13 Rocks

Planning page

Getting started

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- Investigate 35 Looking at rocks
- Animation How sedimentary rocks are formed
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Main ideas
- Chapter 13 crossword

Review
- Chapter 13 test

Essential Learnings for Chapter 13

Essential Learnings	References		
	Student book (page number)	**Workbook (page number)**	**Teacher Edition CD (Assessment task)**
Knowledge and understanding *Earth and beyond* Geological evidence can be interpreted to provide information about past and present events	pages 277–278	page 100 pages 104–105	Assessment task 13 The rock cycle
Science as a human endeavour People from different cultures contribute to and shape the development of science	page 290		
Ways of working Evaluate data, information and evidence to identify connections, construct arguments and link results to theory	Investigate 33 page 279 Investigate 34 page 289		
Communicate scientific ideas, explanations, conclusions, decisions and data, using scientific argument and terminology, in appropriate formats		pages 102–105	

QSA *Science Essential Learnings by the end of Year 9*

Vocabulary

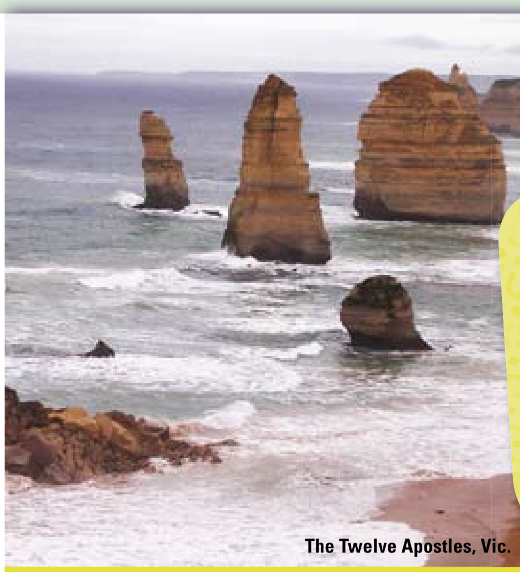
conglomerate
crystal
cycle
dormant
erosion
extinct
glacier
granite
igneous
limestone
lithosphere
magma
mantle
metamorphic
plutonic
pumice
quartz
sediment
shale
volcanic
weathering

Focus for learning

Infer the origin of several Australian landforms (page 275).

Equipment and chemicals (per group)

Investigate 33 page 279	two 250 mL beakers, burner, tripod and gauze mat, stirring rod, watch glass, styrofoam box or Esky, hand lens (optional), potash alum (aluminium potassium sulfate), copper sulfate
Activity page 280	samples of granite and basalt, hand lens and stereomicroscope, pieces of quartz, feldspar and biotite mica for the class to share
Activity page 283	plastic water bottle (never use a glass bottle) with tight-fitting lid
Investigate 34 page 289	**Part A:** sediment (mixture of dried mud, sand and gravel), clear plastic bottle with lid **Part B:** sand, gravel and clay, a range of cements (eg plaster of Paris), cement powder, PVA glue, PVC pipe, wooden dowel to fit inside pipe
Investigate 35 page 292	variety of rocks or rock kit, hand lens, table knife or metal spatula, 1 M HCl

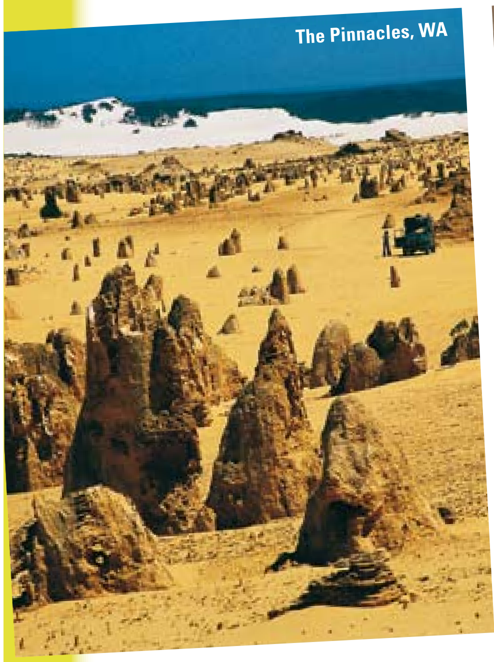

The Twelve Apostles, Vic.

