your pile with another group or person

Looking at your own compacted and cemented sedimentary rock, can you work out which way is “up”? __________________________________________________________________________

Looking at the other rock, can you work out which way is up? ________________________

Can you align all the piles so that all your fossils line up? __________________________
Melting and Crystallising – Teacher Notes

When rocks melt due to increased pressure and heat within the Earth, they will subsequently rearrange their molecules into crystalline minerals that are stable under those particular conditions. Sediments may recrystallise to form granites. Not all minerals melt at the same time. When rocks are metamorphosed only those which are unstable at that temperature will melt and recrystallise into new minerals.

Misconception
Students commonly confuse melting with solution. Laboratory activities using solutions of chemicals to form crystals may be partly responsible for this.

Melting
A change of state from solid to liquid involving an increase in temperature/increase in kinetic energy.
ONLY ONE SUBSTANCE IS INVOLVED

Dissolving
Molecules of the solid are spread out within the liquid.
Solute + solvent = solution
TWO OR MORE SUBSTANCES ARE INVOLVED.
In the cases of sugar or salt the solid may no longer be visible but does not disappear as it can still be tasted in the solution. Potassium permanganate can be seen to disperse in solution.

Demonstration Melting and solution

Materials
- Sugar
- Two small beakers
- Water
- Crucible
- Tripod
- Gauze
- Matches
- Glasses

1. Demonstrate sugar dissolving in water.
Name the solute (solid) Sugar
Name the solvent (liquid) Water
Name the solution Sugar solution
Observe the solution. How can we tell that the sugar has not disappeared?
We can still taste the sugar in the water.
How many substances were produced when sugar dissolved in water? One

2. Repeat using water and potassium permanganate (Condy’s crystals)
Name the solute (solid) potassium permanganate
Name the solvent (liquid) Water
Name the solution Potassium permanganate solution
Observe the solution. How can we tell that the sugar has not disappeared?
We can see the purple potassium permanganate dispersed through the water.
How many substances were produced when potassium permanganate dissolved in water? One – a mixture
3. Place sugar in crucible, light Bunsen and heat until sugar melts.
4. Allow to cool

   How many substances were heated? One
   How many substances were there when it cooled? One

When sugar dissolved in water, was this a physical change or a chemical change? Explain your answer. It was a physical change as no new substance was produced. The mixture contained both of the original substances which could be physically separated by evaporation and condensation. Dissolving is a change of state.

When sugar was melted, was this a physical change or a chemical change? It was a physical as no new substance was produced. Melting is a change of state.

A simple 5 minute video reinforcing these concepts can be found on You Tube http://www.youtube.com/watch?v=vA_f38UDoR4

Crystals

When we want to make chemicals form crystals in schools, we often dissolve them in water. Convection currents moves heat to the mineral molecules and allows them to heat without burning (oxidising in the atmosphere) in much the same way as we use water to cook potatoes and oil to cook chips without burning. Removing heat allows the molecules to rearrange themselves into different crystalline pattern. Rapid heat loss produces small crystals whilst geologically slow cooling can create large crystals. Igneous rocks are hard because their crystals are interconnecting

More information and activities involving crystals can be found in the Minerals and Igneous rocks sections of this package or at www.earthsciencewa.com.au
When rocks melt due to increased pressure and heat within the Earth, they rearrange their molecules to form crystalline minerals that are stable under those particular conditions. Sediments may recrystallise to form granites.

This orbicular granite is from Western Australia. Its minerals became arranged in highly unusual patterns when they crystallised. We still do not understand how this could occur!

**BEWARE!** People commonly confuse melting with solution. The processes are different.

Your teacher is going to demonstrate two examples of solution.

**Demonstration of sugar (C₆H₁₂O₆) dissolving in water (H₂O).**

- Name the solute (solid) ___________________________________________________
- Name the solvent (liquid) ________________________________________________
- Name the solution ______________________________________________________

Observe the solution. How can we tell that the sugar has not disappeared?

__________________________________________________________________________

How many substances were produced when sugar dissolved in water? ____________
Demonstration of potassium permanganate (KMnO₄) dissolving in water (H₂O).

Name the solute (solid) _______________________________________________________

Name the solvent (liquid) ____________________________________________________

Name the solution __________________________________________________________

Observe the solution. How can we tell that the potassium permanganate has not disappeared?

__________________________________________________________________________

How many substances were produced when sugar dissolved in water? ________________

Demonstration of melting sugar.

Gold is melted so that it can be poured into ingots. These are easier to transport and their value is easier to estimate.

How many substances were heated? _____________________________________________

How many substances were there when it cooled? _________________________________

When sugar dissolved in water, was this a physical change or a chemical change? Explain your answer.

__________________________________________________________________________

__________________________________________________________________________

When sugar was melted, was this a physical change or a chemical change? Explain your answer.

__________________________________________________________________________

__________________________________________________________________________
Fill in the missing words

**Melting** is a _______________________________ change as the solid substance changes from being a _________________ to a ___________________________ involving an increase in _________________.

___________________________ substance/s is/are involved

**Dissolving** is a _______________________________ change as the solid substance

___________________________.

___________________________ substance/s is/are involved

**Crystals**

*Crystals are inorganic minerals with a constant geometric form and chemical composition.* They form when materials are melted within the Earth due to great heat and pressure at depth. Common crystals are quartz, feldspar, diamond and pyrites (Fool’s gold).

When we want to make chemicals from crystals in schools, we often dissolve them in water before heating them. Convection currents in the solution moves heat to the mineral molecules and allows them to heat without burning (oxidising in the atmosphere) in much the same way as we use water to cook potatoes and oil to cook chips without burning. Removing heat allows the molecules to rearrange themselves into a different crystalline pattern.
Tectonic movements uplift and down warp our crust. They raise mountains and create sedimentary basins. In Western Australia the Yilgarn and Pilbara cratons are slowly moving upwards and being eroded whilst the major sedimentary basins such as the Perth Basin, Canning Basin and Eucla Basins are slowly moving downward and being filled with sediment.

Uplift is the result of two forces working in concert, temperature and density

1. Temperature causes expansion or contraction creating density changes and the formation of convection currents within the asthenosphere (crust/mantle interface zone)
2. Density changes permit vertical and horizontal movement of rock masses

Density
Density is a measure of mass per unit volume.

If each of these pictures represented a 1 cubic centimetre (1cm³) box, what is the wasp density in each box?
Two wasps per cubic centimetre (2/cm³), four wasps per cubic centimetre (4/cm³) and one wasp per cubic centimetre (1/cm³).

If each wasp had a mass of 1 gram (1g) what would the density of each cube be?
2g/cm³, 4g/cm³ and 1g/cm³.

Students who are still using concrete operational thinking may require practical experience of density and often find using the “density triangle” useful. 

\[
\text{MASS} = \text{VOLUME} \times \text{DENSITY}
\]

To find “Volume”, students cover “VOLUME” with their finger and see that volume = mass divided by density. To find “Mass”, students cover that and see mass = volume multiplied by density. (The word “mass” comes from Greek for a barley case or lump of dough). Similarly “Density” is mass divided by volume.
To find what happens when substances of different densities are placed in the same container.

Materials per student or group:
- 1 test tube
- Equal volumes of water and vegetable oil (20mL)
- Test tube rack or beaker to hold it upright
- A measuring cylinder

1. Measure out 20mL of oil and 20mL of water. HINT: It is easier if you measure the water first. Remember to take your eye down to the level of the liquid and measure from the bottom of the meniscus.
2. Place your thumb over the mouth of the test tube to seal it and give the liquids a good shake.
3. Leave the test tube upright and note what happens to the oil and water.
4. Repeat three times.

<table>
<thead>
<tr>
<th>Test</th>
<th>Observation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Oil is less dense than water and therefore “floats” on it</td>
</tr>
<tr>
<td>2</td>
<td></td>
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<tr>
<td>3</td>
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</tbody>
</table>

Why did you repeat the experiment? To ensure accuracy.

*Estimation of relative densities of oil and water may best be performed by the teacher or by a single student as a large volume of oil is necessary to produce a visual and measurable response.

Materials:
- Two 500mL beakers
- Two measuring cylinders
- A triple beam balance or equivalent mass measuring device
- Oil and water

Measure the mass of each beaker
Add 500mL of oil to one and 500mL of water to the other
Measure the mass of liquid + beaker and subtract the mass of the beaker.
Estimate the densities of oil and water
Density varies with temperature, but using this laboratory equipment water will have a density of 1g/cm³ and most cooking oils about 0.9g/cm³

Do we now have scientific data to explain why oil “floats” on water? Explain your answer.
Yes. We have data that is observable, measurable and repeatable. We can make a scientific report.
Density of rocks
Igneous rocks are rich in iron which has a density of 7.87g/cm³. Sedimentary rocks are rich in silicon which has a density of 2.33g/cm³. Core rocks are much more dense than crustal rocks due to gravitational pull.
Which rocks are more common on our Earth’s crust? Less dense sedimentary rocks. Which rocks must have risen up from deeper in the Earth? Igneous rocks, they are denser.

The volume of non-geometrically shaped rocks can be estimated by water displacement. The rock is tied by string and lowered into a beaker which is full to the brim with water. The volume of water displaced is collected into a measuring cylinder. Where rocks are not available concrete and brick may be substituted. If students have made their own replica rocks their densities may me estimated also.

Materials per student or group
- String
- Different rocks
- A large beaker
- A measuring cylinder
- Triple beam balance
- Water

1. Using the triple beam balance measure the mass of the rock. Remember to move the heaviest weights first.
2. Fill the beaker with water and place it somewhere any overflow can be collected by the measuring cylinder, perhaps placing it on the edge of the sink draining board?
3. Tie the rock with string. Some students will need guidance to make “lasso” loops
4. Lower the rock into the water and collect the volume of water it displaces into the measuring cylinder.
5. Use the mass and volume data to estimate the density of each rock.

<table>
<thead>
<tr>
<th>Rock</th>
<th>Mass (g)</th>
<th>Volume (cm³)</th>
<th>Density (g/cm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>
Extra for experts

A contractor has to carry twenty 1 metre cubes of granite and twenty of sandstone to a new building site. His truck is only licensed to carry 10.5 tonnes (1,050,000g). Granite has a density of 2.64g/cm$^3$ and this sandstone has a density of 2.32g/cm$^3$. What is the most efficient way for him to load the truck?

Limiting factor = mass = 10.50tonnes

Mass = volume $\times$ density

Mass of one block of granite = $\frac{(100 \times 100 \times 100) \times 2.64}{1,000,000} = 2.64$ tonnes

Mass of one block of sandstone = $\frac{(100 \times 100 \times 100) \times 2.32}{1,000,000} = 2.32$ tonnes

Answer: 6 loads of 3 granite and 2 sandstone blocks, 2 loads of 1 granite and 3 sandstone blocks and 1 load of 2 sandstone blocks.

As sediments become covered by more and more sediments in a basin, they will compact decreasing pore space, losing water and increasing their density.

Density and mineral ores

Mineral ores have their origins in different rocks at different depths within the Earth. The greater the density the greater the depth. Tectonic forces bring them to the surface for our use.

Please use the data provided to range the minerals from deepest source to least deep.

Manganite (magnesium Mg) 4.32g/cm$^3$  
Bauxite (aluminium Al) 2.45g/cm$^3$  
Galena (lead Pb) 7.5g/cm$^3$  
Gold (Au) 19.32g/cm$^3$  
Siderite (tin Sn) 3.85g/cm$^3$  
Magnetite (iron) 5.12g/cm$^3$

Gold>Galena>Magnetite>Manganite>Siderite>Bauxite  
Gold>Lead>Iron>Manganese>Tin>Aluminium

**CALCULATIONS**

If a rock has a mass of 9g and a volume of 3cm$^3$ then its density will be 3g/cm$^3$.

Trial estimations

1. If the igneous rock gabbro has a mass of 12g and a density of 3.03g/cm$^3$, what is its volume? 3.96cm$^3$

2. If the sedimentary rock sandstone has a volume of 36cm$^3$ and a density of 2.50g/cm$^3$, what is its mass? 90g
3. What is the density of a gold nugget which has a mass of 3g and a volume of 0.16cm$^3$? **19.32g/cm$^3$**

**Extension**
Archimedes “Eureka” moment happened when he solved the problem of whether a crown was made of solid gold after he had been having a bath! What did he do to prove the crown was not pure gold?
His body had displaced water from his bath. He used displacement of water to estimate the volume of the crown and weighed it. This density was compared with the density of a known specimen of gold.

**Heat and density   Convection currents**
Away from tectonic boundaries (hot spots) temperature increases by 25°C for every kilometre of depth. Miners often have to be provided with air conditioning to work in deep mines. As heat increases kinetic energy increases. Molecules become more mobile and bounce off each other pushing each other farther and farther apart. This decreases the density of rocks with depth. Less dense rocks can rise. Within the sticky partially melted zone of the asthenosphere which lies at the boundary of the crust and mantle, these rising masses of hot rocks create very slow moving convection currents. When the rocks rise, they cool, become denser and create downward currents. There are many convection currents currently at work moving rocks around. Australia is slowly moving northwards at the same rate as your fingernails grow powered such a convection current in the asthenosphere (crust-mantle interface).

**Teacher demonstration   Convection cell and mountain formation**

Drop a large crystal of potassium permanganate (Condy’s crystals) into one side of a large beaker full of very hot water. The purple dye will outline convection cells in the hot water.

Cooling at the surface and dropping down

Heat causing decrease of density and rising
Convection currents can move two tectonic plates together. If they have the same density their impact zone will crumple and form a mountain range like the Andes in South America or the Great Dividing Range in Australia. This can be demonstrated by pushing two laboratory towels together on a flat surface.

If one plate is denser than the other it will slip below pushing the less dense land mass upward. This is what is happening in the Himalayas. The Indian plate is pushing under the Asian plate causing the continuing rise of the mountains. This can be demonstrated by pushing the spine of a towel or newspaper against a denser textbook.

Where currents move the crust apart, molten material from below the crust is able to rise and create a line of volcanic activity such as the mid-Atlantic ridge.
Uplift - Student Activity

Tectonic movements uplift and down-warp the crust of our planet. Tectonic movements raise mountains and create sedimentary basins. In Western Australia the Yilgarn and Pilbara cratons are slowly moving upwards and being eroded whilst the major sedimentary basins such as the Perth Basin, Canning Basin and Eucla Basins are slowly moving downward and being filled with sediment.

Uplift is the result of two forces working in concert, temperature and density:

1. Temperature causes expansion or contraction creating density changes and the formation of convection currents within the asthenosphere (crust/mantle interface zone)
2. Density changes permit the vertical movement of rock masses

Density
Density is a measure of mass (amount of matter) per unit volume (space taken up).

If each of these pictures represent a 1 cubic centimetre (1cm³) box, what is the wasp density in each box?

___________________________________________________________________________

If each wasp had a mass of 1 gram (1g) what would the density of each cube be?

___________________________________________________________________________

MASS
VOLUME \times DENSITY

To find what happens when liquids of different densities are placed in the same container.

Materials per student or group
- 1 test tube
- Equal volumes of water and vegetable oil (20mL)
- Test tube rack or beaker to hold it upright
- A measuring cylinder

Measure out 20mL of oil and 20ml of water. HINT it is easier if you measure the water first. Remember to take your eye down to the level of the liquid and measure from
An initiative supported by Woodside and ESWA

Uplift - Student Activity

the bottom of the meniscus. Place your thumb over the mouth of the test tube to seal it and give the liquids a good shake. Leave the test tube upright and note what happens to the oil and water. Repeat three times.

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</table>

Why did you repeat the experiment? __________________________________________

Your teacher will demonstrate how to measure the densities of oil and water.

What was the density of water? _______________________________________________

What was the density of oil? _________________________________________________

Do we now have scientific data to explain why oil “floats” on water? Explain your answer.

___________________________________________________________________________
___________________________________________________________________________

Density of rocks
Igneous rocks are rich in iron which has a density of 7.87g/cm³. Sedimentary rocks are rich in silicon which has a density of 2.33g/cm³. Core rocks are much denser than crustal rocks due to gravitational pull.
Which rocks are more common on our Earth’s crust? ___________________________

Which rocks must have risen up from deeper in the Earth? _______________________

The volume of non-geometrically shaped rocks can be estimated by water displacement.

