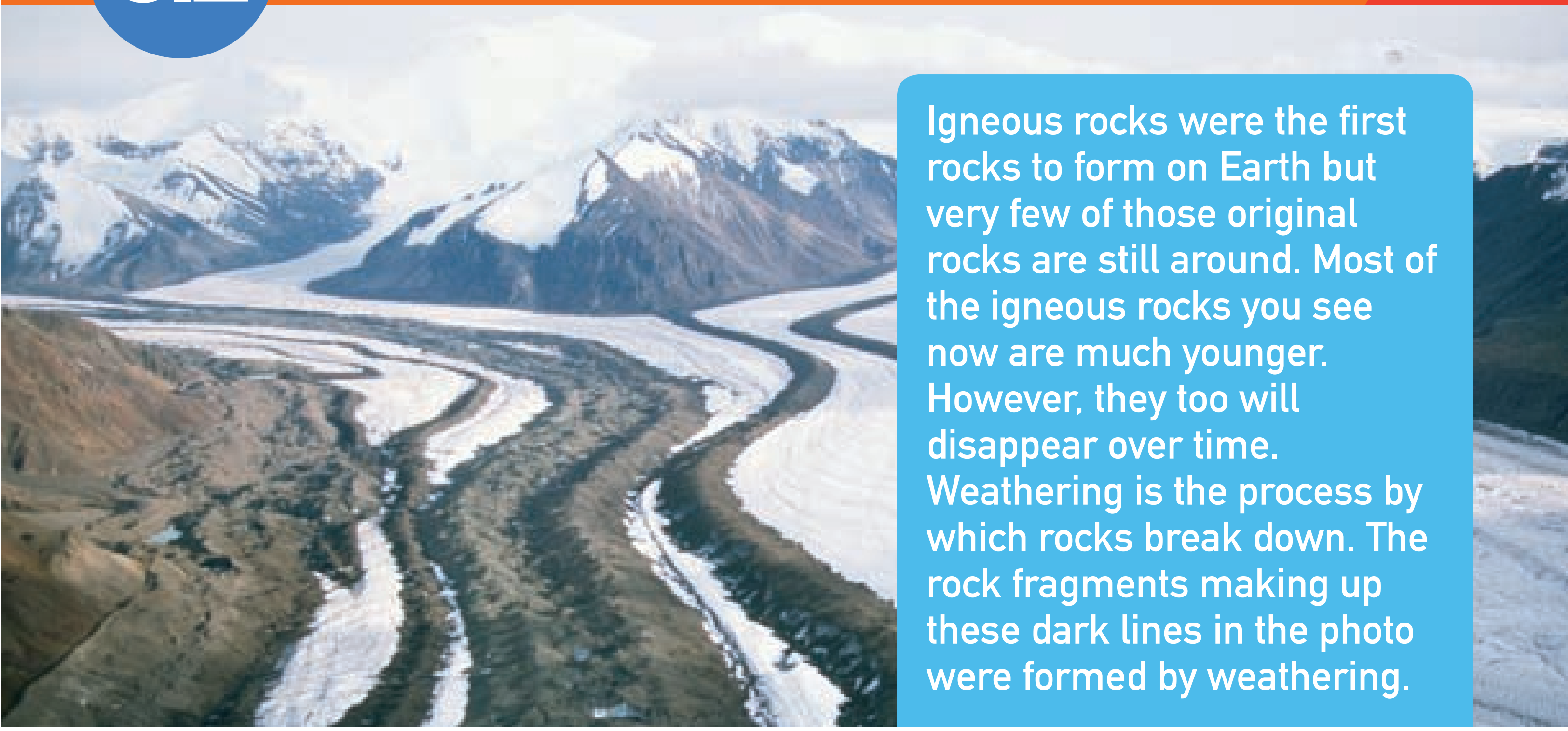
8.2 Weathering



Igneous rocks were the first rocks to form on Earth but very few of those original rocks are still around. Most of the igneous rocks you see now are much younger. However, they too will disappear over time. Weathering is the process by which rocks break down. The rock fragments making up these dark lines in the photo were formed by weathering.

Weathering

People often comment on the weather, complaining that it is too cold or too hot, too wet or too dry. In geology, a similar word is used but it has a very different meaning. **Weathering** in geology means the physical and chemical processes that break rocks down. Rocks do not last forever because weathering breaks them down into smaller pieces.

Figure 8.2.1 This large rock has been split by temperature changes.

Physical weathering

Weathering can happen because of:

- temperature change
- the action of water and ice
- crystallisation of salts
- wind
- living plants.

Weathering due to these processes is called **physical weathering**.

Temperature

Solids expand (get larger) when they are heated and contract (get smaller) when they are cooled. If the temperature change between day and night is very fast, this expansion and contraction can crack a rock. Once the rock splits, pieces can break off, especially if other physical processes are going on at the same time. Figure 8.2.1 shows where a piece of rock has broken away to expose a lighter grey, fresh rock surface. There are several cracks in the rock that show where pieces are likely to break away in the future.

Ice and water

Ice can split rocks by cooling them rapidly. Ice also widens cracks in rocks. This is because any water that enters cracks will expand if it freezes. This is common in colder climates and on the cold tops of hills and mountains.

Glaciers are like frozen rivers of ice that move along their valleys very slowly. As they move, the ice scrapes pieces off the surrounding rocks, forming valleys that are U-shaped, rather than the V-shape carved by a river. The sides of the valley have been worn away by the ice. Where glaciers merge together, there are often dark lines that show the tracks of the dark rock particles being carried by the glacier. You can see some in the opening photo on page 289 at the start of this unit. Figure 8.2.2 shows how a U-shaped valley forms. Glaciers are only found in extremely cold places. Today this means places such as Greenland and on high mountains such as in New Zealand. They also occurred in Australia in the past, when the climate was much, much colder.

Water running or washing over rock can also gradually wear away some material. The rate of the weathering depends on the type of rock and the speed and power of the water. Rivers can cut deep through rock, forming gorges. Pounding waves at the beach also have this effect. For example, the rock cliffs near the Twelve Apostles in Victoria have been weathered faster in some places and weathered more slowly in others, leaving rock stacks behind. Some are shown in Figure 8.2.3.

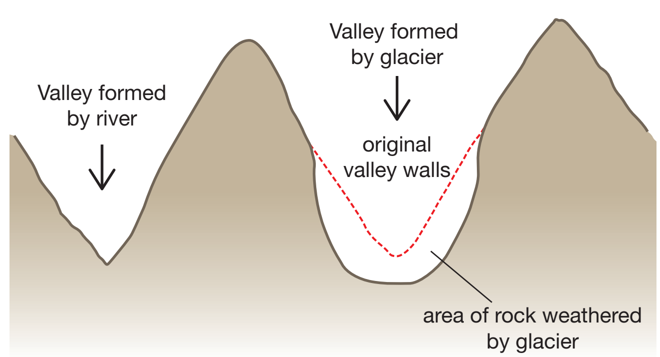


Figure 8.2.2 The characteristic U-shaped valley is caused by rocks being scraped away by a glacier.

Figure 8.2.3 The Twelve Apostles in Victoria show the effect of weathering by wave action. All will eventually fall into the sea. Weathering will also cause new ones to form.

Salts

Water in the soil often contains dissolved chemicals called salts. One example is common table salt—sodium chloride. Salts such as sodium chloride and calcium sulfate form crystals as the water evaporates. If the crystals form inside a rock, then the expanding crystals can put a tremendous pressure on the rock and can break pieces off it. A similar effect can occur in brick and limestone walls.

INQUIRY science 4 fun

Stretching water

Yes

What happens to water when it freezes?

Collect this …

- small narrow container like an egg cup or spice bottle (no cap)
- access to freezer
- water

Do this …

1. Fill the container right up to the top and place it in the freezer. Leave the top off.
2. Next day, check the container and observe the level of the ice at the top of the container.

Record this …

Describe what happened.
Explain why you think this happened.

Wind
Fine particles of rock carried by wind can cause physical weathering. These fine rock particles blast the rock surface, wearing pieces away.

Plants
As Figure 8.2.4 shows, plant roots can split rocks. They can grow through fine cracks, or even create their own cracks. As the root thickens, it splits the rock. Tree roots can be strong enough to seriously damage homes, paving and driveways.

Figure 8.2.4

Tree roots can split rocks and walls.

Chemical weathering
Chemical weathering involves water and chemicals in the water and air reacting with the rock and changing it.

Gases
Air contains oxygen and carbon dioxide, and both can react with certain types of rocks. These gases make the rock change to form different chemicals that do not hold together as strongly. This causes the rock to crumble. The colour of the rock often changes too. For example, you often see red colours wherever dolerite rock weathers. This is because the iron in the dolerite forms iron oxide, a red substance similar to rust. Its colour is clearly seen in the soil of Figure 8.2.5.

Acids
Rainwater contains dilute acids that attack the rock. The acids can naturally form in the air during lightning, but pollution also forms acids in the air. This is known as acid rain.

Figure 8.2.5

This red soil is the remains of dolerite after it has been chemically weathered.