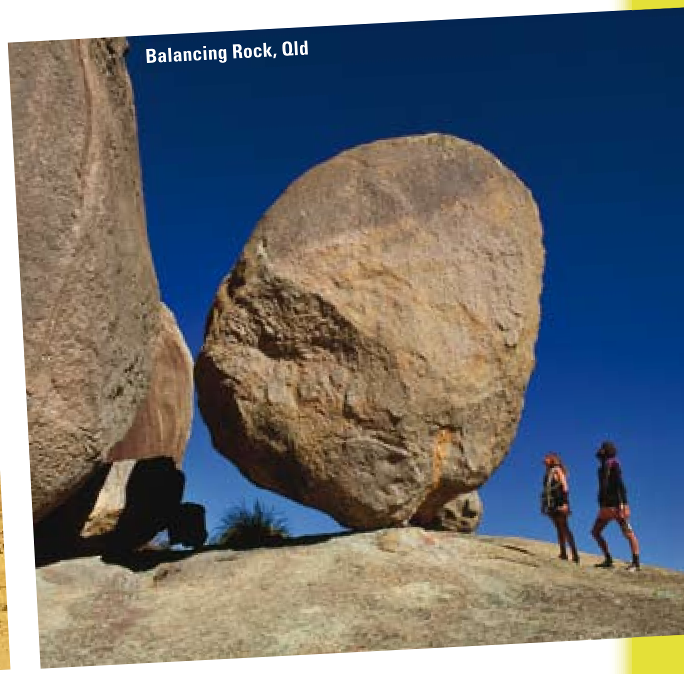
13 Rocks

Getting Started

If you travel around Australia you will see many interesting landforms.

- Working in a small group, study the three photos on this page and try to infer how each was formed. Keep your answers for further discussion later in the chapter (page 286).


The Pinnacles, WA


Balancing Rock, Qld

Starting point

Australia is a geologically diverse country and in this chapter students study and understand some of the interesting natural land formations, such as the Glasshouse Mountains, the Twelve Apostles, the Three Sisters and the Chillagoe-Mungana caves.

Start the lesson by displaying some interesting rocks and gemstones. Ask your lab technician for help in locating and laying out the specimens. If you don't have enough rock and gemstone specimens, search the web and make a PowerPoint display showing different natural land formations, rocks and gemstones.

Alternatively, you can ask the class to conduct a web search and collectively make a PowerPoint display, which can be screened for the whole class. You can allocate groups different things to find, eg landscapes, rocks, cliff formation, gemstones etc.

Ask the students to recall and list any rock formations they are familiar with in Australia, especially any local formations: for example Uluru, Kata Tjuta, Karlu Karlu (the Devil's Marbles), Wave Rock, the Organ Pipes.

Hints and tips

Remind students what an inference means in the context of science. Get the students to read the text on this page and count how many inferences there are.

13.1 Rocks from fire

Inside the Earth

Scientists infer that the Earth formed about 5000 million years ago from part of a cloud of dust and gas around the Sun. As the dust and gas started to cling together, a ball of hot rock formed. Scientists think that the Earth is still cooling down. It is a bit like a baked potato: the outside crust cooled first, but the inside is still very hot.