To estimate the volume, mass and density of a rock
Materials per student or group
• String
• Different rocks
• A large beaker
• A measuring cylinder
• Triple beam balance
• Water
1. Using the triple beam balance measure the mass of the rock. Remember to move the heaviest weights first.
2. Fill the beaker with water and place it somewhere any overflow can be collected by the measuring cylinder, perhaps placing it on the edge of the sink draining board?
3. Tie the rock with string.
4. Lower the rock into the water and collect the volume of water it displaces into the measuring cylinder.
5. Use the mass and volume data to estimate the density of each rock.

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<th>Density (g/cm³)</th>
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Extra for experts
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Density and mineral ores
Mineral ores have their origins in different rocks at different depths within the Earth. The greater the density the greater the depth. Tectonic forces bring them to the surface for our use.

Please use the data provided to range the minerals from deepest source to least deep.

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<tr>
<th>Mineral</th>
<th>Density (g/cm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manganite (magnesium Mg)</td>
<td>4.32/cm³</td>
</tr>
<tr>
<td>Bauxite (aluminium Al)</td>
<td>2.45/cm³</td>
</tr>
<tr>
<td>Galena (lead Pb)</td>
<td>7.5/cm³</td>
</tr>
<tr>
<td>Gold (Au)</td>
<td>19.32/cm³</td>
</tr>
<tr>
<td>Siderite (tin Sn)</td>
<td>3.85/cm³</td>
</tr>
<tr>
<td>Magnetite (iron Fe)</td>
<td>5.12/cm³</td>
</tr>
</tbody>
</table>
CALCULATIONS
If a rock has a mass of 9g and a volume of $3\text{cm}^3$ then its density will be $3\text{g/cm}^3$.

Trial estimations
1. If the igneous rock gabbro has a mass of 12g and a density of $3.03\text{g/cm}^3$, what is its volume?

2. If the sedimentary rock sandstone has a volume of $36\text{cm}^3$ and a density of $2.50\text{g/cm}^3$, what is its mass?

3. What is the density of a gold nugget which has a mass of 3g and a volume of $0.16\text{cm}^3$?

Extension
Archimedes “Eureka” moment happened when he solved the problem of whether a crown was made of solid gold after he had been having a bath! What did he do to prove the crown was not pure gold? Interrogate your library and the internet.
Heat and density

Away from tectonic boundaries (hot spots) temperature increases by 25°C for every kilometre of depth. Miners often have to be provided with air conditioning to work in deep mines. As heat increases kinetic energy increases. Molecules become more mobile and bounce off each other pushing each other farther and farther apart. This decreases the density of rocks with depth. Less dense rocks can rise. Within the sticky partially melted zone of the asthenosphere which lies at the boundary of the crust and mantle, these rising masses of hot rocks create very slow moving convection currents. When the rocks rise, they cool, become denser and create downward currents. There are many convection currents currently at work moving rocks around. Australia is slowly moving northwards at the same rate as your fingernails grow driven by such a convection current.
Identifying Common Rock Types
An initiative supported by Woodside and ESWA

Rock Kit Possibilities For Year 8

These are some ideas for sourcing rocks for Year 8 WASP activities (www.wasp.edu.au).

Mineral kits with activities can be borrowed from Earth Science Western Australia (www.earthsciencewa.com.au)

Recipes for making replica rocks are included in this package.

Sedimentary Rocks

<table>
<thead>
<tr>
<th>Rock</th>
<th>Source</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conglomerate</td>
<td>Mt Russel Wiluna.</td>
<td>Replica conglomerate recipe</td>
</tr>
<tr>
<td>Breccia</td>
<td></td>
<td>Replica breccia recipe</td>
</tr>
<tr>
<td>Sandstone</td>
<td>Jurassic sandstone behind Geraldton to Leeming. Donnybrook sandstone Canning Basin, Bunnings pavers are from Rajistan Rural Stone</td>
<td>Replica sandstone recipe</td>
</tr>
<tr>
<td>Siltstone</td>
<td>Cretaceous rocks just under Darling Range, Whicher Range, Kennedy Range &amp; Canning Basin, Irwin river Mingenew</td>
<td>Coalseam Park Worth a visit to view fossils as well</td>
</tr>
<tr>
<td>Mudstone/shale</td>
<td>As above</td>
<td>As above Potter’s clay for mudstone</td>
</tr>
<tr>
<td>Limestone</td>
<td>Coastal Tamala and Quindalup Limestone Building sites</td>
<td>NB some rocks sold as limestone are more correctly sandy limestone or limey sandstone</td>
</tr>
<tr>
<td>Fossiliferous limestone</td>
<td>As above.</td>
<td>Replica fossiliferous limestone recipe</td>
</tr>
<tr>
<td>Coal</td>
<td>Coal along beaches near ports and along railway lines</td>
<td>Steam power or sea coal? Premier Coal Collie?</td>
</tr>
<tr>
<td>Chalk</td>
<td>Gingin Molecap Hill (Ask farmer’s permission on entry)</td>
<td>Big thick chalk sticks</td>
</tr>
<tr>
<td>Spongelite</td>
<td>North &amp; east of Mt Barker Some mechanic shops</td>
<td></td>
</tr>
</tbody>
</table>
**Igneous rock**

<table>
<thead>
<tr>
<th>Rock</th>
<th>Source</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basalt</td>
<td>Bunbury beach</td>
<td></td>
</tr>
</tbody>
</table>
| Dolerite | Almost any black intrusive dyke or sill  
Road metal or blue metal | Railway tracks – used as ballast. |
| Gabbro   |                                 | Dimension stone importers (Roadstone)  
Monumental masons                     |
| Pumice   | Some floats in from Antarctica on the south coast of WA | Chemist pumice is often crushed and reconstituted. It will not float but remains abrasive. |
| Andesite |                                 |                                                   |
| Granite  | Most of Pilbara & Yilgarn Cratons.  
Bunnings’ pavers.  
Most light coloured rock in quarries on cratons  
Monumental masons. |                                                   |
## Rock Kit Possibilities For Year 8

### Metamorphic rocks

<table>
<thead>
<tr>
<th>Rock</th>
<th>Source</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slate</td>
<td>Bunning’s pavers Old building sites’ roofs Kitchen &amp; bathroom floor</td>
<td></td>
</tr>
<tr>
<td>Schist</td>
<td>Bindoon (in new suburbs south of town centre)</td>
<td></td>
</tr>
<tr>
<td>Marble</td>
<td>Kitchen &amp; Bathroom decorating tiles Monumental masons</td>
<td></td>
</tr>
<tr>
<td>Gneiss</td>
<td>Margaret River to Cape Naturalist</td>
<td>Good specimens on groyne at Cottesloe (for viewing only)</td>
</tr>
</tbody>
</table>

If you have suggestions for sources of rock, please contact me, julia@wasp.edu.au I’d be delighted to share!
Definitions

Classification means breaking things into groups with similar characteristics. Rocks are solids found naturally at the earth’s surface.

Early man classified rocks according to their composition and usage. My grandfather told me there were only two kinds of rocks, whinstone and sandstone. Whinstone was any rock that was hard enough to sharpen a knife and anything else was sandstone! He classified rocks by their hardness.

Even the names of rocks have changed in time. Basalt is the name given for a dark coloured volcanic rock nowadays. The name originally came from the Greek for any “very hard stone”. The Ancient Egyptians used the same word for slate.

The name sandstone means a rock made of medium grained quartz clasts (broken bits of rock) cemented together by silica or lime. In Western Australia, many of our fabulous “sandy” beaches are mostly composed of broken aragonite seashells with minor quartz clasts. The rock made when these are compacted is sandy limestone not sandstone. The white sands of Albany and Esperance are almost pure quartz (silica) and they would become cemented and compacted into sandstone.

Interesting fact: On the Island of Mull in Scotland a molten dolerite dyke intruded through a bed of mudstone baking it into naturally formed brick. Rocks like this are called “Mullite”.

ACTIVITY How can we classify rocks?

This activity gives students a chance to compare and contrast a variety of rocks. Igneous, sedimentary and metamorphic rocks should be included. They first work in groups of three or four and then bring their findings to be shared with their classmates. It is important for scientists to first trial their experiments to see if they will work. Finding what doesn’t work is as important as finding what does!

Materials per student

- 2 different kinds of rock. Many students are happy to bring in rocks from home collections. Bags of different rock pebbles are available from garden centres and aquarium suppliers. (Broken brick and cement are manmade and therefore not acceptable).
- A hand lens to examine their rock
- OPTION Water to wet rock

NOTE Using a hand lens or magnifying glass

Many students do not realise that the glass should be held close to the eye and the object, in this case a rock, be brought close to the glass until it comes into focus. Students may wish to practise focussing on their thumb nails or bare knees first. (Moving the glass up and down promotes nausea). Many geologists will breathe heavily on a rock or wet it to help make detail more visible.

The rock in this case is igneous. It is a basalt from Melbourne.
Part 1  Trialling the ideas

1. In their groups of three or four, students are asked to examine their own rocks carefully
2. They then compare and contrast their group’s rocks, entering the data on the worksheet provided.
3. They then decide which characteristics are most important for meaningfully separating rocks into groups
4. One team member reports to the class and answers are boarded
5. Using the classes observations, all the rocks are then placed in the suggested groups
6. The class discusses how this classification system could be improved.

Suggestions  Colour, size, shape, origin, use, rarity, hardness, crystal size, clast size, mineralogy and chemistry

Problems
- Colour - can be changed by weathering. Basalt is black when fresh and bright red when weathered. Sandstone and rubies would be in the same group. Many rocks have many different colours e.g. granite is white, black and grey. Colour is however one of the characteristics that may be used.
- Size - a broken piece of rock would be classified differently to the original piece
- Shape - a medium sized piece of sandstone would be classified the same as a medium sized piece of chalk and yet be different in every other respect
- Origin - all the rocks in the Pilbara would be classified as the same. This would make finding iron ore or gold very difficult
- Use - limestone, granite and sandstone are all used to build walls. Their differences however require different cutting tools, lifting equipment, polishing tools and cements. They will also weather at different rates. There is an inscribed red porphyry statue in ancient Egypt that has hardly weathered over seven thousand years whilst limestone gravestones a mere one hundred years old have lost their shapes and inscriptions.
- Rarity - Mookaite is a beautiful radiolarian chert found on Mooka Creek near Gascoyne junction. http://www.outbackmining.com/mookaite. Equally rare are diamonds found at Argyle.
- Crystal size - comparison of size of the same mineral crystals in rocks can give indication of rate of cooling but comparison cannot be made between different minerals
- Clast size - gives good indications of distance from source rock but different rocks will break down at different rates.
- Minerology - will give a good indication of type of magma in igneous rocks and type and degree of metamorphism in metamorphic rocks.
Part 2  Classification
Geologists classify rocks into three groups:

1. Igneous (fire born) rocks
   These are crystalline and usually hard. The size of the crystals indicates the rate of cooling of the rock from original molten magma. e.g. granite, basalt and pumice.

2. Sedimentary rocks
   These are assembled from broken bits of rock (clasts) and may contain remnants of living things. These have been compacted and cemented to form rock. They often show bedding structure. e.g. sandstone, slate and limestone.

3. Metamorphic rocks
   These are rocks which have been subjected to pressure and partially remelted. They retain some of their original sedimentary or igneous structures. They are crystalline in part and some of the crystals are aligned by pressure forming schistocity (natural planes of weakness)

Teachers’ notes on more specific classification for the three rock types are included in this package (with photographs).

Teacher demonstration - Eggciting Eggsamples

Materials

- Frypan
- 4 eggs

Students are asked to draw and describe the changes that happen to the raw egg as it is laid down uncooked (sedimentary rock), fried (metamorphic rock)/partial changes and scrambled (igneous rock)

Using eggs as examples

<table>
<thead>
<tr>
<th>Rock type</th>
<th>Drawing of egg</th>
<th>Changes to egg</th>
<th>Rock types</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sedimentary rock (Laid down)</td>
<td>Scale?</td>
<td>Fresh egg&lt;br/&gt;Control against which change can be measured. Separate white and yolk zones&lt;br/&gt;Yolk domed higher than white</td>
<td>1. Sandstone&lt;br/&gt;2. Limestone&lt;br/&gt;3. Siltstone&lt;br/&gt;Mudstone&lt;br/&gt;Conglomerate&lt;br/&gt;Evaporites&lt;br/&gt;Breccia&lt;br/&gt;Limestone&lt;br/&gt;Chalk</td>
</tr>
<tr>
<td>Metamorphic rock (Pressure and heat)</td>
<td>Scale?</td>
<td>Fried egg&lt;br/&gt;Egg size decreases&lt;br/&gt;Egg becomes more solid</td>
<td>1. Marble (meta-limestone)</td>
</tr>
</tbody>
</table>
### Rock Classification – Teacher Notes

| Igneous rock (Reassembled) | Scale? | Yolk dome flattens  
|                           |        | Colours change  
|                           |        | Still similar to original egg  
|                           |        | with yolk and white  
|                           |        | 2. Quartzite  
|                           |        | (meta-sandstone)  
|                           |        | 3. Gniess  
|                           |        | (meta-granite)  
|                           |        | Schists (meta-sandstone & shale)  
|                           |        | Slate (meta-mudstone)  
|                           |        | Scrambled egg  
|                           |        | Not similar to original egg  
|                           |        | in structure or shape.  
|                           |        | Separates into solids and a liquid  
|                           |        | Colour changes  
|                           |        | 1. Granite  
|                           |        | 2. Basalt  
|                           |        | 3. Dolerite  
|                           |        | Gabbro  
|                           |        | Andesite  
|                           |        | Pumice  
|                           |        | Diorite  
|                           |        | Rhyolite  

Did the chemical composition of the egg change? The same elements are there but in different combinations.

To which rock classification did your two rocks belong?

Rock A ____________________________________________

Rock B ____________________________________________
It is important that Scientists trial their ideas to find what works and what doesn’t. We are going to find out what characteristics are good for classifying rocks.

**Classification** means breaking things into groups with similar characteristics.

**Materials per student**
- 2 different kinds of rock.
- A hand lens to examine the rock

**NOTE** When using a hand lens or magnifying glass, **ALWAYS** keep the lens close to your eye and move the object you want to look up towards the lens. **NEVER MOVE THE LENS!**

Practise using the lens first.

Moistening the rock makes some features more obvious.

The rock above is basalt from a lava flow. The massive volcanic outpourings occurred 35 million years ago in North Melbourne. It looks uniform and grey to the naked eye. If however you wet it and use magnification, it can be seen to consist of many grey and black interlocking crystals. Small pockets of quartz crystals are due to chilled gassy bubbles released during the eruption.

Write down a description of your rocks below.

Rock A is
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Rock B is
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
Rock Classification - Student Activity

Place all the rocks from your group together and compare (What is the same?) and contrast (What is different?).

<table>
<thead>
<tr>
<th>COMPARE</th>
<th>CONTRAST</th>
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Which descriptions should you use to classify rocks, compare or contrast? ______________

**Classification** means breaking things into groups with similar characteristics. Try and select the four best scientific groups into which we could classify our rocks.
Rock Classification - Student Activity

What is good about this classification? ____________________________________________
___________________________________________________________________________

What doesn’t work well? ________________________________________________________
___________________________________________________________________________

Geologists first classify rocks into three groups according to their formation:

1. **Igneous (fire born) rocks**
   These have been formed from molten magma e.g. granite and basalt.

2. **Sedimentary rocks**
   These are assembled from broken bits of rock (clasts) and may contain remnants of living things e.g. sandstone and fossiliferous limestone.

3. **Metamorphic rocks**
   These are rocks which have been subjected to pressure and partially remelted. They retain some of their original sedimentary or igneous structures e.g. marble and schist.

Draw and describe the changes that happen to the raw egg as it is laid down (sedimentary rock), fried (metamorphic rock) and scrambled (igneous rock)

Using eggs as examples

<table>
<thead>
<tr>
<th>Rock type</th>
<th>Drawing of egg</th>
<th>Changes to egg</th>
<th>Examples</th>
</tr>
</thead>
</table>
| Sedimentary rock       | Fresh egg      |                | 1. Sandstone
| (Laid down)            |                | 2. Limestone   |
|                        |                | 3.            |
| Metamorphic rock       | Fried egg      |                | 1. Marble   |
| (Pressure and heat)    |                | 2.            |
|                        |                | 3.            |
| Igneous rock           | Scrambled      |                | 1. Granite  |
| (Reassembled)          |                | 2.            |
|                        |                | 3.            |
Rock Classification - Student Activity

Did the composition of the egg change?  