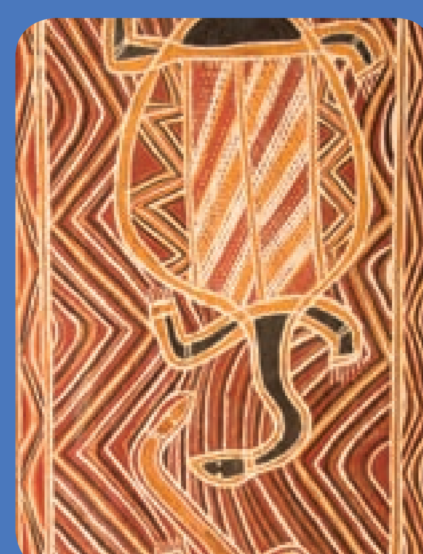
Water
Some rocks have soluble materials in them. This means that they can be dissolved by rain and running water, removing the 'cement' that holds the rock together. This can make the rock crumble.

1 p296

8.3

SciFile

Red ochre
Australian Aborigines discovered that some rocks break down into a red-coloured clay, called ochre. The red colour comes from the chemical weathering of iron-rich rocks to a rust-like iron oxide. Ochre can be mixed with other materials to change the colour and paint bodies and caves, and to make bark paintings.



Erosion

Small particles of rock broken off by weathering can be carried away by water, wind and ice. This removal of small rock particles is called **erosion**, and the water, wind and ice are said to be **agents of erosion**. Erosion is the carrying away of the particles, and is not the same as the weathering that breaks the particles off the rock in the first place.

The most common place that erosion occurs is on mountains or hills. This is because gravity makes water move more rapidly down a slope than on level ground.

Sedimentation

The small rock particles that are carried away from the weathered rock are eventually dropped somewhere. The process of depositing eroded rock particles is called **sedimentation** or deposition.

Sedimentation occurs where the moving water, wind or ice that is carrying the particles slows down. In the case of rivers, this slowing down occurs in the bends of rivers, and also where rivers leave the mountains and enter plains. There the rivers slow down dramatically and larger rock particles are deposited. A river slows and stops once it has entered a lake or sea, so the smaller particles can no longer be carried. This is why lakes gradually fill up with sediment, and why new land often builds up at the mouth of a river. Rivers can also break their banks in a flood and deposit sediment on any plains that surround them. Figure 8.2.6 shows how sediments build up in a lake.

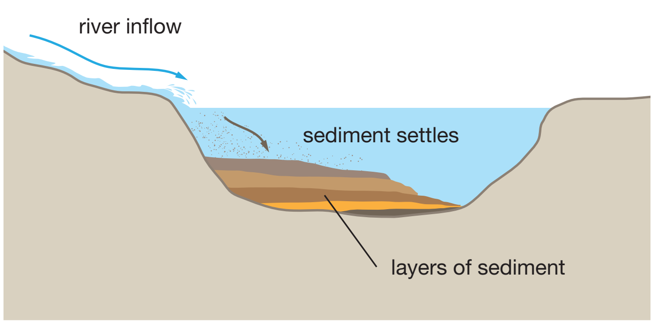


Figure 8.2.6 Sedimentation occurs where rivers slow down.

INQUIRY science 4 fun

Sedimentation

What happens when sediments settle in water?

Yes

Collect this ...

- 2 L soft-drink bottle with the top 5 cm cut off
- mixture of soil particles of different sizes, such as gravel, sand and clay

Do this ...

1. Do this outside. Pour water into the bottle to about 5 cm from the top.
2. Drop a handful or two of your mixed soil into the container and let it settle without moving the container. Observe what is happening and then observe it again after a few hours.

Record this ...

Describe what happened.
Explain why you think this happened.

Soils

Sediments are the basic components of soil. The other components of soil are living organisms (such as bacteria and fungi), decaying wastes, dead leaves, twigs and insects, water, dissolved minerals and gases.

Soils affect plant growth and are therefore vital for the survival of many organisms, including humans. Soils affect humans in other ways as well, since they form the foundations of all our buildings, roads, bridges, sporting fields and other structures.

Plant growth depends on several characteristics of the soil, such as its texture, structure, water-holding capacity, permeability and consistency. Several of these characteristics also affect buildings.

Texture

Texture is determined by the size of the particles that make up the soil. The main particles in soil are classified into clay, silt and sand (Figure 8.2.7). There are others as well, such as gravel. Clay and silt particles are tiny. There are hundreds to thousands more particles of clay and silt than sand in a spoonful of soil. Most soils have various combinations of these particles. For example, a soil described as 'clay' may be 40% clay, 40% sand and 20% silt.

One way that texture can affect plant growth is in its effect on plant nutrients in the soil. Clay is better than sand at holding onto and releasing minerals needed for plant growth. So plants usually grow well in soils that have some clay in them. One that is not growing well is shown in Figure 8.2.8.

8.4

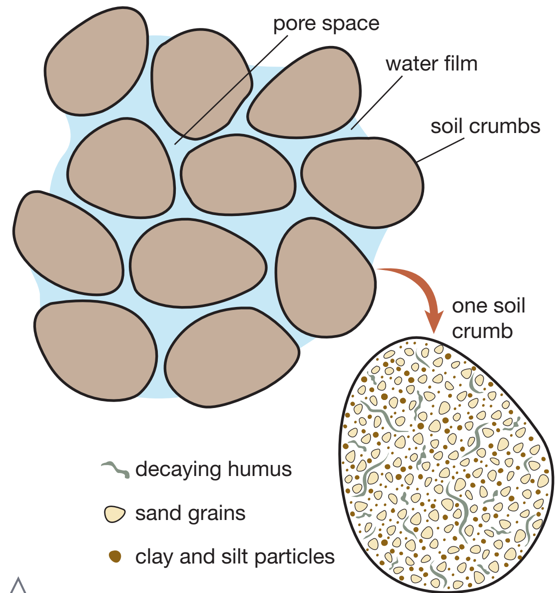


Figure 8.2.9 Soil structure is about how particles clump together.

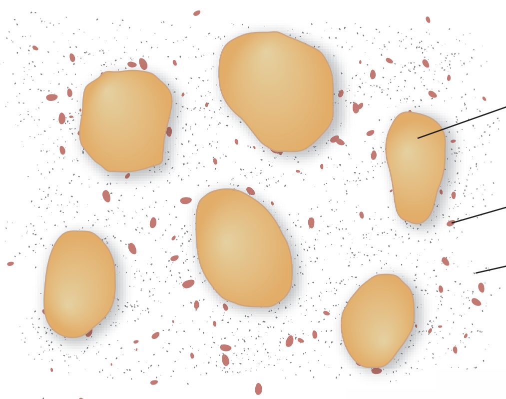


Figure 8.2.7 Soils are composed of particles of different sizes, such as clay, silt and sand.

Figure 8.2.8 Plants can wilt and die if soil cannot hold water or holds too much of it.

Structure

Structure refers to how well the soil particles join up to form soil clods or crumbs. In most soils these crumbs are 3–5 millimetres wide. The size is important because it allows spaces called **pore spaces** to exist between the crumbs. As Figure 8.2.9 shows, pore spaces let water and air enter the soil to improve plant growth.

SciFile

The Leaning Tower of Pisa

The Leaning Tower of Pisa in Italy was finished around 1272. Since then it has been sinking on one side because there was more clay in the soil on that side than the other. Changing water levels affected the clay, making the soil very unstable. Work done in the 1990s may have stopped the sinking.

Water-holding capacity

Water-holding capacity is a measure of how much water a particular amount of soil can hold. Some soils hold onto water very strongly, so strongly that it is hard for plants to extract the water they need from them. Soils high in clay are like this.

Some clay soils can expand when they are wet and contract when they are dry. This can damage buildings, making them crack and potentially unsafe. Many wet clay soils are weak and cannot support buildings. For example, bridges may have to be built on piles that are hammered into rock beneath the soil, as shown in Figure 8.2.10.

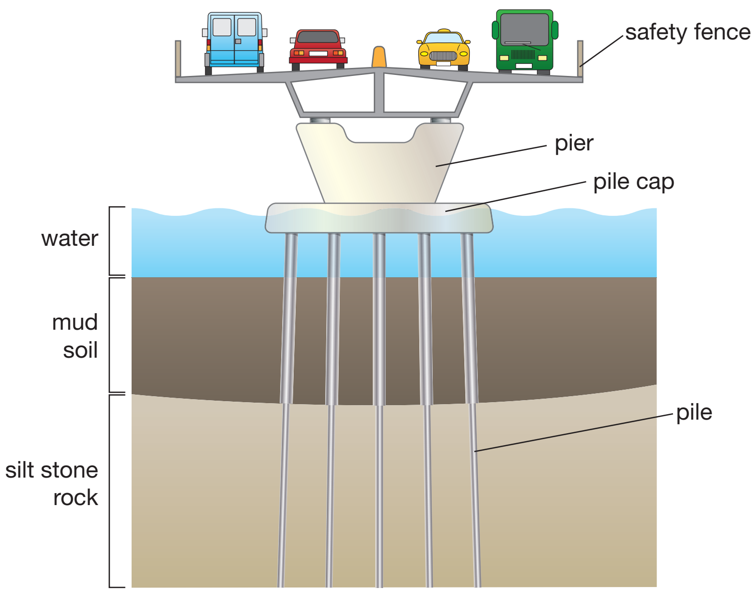


Figure 8.2.10 Piles anchored into rock can be used to support bridges and other structures built on clay soils.

Permeability

Permeability is a measure of how fast water enters the soil. If water enters the soil slowly and permeability is low, then the water is likely to run off and not enter the soil. This is a problem for farmers and gardeners because plants will dry out and die.

Consistency

Consistency is the tendency of soil particles to stick together. Clay particles are attracted to each other and stick together very well, while sand particles do not. In farming, mine rehabilitation and market gardening, soils are commonly compacted by vehicle wheels. The soil forms a layer that sets like concrete, preventing water and air from entering.