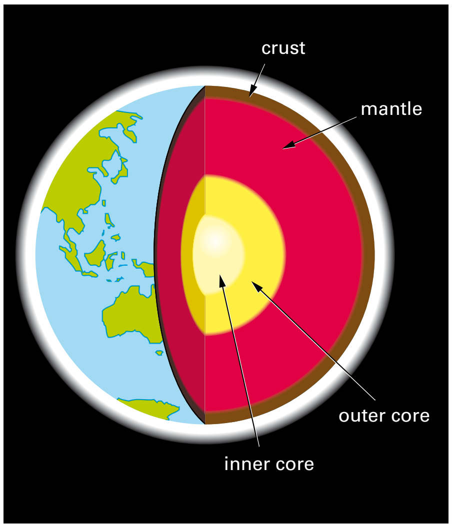


Fig 4 A cut-away view of the inside of the Earth

Scientists have never directly observed the centre of the Earth. They have observed molten rock from volcanoes, and have drilled holes to get rock samples from deep in the Earth's crust. They have also observed what happens to earthquake waves travelling through the Earth. From these observations they have inferred what is inside the Earth.

The evidence suggests that the Earth is not the same all the way through, and that there are layers, a bit like in a boiled egg. Scientists infer that there are four layers—the crust, the mantle, the outer core and the inner core, as shown above.

The *crust* is like a thin skin, with an average thickness of about 30 kilometres. (The distance to the centre of the Earth is 6370 kilometres.) Beneath the crust is the *mantle*—about 3000 km thick. It consists of solid rock, but under certain conditions it can bend and flow like a thick paste.

The crust and the top of the mantle is called the *lithosphere* (LITH-os-fear) which means 'rocky sphere'. Below the lithosphere the rocks are under immense pressure. They are very hot, and in parts molten. This molten rock is called **magma**. It also contains dissolved gases.

At the centre of the Earth is the *core*. Scientists infer that it is made of the same materials as in most meteorites—iron and nickel. They also infer that the outer core is liquid, and the inner core is solid due to the enormous pressures.

Movements in the crust

The Earth's crust is more rigid than the mantle beneath it. In fact, the crust can be thought of as floating on the mantle, a bit like the skin on cooling custard. The mantle is constantly moving and sometimes large sections of the crust move very slowly upwards or downwards as the magma moves. When the magma underneath a pushed up part of the crust cools, it turns into rock, forming a dome-shaped mountain. However this process is very slow, and usually takes millions of years.

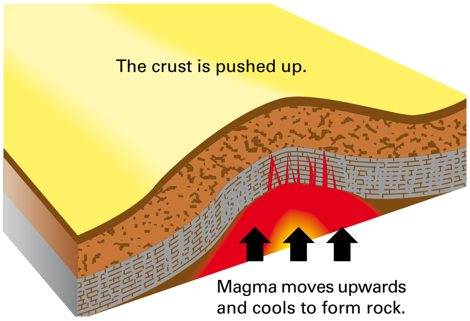


Fig 5 How moving magma can buckle the Earth's crust

Learning experience

On poster paper the students could draw what the inferred structure of the Earth is like. They should write dot points about each layer, including information about its thickness and what it consists of.

Learning experience

Using large styrofoam balls, make models of the Earth. Cut out a quarter piece from the foam and use different colours to illustrate and label the parts of the Earth's interior. To label, simply make small flags on skewers or toothpicks and push them into the foam. Suspend the models from the ceiling for a dramatic display.

Learning experience

To give students a more visual approach in understanding the movements of the Earth's crust, use different colours of plasticine or playdough to make a flat multi-layered bed. Then push up from the bottom and observe the layers slowly buckle and form mountains. This upwards force is similar to those that act from the Earth's interior as the magma pushes up on the crust.

Fig 6 Lava flowing from an active volcano

Volcanoes

There are sometimes weak spots in the Earth's crust that may crack and allow the magma to flow to the surface. When this happens a volcano forms. The pressure inside the Earth pushes the magma upwards. Sometimes the molten rock oozes out steadily. At other times it blasts out with incredible force.

To understand this, think of what happens when you shake a can of soft drink. Pressure builds up inside the can. When you open the can you release the pressure, causing an eruption.