To which rock classification did your two rocks belong?

Rock A

Rock B
Rock Classification - Dichotomous Key

This is a very general way of classifying rocks used at Year 8 level. Rocks that are very fine grained are difficult to classify unless you can take thin sections and examine them under a microscope.

1. Rocks which have crystals
   - Go to 2
   - Rocks which do not have crystals
     - Go to 6

2. Rocks which are made entirely of inter-grown crystals
   - Igneous - Go to 3
   - Rocks which are not made entirely of inter-grown crystals
     - Metamorphic e.g. slate, schist, quartzite, marble and gneiss

3. Rocks which have crystals large enough to see using a hand lens
   - Igneous intrusive - Go to 4
   - Rocks which are crystalline but their crystals are difficult to see using a hand lens
     - Igneous extrusive - Go to 5

4. Rocks which are dark and dense
   - Igneous, intrusive & mafic e.g. gabbro
   - Rocks which are neither dark nor dense
     - Igneous, intrusive & felsic e.g. granite, pegmatite

5. Rocks which are dark and dense
   - Igneous, extrusive & mafic e.g. basalt
   - Igneous, extrusive & felsic e.g. rhyolite

6. Rocks which are non crystalline and are made of clasts
   - Sedimentary, clastic - Go to 7
   - Rock which are non crystalline but are not made of clasts
     - Sedimentary, biogenic e.g. limestone, chalk, coal

7. Rocks with large clasts
   - Go to 8
   - Rocks without large clasts
     - Go to 9

8. Rocks with large clasts which are rounded
   - Sedimentary, clastic e.g. conglomerate
   - Rocks with large clasts which are not rounded
     - Sedimentary, clastic e.g. breccia

9. Rocks with medium rounded clasts
   - Sedimentary, clastic medium grained e.g. sandstone
   - Rocks with less than medium size clasts
     - Sedimentary, clastic fine grained e.g. siltstone, mudstone
Replica Rock Recipes

Conglomerate (left), breccia (top) and sandstone (right)

This activity helps students remember the difference between matrix and clasts. It also reinforces that clastic sedimentary rocks are classified according to their clast size. Mortar can be used instead of cement and sand mix.

**To make a mould**

Lightly fill an old container or tray with damp sand or soil. Push down firmly to form a mould for the rock. The surrounding sand stops the wet rock from bonding to the container.

Alternatively make a rock sized depression in damp soil in the garden or yard.

**Replica conglomerate** - Clastic sediment

Clasts
- rounded pebbles (aquarium, garden centre, creek)

Matrix
- Cement (1 part) + sand (3 parts) + water
- Optional grout colouring (NOTE: Grout colouring is mostly iron oxide and not ochre. It is therefore acceptable for non-indigenous use)
Replica Rocks - Teacher Notes

1. Make rock sized depressions in damp sand or soil and partially press rounded pebbles into the sand
2. Mix matrix of sand (3 parts), cement (1 part) and water to a thick mix.
3. Add grout colour, if you wish
4. Pour matrix into the depression making sure not to displace pebbles
5. Place remaining pebbles on top and press gently in
6. Leave to set for 24 hours
7. Remove, leave to dry and brush away excess sand/soil

Extra If you have access to a grinder, cut across pebbles to create a clean cross section

**Replica breccia** - Clastic sediment

Repeat process for conglomerate using angular clasts of road metal or gravel.

**Replica sandstone** - Clastic sediment

If different groups make different coloured mixes, they can exchange them to create different beds in their sandstone
- Sand. The sand can be of different colours and clast size.
- Cement (1 part) + sand (3 parts) + water
- Grout colouring
  1. Mix the sand, cement and water to make a stiff mix
  2. Pour a thin layer (about a quarter) of the mix into the depression.
  3. Add a little colouring and pour another layer of the mix.
  4. Sprinkle a layer of sand round the edge of the underlying cement
  5. Add more colour and pour the rest of the mix
  6. Leave for 24 hours to dry
  7. Remove and brush away excess sand or soil

**Replica Limestone** - Biogenic sediment

Fossils
- Shells (sea shells or land snail shells)

Matrix
- Pale yellow coloured mortar or white sand and cement
- Water
- Shells
Replica Rocks - Teacher Notes

1. Press some shells into the sand mould
2. Add some mixed mortar
3. Sprinkle most of the shells on top of the mortar layer
4. All the rest of the mortar
5. Sprinkle remaining shells on top
6. Leave 24 hours to dry
7. Remove and brush away excess sand and dirt

And ... of course ... the rock was made by a human!

Physical facts about replica rocks

1. The mass of an object is a measure of the amount of matter in the object.
   Students confuse mass and weight. Weight also has a component of gravitational force. Objects of the same mass will weigh less on the moon than on Earth. The word “mass” comes from the Ancient Greek for a lump of dough or barley cake.
   Which object has the greatest mass?
   
   1kg iron       2kg lead       0.5kg water      2kg lead

2. The volume of an object is a measure of the amount of space it takes up.
   Some students have problems with conservation of volume. If you ask them to pour a measured 50mL of water into a Petri dish, a test tube and a large beaker they may not understand that the height of a liquid in the container does not directly relate to its volume. Filling a collection of different old shampoo or detergent bottles may also be useful to those who still use concrete operational ways of thinking.
   Which object has the greatest volume?
   
   1kg iron       2kg lead       0.5kg water      0.5kg water

3. The density of an object is a measure of mass per unit volume
   Which object has the greatest density?
Replica Rocks - Teacher Notes

1kg iron 2kg lead 0.5kg water 2kg lead (more “stuff” packed into a smaller volume)

You shall measure the density of your replica rocks and compare your finding with those of others.

Scientists only accept data that is

Observable (using our senses – except taste)

Measurable (using international standards SI)

Repeatable (to enable statistical accuracy and remove the effect of outliers)

Materials required per student or group

To measure mass

• Triple beam balance or weighing machine
  1. Select units of measurement that are appropriate.
  2. Place the rock on the pan and weigh.
  3. Repeat twice and find the average mass. Enter this in the table provided.

To measure volume

• Beaker filled to the brim with water
• Measuring cylinder

Since rocks are not regular geometrical shapes we can estimate their volume by the amount of water they displace.

Gently place the rock into the beaker full of water and collect the water it displaces in the measuring cylinder. The volume of water in the cylinder is the same as the rock

Repeat twice and find the average volume. Enter this in the table provided. (Don’t forget to write down the units!)

Mass = Volume X Density
Volume = Mass over Density
Density = Mass over Volume

An initiative supported by Woodside and ESWA
To estimate density

Divide the average mass by the average density. (Don't forget to write down all the units!)

<table>
<thead>
<tr>
<th></th>
<th>MASS</th>
<th></th>
<th>VOLUME</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>Average</td>
</tr>
<tr>
<td>Breccia</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conglomerate</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Sandstone</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Limestone</td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>Average</td>
</tr>
</tbody>
</table>

Rate your rocks from densest to least dense  
Rating depends on materials used – usually sandstone is densest

Compare your results with those of other class members  
Results will vary because different students will choose to use varying number and size of large clasts and shells in their rocks

Which rocks had the greatest range of densities? Usually conglomerate

Why is this so? Not everyone used the same number of same sized clasts in their rocks

Would you expect this to happen with real rocks? The same. Rock density is variable. Students may wish to compare their results with real specimens. Real rocks are not only cemented but have been compacted when they were buried in the Earth and are usually much denser than replicas.
Replica Rocks – Student Activity

To make a mould

Lightly fill an old container or tray with damp sand or soil. Push down firmly to form a mould for the rock. The surrounding sand will stop wet rock from bonding to the container.

Alternatively make a rock sized depression in damp soil in the garden or yard.

Replica conglomerate

Conglomerate is made of large rounded unsorted clasts that are cemented by a finer matrix of sand.

Clasts
- Rounded pebbles

Matrix
- Cement (1 part) + sand (3 parts) + water
- Optional grout to colour matrix
Replica Rocks – Student Activity

1. Make rock sized depressions in damp sand or soil and partially press rounded pebbles into the sand
2. Mix matrix of sand (3 parts), cement (1 part) and water to a thick mix.
3. Add grout colour, if you wish
4. Pour matrix into the depression making sure not to displace pebbles
5. Place remaining pebbles on top and press gently in
6. Leave to set for 24 hours
7. Remove, leave to dry and brush away excess sand/soil

Replica breccia Clastic sediment
Breccia is made of angular unsorted clasts set in a sandy matrix. Repeat process for conglomerate using angular clasts.

Replica sandstone Clastic sediment
Sandstone is made of beds of sands in a finer matrix. Use different coloured layers to replicate bedding.

- Sand. The sand can be of different colours and clast size.
- Cement (1 part) + sand (3 parts) + water
- Grout colouring
  1. Mix the sand, cement and water to make a stiff mix
  2. Pour a thin layer (about a quarter) of the mix into the depression.
  3. Add a little colouring and pour another layer of the mix.
  4. Sprinkle a layer of sand round the edge of the underlying cement
  5. Add more colour and pour the rest of the mix
  6. Leave for 24 hours to dry and brush away excess sand or soil

Replica Limestone Biogenic sediment
Biogenic limestone is formed from cemented calcareous fragments of living things such as shells and coral.

Fossils
- Shells (sea shells or land snail shells)

Matrix
- Pale yellow coloured mortar or white sand and cement
- Water
Replica Rocks – Student Activity

1. Press some shells into the sand mould
2. Add some mixed mortar
3. Sprinkle most of the shells on top of the mortar layer
4. All the rest of the mortar
5. Sprinkle remaining shells on top
6. Leave 24 hours to dry then remove and brush away excess sand and dirt

Physical facts about replica rocks

The mass of an object is a measure of ____________________________________________

Which object has the greatest mass?

1kg iron  2kg lead  0.5kg water  ___________

The volume of an object is a measure of ____________________________________________

Which object has the greatest volume?

1kg iron  2kg lead  0.5kg water  ___________

The density of an object is a measure of ____________________________________________

Which object has the greatest density?

1kg iron  2kg lead  0.5kg water  ___________
Replica Rocks – Student Activity

You shall measure the density of your replica rocks and compare your findings with those of others.

Scientists only accept data that is:

O __________________________
M __________________________
R __________________________

Materials required per student or group

To measure mass
- Triple beam balance or weighing machine

1. Select units of measurement that are appropriate.
2. Place the rock on the pan and weigh.
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- Beaker filled to the brim with water
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Since rocks are not regular geometrical shapes we can estimate their volume by the amount of water they displace.

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2. Repeat twice and find the average volume. Enter this in the table provided. (Don’t forget to write down the units!)

To estimate density

Divide the average mass by the average density. (Don’t forget to write down all the units!)
**Replica Rocks – Student Activity**

<table>
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<tr>
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<th>MASS</th>
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<th>DENSITY</th>
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<tbody>
<tr>
<td></td>
<td>1</td>
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<td>3</td>
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</table>

Rate your rocks from densest to least dense ________________________________

Compare your results with those of other class members. Which rocks had the greatest range of densities?

___________________________________________________________________________

Why is this so? _____________________________________________________________

___________________________________________________________________________

Would you expect this to happen with real rocks? ____________________________

___________________________________________________________________________

___________________________________________________________________________
Sedimentary rocks are formed from clasts (broken pieces) of earlier rock and organic material. They are the product of weathering, erosion, deposition, compaction and cementation.

1. **Sedimentary strata** are groups of the same kind of rocks. They are composed of fragments of older rocks and organic material. These can be many hundreds of metres thick and can be followed across great geographical distances. They represent deposition over long geological period. *e.g. Eocene strata underlies most of the Eucla basin and was deposited between 34 and 55 million years ago.*

   Massive cross-bedded sandstone strata in Mt Zion USA (courtesy of Lawrie Davidson)

2. **Sedimentary beds** are much smaller and have distinct depositional boundaries *e.g.* Dune bedding in sandy limestone and cross bedding in river delta deposits. These can be mm to m thick and represent deposition over a short geological period.

   Sand and silt beds from the Collie coal field
Sedimentary rocks are presently being deposited in the five great basins of Western Australia, the Perth Basin, the South and North Carnarvon Basins, the Canning Basin and the Eucla Basin, where they are being actively prospected for oil and gas.

Sedimentary basins surround our two ancient cratons, the Yilgarn craton and the Pilbara craton. Cratons are large bodies of igneous and metamorphic rock (coloured pink on the map) which have been largely unchanged for billions of years. It is from the weathered and eroded material from these cratons that our sediments are formed.

**Geological map of Western Australia**
*(Courtesy of GSWA)*

Large copies of this map can be obtained from the Geological Survey of Western Australia or by contacting Earth Science Western Australia through our website [www.earthsciencewa.com.au](http://www.earthsciencewa.com.au)
Identifying Sedimentary Rocks – Teacher Background

Sedimentary rocks are classified as being composed of:
   A. Clastic sediments
   B. Biogenic sediments
   C. Chemical sediments

Many rocks can have a combination of all three types. e.g. limestone can be assembled from fragments of shell, grains of sand and be cemented by chemicals in groundwater.

A. Clastic sediments
These are classified according to clast size. Clasts are broken bits of earlier rock which are compacted and cemented to make the new rock.

Breccia
Breccia (Italian –broken) is similar to conglomerate but the large unsorted clasts are quite angular. Many breccias represent scree or talus materials that lay along hill slopes or cliff bases like the scree deposits present along the face of the Darling Scarp.

Angular talus of banded Iron Formation

Talus compacted and cemented to form breccia

Conglomerate
Conglomerate is a poorly sorted rock with rounded pebbles over 2mm in size set in a fine or medium grain matrix. It forms when mountains are being rapidly eroded by water. The pebbles become rounded in mountain streams but are dropped unsorted when the streams arrive at the plain and lose energy to carry material.

Rounded pebbles from river

Compacted and cemented to form conglomerate
Sandstone
Sandstone is usually well sorted and demonstrates bedding. Each bed demonstrates grain size decreasing upwards. Clasts are usually between 2mm and 1/256mm and are easy to feel. Sandstones are usually deposited by wind or water. Desert sandstones have well rounded polished or frosted surfaces due to impact and tend to be red. Sandstones can be cemented by silica or carbonates.

Siltstone
Siltstone has fine clasts that can just be discernable by the naked eye. (Their grittiness can just be felt by dragging the rocks across your teeth – not to be recommended in class!). It tends to be grey, brown and black and often shows fine laminated bedding.

Siltstone forms from sea, river and lake sediments.
Identifying Sedimentary Rocks – Teacher Background

**Mudstone**
Mudstone is fairly homogenous and formed from clay minerals. Clays are flat lightweight alumina-silicates and are easily transported out into deep water before deposition. Mudstone also forms under coastal lagoonal swampy conditions.

Mudstone tends to be grey or black and the grains (<1/256mm) are too small to be seen by the naked eye. The rocks often feel smooth and silky.

**B. Biogenic sedimentary rocks**
The most common biogenic rocks in Western Australia are coal, chalk, spongelite and reef limestone. (Humans can deposit bile salts to form kidney stones which can fall into this classification!)

**Coal** is formed from carbon rich organic matter deposited in ancient swamps. The anaerobic conditions preserved the organic material. It is black or grey and may or may not contain fossils. Most coal around the world formed in the Carboniferous Period however our coal in Western Australia is much younger being Permian in age (270my). Coal is found in the Collie and Irwin basins. Most of Western Australia’s electricity is produced in coal-powered stations.

**Chalk** was biogenically deposited in Australia in the warm shallow seas that were created when Australia and India separated from Africa as the great super-continent of Gondwana broke up about 66 million years ago. It is made of calcite (CaCO₃) from the shells of tiny marine foraminifera (plankton) called coccolithophores. Chalk is found in the North Perth and Carnarvon Basin sediments. It has a white streak.

Most teachers’ chalk in Australia comes from Germany. It is crushed and then reassembled into sticks. The calcium carbonate was laid down at the same time that dinosaurs were alive. They breathed
out carbon dioxide which could possibly have been taken in by the coccoliths and converted into calcium carbonate. We might be using fossilised dinosaur breath to use on blackboards! (So much more romantic???)