Consistency is important for sporting surfaces such as cricket pitches. A good cricket pitch should have about 50% clay. Watering and compacting the soil with a heavy roller makes it set to a hard surface that gives good bounce for the ball. This is being inspected in Figure 8.2.11. The soil also holds together so that it will last for several days.

Figure 8.2.11 Australian cricketer Ricky Ponting is inspecting a pitch that has just been rolled. You can see two different rollers next to the pitch.

8.2 Unit review

Remembering

1 **List** the main agents of:
  a physical weathering
  b chemical weathering.

2 **List** five characteristics of soils important for plant growth.

3 **List** the agents of erosion.

Understanding

4 **Define** the following terms.
  a weathering
  b sedimentation

5 **Explain** why igneous rocks exposed at the Earth's surface are not identical to how they were just after they were formed.

6 **Explain** how temperature change and water can split a rock.

7 **Explain** why sediments carried by a river will be deposited when the river flows into a lake or sea.

8 **Explain** what is meant by *soil structure*.

9 Plant growth is affected by soil texture, structure and consistency. **Explain** how.

Applying

10 Figure 8.2.12 shows a satellite image of the coast of New South Wales.
  a **Identify** the process occurring in this photograph.
  b **Explain** what is happening.

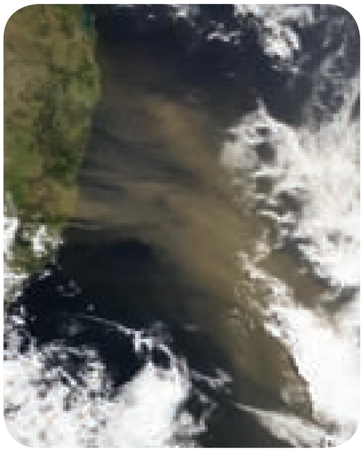


Figure 8.2.12

11 Builders should know something about rocks and soils. **Apply** what you have learnt in this unit to **explain** why.

Analysing

12 **Contrast** a crumb and a particle of rock in soil.

13 **Compare** erosion and weathering.

Evaluating

14 **Propose** ways in which you could minimise soil erosion when camping, bushwalking or boating.

15 When a hilly area is excavated (dug out) to make a road, exposed banks are often left along the side. Workers sometimes cover these banks with various materials, such as a spray-on paper-like material that has plant seeds mixed with it. **Propose** reasons why they do this.

16 a **State** what caused the grey colouring in the rock in Figure 8.2.1 on page 289.
  b **Propose** what caused the red colouring.

Creating

17 **Construct** a poster informing home gardeners of the differences in soils that may affect their garden plants.

Inquiring

1 Design an investigation to demonstrate erosion caused by water as it runs across different soil types. You need to be able to test how the slope of the land affects this.

2 Design an investigation to compare the amount of pore space (air space) in sand and clay soils. Equipment that would be useful is two measuring cylinders, a beaker, some water and different soils. Show your procedure to your teacher and ask them if you can try your experiment.

3 Find a container of plant fertiliser and read the label to find out what plant nutrients are in the container. Pick three nutrients and research why they are needed by plants. Present your findings in a table or about ten lines of writing.

4 Research erosion of soil on farms and the methods farmers use to reduce the effects of erosion.

5 Research the preparation of a turf cricket pitch and explain the characteristics of soil that affect how a pitch performs.

8.2 Practical activities

1 Simulating weathering

Purpose
To investigate how ice and chemicals can cause weathering.

SAFETY
Do not mix plaster with bare hands.

Materials

Part A: The effect of acid and water
- 6 test-tubes and a test-tube rack
- 2 small samples each of granite, limestone and sandstone (to fit test-tubes)
- vinegar

Part B: The effect of temperature
- 2 margarine containers or milk cartons
- small water balloon
- plaster of Paris
- spoon or spatula

Procedure

Part A: The effect of acid and water
1. Label your test-tubes 1 to 6. Put small samples of granite into test-tubes 1 and 2, limestone in test-tubes 3 and 4, and sandstone in test-tubes 5 and 6 as shown in Figure 8.2.13.
2. Add water to test-tubes 1, 3 and 5.
3. Add the vinegar to test-tubes 2, 4 and 6.
4. Leave the test-tubes in the test-tube rack and record any observations. Leave them set up overnight or until your next science class.

Part B: The effect of temperature
5. Mix up enough plaster with water to half-fill two margarine containers or cut-down milk cartons.
6. Fill a small balloon with water and tie it. Push the balloon into the plaster in one container and keep it below the surface until the plaster sets.
7. At the end of class, put both the margarine containers or cut-down milk cartons in the freezer.

Results
Record your observations next class for the test-tubes and the containers in the freezer.

Discussion
1. a **Describe** what happened to different rocks when placed in the acid.
   b **Use** this observation to **explain** weathering of rocks by chemicals.
2. a **Describe** what happened to the plaster and the jar left in the freezer.
   b **Explain** what happened.
3. **Explain** why this experiment is relevant to the weathering of rocks.

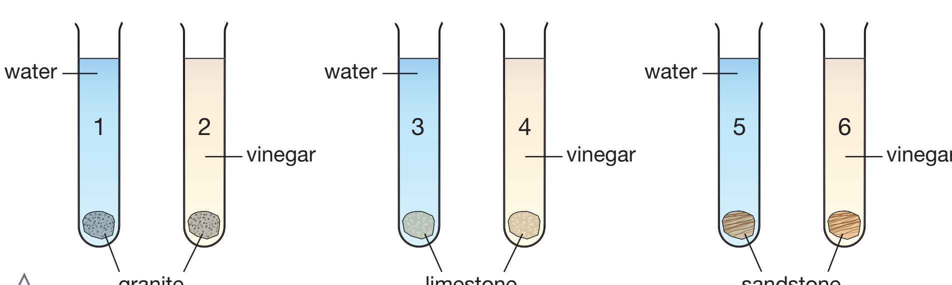
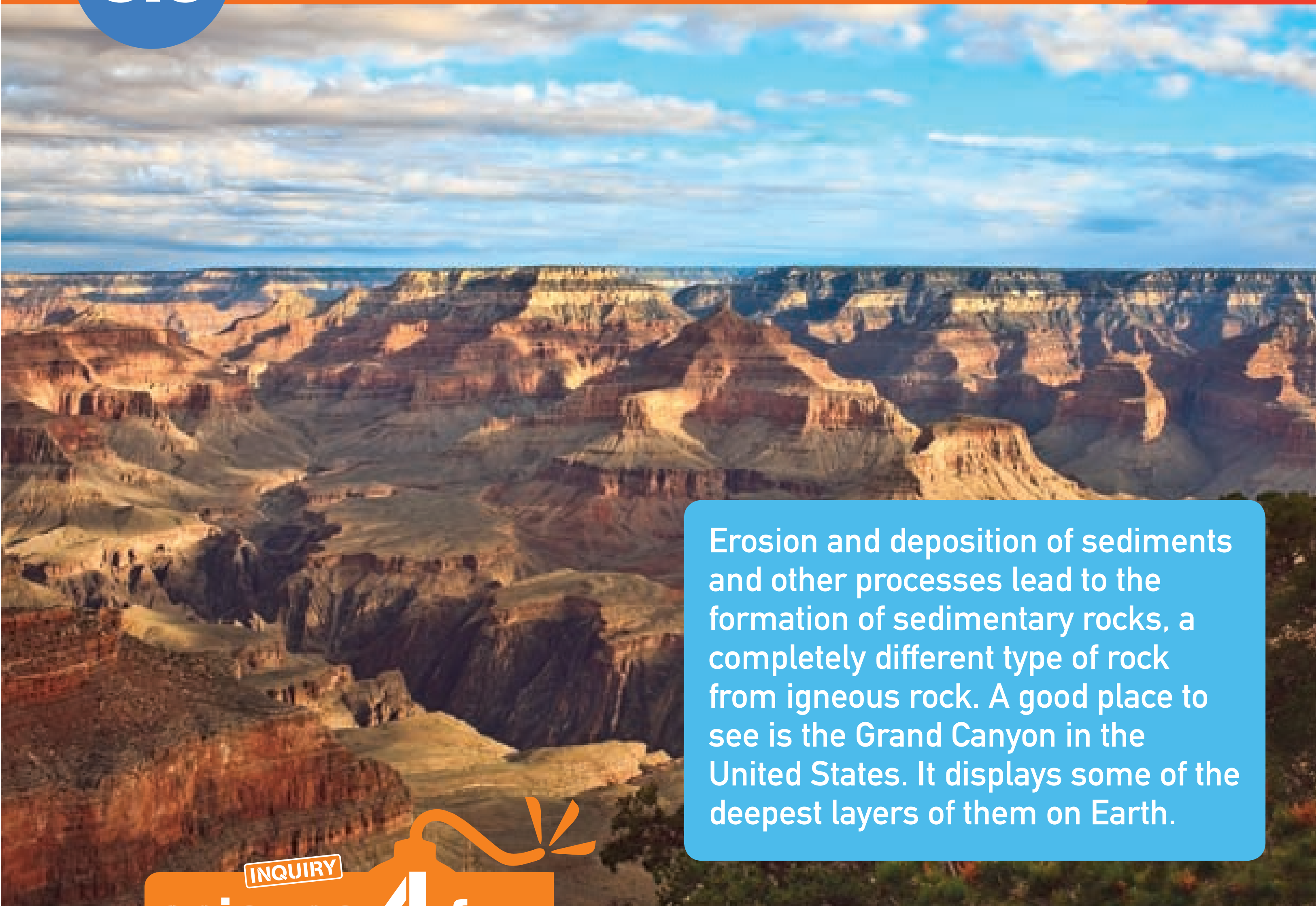


Figure 8.2.13

8.3 Sedimentary rocks



Erosion and deposition of sediments and other processes lead to the formation of sedimentary rocks, a completely different type of rock from igneous rock. A good place to see is the Grand Canyon in the United States. It displays some of the deepest layers of them on Earth.