After a volcano has erupted and the pressure has been released, the magma may harden to form a plug that blocks the vent. When this happens the eruption stops, and we say the volcano is *dormant*, or sleeping. On the other hand, if the pressure builds up, it may become active again. If it doesn't erupt again for a very long time we say it is *extinct*, or dead.

There are about 500 active volcanoes around the world. There are no active volcanoes in Australia, but there are many extinct ones; for example, Tower Hill in Victoria, Mt Warning in New South Wales and Mount Gambier in South Australia.

When magma reaches the surface it is called **lava**. It is usually about 1000 °C, and red-hot. As it cools, it turns to solid rock. This may take weeks, or it may happen very quickly if the lava flows into water. Some volcanoes erupt quietly, with the lava spreading out to form a flat shield-shaped volcano. The volcanoes on the Hawaiian Islands are like this. Sometimes the lava is thin and runny. At other times it is thick and lumpy, like porridge, and hardly flows at all.

Volcanoes also produce gases, and some of these are poisonous. When lava contains a lot of gas it may froth violently. When this lava cools, the rock formed is full of holes where the gas bubbles used to be. *Pumice* rock is so full of holes, it is very light and floats on water. You often see it washed up on the beach.

Igneous rocks

Rocks that formed from the molten rock of the mantle are called **igneous rocks**. The word igneous (IG-nee-us) means 'from fire'. Examples of igneous rocks are granite and basalt.

Igneous rocks are made of interlocking **crystals**. These form from the substances in the magma, and have definite shapes and straight sharp edges—like sugar crystals. The crystals in granite are quite large, but the crystals in basalt are much smaller. You can usually infer how an igneous rock was formed from the size of its crystals. In Investigate 33 on page 279 you can see how different cooling rates produce different-sized crystals.

Hints and tips

When introducing igneous rocks, place some around the room so that students can look and touch them as you discuss how these rocks are formed. You can then ask students to draw and colour pictures of these rocks. Suggested rocks include pumice, granite, basalt, diorite and trachite.

Learning experience

As a quick demonstration, you can show how explosive volcanoes can be using Condy's crystals. On a heatproof mat, place a small mound of potassium permanganate crystals. For safety, place this in a fume cupboard. Make a small depression in the top of the mound and pour some glycerol into it. After a little while, the chemicals will start to react and a small explosion will take place. Ensure that students are standing well clear.

Research

Ask students to research the differences between extinct, dormant and active volcanoes. Ask them to find some important facts about these volcanoes so that they can write a newspaper article about them. The article could include the formation of volcanoes, types of eruptions, changes in the volcanic activity, and specific examples of volcanoes.

Students will need help with writing a newspaper article. There are numerous websites on this, or see *ScienceWorld 2 Workbook* page 55 for a template. You can also liaise with your school librarian who should have a range of hints and tools to assist students in this task.

Learning experience

Making a wax mini-volcano is a quick and easy activity. Ask your lab technician to approximately half-fill a 250 mL beaker with wax. Let it cool so that it sets to the shape of the beaker. Then simply add about 100 mL water so that it sits on the surface of the wax. Sit the beaker on a tripod and gauze mat and heat gently over a Bunsen flame. Watch the wax try to make its way to the surface. Explain to the students that the wax represents the magma, while the water is the Earth's crust. The wax can ooze out slowly, as if it is forming bands of igneous rock (dykes or sills), or, if the wax is heated too strongly, can blast out with incredible force. Ensure that students are standing well clear of the demonstration and you are wearing safety glasses.

Hints and tips

The faster a solid cools the smaller the crystals that are formed: large crystals = slow cooling, small crystals = fast cooling.

Explain this using honey as an example. When honey starts to solidify the crystals are quite evident. This is because the honey has cooled slowly. To reverse the process, melt the honey in the microwave and put it into the fridge for fast cooling and therefore small crystals.

Rocks with big crystals are often formed underground where they can cool slowly. Volcanic rocks that have small crystals are usually formed as a result of molten rock cooling quickly (often in the ocean) after an eruption.