**Spongelite** is formed from tiny sponge spicules. These are silica skeletons that support the sponge. When the sponge dies the spicules rain down onto the sea floor and over millions of years become an open network of silica spines despite compaction. Legend has it that the deposit was first recognised by a farmer who urinated on a rock and was astonished to find the fluid was instantly absorbed into the rock. Being curious he then knocked a hole in the outcrop, inserted a stick of fracture (explosive) and stood back to watch. There was just a dull thud and the hole was marginally wider. The spaces between the spines absorbed both the fluid and the explosion. Near Mt Barker north of the Stirling Range a company operates an open cut to mine and sell spongelite for industrial oil spills and cat litter. Spongelite is mostly greyish white and looks like chalk however it does not release gas when tested with acid.

**Limestone** can either be produced purely biogenically or chemically. The great Devonian limestone fossil coral reef deposits that make up Cape Range National Park and parts of the Kimberley were formed in warm tropical seas over 360my ago. More commonly the original biogenic deposit has been affected by later chemical solution then re-deposition of minerals.

[Limestone image]

*Tamala limestone*

Broken carbonate rich shells were blown inland to form great sand dunes. Ground water initially dissolved away the carbonate but later redeposited it in hollows where roots were. This explains why some areas have both yellow silica sands and carbonate rhizoliths (fossil root shapes).
C. Chemical sediments are formed when inorganic material builds up into a mass.

Evaporites are formed when large masses of water dry up leaving salt (halite), gypsum (hydrated calcium sulphate and anhydrite (calcium sulphate). When evaporates are covered by more sediments and compacted they behave like slabs of soap. They slide upwards to form domes in the overlying sediments. Our salt lakes are accumulating evaporates.

Chemical limestone is deposited from dissolved lime in groundwater or sea water. The coastal limestone of Western Australia was created by shelly dunes being dissolved by groundwater. The lime was later redeposited elsewhere to create sandy (lime poor) sections and hard lime rich areas.
Broken carbonate rich shells were blown inland to form great sand dunes. Ground water initially dissolved away the carbonate but later redeposited it in hollows where roots were. This explains why some areas have both yellow silica sands and carbonate rhizoliths (fossils root shapes).
Limestone is mostly calcium carbonate though some limestones have a magnesium carbonate component also. Slightly acidic groundwater will dissolve the limestone. Cavities will appear when roots that have penetrated the dunes rot away. Water containing dissolved calcium carbonate will follow this route and as it evaporates, calcium will be deposited to eventually fill the space. Since these are not petrified roots they are called rhizoliths (root rocks).
Sedimentary rocks are made of clasts and are usually softer than igneous or metamorphic rocks. They are not crystalline. They show signs of bedding and sometimes contain fossils.

**Clastic sediments** are classified by their grain size. They show signs of bedding.

- **large easy to see clasts (2mm+)**
- **rounded clasts**
- **clasts that can be seen by eye (1.26-2mm)**
- **angular clasts**
- **grains felt by touch**
- **clasts that can only be seen under magnification**
- **gritty against teeth**
- **smooth**

**Biogenic sediments** have no clasts and **often** have fossils. They can be massive with few signs of bedding.

<table>
<thead>
<tr>
<th>Name</th>
<th>Colour</th>
<th>Source</th>
<th>Texture</th>
<th>Test with acid</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>Black</td>
<td>Swamp vegetation</td>
<td>Soft, can scrape with metal blade</td>
<td>No result</td>
<td>Will ignite</td>
</tr>
<tr>
<td>Limestone</td>
<td>Grey to buff</td>
<td>Coral reefs and shells</td>
<td>Variable</td>
<td>Effervesce</td>
<td>Can be massive</td>
</tr>
<tr>
<td>Chalk</td>
<td>White</td>
<td>Marine algal shells</td>
<td>Very soft. You can scrape with fingernail. Will leave a white stripe on wood.</td>
<td>Effervesce</td>
<td>Tiny marine algal shells</td>
</tr>
<tr>
<td>Spongelite</td>
<td>Many colours, mostly white</td>
<td>Microscopic silica skeletons of sponges</td>
<td>Harsh to touch</td>
<td>No result</td>
<td>Microscopic silica skeletons of sponges</td>
</tr>
</tbody>
</table>
Recognising Sedimentary Rocks – Teacher Notes

**Chemical sediments** are formed when inorganic material builds up into a mass. Most of the rocks above also have chemical components.

**Evaporites** are formed when large masses of water dry up leaving salt (halite), gypsum (hydrated calcium sulphate) and anhydrite (calcium sulphate). When evaporites are covered by more sediment and compacted they behave like slabs of soap and slide upwards to cause domes in the overlying sediments.

**Chemical Limestone** is deposited from dissolved lime in groundwater or seawater. Tamala limestone is the name given to our white coastal limestone that was used for building much of old Fremantle. The sea deposited sand dunes rich in shells. Lime from the sea shells was dissolved into groundwater and later redeposited elsewhere to leave sandy (lime poor) sections and make hard lime rich areas. This means that Tamala limestone is not laid down in time specific beds but is the generic name for chemically deposited limestone zones within sediments.

Where students do not have sedimentary rocks in their collection, they may wish to make their own using the “Replica rocks” activity

**Recognising sedimentary rocks activity**
The following pictures are of sedimentary rocks from Western Australia. Name each rock type and explain which characteristics led you to this conclusion

**Conglomerate from the Canning basin** is a clastic sediment. Note the poorly sorted, well rounded boulders and pebbles (clasts) in a finer grained matrix. Conglomerates often indicate unconformities where there has been rapid uplift and much younger sediments have been deposited on older sediments with a time gap between. The rounding is due to fast flowing streams from the uplifted mountains. Conglomerate used to be called “pudding stone” because it resembled an old-fashioned fruit pudding.

**HINT**  *The hammer gives you an idea of scale*
Recognising Sedimentary Rocks – Teacher Notes

Chalk is a biogenic sediment formed from the skeletons of tiny marine coccoliths. Their dead bodies “rained” down onto the floor of a warm sea. They have been compacted and cemented and turned into rock.

_HINT_ This rock leaves a white streak on wood

Breccia is a clastic sediment. The angular clasts demonstrate that it was deposited close to where the original rock was weathered. Breccias are the result of rapid tectonic movement due to folding or faulting.

_HINT_ The mountains were rising very very fast

Fossiliferous limestone is a biogenic sediment. The fossils tell us how old the rock is (about 1.2 million years). The unbroken nature of the shells tells us that they weren’t deposited at the “swash zone” at the edge of the sea where they would have been rapidly broken down into smaller fragments. They must have been deposited above high tide line during a storm.

_HINT_ Beach
Siltstone is a fine grained clastic sediment which is often deposited at the outfall of river deltas where alternating sands and mud is being deposited. Although it feels smooth to the hand the fine sandy particles will scrape your teeth. This specimen is from the Irwin River valley.

**HINT** Smooth but will scrape your teeth

Sandstone is a medium grained clastic sediment. When the clasts are viewed through a hand lens they are seen to be well rounded due to their weathering by wind and water. This specimen is from the beach near Broome

**HINT** Fees rough and gritty

Mudstone is a very fine grained clastic sediment. It feels smooth and is soft.

**Hint** It can be scraped by a finger nail.
Recognising Sedimentary Rocks - Student Activity

Sedimentary rocks are made of clasts and are usually softer than igneous or metamorphic rocks. They are not crystalline. They show signs of bedding and sometimes contain fossils.

**Clastic sediments** are classified by their grain size. They show signs of bedding.

- large easy to see clasts (2mm+)
- clasts that can be seen by eye (1.26 - 2mm)
- clasts that can only be seen under magnification
  - rounded clasts
  - angular clasts
  - grains felt by touch
  - gritty against teeth
  - smooth

**Biogenic sediments** have no clasts and often have fossils. They can be massive with few signs of bedding.

<table>
<thead>
<tr>
<th>Name</th>
<th>Colour</th>
<th>Source</th>
<th>Texture</th>
<th>Test with acid</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>Black</td>
<td>Swamp vegetation</td>
<td>Soft, can scrape with metal blade</td>
<td>No result</td>
<td>Will ignite</td>
</tr>
<tr>
<td>Limestone</td>
<td>Grey to buff</td>
<td>Coral reefs and shells</td>
<td>Variable</td>
<td>Effervesce</td>
<td>Can be massive</td>
</tr>
<tr>
<td>Chalk</td>
<td>White</td>
<td>Marine algal shells</td>
<td>Very soft. You can scrape with fingernail. Will leave a white stripe on wood.</td>
<td>Effervesce</td>
<td>Tiny marine algal shells</td>
</tr>
<tr>
<td>Spongelite</td>
<td>Many colours, mostly white</td>
<td>Microscopic silica skeletons of sponges</td>
<td>Harsh to touch</td>
<td>No result</td>
<td>Microscopic silica skeletons of sponges</td>
</tr>
</tbody>
</table>
Recognising Sedimentary Rocks - Student Activity

**Chemical sediments** are formed when inorganic material builds up into a mass. Most of the rocks above also have chemical components.

**Evaporites** are formed when large masses of water dry up leaving salt (halite), gypsum (hydrated calcium sulphate and anhydrite (calcium sulphate)).

**Chemical limestone** is deposited from dissolved lime in groundwater or seawater. Tamala limestone is the name given to our white coastal limestone that was used for building much of old Fremantle. The sea deposited sand dunes rich in shells. Lime from the sea shells was dissolved into groundwater and later redeposited elsewhere to leave sandy (lime poor) sections and make hard lime rich areas. This means that Tamala limestone is not laid down in time specific beds but is the generic name for chemically deposited limestone zones within sediments.

The following pictures are of sedimentary rocks from Western Australia. Name each rock type and explain which characteristics led you to this conclusion

*HINT* The hammer gives you an idea of scale

*HINT* This rock leaves a white streak on wood
Recognising Sedimentary Rocks - Student Activity

HINT  The mountains were rising very very fast

HINT  Beach

HINT  Smooth but will scrape your teeth
Recognising Sedimentary Rocks - Student Activity

**HINT** Feels rough and gritty

**Hint** It can be scraped by a finger nail.
Classification of igneous rocks

Igneous (Latin ig = fire, neous = born) rocks are formed from molten magma. They have interlocking crystals and are therefore hard. Crystal size tells us how quickly the rock cooled and chemistry tells us of possible sources for the magma.

1. **Extrusive or intrusive - Crystal size**

   The size of the crystals in a rock can tell us its history. Rocks which have been extruded from a volcano will cool rapidly and the crystals will be microscopic. Intrusive rocks solidify beneath the Earth’s surface over geologically long periods of time resulting in large crystals.

   Students are asked to draw a cross section through a volcano (as above) with surface lava flows, underlying sills (horizontal,) dykes (vertical,) and the magma chamber that feeds molten rock.

   - Obsidian, or volcanic glass is explosively ejected from volcanoes and cools instantly to glass before crystals can form. Pumice is also rapidly chilled with glass shards fused around gas bubbles. These are igneous extrusive rocks.
   - Basalt lava flows can take months to cool and the crystals formed are often too fine grained to see with the naked eye. It is also extrusive.
Recognising Igneous Rocks – Teacher Notes

- Dolerite has the same chemical composition as basalt but is intruded into cracks at depth within the crust to form semi vertical dykes (walls) or along bedding planes to form horizontal sills between beds. Slower cooling results in crystals that can be seen with a hand lens. It is intrusive into country rock. These rocks sometimes demonstrate chilled margins (edges) of finer crystal size.
- Gabbro also has the same chemical composition as basalt and dolerite, however it has large well formed interlocking crystals suggesting very slow cooling and crystallisation at depth. Granite also cools at depth over geological time and has large well-formed crystals. It is intrusive.

NOTE: When the rocks in the magma chamber have almost completely crystallised the last quartz rich fluids flow into cracks formed in the cooling rock. Space and time permits the formation of very large well formed crystals and are the source of some of our gem stones such as emerald and sapphire.

2. Chemical composition - felsic (Fe+Si) or mafic (Mg+Fe)
Igneous rocks are also classified by whether they are silica rich (felsic) or silica poor (mafic). Silica rich rocks such as granite have a lot of quartz and tend to be light in colour. Silica poor rocks such as basalt are richer in iron and magnesium minerals making them darker and denser.
Granite is rich in iron (Fe) and silica (Si) and is the most abundant igneous rock at the surface. It is formed from melting older crustal rocks at depths greater than 9km.
Magma from deeper in the crust or upper mantle has more magnesium (Mg) and iron (Fe) and is denser.
Molten rock is less dense than solid rock and it will slowly begin to rise up through the surrounding rock to the surface. If it reaches the surface it will form a lava flow. If it solidifies below the surface it may have to wait for the overlying rock to be eroded away to emerge.

Some igneous rocks

<table>
<thead>
<tr>
<th>Volcanic Extrusive Fine grained</th>
<th>Mafic</th>
<th>Intermediate</th>
<th>Felsic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basalt</td>
<td></td>
<td>Andesite Scoria</td>
<td>Rhyolite Obsidian Pumice</td>
</tr>
<tr>
<td>Dolerite</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Gabbro</td>
<td>Diorite</td>
<td>Granite</td>
<td></td>
</tr>
</tbody>
</table>
The student activity asks them to look at pictures of various igneous rocks and classify them as intrusive or extrusive and as felsic, intermediate or mafic, on their visible features. Students need not necessarily be able to name each rock. This should be followed up with classification of school specimens.

<table>
<thead>
<tr>
<th>Picture</th>
<th>Comment</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Light white to cream rock." /></td>
<td>Light white to cream rock. Porous Crystals cannot be seen by naked eye. Floats on water. From Mt Tarawera New Zealand.</td>
<td>Pumice. Igneous felsic extrusive. Pumice has very small (cryptocrystalline) crystals. It is really shards of volcanic glass. Silica rich rock with gassy bubbles. Floats on water. White to cream. Used to make light weight concrete, in polishes and to remove dead skin. The ancient Greeks used it to remove hair from the body (ouch!)</td>
</tr>
<tr>
<td><img src="image2" alt="Light grey rock" /></td>
<td>Light grey rock Porous Crystals cannot be seen by naked eye. Does not float on water. From New Zealand and Iceland.</td>
<td>Scoria. Igneous intermediate extrusive. Scoria can be both felsic and mafic. It is a gassy layer which forms at the top of lava flows. Its stickiness forms cinder cones and explosive eruptions as the gas trying to escape has to push the cooled solid scoria out of the way. Pompeii was covered with scoria when Vesuvius erupted. It was mined to make the distinctive top knots on the head of Easter Island sculptures.</td>
</tr>
<tr>
<td><img src="image3" alt="Speckled grey rock with obvious white, grey and black crystals." /></td>
<td>Speckled grey rock with obvious white, grey and black crystals. From Mundaring WA.</td>
<td>Granite. Igneous intrusive felsic. Large obvious crystals of quartz, feldspar and hornblende indicate granite crystallised slowly at great depth. Granite is the most common rock of the Earth’s continental crust. It has been intruded throughout Earth’s history but was more common in Archaean times. It forms the Pilbara and Yilgarn cratons of WA. Polished granite is used for gravestones, memorials and kitchen tops.</td>
</tr>
</tbody>
</table>
## Recognising Igneous Rocks – Teacher Notes