INQUIRY **science 4 fun**

Plaster rocks

What can plaster do to pieces of rock?

No

Collect this …

- half a margarine container of small rock pieces of fingernail size
- spatula
- plaster of Paris

SAFETY
Do not mix plaster with your bare hands.

Do this …

1. Place enough plaster in the container to fill all the gaps between the rocks. Pour in water a little at a time while mixing until the mixture is like cream. It must not be runny or it will take a long time to set. Leave the container to set.
2. When the contents look as though they have set hard, remove the mixture from the container by tipping it upside down and tapping the bottom hard.
3. Try to bend the solid mixture to see how strong it is.

Record this …

Describe what happened to the mixture and how strong it was.
Explain why you think this happened.

How sedimentary rocks form

As the name suggests, **sedimentary rocks** are rocks made from sediments. To form the rock, the sediments need to be cemented (stuck) together somehow. This occurs through pressure and because there are substances in rocks and soil that act as natural cements. One type of cementing material is plaster of Paris. This is used in making plaster casts for broken limbs, and for fixing internal walls in homes. Plaster of Paris comes from heating gypsum, the common name for the mineral calcium sulfate, which occurs naturally in the ocean, groundwater and many rocks. Gypsum can cement sediments to form rocks.

Sedimentary rocks are classified by their type of sediment. There are three basic types of sediment:

- from pieces of weathered rock
- from minerals crystallising from solution
- from dead animal or plant material.

Weathered rock sediments

Weathered rock sediments are the sediments from weathering of rocks. The weathered rock can be from any type of rock. Sedimentary rocks formed from weathered rock sediments are known as **clastic sedimentary rocks**. Within the sediments you can sometimes find fossilised remains of long-dead organisms. **Fossils** are preserved remains of organisms that were once living. You can see a fossil in Figure 8.3.1.

Figure 8.3.1 This fossilised lizard was found in a limestone quarry in Germany.

Natural cements are chemicals that can flow around the sediments and then set like cement. Natural cements include calcium carbonate (calcite), silica, quartz, iron oxide and clay minerals. Portland cement (used in bricklaying and to make concrete) is made from natural cements that contain silica. The cements set because the rock layer is squashed under pressure from the weight of all of the sediment above. This squeezes out the water in the sediment layer and lets the cementing agent solidify (Figure 8.3.2).

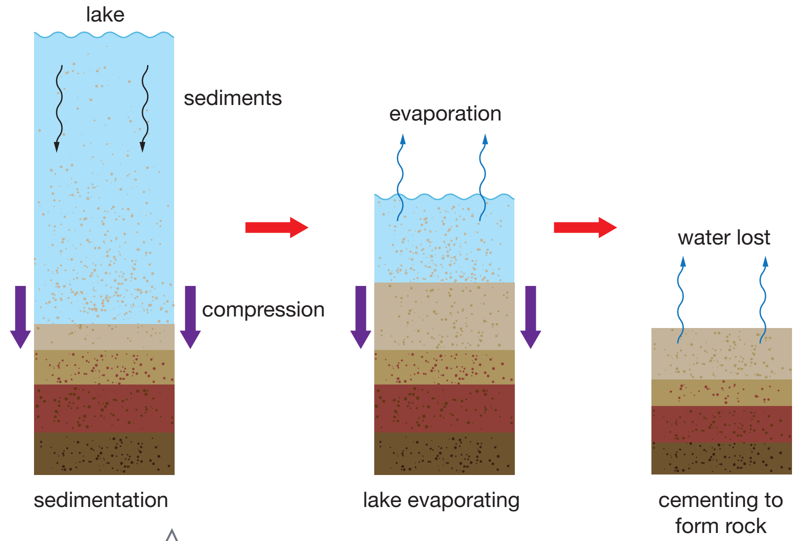


Figure 8.3.2 Formation of clastic sedimentary rock involves sediments, cement and pressure.

Chemical sediments

Chemical sedimentary rocks form when materials dissolved in water come out of solution, form a solid and sink to the bottom. This process is crystallisation, in which the dissolved minerals turn into solid crystals as the water evaporates. This process is shown in Figure 8.3.3.

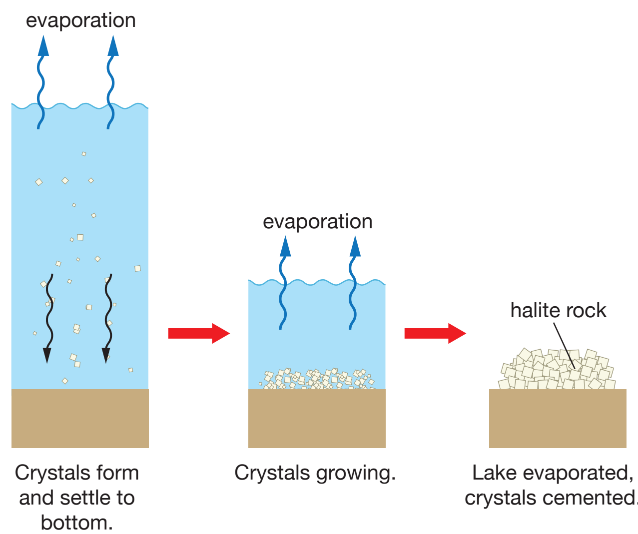


Figure 8.3.3 Chemical sedimentary rocks form by evaporation and crystallisation.

SciFile

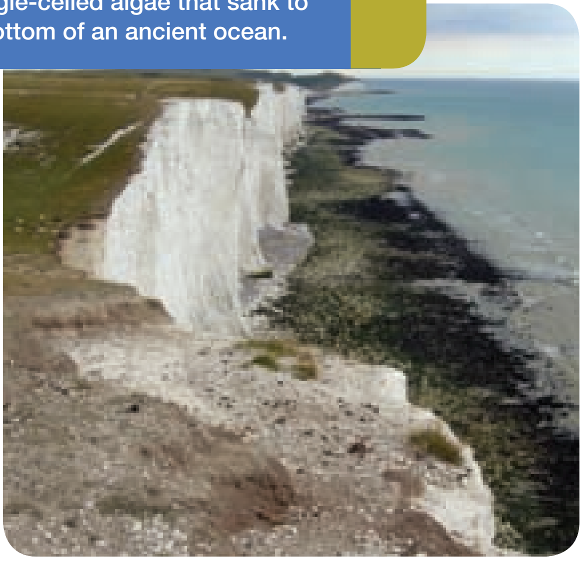
Fibre optic rock

A chemical sedimentary rock called ulexite has amazing properties. Ulexite transmits light and images just like a fibre optic cable. Fibre optics have many uses including communication and decorations. A call from your mobile phone is coded into light signals that are passed along a fibre optic cable between the mobile phone towers.

The White Cliffs of Dover

SciFile

The English town of Dover is famous for its white cliffs. The cliffs are about 100 metres high. They are composed mainly of soft sedimentary limestone and are commonly called chalk. The limestone came from the skeletons of single-celled algae that sank to the bottom of an ancient ocean.



Organic sediments

Organic sedimentary rocks form when dead plant matter or animal debris accumulates and is then cemented together. The sediments are mostly from organisms, but there may be small amounts of clastic sediment. The formation of organic sedimentary rock is shown in Figure 8.3.4.

1 p303

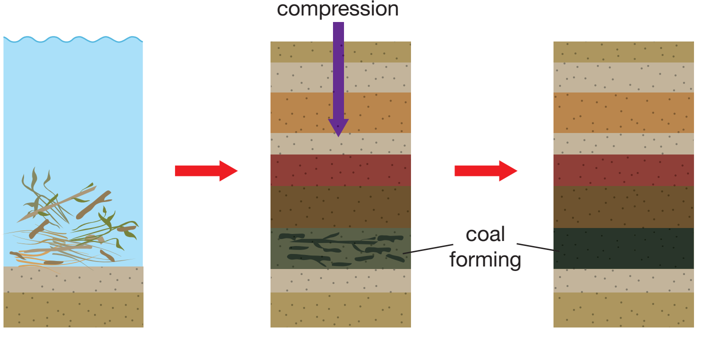


Figure 8.3.4 Coal is an organic sedimentary rock.

Characteristics of sedimentary rocks

There are three different types of sedimentary rocks:

- clastic
- chemical
- organic.

All have different characteristics because they were formed in slightly different ways.

Clastic sedimentary rocks

Clastic sedimentary rocks have the following characteristics.

- They have layers like a stack of pages or books because the sediments build up one on top of the other as they are deposited. You may not see layers in a small piece of rock, but they are obvious when you are looking at several metres of a rock face.
- The grains do not interlock because they did not crystallise and grow together in the rock. They were cemented together.
- The rock may contain fossils, such as shells. Dead organisms sometimes sink into sediments, especially in water, become covered by them, and are preserved in the rock.

These characteristics are summarised in Figure 8.3.5.

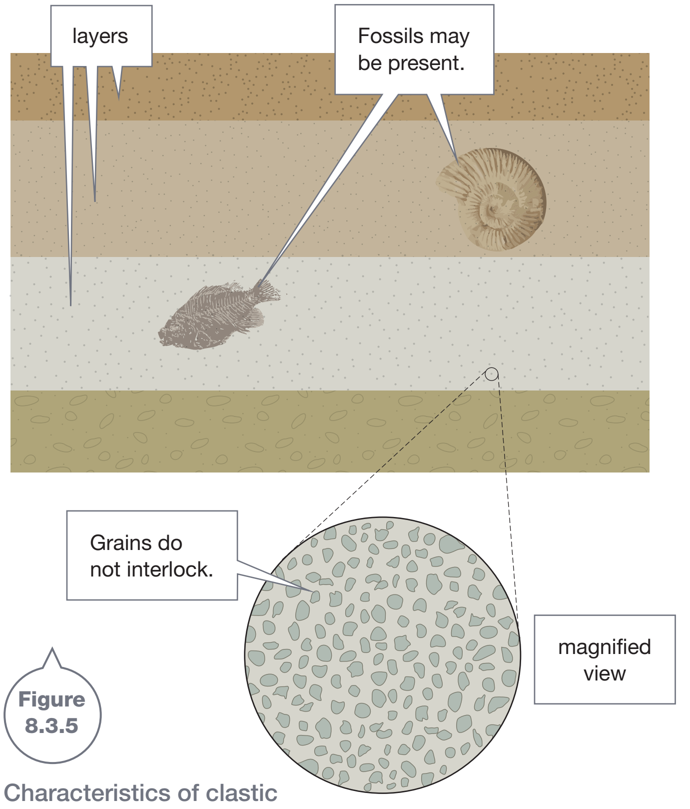


Figure 8.3.5 Characteristics of clastic sedimentary rocks

Clastic sedimentary rocks are classified mainly according to the size and nature of the rock grains and the chemical composition of the cement. You can see some in the photos in Figure 8.3.6.

Figure 8.3.6 Four different clastic sedimentary rocks

Chemical sedimentary rocks

Most chemical sedimentary rocks have crystals in them. Chemical sedimentary rocks are quite soft, and this helps to distinguish them from the much harder igneous rocks. It is rare to see any layering in chemical sedimentary rocks. Occasionally some contain fossils, but only as a small proportion of the rock. Figure 8.3.7 shows some types of these rocks.

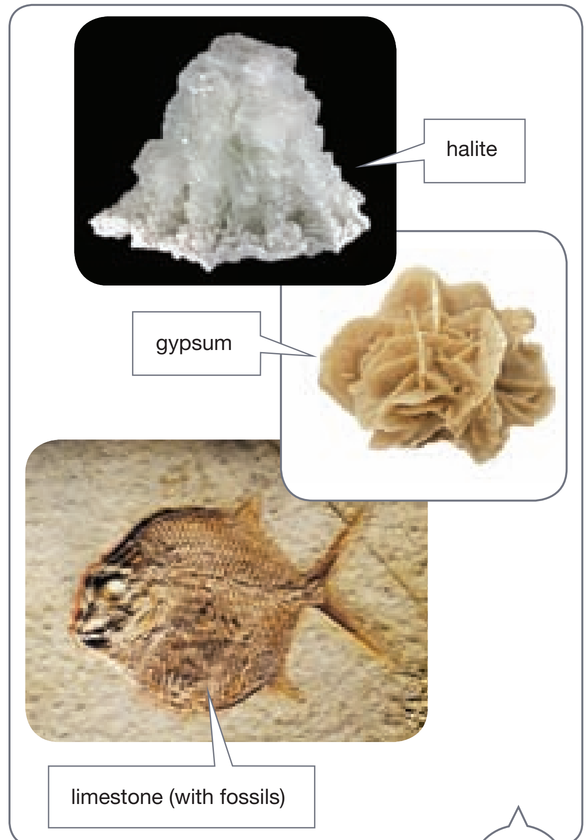


Figure 8.3.7 Chemical sedimentary rocks

Organic sedimentary rocks

Organic sedimentary rocks can be layered, depending on the way in which the fossils and sediments are deposited. They are usually soft, although a few such as chert (also called flint) can be fairly hard. Some examples are shown in Figure 8.3.8.

2 p304
8.5

Figure 8.3.8 Organic sedimentary rocks

Uses of sedimentary rocks

Sedimentary rocks have many uses because there are so many types with lots of different properties. The rock used in your area will depend on what stone occurs naturally near you. For example, sandstone is common in New South Wales, while limestone is widely available in Western Australia.

Limestone is often used in garden walls and paving such as that in Figure 8.3.9. It once was widely used in buildings (Figure 8.3.10), but is not used as much now because it weathers very quickly. It can also be used as a base for roads.

Figure 8.3.9 Limestone paving is often used around pools.

Figure 8.3.10 Limestone was once often used in buildings such as the Fremantle Prison in Western Australia.

Sandstone was often used in buildings in the early years of European settlement of Australia, particularly in Sydney. One is shown in Figure 8.3.11. Sandstone is more resistant to weathering than limestone but is still soft enough to cut easily and to carve. This means it is suitable for decorative ornaments. Sandstone is still used in external and internal walls, foundations and paving.

Figure 8.3.11 This government building in Sydney was built from sandstone in 1880.

In industry, sedimentary rock is used in many ways.

- Limestone is used in making cement, glass and steel.
- Sandstone is also used in making glass.
- Gypsum is used to make plaster.
- Rock phosphate (formed from ancient bird droppings) is used to make phosphate fertilisers.
- Coal (an organic sedimentary rock) is used for energy supply.

Some sedimentary rocks are used as a source of minerals, rather than the rock itself being used. Haematite is a mineral found in rocks and is a source of iron. Bauxite in rocks is a source of aluminium.

8.3 Unit review

Remembering

1 **Name** the three main types of sedimentary rock.

2 **List** natural cements found in clastic sedimentary rocks.

3 **State** the general characteristics of clastic sedimentary rocks.

4 **List** five sedimentary rocks and their uses.

Understanding

5 **Explain** how pressure from overlying sediments contributes to the formation of clastic sedimentary rocks.

6 **Explain** the reasons for the general characteristics of clastic sedimentary rocks.

Applying

7 **Use** your knowledge of chemical sedimentary rocks to **explain** how they may form in a salt lake.

Analysing

8 **Contrast** a breccia and a conglomerate.

9 Igneous rocks and chemical sedimentary rocks often have crystals in them. **Distinguish** between them.

10 **Classify** each of the following sedimentary rocks as clastic, chemical or organic.

- a mudstone
- b coal
- c chalk
- d gypsum
- e sandstone

11 Consider the following two facts about sedimentary rocks.

- Oil, gas and coal are only found in sedimentary rocks.
- Rock sediments contain fossil pollen grains from ancient plants now long extinct but that were common in the time that oil began forming.

Analyse these statements and **explain** how they may be used by geologists searching for oil, gas or coal.

Evaluating

12 Early colonial settlers in Australia built most of their houses from wood rather than stone. The stone buildings they did construct were often made from sedimentary rocks such as sandstone or limestone. The stone buildings lasted longer than the wooden ones, but some of these early stone buildings are badly in need of repair. **Propose** reasons for these observations.

Creating

13 **Construct** a table summarising the formation and characteristics of the three different types of sedimentary rocks.

Inquiring

1 Research how plaster of Paris and Portland cement are made, and how they relate to sedimentary rocks.

2 Early colonial settlers in Australia burnt oyster shells to make building mortar. Research why this was done, what a mortar is, and how the shell mortar worked.

3 Chemical sedimentary rocks often form in caves. Stalactites and stalagmites can be found in limestone caves. Research on the internet and explain how stalactites and stalagmites form.

4 Design an experiment to test out the strength of different proportions of Portland cement and bricklayers' sand mix as recommended on a bag of cement for various tasks. Ask your teacher if you can try the experiment, and then determine the strongest mix and compare it with the information on the bag.

8.3 Practical activities

1 Making sedimentary rocks

Purpose

To investigate what factors affect the strength of an artificial sedimentary rock.

Materials

- gravel (about 5 mm diameter) and bricklayers' sand mix
- blue metal (similar size to gravel) and bricklayers' sand mix
- bricklayers' sand
- plaster of Paris
- Portland cement
- ice-cream container
- 4 margarine containers
- spoon or spatula
- setting box (see Figure 8.3.12)
- water
- 250 mL plastic beaker with volume scale
- G-clamp
- 6×500 g mass sets
- wire 15cm long by 1.5mm thick
- old towels or foam rubber
- slops bucket at front of class

SAFETY

Do not mix cement or plaster of Paris with your hands. They can damage your skin.

Wear rubber gloves and safety glasses at all times.

Procedure

1 Each team in the class will be given one cement type (either Portland cement or plaster of Paris). Collect about 150 mL of your cement. Obtain about 100 mL of each of the three particle sizes in separate margarine containers.

2 For each margarine container, add 50 mL of your cement type. Mix with the spatula or spoon while dry. Slowly add water a little at a time while mixing until the particles are wet and stick together well. The mix should be like whipped cream rather than 'runny' like milk.

3 Transfer each cement–particle mix to a different section of the setting box. Label which is which. Leave the mixtures aside to dry for two days.