<table>
<thead>
<tr>
<th>Picture</th>
<th>Comment</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.jpg" alt="Basalt" /></td>
<td>Dark, heavy very fine grained rock. Crystals only just visible with a hand lens. Massive</td>
<td><strong>Basalt. Igneous mafic extrusive</strong> Basalt commonly forms massive lava flows from volcanoes. It weathers to a rusty brown colour because of its high iron content. Because it is massive (homogenous) it breaks into uneven clasts which are useful for road ballast being both porous and permeable.</td>
</tr>
<tr>
<td><img src="image2.jpg" alt="Diorite" /></td>
<td>Grey crystalline rock with obvious white and grey crystals. Medium density. Found in New Zealand, Scotland and the Andes Mountains.</td>
<td><strong>Diorite. Igneous intermediate intrusive</strong> It has been described as intermediate between granite and gabbro. It forms the roots of mountain chains in New Zealand, the Andes and Scotland. It is used for cobblestones, pavements and kitchen tops. It can be mistakenly called black granite.</td>
</tr>
<tr>
<td><img src="image3.jpg" alt="Obsidian" /></td>
<td>Curved glassy fragments of rock. Very sharp edges. No crystals visible even under a microscope. New Zealand</td>
<td><strong>Obsidian. Igneous extrusive felsic.</strong> This volcanic rock degassed as it left the volcano and chilled instantly to glass before crystals could form. Early man used it to make knives and sickles. This allowed them to hunt and butcher game more effectively.</td>
</tr>
<tr>
<td>Picture</td>
<td>Comment</td>
<td>Classification</td>
</tr>
<tr>
<td>---------</td>
<td>---------</td>
<td>----------------</td>
</tr>
<tr>
<td><img src="image1.jpg" alt="Black heavy, massive fine grained rock. Crystals only just visible under a hand lens. Beach and hill in Bunbury WA" /></td>
<td><strong>Black heavy, massive fine grained rock. Crystals only just visible under a hand lens. Beach and hill in Bunbury WA</strong></td>
<td><strong>Basalt. Igneous extrusive mafic.</strong> This was part of a massive outpouring of flood basalts during an eruption near Bunbury about 130 million years ago when the Australian continent separated from Gondwanaland.</td>
</tr>
<tr>
<td><img src="image2.jpg" alt="Pink silica rich rock. Light Fine crystals just visible Rotor New Zealand" /></td>
<td><strong>Pink silica rich rock. Light Fine crystals just visible Rotor New Zealand</strong></td>
<td><strong>Rhyolite. Igneous extrusive felsic</strong> Rhyolite is a thick sticky lava that builds up domes (stratovolcanoes). From the Rotorua-Taupo volcanic zone in New Zealand. Light and abrasive. Pumice has been described as rhyolite “froth”.</td>
</tr>
<tr>
<td><img src="image3.jpg" alt="Very, very large well formed crystals. A light bright rock found in veins within other rocks in the ancient Yilgarn craton in WA." /></td>
<td><strong>Very, very large well formed crystals. A light bright rock found in veins within other rocks in the ancient Yilgarn craton in WA.</strong></td>
<td><strong>Pegmatite. Igneous intrusive felsic</strong> When rocks such as granite cool they shrink and crack. The final fluids enter these cracks and slowly cool to form large crystals. Can contain rare earth minerals such as lithium and spodumene. Gems such as amethyst, emerald and rubies and lithium ore are found in pegmatite.</td>
</tr>
</tbody>
</table>
### Recognising Igneous Rocks – Teacher Notes

<table>
<thead>
<tr>
<th>Picture</th>
<th>Comment</th>
<th>Classification</th>
<th>Extrusive or intrusive</th>
<th>Felsic or mafic?</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Dolerite" /></td>
<td>Dark medium density rock whose crystals can only be seen with a hand lens. It forms a wall like structure cutting through other country rock. Exposed in road metal quarry in Darling Ranges.</td>
<td><strong>Dolerite. Igneous intrusive mafic</strong></td>
<td>Dolerites form dykes and sills intruded into country rock. Their interlocking crystals make them hard and they are used as ballast to lay under railways and as “blue metal” for road surfaces.</td>
<td></td>
</tr>
</tbody>
</table>

**Why is the Geoscience Australia card included in each picture?** To provide scale for estimating rock and crystal size.

If you had to carry a bucket of rock, which rock type above would you choose? Explain your answer. Pumice is the least dense. A bucket of pumice would lightest.

If you were being attacked and had to quickly pick a rock to throw, which would you choose? Explain your answer. A small gabbro rock would be densest and have the greatest impact (Pressure = Mass X Acceleration).

You are going to design the front of a new art gallery. Which igneous rock would you choose for the front of the building? Most igneous rocks have interlocking crystals and are hard. Granite and gabbro have large crystals which would polish well. Gabbro might be a little dark and sombre (which is why it is used in mausoleums).

You have been asked to demonstrate how to make a stone knife. Which rock would you select? Explain your answer. Obsidian. Since Obsidian is quartz it is relatively hard and will break into curved sharp edged clasts which can be hafted onto wood.
Igneous (Latin ig = fire, neous – born) rocks form from molten magma. They are made from interlocking crystals and are therefore hard.

We classify igneous rocks by where they became solid and their chemical composition.

1. **Extrusive or intrusive**
   - Small crystals mean fast cooling = extrusive/volcanic at the Earth’s surface
   - Large crystals mean slow cooling = at depth

   Using the library or the Internet draw and label a simple diagram of a volcano with its lava flows, underlying sills, dykes and magma chamber. Indicate where extrusive rock would form and where intrusive rock would form.

2. **Chemical composition - felsic (Fe+Si) or mafic (Mg+Fe)**
   - Rocks rich in silica/quartz are called **FELSIC**. Since silica is common in Earth’s crust these are probably melted crustal rocks. They are usually light in colour and light in weight.
   - Rocks rich in iron and magnesium are called **MAFIC**. Since these elements are more common in Earth’s mantle, they probably have a component of mantle material. They are usually darker in colour and heavier in weight.

The following page has pictures of igneous rocks. See if you can classify them as extrusive or intrusive and as felsic, intermediate or mafic.
Recognising Igneous Rocks - Student Activity

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<th>Picture</th>
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<th>Classification</th>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><img src="image2.jpg" alt="Image" /></td>
<td>Light grey rock Porous Crystals cannot be seen by naked eye. Does not float on water From New Zealand and Iceland</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><img src="image3.jpg" alt="Image" /></td>
<td>Speckled grey rock with obvious white, grey and black crystals. From Mundaring WA</td>
<td></td>
<td></td>
<td></td>
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Recognising Igneous Rocks - Student Activity

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<td><img src="image1.jpg" alt="Picture" /></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><img src="image2.jpg" alt="Picture" /></td>
<td>Grey crystalline rock with obvious white and grey crystals. Found in New Zealand, Scotland and the Andes Mountains.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><img src="image3.jpg" alt="Picture" /></td>
<td>Curved glassy fragments of rock. Very sharp edges. No crystals visible even under a microscope. From New Zealand</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Picture</td>
<td>Comment</td>
<td>Classification</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------</td>
<td>---------</td>
<td>----------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td><img src="image1.png" alt="Image" /></td>
<td>Black, heavy, massive, fine grained rock. Crystals only just visible under a hand lens. From the beach in Bunbury WA</td>
<td>Extrusive or intrusive Felsic or mafic</td>
<td></td>
<td></td>
</tr>
<tr>
<td><img src="image2.png" alt="Image" /></td>
<td>Pink silica rich rock. Light. Fine crystals just visible. From Rotorua New Zealand</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><img src="image3.png" alt="Image" /></td>
<td>Very, very large well formed crystals. A light bright rock found in veins within other rocks in the ancient Yilgarn craton in WA.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Recognising Igneous Rocks - Student Activity

<table>
<thead>
<tr>
<th>Picture</th>
<th>Comment</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image.png" alt="Picture of rock" /></td>
<td>Dark medium density rock whose crystals can only be seen with a hand lens. It forms a wall like structure cutting through other country rock. Exposed in a road metal quarry in the Darling Ranges.</td>
<td>Extrusive or intrusive Felsic or mafic</td>
</tr>
</tbody>
</table>

Why is the Geoscience Australia card included in each picture? ________________

___________________________________________________________________________

We carefully select rocks to use because of their **physical characteristics**.

If you had to carry a bucket of rock, which rock type above would you choose? Explain your answer.

___________________________________________________________________________

___________________________________________________________________________

If you were being attacked and had to quickly pick a rock to throw, which would you choose? Explain your answer.

___________________________________________________________________________

___________________________________________________________________________
You are going to design the front of a new art gallery. Which igneous rock would you choose for the front of the building? Explain your answer.

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

You have been asked to demonstrate how to make a stone knife. Which igneous rock would you select? Explain your answer

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
Metamorphism can refer to partial melting of rock due to pressure, temperature or a combination of both. (Latin. meta = change, morpho = body)

**Regional Metamorphism**

Tectonic movements cause some parts of the Earth’s crust to thin and sag to form basins and other parts to rise as mountains. During ancient geological times Australia, India, Africa, New Zealand and Antarctica were welded together to form the super-continent of Gondwanaland. About 184 million years ago the super-continent began to break up and the present continental plates started to move apart. Continental crust between the separating plates was stretched thin and split by a series of faults. The stretched crust then sagged to create a marine sedimentary basin presently filled by the Indian Ocean.

Lower layers of sediment were compressed and dewatered by pressure from overlying deposits. (A student activity demonstrating pressure dewatering sediments is given in our WASP 7 materials in the “Oil” section). Clasts will compact and also align at right angles to the direction of pressure.

This is particularly true of mud and silt. Their platy alumina-silicates align well under pressure. The sediments compress and compact to form slate and then with further increase in temperature and pressure, schist.

*Progression from mudstone on left, to slate in centre to schist on right*
Teacher demonstration - Platy materials aligning under pressure

Materials
- 2 rulers or thick books
- Handful of dried long pasta pieces

Pieces of dried spaghetti or elongate noodles are dropped on the desk to form a random pattern. Hold the parallel rulers vertically like walls on either side and slowly compress the pile. The pasta pieces align like mica does in metamorphic rock.

We can see the effect of pressure when we compact a fluffy snowball in our hands. The highly compressed centre of the ball recrystallises to form ice.

Temperature also increases with depth, roughly 25°C for every kilometre. Minerals melt and reform to take on a different crystalline form that is more stable under the new conditions of higher temperature and pressure.

<table>
<thead>
<tr>
<th>Depth</th>
<th>Rock</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface</td>
<td>Mud</td>
</tr>
<tr>
<td>5 km</td>
<td>Shale</td>
</tr>
<tr>
<td>10 km</td>
<td>Slate (different micas form)</td>
</tr>
<tr>
<td>15 km</td>
<td>Schist (garnet appears)</td>
</tr>
<tr>
<td>20 km</td>
<td>Gneiss (staurolite appears)</td>
</tr>
</tbody>
</table>

**Contact metamorphism**

An intrusion of hot magma, perhaps granite or a dolerite dyke, alters the surrounding country rock. In this case heat, not pressure, is the major agent of metamorphism. Changes grade away from the contact to create an aureole of metamorphism.

Since some components of the original rock will be affected before others, partial melting of the rock occurs. This also contributes to lines of weakness or schistosity.
Recognising Metamorphic Rocks - Teacher Notes

Teacher demonstration Metamorphism examples

When fossil rich limestone is subjected to increased temperature and pressure it metamorphoses into marble. Often traces of bedding and fossil shapes remain.

Materials
- Toasted sandwich maker
- Bread
- Grated cheese
- Tomato slices

1. Assemble two sandwiches. One is the control against which change is to be measured and the other is the experimental sandwich.
2. After the sandwich has been compressed and heated cut cross sections of both then compare and contrast.

Bread - No physical change but graded chemical change. The bread will be most affected by heat on its outer surface, where it is brown sugars have caramelised in response to heat. The slice will have maintained its shape but be thinner/compressed. If you compare the taste of the bread with and without toasting, toasted bread is sweeter as some of the carbohydrates in flour have broken down to form sugars.

Cheese - Major physical change and chemical change. The grated cheese component has decreased in volume. The protein chains have shrunk. The cheese is no longer discrete grated particles but has melted into one plastic band.

Tomato - Slight physical and chemical changes The tomato has become slightly liquid and tastes sweeter than the original slightly acid raw tomato. Its shape is still recognisable

Extension: Students may wish to make toasted sandwiches with fossil shapes cut from cheese slices and observe changes. Slices of apple or pieces of ham may be added.

<table>
<thead>
<tr>
<th>Original rock</th>
<th>Metamorphosed rock</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mudstone</td>
<td>slate</td>
</tr>
<tr>
<td>Sandstone</td>
<td>quartzite</td>
</tr>
<tr>
<td>Limestone</td>
<td>marble</td>
</tr>
<tr>
<td>Granite</td>
<td>gneiss</td>
</tr>
</tbody>
</table>

An initiative supported by Woodside and ESWA
Recognising Metamorphic Rocks - Student Activity

Metamorphic rocks are igneous or sedimentary rocks which have been partially recrystallised. They contain the same material as the original rock but in a different form.

METAMORPHOSIS means _____________________________________________________

Insects metamorphose. The same creature has different body shapes during its life. The change is caused by time.

<table>
<thead>
<tr>
<th>Earlier</th>
<th>Later</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="https://example.com/earlier.png" alt="Image" /></td>
<td><img src="https://example.com/later.png" alt="Image" /></td>
</tr>
<tr>
<td><img src="https://example.com/earlier.png" alt="Image" /></td>
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<td><img src="https://example.com/later.png" alt="Image" /></td>
</tr>
<tr>
<td><strong>Your example</strong></td>
<td></td>
</tr>
</tbody>
</table>

Metamorphosis of rocks is the result of heat and pressure.
Regional metamorphism
Your teacher will demonstrate the effect of pressure on the alignment of pasta pieces.
Describe what happened

___________________________________________________________________________
___________________________________________________________________________

Under heat and pressure mudstone becomes slate
Under heat and pressure sandstone becomes quartzite
Under heat and pressure limestone becomes marble
Under heat and pressure granite becomes gneiss
Rocks are solid materials found at the Earth’s crust. Minerals are the building blocks of rocks. A mineral is an inorganic crystalline substance. Resources are things that are useful to humans.

Many people find these terms confusing and mistakenly use them interchangeably. Newspapers in particular use the terms minerals and resources interchangeably.

Rocks and minerals

1. Minerals have a reasonably regular chemical composition
2. Minerals have regular shapes (they form crystals)
3. Minerals are inorganic crystals
4. The size of mineral crystals relates to the rate of cooling
5. Minerals are the building blocks of rocks

NOTE! If you do not have access to good specimens of minerals and crystals, visit the Earth Science Western Australia website [www.earthsciencewa.com.au](http://www.earthsciencewa.com.au) and discover how you can borrow a box of specimens with accompanying teachers guide and student activity sheets at no cost. The site will tell you where the closest kit can be accessed free.

The E De C Clarke museum at University of Western Australia and the museum at the Kalgoorlie School of Mines have excellent mineral specimens.

1. **Minerals have regular chemical compositions**
   All diamonds have the same chemical composition. All are pure carbon however very tiny amounts of other atoms may cause them to be different colours. The “Crystals and Minerals” activities enable students to see and measure the difference between crystals of salt (NaCl) and alum (KAl(SO₄)₂). Salt crystals will be cubic whilst alum forms an octahedral crystal.

**Interesting facts**: Salt has a long history of use in food preservation and the chemical industry whilst alum is used in preserving pickles as it helps the vegetables to retain their crispness.

**Interesting facts**: Many gem and industrial crystals are now made artificially in laboratories. Industrial diamonds are created for their hardness in cutting and grinding, quartz crystals are used in electronics, calcite crystals allow us to polarise light and silicon crystals are used for computers.
2. **Minerals have regular shapes**

Planes of weakness within crystals cause cleavage where they break into regular geometric shapes. Bonding between molecules controls these planes. Since both salt and pyrites are cubic, minerals cannot be identified by their symmetry alone.

3. **Minerals are inorganic crystals**

Not all crystals are minerals. Organic substances are formed from living things. Some organic materials such as urine and DNA can form crystals. You may have noticed the needle like crystals dried on the kitchen floor if your child, puppy or kitten has “made a mistake”. These are organic and cannot be minerals. Inorganic substances are produced in non-living materials such as magma (molten rock), hydrothermal fluids and gasses. These cool over geological time and can form large crystals.

**Misconception:** Many students assume that “organic” means alive. The descriptor “organic” also includes anything that was alive and is now dead. Even 2.2 billion year old bacterial fossils are classified as organic.

4. **The size of minerals relates to the rate of cooling**

Crystal size is controlled by many factors. At year 8 level however the faster a magma cools the smaller its crystals are.

<table>
<thead>
<tr>
<th>Example rock</th>
<th>Place of cooling</th>
<th>Rate of cooling</th>
<th>Crystal Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass (obsidian)</td>
<td>Volcanic (extrusive)</td>
<td>Instant</td>
<td>Cryptocrystalline – a state between crystal and gas</td>
</tr>
<tr>
<td>Basalt</td>
<td>Volcanic (extrusive)</td>
<td>Rapid</td>
<td>Small – visible by hand lens</td>
</tr>
<tr>
<td>Dolerite</td>
<td>Intrusive</td>
<td>Slower</td>
<td>Visible by eye</td>
</tr>
<tr>
<td>Granite</td>
<td>Deep intrusive</td>
<td>Very slow</td>
<td>Large</td>
</tr>
</tbody>
</table>


5. **Minerals are the building blocks of rocks**

Igneous rock is sourced from within the Earth (molten magma). These rocks are characterised by interlocking crystals (minerals) that usually make them hard and difficult to break.

Sedimentary rocks are made from weathered and eroded clasts (broken bits) of earlier rocks. Minerals from the earlier rocks are deposited, compacted and cemented to form sedimentary rock. In cold wet climates the minerals quartz (old German for “hard”) and feldspar (Old German for “field rock”) will not weather easily and will survive into the new sediments. In warm climates rocks weather much faster and complex minerals will be broken down to form silt and mud.
Metamorphic rock is partially melted igneous or sedimentary rock. Some original minerals will have been changed by heat and/or pressure to form new minerals which are stable at the new conditions.

**Interesting fact:** Although the Earth became solid about 4.5 billion years ago (bya) we have no rocks we can date until about 3.8 bya. When a rock melts, radioactive materials in the minerals start to decay and we can tell how long since the rock became solid. It has been suggested that at 3.8 bya Earth was struck by an asteroid or planet about the size of Mars. At Jack Hills near Geraldton in Western Australia mineralogists have found crystals of the mineral zircon. The centres of these date to 4.2 bya and have been rounded and smoothed by erosion in a flowing liquid. It is suggested that these are clasts of an earlier rock that have been included into a later one. These are currently the oldest dated minerals in the world.

**Resources**
The major resources on Earth are water, air, living things, rocks (including minerals and fossil fuels), soil and energy from the Sun. Materials will move between different reservoirs in Earth at different rates for different periods of residence. Since the biosphere, atmosphere, lithosphere and hydrosphere are all inter-connected, each is of equal importance in maintaining sustainability.
<table>
<thead>
<tr>
<th>Name</th>
<th>Colour</th>
<th>Hardness</th>
<th>Specific gravity</th>
<th>Streak</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Azurite (Copper ore) Cu₃(CO₃)₂(OH)₂</td>
<td>Deep blue</td>
<td>3.5-4</td>
<td>3.8</td>
<td>Light blue</td>
<td>Found above weathered copper deposits</td>
</tr>
<tr>
<td>Biotite (black mica)</td>
<td>Black to brown</td>
<td>2.5-3</td>
<td>2.9</td>
<td></td>
<td>Tabular pseudo-hexagonal crystals</td>
</tr>
<tr>
<td>Calcite CaCO₃</td>
<td>White or clear</td>
<td>3</td>
<td>2.71</td>
<td></td>
<td>Rhombohedral, effervesces with acid</td>
</tr>
<tr>
<td>Chalcopyrite (Copper ore) CuFeS₂</td>
<td>Brass yellow</td>
<td>3.5-4</td>
<td>4.1-4.3</td>
<td>Deep yellow</td>
<td>Iridescent tarnish, metallic lustre</td>
</tr>
<tr>
<td>Diamond</td>
<td>Colourless</td>
<td>10</td>
<td>3.5</td>
<td></td>
<td>Adamantine lustre, octahedral crystals</td>
</tr>
<tr>
<td>Feldspar</td>
<td>White/yellow/pink</td>
<td>6</td>
<td>2.5-3</td>
<td></td>
<td>Vitreous lustre</td>
</tr>
<tr>
<td>Fluorite</td>
<td>White, green or purple</td>
<td>4</td>
<td>3-3.5</td>
<td>White</td>
<td>Octahedral crystals</td>
</tr>
<tr>
<td>Garnet</td>
<td>Red-brown</td>
<td>6.6-7.5</td>
<td>3.5-4.3</td>
<td>White</td>
<td>Rhombohedral crystal faces</td>
</tr>
<tr>
<td>Galena (lead sulphide)</td>
<td>Purplish silver</td>
<td>2.5</td>
<td>7.5</td>
<td>Lead grey</td>
<td>Cubic crystals, metallic lustre</td>
</tr>
<tr>
<td>Graphite (pencil lead)</td>
<td>Black</td>
<td>1</td>
<td>2.3</td>
<td>Black</td>
<td>Transmits electricity. Feels greasy</td>
</tr>
<tr>
<td>Gypsum (Plaster of Paris) CaSO₄2H₂O</td>
<td>Grey to white</td>
<td>2</td>
<td>2.3</td>
<td>White</td>
<td>Can form desert roses</td>
</tr>
<tr>
<td>Gold</td>
<td>Yellow to white</td>
<td>2.5-3</td>
<td>12-20</td>
<td>Gold</td>
<td>Cut with knife</td>
</tr>
<tr>
<td>Halite (rock salt)</td>
<td>Clear to white</td>
<td>2-2.5</td>
<td>2.2</td>
<td>White</td>
<td>Salty taste</td>
</tr>
<tr>
<td>Haematite</td>
<td>Black/red</td>
<td>5.5-6.5</td>
<td>5</td>
<td>Red</td>
<td>Major component of iron ore</td>
</tr>
<tr>
<td>Hornblende</td>
<td>Green/black</td>
<td>5-6</td>
<td>3-3.5</td>
<td></td>
<td>Vitreous lustre</td>
</tr>
<tr>
<td>Kyanite</td>
<td>Blue to white</td>
<td>6.5-7.5</td>
<td>3.6</td>
<td></td>
<td>Flat bladed crystals</td>
</tr>
<tr>
<td>Malachite (copper ore) Cu₂CO₃(OH)₂</td>
<td>Green</td>
<td>3.5-4</td>
<td>4</td>
<td>Pale green</td>
<td>Often botryoidal (lumpy)</td>
</tr>
<tr>
<td>Magnetite</td>
<td>Black</td>
<td>5.5-6.5</td>
<td>5.2</td>
<td>Black</td>
<td>Magnetic</td>
</tr>
<tr>
<td>Muscovite (white mica)</td>
<td>Clear pale greenish</td>
<td>2.2-2.5</td>
<td>2.9</td>
<td></td>
<td>Pearly lustre, platy</td>
</tr>
<tr>
<td>Opal or Chalcedony</td>
<td>Milky white to black</td>
<td>1.8-2.3</td>
<td>5.5-6.5</td>
<td></td>
<td>Conchoidal fracture, semi-precious</td>
</tr>
<tr>
<td>Pyrite (Fool’s gold)</td>
<td>Brass yellow</td>
<td>6-6.6</td>
<td>4.8-5.7</td>
<td></td>
<td>Striated cubes</td>
</tr>
<tr>
<td>Quartz</td>
<td>Varies</td>
<td>7</td>
<td>2.65</td>
<td></td>
<td>Hexagonal with stepped terminal faces</td>
</tr>
<tr>
<td>Talc</td>
<td>Green to white</td>
<td>1-2.5</td>
<td>2.75</td>
<td>White</td>
<td>Pearly lustre</td>
</tr>
<tr>
<td>Tourmaline</td>
<td>Black, blue, green, red</td>
<td>7-7.5</td>
<td>3.1</td>
<td></td>
<td>Semi-precious, found in pegmatites</td>
</tr>
</tbody>
</table>
Minerals are inorganic substances found naturally in the Earth’s crust. Minerals have a regular shape if they are able to crystallise properly.

Firing X rays through thin sections of minerals has revealed their underlying atomic structure. The regular shapes are due to the geometrical arrangement of their atoms during crystallisation. As the liquid cools the atoms, ions or molecules take on a regular, orderly arrangement to bond together. The minerals cleave or break naturally along the planes of their least strong bonds.

The mineral calcite (CaCO$_3$) has regular cleavage at 60° and 120° resulting in a beautiful rhombic crystal whereas iron pyrites (FeS$_2$) has 90° cleavage resulting in cubic crystals known by old time miners in WA as “Devil’s dice”.

Often the crystals do not have enough space or time to crystallise perfectly and twins and intergrowths occur.
**Vocabulary**

Solute + Solvent = Solution
Solid + Liquid = Solution
Evaporation Liquid becomes gas

**Fill in the blank spaces in the table below**

<table>
<thead>
<tr>
<th>Solute</th>
<th>Solvent</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Banana</td>
<td>Milk</td>
<td>Banana milk shake</td>
</tr>
<tr>
<td>Ice cream</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coffee grounds</td>
<td>Water</td>
<td>Coffee</td>
</tr>
<tr>
<td>Sugar</td>
<td>Milk</td>
<td></td>
</tr>
<tr>
<td>Salt</td>
<td>Water</td>
<td>Seawater</td>
</tr>
</tbody>
</table>

Mineral crystals form when a mineral rich solution cools. Alum and salt are both naturally occurring minerals that have been used to preserve food for a very long time. The hotter the solvent the more solute will dissolve. Higher kinetic energy permits more movement between molecules. Stirring also increases solubility and permits the formation of a supersaturated solution. If the solution is stored away from breezes and movement it will evaporate to leave crystals. The surface area of the solutions and ambient heat and humidity controls the rate of crystal formation. Although both crystals are transparent and colourless, their forms are different. Salt is cubic and alum forms rhomboids.

**Materials per person or group**

- Salt crystals NaCl
  - 250mL beaker (or jam jar)
  - Stirring rod
  - 50mL hot water
  - Dry tea spoon
  - Kitchen salt (sodium chloride)
  - Half of a Petri dish or saucer

1. Carefully pour about 50mL of hot water into the beaker
2. Add salt to the water using the rod to keep the water moving. Wait until it has all dissolved before adding more.
3. When the solution will dissolve no more salt stop.
4. Pour the super-saturated solution into the Petri dish and place this on a shelf or on a windowsill where it will not be disturbed for a few days.
5. Observe and measure the crystals formed
Minerals Form Crystals – Teacher Notes

Materials per person or group

- Alum crystals KAl(SO₄)₂·12H₂O
- Two 250mL beakers or jam jars
- Stirring rod
- 50mL hot water
- A dry tablespoon
- About two tablespoonsful of alum
- One piece of paper towel

1. Add the alum to the hot water a little at a time stirring until no more will dissolve
2. Remove the stirring rod and cover with paper to exclude dust
3. When cool, pour into Petri dish and leave to cool

The alum crystals will form on any surface including those earlier crystals. The result is often an inter-grown mass of crystals.

EXTRA for EXPERTS

- Dissolve alum as before
- Leave to settle overnight. Crystals will have started to form at the bottom of the beaker
- Decant the clear liquid above into the clean beaker
- Select the largest of the alum crystals lying on the base of the old beaker. This will be your “seed” crystal
- Tie a piece of nylon thread to a pop stick or pencil. Tie your seed crystal and let it dangle within the clear liquid in the new beaker. Do not let it touch the bottom or sides of the beaker
- Leave for a week

If crystals do not grow the solution is too weak. Warm in the microwave and add more alum.

Alum is inexpensive and available from hardware shops.
Minerals have a regular shape if they have room to crystallise slowly. Recognising the geometry of the crystal will help us recognise the mineral.

When liquid magma cools, mineral crystals form and rock becomes solid. How many different mineral crystals can you spot in the granite below?

Answer: ___________________________________________________________________

This mineral crystal is present in the granite above. Draw an arrow to show where it can be found in the granite.
The darker grey mass is the mineral quartz. Because it was the last to crystallise it had to fill in whatever space was left and could not take up good crystalline form.

We will be making two common mineral crystals, salt and alum. Both are used to preserve food. To do this we will have to dissolve a solute into a solvent to form a solution

What is a solute?____________________________________________ e.g. __________

What is a solvent?____________________________________________e.g. __________

Fill in the blank spaces in the table below and add an example of your own

<table>
<thead>
<tr>
<th>Solute</th>
<th>Solvent</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coffee grounds</td>
<td>Milk</td>
<td>Banana milk shake</td>
</tr>
<tr>
<td>Sugar</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salt</td>
<td></td>
<td>Seawater/salty water/saline solution</td>
</tr>
<tr>
<td>Your example</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
AIM  To create sodium chloride (salt) crystals and observe if they have a regular shape

Materials per person or group

- 250mL beaker
- Stirring rod
- 50mL hot water
- Dry tea spoon
- Kitchen salt (sodium chloride)
- Half of a Petri dish or saucer

1. Carefully pour about 50mL of hot water into the beaker
2. Add salt to the hot water using the rod to keep the water moving. Wait until the salt has all dissolved before adding more.
3. When the solution will dissolve no more salt, stop. This is a supersaturated solution
4. Pour the super-saturated solution into the Petri dish and set aside to crystallise.
5. Observe the crystals formed and draw three well-formed crystals into the space below. Use a protractor to measure angles. Scientific data is only acceptable if it is observable, measurable and repeatable.

Results

SCALE: __________

Conclusion

___________________________________________________________________________
___________________________________________________________________________

An initiative supported by Woodside and ESWA
We are now going to change one variable (to make this a fair test).

**Aim**  To create hydrated potassium aluminium sulphate (alum) crystals and observe if they have a regular shape

Repeat the experiment but use alum (hydrated potassium aluminium sulphate) as the solute.

**Results**

SCALE:_________

Compare (how are they the same?) and contrast (how are they different) the two crystals

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________
Extension for experts

**Aim**  To create a large alum crystal

**Method**
- Dissolve alum as before
- Cover and leave to settle overnight. Crystals will have started to form at the bottom of the beaker
- Decant the clear liquid above into a clean beaker
- Select the largest of the alum crystals lying on the base of the old beaker. This will be your “seed” crystal
- Tie a piece of nylon thread or fishing line to a pop stick or pencil. (Do not use cotton as crystals will grow along this). Tie your seed crystal and let it dangle within the clear liquid in the new beaker. Do not let it touch the bottom or sides of the beaker.
- Leave for a week

If crystals do not grow the solution is too weak. Warm in the microwave and add more alum.

Alum is inexpensive and available from some hardware shops.
Minerals are natural inorganic substances having regular crystal structure and distinctive chemical composition,
Minerals are the building blocks of rocks,

This section is for those schools that have mineral collections. These are some of the physical tests lower school students can use to classify common minerals. Some of the tests are destructive. It is advisable to use only what can be easily replaced. A reference guide to common mineral characteristics is included in this package.

When a geologist goes into the scrub they usually carry a small pack with tools to help them recognise minerals. They would usually have:
- A hand lens to better see the specimen
- A nail, an old 2c coin, a piece of glass and their fingernails to test the hardness of the specimen
- A magnet
- A little bottle of vinegar (acetic acid)

Geologists often blow on a specimen to clear the surface then breathe heavily on it. The film of moisture often makes mineral features stand out better.

**Minerals are examined by the following physical properties**

A. Colour

In most metallic ores colour can be a useful clue to mineral composition. Green and blue often indicate copper whilst red usually indicates iron. With crystals trace elements can cause great variety of colour differences. Colour should only be used in freshly broken rock.

![Kyanite - its name means “blue”](image)

**Note**: Colour should be described in as much detail as possible. For example these kyanite samples could be described as dark blue with green and white tinges.
B. Crystal shape

Or crystalline habit (prismatic, cubic, tabular etc) is due to the arrangement of atoms. Sodium chloride forms cubic crystals whereas calcite forms hexagonal ones.

\[\text{e.g. Calcite}\]

Note: There is a large bank of terms used for describing crystal shapes. Students might like to stick to common terms (many of these are used for describing minerals).

C. Streak

Streak can be determined by scratching the mineral across a white plate or the unglazed side of a white tile. The streak is the colour of the powder of the mineral so it can also be crushed or filed. Often the streak can be a different colour than the mineral appears. Iron pyrites which appears golden to the eye, hence its name “fools gold” has a greenish or brownish-black streak. Streak is a good way to differentiate between iron ores. Haematite is dark red-brown, magnetite is black whilst limonite is yellow.

Note: It is important to be aware that if the mineral is harder than the streak plate you will not be able to produce a streak. Also, many minerals have a white streak so students should look carefully for this.

D. Cleavage

The planes along which crystals break and the angles these surfaces make with each other. This is due to the bonding between molecules. These can be estimated by eye or measured with a protractor. Mica has one cleavage plane which breaks it into flat sheets. Iron pyrites (fool’s gold) has six which break it into cubic prisms.