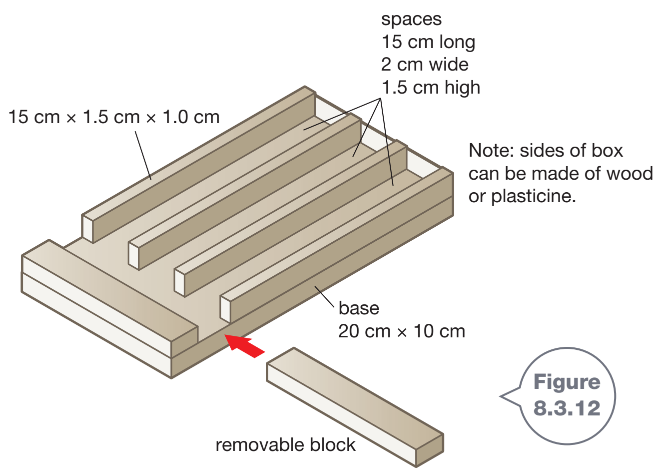


Figure 8.3.12

4 When your sedimentary 'rocks' are dry, remove them from the setting box.

5 Clamp one end of your rock to the edge of the bench, allowing about 8 cm to project over the edge. Loop the wire over the centre of the rock and attach the weight holder. Place the towels underneath to catch any weights that fall.

6 Add masses 100 g at a time until the 'rock' breaks. Make sure the rocks don't fall onto your feet. Copy the two tables shown below and enter your results in your Team results table.

Results

1 Record your team's results onto the class results table on the board.

2 Copy the class results into your workbook when all teams have entered their results.

Team results

Particle size	Mass added to 'rock' to just break it (g)
Gravel/sand	
Blue metal/sand	
Sand	

Class results: Average mass held before breaking (g)

Cement type	Particle size		
	Gravel/ sand	Blue metal/ sand	Sand
Plaster of Paris			
Portland cement			

Making sedimentary rocks continued on next page

Making sedimentary rocks continued

Discussion

1 a Considering only your team results, **assess** which rock was strongest and which was weakest.

b **Justify** your decision.

2 a Considering the class results, **assess** which rock was strongest and which the weakest.

b **Justify** your decision.

3 Portland cement and plaster of Paris both come from natural cements found in sedimentary rocks. Portland cement is used in making concrete and mortar for brick walls in buildings. Plaster is used to cover walls, fix decorative edges on ceilings, and make lightweight panels for inside walls on houses. **Explain** how this experiment relates to these building uses.

2 Observing sedimentary rocks

Purpose

To observe and describe different sedimentary rocks.

Materials

- stereo microscope and/or hand lens
- numbered set of sedimentary rocks such as breccia, conglomerate, sandstone, limestone, coal, shale, mudstone, rock salt and gypsum

Procedure

1 Choose a rock and write down its number. In a table like that shown on the right, write a brief description of what it looks like. (This is called a macroscopic view.) Note features such as colour, texture, layering and fossils.

2 Now take a microscopic view of the rock by viewing it with the microscope or hand lens. Try to determine if any grains are present. Note any grain colours, size and shape. Draw some grains.

3 Try to classify your rock into one of the three types of sedimentary rocks. Then give your rock a name.

4 Repeat with the next rock until you have examined them all.

Results

In your workbook, construct a table like the one shown below.

Rock number	Macroscopic view	Microscopic view	Classification

Discussion

Justify your classification of each rock.

8.4 Metamorphic rocks

Igneous and sedimentary rocks can be altered to form a third type of rock, known as metamorphic rock. Sometimes these rocks are very brightly coloured, and may contain precious minerals. Metamorphic rocks also weather and break down into smaller particles. This cycle of never-ending changes in rocks is called the rock cycle.

INQUIRY science 4 fun

Fire a rock

What happens to clay if you heat it?

Collect this …

- modelling clay
- ice-cream container
- spatula

No

Do this …

1. Make two identical models with your clay. Put one in a sunny place and take the other to the Art department to be fired in a kiln.
2. When the fired clay model is ready, compare it with the one that you left in the sunshine by trying to break a piece off each. See how strong the two pieces of clay are.

Record this …

Describe what happened.
Explain why you think this happened.

Formation of metamorphic rock

Metamorphic means that the rock has changed form. **Metamorphic rocks** form when high temperature and pressure alter existing igneous and sedimentary rocks. Metamorphic rocks can also be formed from other metamorphic rocks.

Rock changes into metamorphic form when it experiences intense heat and extreme pressure. These changes can be physical or chemical, and include the formation of new minerals not seen in igneous or sedimentary rocks. For example, garnets (Figure 8.4.1) and the precious gems sapphire and ruby occur in metamorphic rocks.

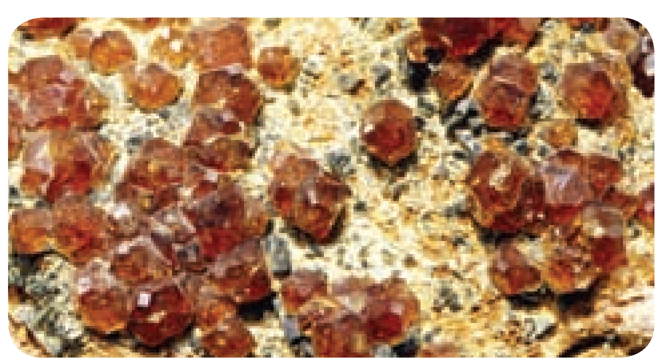


Figure 8.4.1 Garnets are semiprecious stones that can form in metamorphic rocks.

Types of metamorphism

Metamorphic rocks can be formed deep beneath the Earth's surface, where the pressure is very high. The great weight of the rock above means the pressure can be thousands of times greater than the pressure of the atmosphere at the Earth's surface. Pressure alone may be enough to alter some rocks.

It also gets much hotter as you go deeper and deeper into the Earth's crust and mantle. The temperatures may be hundreds to thousands of degrees. Heat alone can alter rocks. This suggests that most of the lower part of the Earth's crust is probably made of metamorphic rock.

Extreme heat and pressure can also be caused by movements within the Earth's crust. The crust is broken into massive plates larger than continents, called **tectonic plates**. These move around on the mantle, and can collide and scrape past each other, and are heated up and compressed in the process. Some parts of the crust may sink down under other parts.

Metamorphism over a wide area as described above is called **regional metamorphism**.

A second type of metamorphism occurs in rocks that come in contact with hot magma as it pushes through the mantle and crust. This type is called **contact metamorphism** and it occurs in particular local places on a much smaller scale than regional metamorphism. It means that metamorphic rocks can also form in the crust near the surface. The sites for metamorphism are shown in Figure 8.4.2.

Metamorphic changes

Heat and pressure can melt rock, causing a process called recrystallisation when new crystals grow as the rock cools down. When the rock is molten the particles can move around, and new minerals form in this process. That is why metamorphic rocks have many different minerals compared with igneous rocks.

SciFile

Lapis lazuli

Lapis lazuli is beautiful blue rock formed by contact metamorphism. In ancient Egypt it was used in jewellery and ornaments such as the necklace in Figure 8.4.3.

Figure 8.4.3

This ancient Egyptian necklace is made of lapis lazuli, gold and another metamorphic rock called turquoise.

Diamonds can be formed in metamorphic rock when parts of the crust become pushed into the mantle. The crust sinks to depths of over 150 kilometres, where the high temperature and pressure change the rock. At temperatures of about a thousand degrees, the carbon in the rocks can crystallise to form diamonds. The diamonds are carried back up to the surface millions of years later by rising magma. This magma then solidifies, meaning that diamonds are found in igneous rocks, even though they were not formed there.

Another metamorphic change is in the texture of the rock. Minerals in these rocks can become squashed into layers. Minerals forming under pressure may become squashed flat or into long needle shapes. The rock may then develop layers or bands in a process called **foliation**. The amount of banding depends on the amount of heat and pressure.

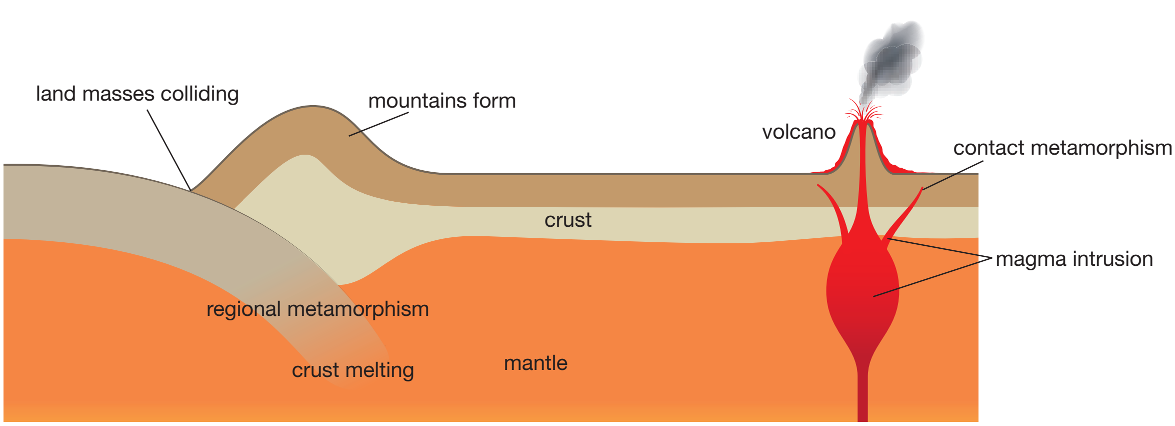


Figure 8.4.2

Metamorphic rocks form in two main ways.

The bands in a rock are not always straight. Pressure can squash and crumple them, causing the bands to be wavy. You can see this in Figure 8.4.4.

Figure 8.4.4 Some metamorphic rocks

Not all metamorphic rocks show bands. Metamorphic rocks without bands are known as non-foliated or unbanded. You can see some of the more common unbanded metamorphic rocks in Figure 8.4.6.

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Figure 8.4.6 Unbanded (non-foliated) metamorphic rocks

SciFile

Big diamond

The Cullinan diamond is the largest gem-quality diamond ever found. It was found in South Africa and with a mass of over 600 grams, the Cullinan diamond was cut into nine gems, the biggest of which are the Great Star of Africa (Figure 8.4.5) and the Cullinan II.

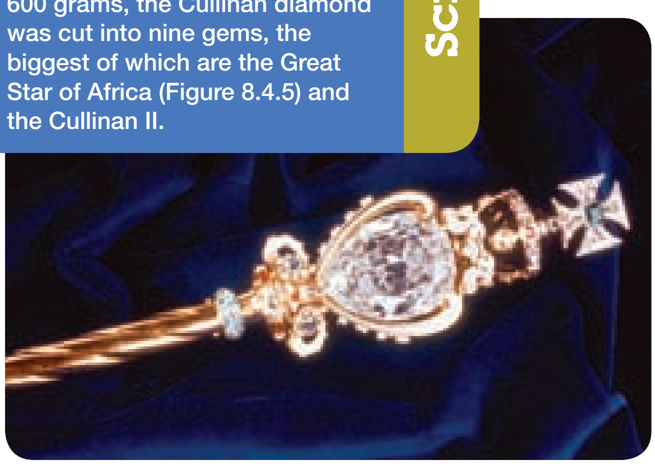


Figure 8.4.5 The Great Star of Africa (or Cullinan I) is part of the British Crown Jewels

Uses of metamorphic rocks

Metamorphic rocks are used for a variety of purposes. Some are shown in Figure 8.4.7 on page 308. Many metamorphic rocks are very hard and suited for building work. Gneiss and quartzite are good examples. Slate splits into flat sheets and is used for floors and roofing.

Many gemstones are found in metamorphic rocks, such as ruby, sapphire, turquoise, lapis lazuli, jade and garnet. These are all used in jewellery. Garnets are also used in abrasives. Diamonds are used as gemstones in jewellery and also on blades for power saws because they are the hardest natural substance. Diamond drill bits are used to cut through rock in oil exploration.

One widely used metamorphic rock is marble, which is used in sculptures because it is easily cut and carved. Marble is also used in building for walls and floors.

Quartzite is used in making glass because it has a high content of silica.

8.6

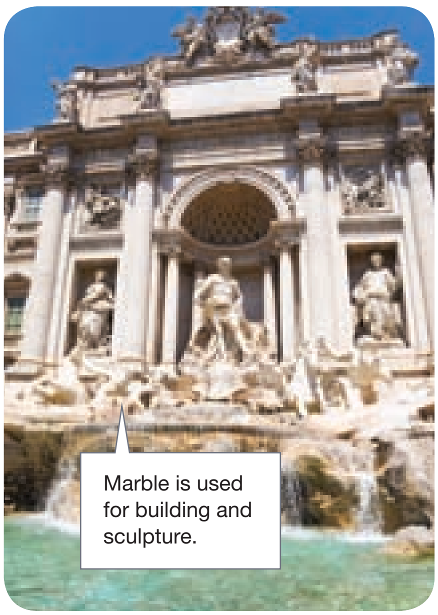


Figure 8.4.7 Metamorphic rocks are hard and beautiful, making them useful in buildings, sculptures and industry.

The rock cycle

The **rock cycle** is a model geologists use to explain the endless cycle of change that rocks undergo. Figure 8.4.8 shows how it works. Rocks do not always stay the same after they are formed. Weathering breaks them continually down into smaller pieces. These pieces are then carried away by agents of erosion (water, wind and ice). The pieces can be deposited as sediments and re-form into sedimentary rocks. Any rock can also be melted by magma and turned into a metamorphic rock. All these changes are part of the process called the rock cycle.

2 p310

8.7

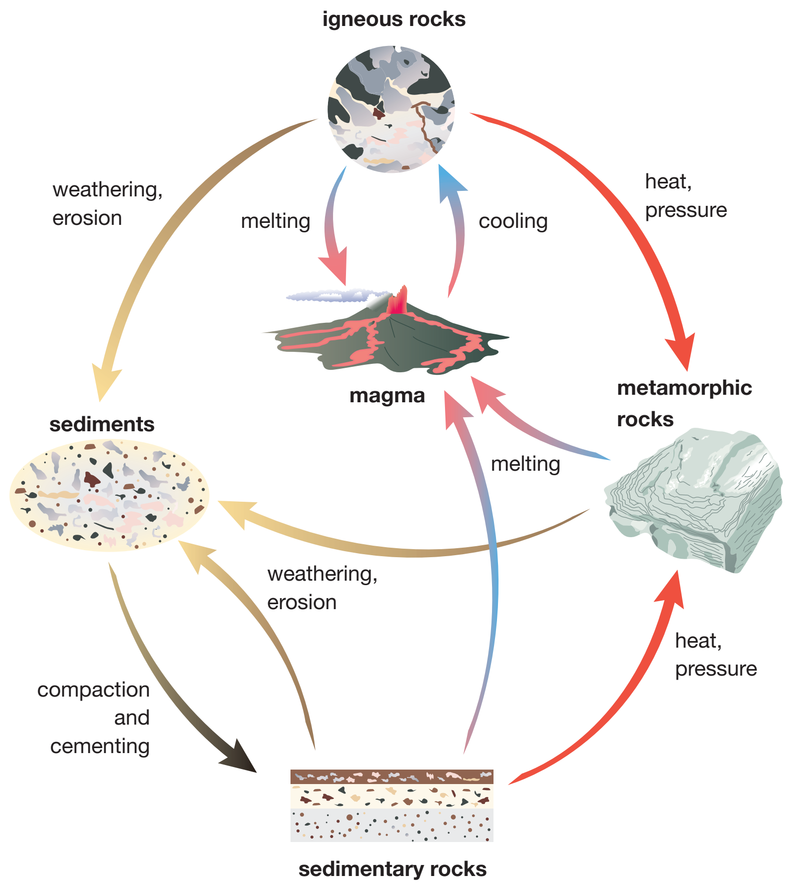


Figure 8.4.8 All the rocks of the Earth are part of the rock cycle.

8.4 Unit review

Remembering

1 **State** where metamorphic rocks form.

2 **List** the two main factors involved in forming metamorphic rock.

3 **State** the types of change that occur in rocks as they become metamorphic rock.

4 **Name** the model geologists use to explain the changes in rocks from one type to another.

Understanding

5 **Outline** the factors that affect the pressure acting on a metamorphic rock as it forms.

6 A cycle is something that returns to its starting point. **Explain** why the rock cycle is called a cycle.

7 **Explain** what occurs to turn a rock into a foliate (banded) rock.

8 **Explain** how heat energy and force are important in the formation of metamorphic rock.

- a **Name** the type of metamorphic process that forms lapis lazuli.
- b **Outline** how this happens.

Applying

9 It would be possible for metamorphic rocks to form at the Earth's surface. **Propose** how this might happen.

10 **Identify** what feature of a sedimentary rock would help you decide that it formed from weathering of a metamorphic rock.

Analysing

11 Consider the following description of a rock.

It is a light-coloured rock with white and grey crystals visible. The grains seem to be interlocking. It looks a bit like granite, but there are five wavy darker bands running right through the rock. The grains in the bands look like they are black or dark green. They seem to be very flat under the microscope, and fracture easily when they are squeezed by a needle. The flat dark crystals seem to be all lined up.

- a **Classify** this rock as foliate (banded) or non-foliate.
- b This rock is called a granite gneiss. **Identify** the feature that gives you a clue that this is a metamorphic rock.
- c **Contrast** this rock with granite, from which it was formed.

Evaluating

12 From the information in Question 11, **justify** your decisions by explaining how the rock probably formed.

13 Sometimes shale can turn into slate. Other times it may turn into schist. On other occasions again it can become another rock type called phyllite. **Propose** ways in which three different rocks could form from shale.

Creating

14 **Design** a rock cycle poster. Include on it diagrams or photos of some actual rock types. Include brief outlines of the process that formed each rock.

Inquiring

1 Lake Argyle Mine in Western Australia used to be the largest diamond mine in the world, but the diamonds are running out in this mine. Research how diamonds form and how diamond miners in Australia are searching for new sources of diamonds.

2 Research an Australian landform such as Uluru, the Olgas, the Warrumbungles or a different one if you prefer. Discuss the geological history of its formation. Include local Aboriginal views on the landform, and why it is an important area.

3 Research how Aboriginal Australians skilfully used rocks to make stone tools. Describe the types of rocks used and the process by which the tools were made by 'knapping' rocks together and by flaking with sticks.

4 Research and compare how long it takes for igneous, sedimentary and metamorphic rocks to form. Relate the time taken for formation of these rocks to processes such as weathering and erosion that are involved in their formation. A rock cycle diagram may assist you.

8.4 Practical activities

1 Metamorphic rocks

Purpose

To observe metamorphic rocks and compare them with their parent igneous and sedimentary rocks.

Materials

- labelled rock samples in containers: limestone and marble, shale and slate, shale and schist, granite and gneiss, sandstone and quartzite
- stereo microscope
- hand lens

Procedure

1. Use the microscope and hand lens to examine the rock samples.
2. Use the information in this chapter and any other information available to you to match each metamorphic rock to its parent rock.
3. For each pair of rocks, write the name of the parent rock first and describe its characteristics. Then do the same for the metamorphic rock.