Note: Many samples are sold in their crystal form. The only way to examine their cleavage is to break them.
E. Lustre

Light reflected from a fresh face of the mineral gives it its lustre. This depends on the refraction, absorption and reflection of light on the surface of the mineral. Lustres are described as metallic (like a metal e.g. galena), vitreous (like glass e.g. quartz), resinous (like wax e.g. opal), pearly (e.g. mica), silky (e.g. asbestos) and adamantine (e.g. diamond).

F. Transparency

The mineral may be transparent (allows light to pass through), translucent (allows light to pass through but the image is not clear) and opaque (light does not pass through).

G. Hardness

Friedrich Mohs created a scale (the Mohs Scale) of hardness relative to some common minerals and commonly accessible materials. By comparing the ability of one mineral to scratch another, a scale has been developed.

<table>
<thead>
<tr>
<th>Hardness</th>
<th>Mineral</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>DIAMOND</td>
</tr>
<tr>
<td>9</td>
<td>CORRUNDUM</td>
</tr>
<tr>
<td>8</td>
<td>TOPAZ</td>
</tr>
<tr>
<td>7</td>
<td>QUARTZ</td>
</tr>
<tr>
<td>6</td>
<td>ORTHOCLASE FELDSPAR</td>
</tr>
<tr>
<td>5</td>
<td>APATITE</td>
</tr>
<tr>
<td>4</td>
<td>FLUORITE</td>
</tr>
<tr>
<td>3</td>
<td>CALCITE</td>
</tr>
<tr>
<td>2</td>
<td>GYPSUM</td>
</tr>
<tr>
<td>1</td>
<td>TALC</td>
</tr>
</tbody>
</table>

As a rough guide we can use:

- 6.5 Steel nail
- 5.5 Knife blade
- 5 Glass
- 4 “Copper” coin
- 2.5 Finger nail

Note: Mohs scale is a comparative scale, there are large jumps in hardness along this scale (in particular from 9 to 10). Using this scale you might find an unknown mineral is scratched by orthoclase feldspar but scratches apatite you can say that it’s hardness is less than 6 and more than 5. Or if you don’t have a set of Mohs scale minerals an unknown mineral may be scratched by glass but not by a ‘copper’ coin. You can say its hardness is greater than 4 and less than 5.

H. Specific gravity

This measures the relative weight of the mineral compared with an equal volume of water. (Weigh the stone in air. Then place the stone in a measuring cylinder full to the brim with water. Weigh the volume of water displaced by the stone OR since 1mL of water weighs 1 gram estimate the weight by measuring the volume of water displaced. Divide the weight in air by the weight of water). Precious stones such as diamond, zircon and rubies are easily distinguished by this process.
Recognising Minerals – Teacher Notes

For more advanced students an activity on how to measure specific gravity is described at:  
http://serc.carleton.edu/quantskills/activities/14212.html or  
http://www.education.com/science-fair/article/heavy/

I. Special characteristics

Examples might be:
   - Halite (salt) has a specific taste
   - Magnetite is magnetic
   - Calcite is bi-refringent (an image passed through it doubles up) and effervesces with acid
   - Gold is highly malleable (soft)
   - Talc feels greasy
Recognising Minerals – Student Activity

Minerals

1. Minerals are the building blocks of rocks
2. Minerals have regular shapes (they form crystals).
3. Minerals have reasonably regular chemical composition
4. The size of mineral crystals relates to the rate of cooling
5. Minerals are inorganic crystals

Minerals are natural inorganic substances having regular crystal structure and distinctive chemical composition. Minerals are the building blocks of rocks.

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![Calcite](image)

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<th>CORRUNDUM</th>
<th>As a rough guide we can use:</th>
</tr>
</thead>
<tbody>
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<td>10</td>
<td></td>
<td></td>
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<td>8</td>
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<td></td>
<td>QUARTZ</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td>ORTHOCLASE FELDSPAR</td>
<td>6.5</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td>APATITE</td>
<td>Knife blade</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td>FLUORITE</td>
<td>Glass</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td>CALCITE</td>
<td>“Copper” coin</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td>GYPSUM</td>
<td>Finger nail</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td>TALC</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Softest</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

H. Specific gravity

This measures the relative weight of the mineral compared with an equal volume of water. (Weigh the stone in air. Then place the stone in a measuring cylinder full to the brim with water. Weigh the volume of water displaced by the stone OR since 1mL of water weighs 1 gram estimate the weight by measuring the volume of water displaced. Divide the weight in air by the weight of water). Precious stones such as diamond, zircon and rubies are easily distinguished by this process.

I. Special characteristics

Examples might be:

Halite (salt) has a specific taste
Magnetite is magnetic
Calcite is bi-refringent (an image passed through it doubles up) and effervesces with acid
Gold is highly malleable (soft)
Talc feels greasy
Mineral Composition - Web Search

Minerals are the building blocks of rocks. When a rock forms, the chemicals arrange themselves into a number of different minerals. **Minerals have a regular shape and a regular chemical composition.**

This search should give you data to answer the question “Is the chemical composition of minerals found at the Earth’s crust a reflection of the chemical composition of the crust?” Remember to always give the source of your data.

1. What is an element?
   
   __________________________________________________________
   __________________________________________________________
   __________________________________________________________
   __________________________________________________________
   __________________________________________________________

   Source ___________________________________________________

2. What are the six most common elements found in the Earth’s crust?
   
   __________________________________________________________
   __________________________________________________________
   __________________________________________________________
   __________________________________________________________
   __________________________________________________________

   Source ___________________________________________________

3. Name two minerals that are made of only one element.
   
   __________________________________________________________
   __________________________________________________________
   __________________________________________________________
   __________________________________________________________
   __________________________________________________________

   Source ___________________________________________________

4. What are the two most common minerals in the Earth’s crust?

   __________________________________________________________
   __________________________________________________________

   Source ___________________________________________________

5. Can we call iron ore a mineral? Explain your answer.

   __________________________________________________________
   __________________________________________________________
   __________________________________________________________
   __________________________________________________________

   Source ___________________________________________________
6. What minerals are commonly found in granite?

___________________________________________________________________________

Source ____________________________________________________________________

Using the data you have collected:

7. Granite is a common rock found in the crust of the earth. Does the composition of its minerals reflect the composition of the crust?
Minerals are the building blocks of rocks. When a rock forms, the chemicals arrange themselves into a number of different minerals. Igneous rocks such as granite, basalt and dolerite are hard because their crystals interlocked when they crystallised. Sedimentary rocks are made from clasts, broken bits of other rock compacted and cemented together and therefore tend to be softer.

This search should give students the data to answer the question “Is the chemical composition of minerals found at the Earth’s crust a reflection of the chemical composition of the crust?” They should remember to always give the source of their data.

1. What is an element?

   An element is a substance made of one kind of atom. It cannot be chemically broken into a simpler substance.

2. What are the six most common elements found in the Earth’s crust?

   Most minerals and therefore rocks, at the Earth’s crust, are made of six elements:
   - Oxygen 46.6%
   - Silicon 27.7%
   - Aluminium 8.1%
   - Iron 5%
   - Calcium 3%
   - Sodium 2.8%
   Potassium, magnesium and others form the remainder.
   Rocks from the mantle and core contain a higher percentage of denser metallic elements.

3. Name two minerals that are made of only one element.

   Diamond and graphite are made up of carbon (sometimes with miniscule amounts of other elements).

4. What are the two most common minerals in the Earth’s crust?

   Feldspar and quartz.

5. Can we call iron ore a mineral? Explain your answer.

   No. Iron ore is a rock made up of a high percentage of metallic iron, usually in the form of haematite or magnetite. Iron ore is not usually made up of a single mineral but several.
6. What minerals are commonly found in granite?

Granite is one of the most common rocks of the Earth’s crust. It is made up of quartz and feldspar with small amounts of mica and hornblende.

Using the data you have collected:

7. Granite is a common rock found in the crust of the earth. Does the composition of its minerals reflect the composition of the crust?

Quartz = SiO$_4$

Feldspar = KAlSi$_3$O$_8$ – NaAlSi$_3$O$_8$ – CaAl$_2$Si$_2$O$_8$ (is a group of minerals so will range in composition)

Mica = varying combinations of K, Na, Ca, Al, Mg, Fe, Si, Al, O, H and F.

Hornblende = (Ca,Na)$_2$(Mg,Fe,Al)$_5$(Al,Si)$_8$O$_{22}$(OH)$_2$

Granite does reflect the composition of the earth’s crust with high proportions of O, Si, Al, Fe, Ca and Na. Along with other minor elements.
We live in a resource rich state and in a resource rich country!

Gold in quartz

<table>
<thead>
<tr>
<th>Commodity</th>
<th>WA</th>
<th>Australia</th>
<th>World</th>
<th>WA% of world</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron Ore (Mt)</td>
<td>427</td>
<td>441</td>
<td>2,080</td>
<td>21</td>
</tr>
<tr>
<td>Alumina (Mt)</td>
<td>12</td>
<td>10</td>
<td>87</td>
<td>14</td>
</tr>
<tr>
<td>Nickel (000t)</td>
<td>212</td>
<td>212</td>
<td>1,580</td>
<td>13</td>
</tr>
<tr>
<td>Garnet (000t)</td>
<td>150</td>
<td>150</td>
<td>1,400</td>
<td>11</td>
</tr>
<tr>
<td>Zircon (000t)</td>
<td>106</td>
<td>762</td>
<td>1,442</td>
<td>7</td>
</tr>
<tr>
<td>Gold (t)</td>
<td>180</td>
<td>258</td>
<td>2,763</td>
<td>6</td>
</tr>
<tr>
<td>Ilmenite (000t)</td>
<td>726</td>
<td>1,277</td>
<td>11,310</td>
<td>6</td>
</tr>
<tr>
<td>Diamond (000ct)</td>
<td>7,562</td>
<td>7,562</td>
<td>144,000</td>
<td>5</td>
</tr>
</tbody>
</table>

Western Australia accounted for 70% of Australia’s export merchandise to China. In the same period 8.2% of the population of WA was directly employed in mining and 10% in construction.

In 2012 WA contributed 46% of Australia’s merchandise exports. This was higher than the share of NSW, Victoria and Queensland combined.

<table>
<thead>
<tr>
<th>REGION</th>
<th>2011-12</th>
<th>MAIN COMMODITIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pilbara</td>
<td>84,453</td>
<td>Iron ore 69%, oil &amp; gas 26%</td>
</tr>
<tr>
<td>Goldfields-Esperance</td>
<td>9,145</td>
<td>Gold 66%, nickel 31%</td>
</tr>
<tr>
<td>Peel</td>
<td>5,229</td>
<td>Alumina (76%)</td>
</tr>
<tr>
<td>Wheatbelt</td>
<td>2,671</td>
<td>Iron ore (50%)</td>
</tr>
<tr>
<td>Mid West</td>
<td>2,405</td>
<td>Gold, 35%, iron ore 25%</td>
</tr>
<tr>
<td>Kimberley</td>
<td>1,380</td>
<td>Iron ore 54%, diamonds/oil 25%</td>
</tr>
<tr>
<td>South West</td>
<td>596</td>
<td>Coal 49%, mineral sands 31%</td>
</tr>
<tr>
<td>Gascoyne</td>
<td>124</td>
<td>Salt &amp; gems 99%</td>
</tr>
<tr>
<td>Perth</td>
<td>36</td>
<td>Construction materials, silica &amp; limestone sand 100%</td>
</tr>
<tr>
<td>Great Southern</td>
<td>6</td>
<td>Spongelite, silica and limestone sand 100%</td>
</tr>
</tbody>
</table>

Generally people classify minerals into rock forming minerals and ores. Ores are minerals which can be mined for profit but are a very small percentage of minerals on Earth.

Students could be asked to report on the major mineral resources of three regions of WA (excepting Peel and Perth)
How a rock, sediment or mineral is made can control how and why we use it.
Limestone is a biogenic sediment. It formed from calcium carbonate in shells of marine organisms. Often it is further changed geochemically by groundwater.
The Roundhouse in Fremantle was built from Tamala limestone because it is soft and easy to carve into blocks using simple hand tools and man power provided by convicts. It was light, cheap and locally available.
Unfortunately these characteristics make it prone to weathering. Its porosity and permeability also makes rising damp a problem.

<table>
<thead>
<tr>
<th>Material used</th>
<th>Earth process which created it and why it is useful for this purpose</th>
</tr>
</thead>
</table>
| Granite for use in kitchens, bathrooms and monuments. | Melting to form igneous rock. Interlocking hard crystals make it a hard impermeable rock which polishes into a smooth attractive surface.  
**Igneous rock (Felsic, intrusive)**                                                                   |
| Sand for laying under cement as a house pad.       | Weathering, erosion and deposition produces silica rich medium sized clasts. Sand is porous and permeable allowing water to drain away. It is easily shaped into the base on which to build a house.  
**Sediment**                                                                                           |
| Clay for pipes, roofing tiles, bathroom furniture and fittings. | Weathering, erosion and deposition of very fine alumina-silicate clasts (mud). The flat surfaces allow the clasts to be pressed together and moulded into different shapes before baking to become hard and reasonably impermeable.  
**Sediment**                                                                                           |
| Iron ore for structural steel.                     | Volcanoes erupt iron rich magma. This was weathered, eroded and deposited in ancient seas when there was little oxygen in the atmosphere to form BIF (Banded Iron Formations). This is dug up and sent to the foundry. Steel can be rolled into any shape required for frame construction. It is strong and reasonably resistant to weathering.  
**Mineral**                                                                                           |
| Marble for tiles and decoration.                   | Sedimentary limestone is taken down into the Earth and subjected to increased temperature and pressure (regional metamorphism). The rock partially melts and larger calcite crystals form. These crystals give marble its lustre. They are however relatively soft making the rock easy to carve and polish.  
**Metamorphic rock**                                                                                    |
### Sources of Resources – Teacher Notes

<table>
<thead>
<tr>
<th>Source of Resources</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Talc for toiletries and smoothing out paper.</strong></td>
<td>Talc forms when an ultramafic (extremely rich in iron and magnesium) rock undergoes regional or contact metamorphism. Very flat platy crystals make talc the softest mineral in Mohs scale. The soft flat crystals make it an excellent lubricant. It is not soluble in water and is used to fill gaps in paper and smooth out creases in skin. <strong>Mineral</strong></td>
</tr>
<tr>
<td><strong>Pumice for polishing.</strong></td>
<td>Pumice is a silica (quartz) rich and gas rich volcanic which is ejected from volcanoes. It chill instantly trapping the gas as “bubbles” within the solid rock. The rock is mostly silica, which is a hard and abrasive mineral. <strong>Igneous rock (Felsic, extrusive)</strong></td>
</tr>
<tr>
<td><strong>Quartz sands for glass making.</strong></td>
<td>Igneous rocks are weathered, eroded and deposited. Often winds or the sea separates out the minerals leaving almost pure quartz sand. This is melted at high temperature and poured or rolled into glass. Quartz is a hard mineral, 7 on Mohs scale, and its transparency makes it useful for windows and clear containers. <strong>Sediments</strong></td>
</tr>
<tr>
<td><strong>Slate for roofing</strong></td>
<td>Mudstone is regionally metamorphosed to form slate. The pressure aligns the minerals into plates which makes it fissile (able to be split into flat plates). Partial melting produces hard impermeable surfaces. <strong>Metamorphic rock</strong></td>
</tr>
<tr>
<td><strong>Dolerite for “road metal”</strong></td>
<td>Dolerite is an intrusive igneous rock which forms dykes and sills. It has interlocking crystals which makes it hard and has a high percentage of iron and magnesium making it dense. You need less dolerite to pack into road fill or rail base than most other rocks. Being igneous, it weathers slowly. <strong>Igneous rock (Mafic, intrusive)</strong></td>
</tr>
<tr>
<td><strong>Sandstone for water holding aquifers</strong></td>
<td>Weathering, erosion, deposition, compaction and sedimentation produce sandstone. Sandstone is both porous and permeable allowing rainfall to percolate down into it and collect for an aquifer (stored water resource). <strong>Sedimentary rock</strong></td>
</tr>
</tbody>
</table>
How a rock is made can control how and why we use it as a resource.
Limestone is a biogenic sediment. It formed from the calcium carbonate shells of marine organisms. Often it is further changed (geochemically) by groundwater.
The Roundhouse in Fremantle was built from Tamala limestone because it is soft and easy to carve into blocks using simple hand tools and man power provided by convicts. It was also light, cheap and locally available.
Unfortunately these characteristics make it prone to weathering. Its porosity and permeability also makes rising damp a problem.

Using you knowledge of rocks and earth processes (as well as the internet, if necessary) complete the following table:

<table>
<thead>
<tr>
<th>Material</th>
<th>Earth process which created it and why it is useful for this purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Granite for use in kitchens, bathrooms and monuments</td>
<td></td>
</tr>
<tr>
<td>Sand for laying under cement as a house pad.</td>
<td></td>
</tr>
<tr>
<td>Clay for pipes, roofing tiles, plates, bathroom furniture and fittings.</td>
<td></td>
</tr>
<tr>
<td>Iron ore for structural steel.</td>
<td></td>
</tr>
<tr>
<td>Marble for tiles and decoration.</td>
<td></td>
</tr>
</tbody>
</table>
## Sources of Resources - Student Activity

<table>
<thead>
<tr>
<th>Material</th>
<th>Earth process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Talc for toiletries and smoothing out paper.</td>
<td></td>
</tr>
<tr>
<td>Pumice for polishing.</td>
<td></td>
</tr>
<tr>
<td>Quartz sands for glass making.</td>
<td></td>
</tr>
<tr>
<td>Slate for roofing.</td>
<td></td>
</tr>
<tr>
<td>Dolerite for “road metal”.</td>
<td></td>
</tr>
<tr>
<td>Sandstone for water holding aquifers.</td>
<td></td>
</tr>
</tbody>
</table>
Aboriginal people are the descendants of an early wave of modern humans who moved out from the savannahs of Africa about 70,000 years ago, crossed the great grasslands of Asia and arrived on the northern shores of Australia about 40,000 years ago. They were hunter gatherers, the men hunting large game such as kangaroo, emu and turtles whilst the women hunted smaller game such as lizards and collected shellfish, seeds, fruit and roots. They moved constantly within their own part of the country following game, water and seasonal food.

**Stone tools**

Early humans studied rocks and found the best mineral to produce a sharp cutting edge or piercing point was quartz. Quartz occurs in many varieties. Vein quartz produces clear crystals and white masses.

Chert and flint are precipitated from silica rich solutions and form veins, fill cavities and replace masses in a variety of rocks. In warm conditions silica (SiO₂) will dissolve from rocks and move with groundwater to be deposited as hard mottled bands and nodules. When hit they produce a sharp curved conchoidal (shell shaped) fracture. Humans no longer had to wait and scavenge after carnivores had finished eating to gain meat. Sharp stones could pierce pelt and cut meat. Meat provides protein for brain and muscle development. Melting ice after the last glacial advance left vast savannas rich in grazing animals.
Core tools are made by knocking pieces away from the original rock whereas flake tools are worked slivers struck from the core. In both cases the original shaping would be made by hitting rocks together whilst the final shaping would employ a piece of bone or wood to nibble at the rough edges.

Discarded partly worked pieces of quartz (white) and chert (yellow) from Little Sandy Desert. These are flake tools with “nibbled” or reworked edges.

Aboriginal people rarely carried stone tools. Tools for butchering game would often be made from rocks found near that location. Larger stone tools such as seed or pigment grinding rocks would be left at site for use in later visits. In the absence of quartz, any fine grained rock including quartzite and dolerite would be used. For grinding seed and ochre such coarser grained rocks were preferred. Seeds were moved in a yandy or coolomon to separate sand and chaff from seed then laid on a flat rock and pounded and rolled by a round rock. Most tools were made close to the spot where they were needed and discarded after use. Larger tools such as grinders and anvil rocks were left in shady spots for re-use in later years. Any tools found in the bush may be photographed but should be left where they lie and reported to local elders.

More information on stone tool making can be found in the “Minerals and Crystals” package on the ESWA website. [http://www.earthsciencewa.com.au](http://www.earthsciencewa.com.au/) These free kits provide minerals, teacher’s guides and student activities and include locations of schools where they are currently held.

Rock knife courtesy of Michelle Proctor

An initiative supported by Woodside and ESWA
Aboriginal people chipped away oxidised rock to expose different coloured un-oxidised rock below. Oxidation proceeds very slowly allowing these petroglyphs to remain for many thousands of years. Since petroglyphs are often reworked in later years the cultural reason for their existence must have continued to be very important.

I managed to make one reasonable footprint similar to the one above using only a rock chipper. It took me over two hours in low temperatures with fresh water on tap. Working with heterogeneous rocks such as granite made me realise why the representations must be iconic. Detail is difficult to achieve and the general essence of the subject matter must be overt.

Burrup petroglyphs contain representations of animals like the thylacine which have been extinct from Western Australia for a long time.

Vikings, Celts, Gauls and other Indo-Europeans have used petroglyphs similarly in pre-historic times. In Europe the technique of sgraffito was used to decorate medieval houses and later became fashionable during the Arts and Crafts movement from the second half of the 19th and early 20th centuries. Layers of different coloured plaster were applied to the exterior of houses and artists cut through layers to form a cameo relief.

Students may wish to make their own replica petroglyphs using the sgraffito process. If this is an excitable class I recommend that the teacher mixes and dispenses the plaster of Paris or that it is prepared in a prior class.

Materials per student
- Access to pictures of Aboriginal petroglyphs or the internet
- Half a Petri dish, a a yoghurt pot lid or a small ball of plasticine to use as a mould
- Kitchen spray
- A small beaker or container to make the plaster of Paris mix
- 4 tablespoons full of plaster of Paris
- A spoon or stirring rod
Replica Petroglyph – Teacher Notes

- A little water
- Iron oxide or other colouring material. It is considered offensive for non-Aboriginal people or Aboriginal women to use ochres as pigments.
- A scraper or sharp metal nail

1. If using plasticine, mould it into a shallow dish shape
2. Spray the inside of the mould lightly with oil/kitchen spray if possible. It will prevent sticking
3. Use 2/3 of the plaster of Paris to make the first layer. Mix plaster of Paris and water to a custard consistency. Add sufficient oxide to make a rock-like colour.
4. Quickly spread the plaster over the base of the mould and leave for five minutes to become a little firm

**HINT** Vibrate the mould gently to flatten the plaster
5. Make a moister plaster mix with the remaining plaster of Paris but do not add colour
6. Spread a thin layer of white plaster over the earlier thicker base.

**Hint** The thinner the second layer of plaster is the easier the carving process.
7. Leave the plaster to set. It may take about twenty minutes.
8. Meanwhile research petroglyphs and decide what shape you will make for your own. It should be particularly significant to you. (My Scottish family have the crow as the source of our family name. We were masons and worked in quarries where crows are often found)

**Hint** Less artistically able people like myself find it easier to sketch an outline onto the dried plaster first.

![Replica Petroglyph Image]

These can be sealed using terracotta spray or ornamental sealer found in hardware stores. They make a fine display if stuck onto a card with the student’s explanation of their choice of shape below.
Aboriginal people chipped away oxidised rock to expose different coloured un-oxidised rock below. These petroglyphs remain for many thousands of years. Since petroglyphs are often reworked in later years the cultural reason for their existence must have continued to be very important. Vikings, Celts, Gauls and other Indo-Europeans have used petroglyphs similarly in pre-historic times. Later in Europe the technique of sgraffito was used to decorate medieval houses. Layers of different coloured plaster were applied and artists cut through layers to form a cameo relief. Students may wish to make their own replica petroglyphs using the sgraffito process.

Materials per student
- Access to pictures of Aboriginal petroglyphs or the internet
- A mould (half a Petri dish)
- Kitchen spray
- A small beaker or container to make the plaster of Paris mix
- 2 tablespoons full of plaster of Paris
- A spoon or stirring rod
- A little water
- Iron oxide or other colouring material.
- A scraper or sharp metal nail

1. If using plasticine, mould it into a shallow dish shape
2. Spray the inside of the mould lightly with oil to prevent sticking
3. Make the first mix of plaster of Paris and water, to a custard consistency. Add sufficient oxide to make a rock-like colour.
4. Quickly spread the plaster over the base of the mould and leave for five minutes to become a little firm
5. Make a moister plaster mix but do not add colour
6. Spread a thin layer of white plaster over the earlier thicker base.
7. Leave the plaster to set. It may take about twenty minutes.
8. Meanwhile research petroglyphs and decide what shape you will make for your own. It should be particularly significant to you.
9. Start scraping and chipping your replica petroglyph.
An Excellent Tool – Teacher Notes

Our pre-industrial agricultural ancestors across the world separated wheat from chaff, dried peas from their pods and seeds from soil using the local version of this tool. Flat shallow baskets of woven leaves were used by many early agricultural people for this purpose and are still in use in rural areas in Asia, Africa and South America.

Aboriginal people were hunter-gatherers and were constantly on the move to follow game and seasonal food. Tools needed to be multi-purpose to make them worth being carried. The yandy or coolomon shown in the picture below is a multi purpose woman’s tool which can separate sand from seed and husks from kernels. Its sharpened ends can be used as a digging tool and it was also used to carry babies, water and foraged food. They were often carved from trees where the softer heartwood had been eaten by termites or white ants. Men would use a large hand axe to cut the wood and smaller sharpened scrapers to complete shaping. Any holes could be plugged with melted balga (Xanthorrhoea preissii) resin or spinifex gum.

A Pitjantjatinjara (Western Desert) yandy with a large black lump of balga resin

The Australian continent separated from Asia before natural hybrid wheat appeared in the Middle East. Emmer wheat was unusual in that its grain ripened on the stalk. Armfuls of emmer could be cut, carried to a threshing floor and the wheatears knocked off by walking cattle over it. Australian grass seed does not stay on the stalk when it is ripe. It cannot be harvested by reaping and threshing. It must be won from the soil it has fallen on. Aboriginal women would use the yandy to pick up seed and sand and then move the mixture to separate seed. Women have wider set acetabula (hip joints) than men and they are more efficient “yandiers”. Many of our refugee students were raised to perform this task. They will also throw the material up in the air to let wind blow away lighter husks and dry leaves.

I recommend inviting Aboriginal women “aunties” to tell you more about this useful tool in your community and to demonstrate its use.

Using a yandy to separate seed and sand
Materials per student
- A yandy, laboratory tray, panning dish or meat tray. If supermarkets are given advance warning they may save the polystyrene trays they use to display prepared meats such as kebabs “for the children”.
- A mixture of materials to represent weathered clasts. I recommend using clean sand, white rice, dried peas and marbles as the size and colour difference make the process more obvious. For experts on a windy day add dried leaves or the paper chads left behind in the hole-punch machine.

An initiative supported by Woodside and ESWA
1. Place the materials in the yandy and mix until homogenous.
2. Hold the yandy lightly with one end slightly raised.
3. Gently swirl the materials within the yandy. It really doesn’t matter which movement you use as long as you are consistent so the forces are in a uniform direction.

During early rushes to the developing Goldfields Aboriginal women were stolen to “yandy” or “dry pan” soils and broken rock when there was not enough water to use for conventional panning. Miners would select promising rock and then crush it into smaller pieces in a “dolly pot” in much the same way as we crush spices with a mortar and pestle. The fine crushed material would be given to the girls who would place it in a yandy and toss it into the wind. Gold is very dense and would drop back into the yandy whilst some less dense materials would be blown away.

<table>
<thead>
<tr>
<th>Material</th>
<th>Density (g/cm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand</td>
<td>2.65</td>
</tr>
<tr>
<td>Fool’s gold</td>
<td>4.85</td>
</tr>
<tr>
<td>Lead</td>
<td>11.34</td>
</tr>
<tr>
<td>Gold</td>
<td>19.32</td>
</tr>
</tbody>
</table>

The mix would be yandied and mullock (non-ore bearing rock) would be picked out and removed. The remainder would then be panned using precious water to concentrate gold in a “tail”. Water was often more expensive than gold!

Gold panning in an Australian gully: [http://www.youtube.com/watch?v=fB1ndqTuze4](http://www.youtube.com/watch?v=fB1ndqTuze4)

Gold is still expensive. Lead is less so. Lead shot can be belted with a hammer and sprayed with gold paint to make small passable gold nuggets.

**Using a yandy to separate gold from mullock**

Materials per student
- A yandy or equivalent (See above)
- Sand and pebbles or road metal
- 20 Lead “gold nuggets”

1. Placed the mixed material into the yandy and shake moving consistently in one direction with one end slightly raised
2. Count how many “nuggets” can be easily picked out after two minutes.

**The story of McLeod and Yandeyarra Station**

When the armed forces returned to Australia at the end of World War 2, Aboriginal soldiers were not fairly treated. A Scotsman called McLeod organized some of the Aboriginal people from north of Newman in Western Australia. The groups walked across the Pilbara looking for minerals. At night they stopped and the women yandyed their finds to concentrate the ore. They raised enough money from selling metal ores to buy Yandeyarra cattle station north of Newman. It was the first Aboriginal owned cattle station in Australia.
Trapping game
Stone was used to construct walls for fish traps. Fish could enter at high tide but narrow stone lined channels trapped them when the tide went out. They would be speared or collected by nets at low water.

Starting fires, communication and firestick farming
Striking together fragments of vein quartz, chert or flint produces sparks. Fire was used to keep warm, cook food, to sharpen sticks for hunting and for communication. Dampier commented that as he sailed along the coast Aboriginal fires were lit on land marking their passage. Before different groups met they often introduced their approach by lighting a fire and waiting a little way off. About 40,000 years ago when Aboriginal people first arrived on our northern shores the climate became significantly drier. Aboriginal people used controlled fire to drive animals towards hunters. The fire also burnt off old tough vegetation and encouraged the growth of young fresh plants which then attracted more animals in later seasons. In the Pilbara it is estimated that some areas were burnt approximately every 10 years. It is thought that the combination of a change to drier climate at the end of the Ice Age and Aboriginal use of fire for hunting contributed to the demise of Australian megafauna and a change to more sclerophyll (dry leaf) eucalyptus vegetation. There are several sites on You Tube demonstrating how to light a fire using flint. Small sharp silica flakes fly off when the two rocks collide. **If you intend to demonstrate this to your students please ensure safety glasses, gloves and long sleeved shirts are worn.**

Blindness and scarring were not uncommon among native stone tool makers.

Shelter
Aboriginal people used caves to provide shelter. Some caves in the Kimberley have indications of regular use for over 30,000 years.

Art - Painting
Aboriginal people used ochres, weathered iron and aluminium rich rock as pigments for their rock, wood and body painting. The red, orange and yellow ochre would be ground between stones and mixed with fat, blood or milk. The paste would either be painted using fingers or chewed stick or would be blown from the mouth to produce silhouettes. White was obtained from clay and ash. Black was made from ground charcoal and clay. It is not considered proper for women or non-Aboriginal people to use ochre. However grout colouring purchased from hardware shops will produce the same effect without offense. PVA glue mixed with water helps the pigment to adhere.

‘Water in plenty’ from Punda, near Newman WA
Art - Petroglyphs (rock – drawing)
Petroglyphs are carvings inscribed into weathered rock surfaces. The Burrup Peninsula near Dampier displays some wonderful examples. The weathered surface is removed to reveal fresh rock underneath. There are notes and a student worksheet on petroglyphs in this package.

Petroglyph of Kangaroo. Burrup Peninsula

Water sources
Aboriginal people used soaks which occur where rain water ran from rock outcrops. They often indicated water by carving concentric circles into nearby rock. They also enhanced and covered hollows in the rock where rain water collected. These were called “Gnemma” holes after the snake spirit which was said to have gnawed them. The holes were covered by rock and sticks to prevent animals drinking or fouling the water. Some holes were filled with clean sand as this also reduced the rate of evaporation and stopped animals falling in.
Aboriginal people regarded themselves as guardians of water sources.
The picture on the left shows Walga rock in the Murchison. A large gnamma hole lies in front of a soak at the base of the granite rock. This good source of water made it a major meeting point for tribes in this region.

More information on Aboriginal perspectives on water can be found in the Year 7 WASP package.

An enigma
These curiously shaped elongate basalt pebbles were found in the McDonnell Ranges in Central Australia. The rock they are made from cannot be found within a hundred kilometres. Marks on the sides indicate they have been bashed together. When hit together a pleasant ringing tone is made. They may be tjuringa (story stones) or perhaps something else. They must have been important to have been carried so far.