Discussion

1. For each metamorphic rock, **describe** the characteristics that enable you to decide it is metamorphic.
2. **Explain** the changes that have occurred in each metamorphic rock as it altered from its parent rock.

2 Revising rocks

Purpose

To identify unknown rock samples as igneous, sedimentary or metamorphic and revise the characteristics of each group of rocks.

Materials

- numbered but unlabelled rock samples
- stereo microscope
- hand lens

Procedure

1. Choose a numbered rock sample. Your first task is to describe the characteristics of the rock. Use your microscope and hand lens to take a clear look. Then decide if it is igneous, sedimentary or metamorphic, recording your reasons in a table like the one in the results section. You may need to check the earlier units in this chapter again to remind you. If you feel confident, try to name the rock.
2. Repeat step 1 for each rock.

Results

In your workbook, construct a table like the one shown below.

Rock number	Descri-ption	Classif-ication	Reasons	Rock name

Discussion

1. **State** the characteristic features of each of the main rock types: igneous, sedimentary and metamorphic.
2. **Explain** how the rock cycle is relevant to this practical activity.

8 Chapter review

Remembering

1 **Recall** how each of the main types of rocks form by matching them with the best descriptions below.

igneous	layers
sedimentary	change
metamorphic	volcanoes

2 **Name** two igneous rocks that are:
  a intrusive
  b extrusive
  c dark-coloured.

3 **Name** two igneous rocks in which you cannot see crystals.

4 **Name** an igneous rock that is light enough to float in water and has holes in it.

5 **List** the general characteristics of igneous rocks.

6 **Name** two sedimentary rocks that are:
  a clastic
  b chemical
  c organic.

7 **Name** three metamorphic rocks that are:
  a foliated (banded)
  b non-foliated.

8 Choose three igneous, three metamorphic and three sedimentary rocks and **state** a use for each rock.

Understanding

9 **Define** the term *geology*.

10 **Explain** the difference in crystal sizes of intrusive and extrusive igneous rocks.

11 **Outline** the weathering processes that act on rocks.

12 **Describe** the process of sedimentation.

13 **Outline** the formation of clastic sedimentary rocks.

Applying

14 Choose three igneous rocks that have extreme differences in their appearance and **use** your knowledge of igneous rock formation to **explain** why they are like they are.

15 Choose three sedimentary rocks that have extreme differences in their appearance and **use** your knowledge of sedimentary rock formation to **explain** why they are like they are.

Analysing

16 **Compare** the formation of igneous, sedimentary and metamorphic rocks.

17 **Contrast** foliated (banded) and non-foliated metamorphic rocks.

Evaluating

18 Imagine you had to use rocks to build an important city office building that would last for generations into the future.
  a **Identify** suitable rocks for the walls, floor and roof.
  b **Justify** your choices.

19 **Propose** a reason why it is unwise to plant trees too close to a house.

Creating

20 a **Construct** a diagram of the rock cycle
  b **Explain** why it is a useful model in geology.

21 **Construct** a set of four cards. On each card, describe a type of rock without using its name. Write each rock on the back of the cards and swap with a partner. See if you can work out what rock each is without looking at the answer.

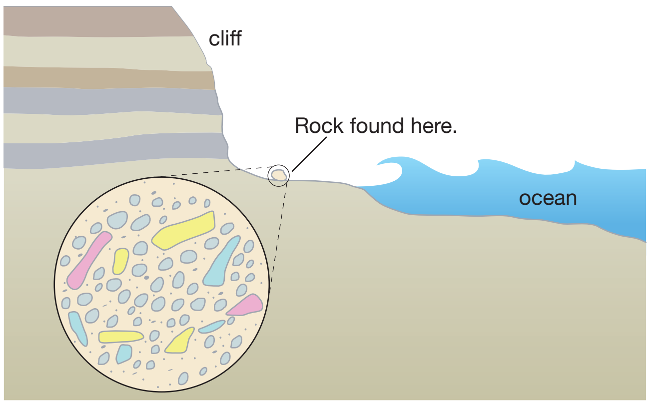
22 **Use** the following ten key terms to **construct** a visual summary of the information presented in this chapter.

rock cycle
sedimentary
igneous
metamorphic
weathering
erosion
sedimentation
crystals
soil
magma

8.8

Thinking scientifically

Questions 1 and 2 refer to the following information.



Q1 Clastic sedimentary rocks have the following characteristics.

- They have layers.
- The grains do not interlock because they were cemented together.
- They may contain fossils.

Which of the following is a good reason to classify the rock in the diagram as a clastic sedimentary rock?

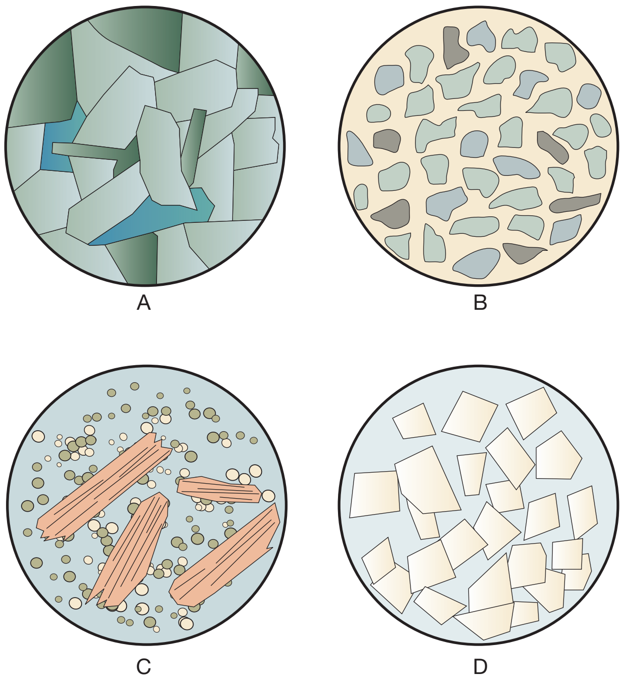
A The rock has layers in it.
B The grains are not interlocking.
C The crystals are large.
D There are no fossils in it.

Q2 Grains in a sedimentary rock may have travelled a long way or a short way from the parent rock before they formed the sedimentary rock. Some rocks contain all rounded grains (like little balls) that are all about the same size. These grains have travelled the furthest before being cemented into the rock. Other rocks have grains with sharp edges and grains of many different sizes. These grains have not travelled very far before being cemented into the rock.

Which of the following would probably be true for the rock found in the diagram above, based on the following information? It was shown to be identical to the rocks in the top layer of the cliff.

A The rock formed from grains that have travelled a long way from their parent rock.
B The grains are similar in size and therefore they were carried a short distance.
C The grains indicate the rock formed from sediments in the rock cliff.
D The rock was formed from parent rocks that were fairly close to the rock cliff.

Questions 3 and 4 refer to the following diagrams of rocks.



Q3 Choose the correct statement in the following.

A Rock A is igneous because the grains are interlocking.
B Rock B is igneous because the grains are angular.
C Rock C is an igneous porphyry because it is a mixture of large and small crystals.
D Rock D is metamorphic because the crystals are large and all the same size.

Q4 In the diagram, the rocks most likely to be sedimentary are:

A A and B
B A and D
C C and D
D B and C.

Glossary

Unit 8.1

Crystal: solid that has a variety of special shapes

Extrusive igneous rocks: igneous rocks that form on the surface of the Earth

Geology: the study of rocks, their history and the processes that form and change them

Igneous rocks: rocks formed from cooling magma

Interlocking crystals: crystals that lock together and grow into each other in a rock

Intrusive igneous rocks: igneous rocks that form below the surface of the Earth

Interlocking crystals

Lava: molten rock reaching the Earth's surface

Magma: molten rock that does not reach the Earth's surface

Mantle: layer of the Earth below the crust

Minerals: chemical substances found in rocks

Unit 8.2

Acid rain: rain water that includes acids from pollution in the air

Agents of erosion: factors that cause erosion—water, wind and ice

Chemical weathering: water or chemicals in the water and air reacting and breaking down rock

Consistency: the tendency of soil particles to stick together

Erosion: removal of weathered rock particles away from the site of the weathering

Permeability: a measure of how fast water enters the soil

Physical weathering: breakdown of rocks by physical processes

Pore spaces: the amount of space in the soil that could be filled with air or water

Physical weathering

Sedimentation: the process of water or wind depositing eroded rock particles

Structure: how well the soil particles join up to form lumps

Texture: the size of the particles that make up soil

Water-holding capacity: measure of how much water a particular amount of soil can hold

Weathering: the physical and chemical processes that break rocks down into smaller pieces

Unit 8.3

Chemical sedimentary rocks: sedimentary rocks that form when dissolved materials precipitate from solution

Clastic sedimentary rocks: sedimentary rocks made from weathered sediments of other rocks

Fossils: preserved remains of living organisms

Natural cements: chemicals that can flow around sediments in water and then set like cement

Organic sedimentary rocks: rocks that form by the accumulation of plant or animal debris, which is then cemented together

Sedimentary rocks: rocks made by sediments being cemented together

Unit 8.4

Contact metamorphism: metamorphism by contact with hot magma as it pushes through the mantle and crust

Foliation: process where minerals under pressure become squashed flat and the rock develops layers or bands

Metamorphic rocks: rocks formed when high temperature and pressure alter existing rocks

Regional metamorphism: metamorphism over a wide area below the crust caused by huge movements of the Earth's crust

Rock cycle: model geologists use to explain the endless cycle of change that rocks undergo as they change from one form to the other

Tectonic plates: massive plates that make up the Earth's crust