Issues

'Mining is a multi-billion dollar industry in Australia. It is supplying the world with needed resources and making this country wealthy. However, many people are concerned that this industry is unsustainable as it is stripping the Earth of its natural resources and harming environments.'

Ask students to form groups and research mining in Australia, focusing on a particular mineral or ore. They should describe what rocks and minerals are mined, the processes involved in mining, and then finally present points for and against mining the mineral in Australia.

Volcanic and plutonic rocks

There are two important groups of igneous rocks—volcanic and plutonic. **Volcanic** rocks are produced from rapidly cooling lava on or just below the surface of the Earth. The time taken for these rocks to solidify would be only days or perhaps months, depending on the thickness of the lava flow. Because the rock cools quickly it does not have time to form large crystals. Basalt is formed in this way.

If magma solidifies to form rocks well below the surface, the rocks are said to be **plutonic** (ploo-TON-ic) after Pluto, the Greek god of the underworld. The crystals in a plutonic rock are large because they have had time to grow—as long as a million years. Granite is formed in this way.

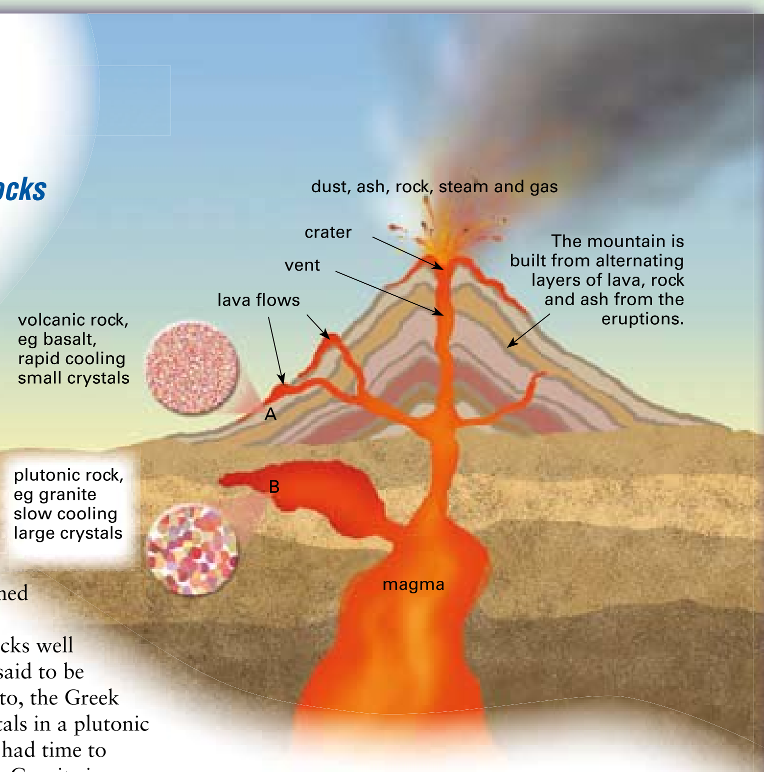


Fig 7 How volcanic and plutonic rocks form. The rocks at A are volcanic. They cooled rapidly and have small crystals. The rocks at B are plutonic. They cooled slowly and have large crystals.

Minerals and crystals

All rocks are made of **minerals**. These are the building blocks of rocks. Some rocks contain only one mineral. For example, limestone contains only calcite (calcium carbonate). Most rocks, however, are a mixture of several different minerals. For example, granite is a mixture of three minerals—quartz, feldspar and mica. (See the activity on page 280.)

As magma solidifies, some minerals become concentrated in certain places. For example the minerals may dissolve in hot water in the cooling rock. This hot water may then seep into the surrounding rocks, carrying the minerals with it. When the water evaporates, the minerals are left behind as crystals. These minerals may contain metal compounds called **ores**, which can be mined and the metals extracted. The table on the right shows some common uses of ores mined in Australia.

Under certain conditions, minerals occur as large crystals. These crystals have definite shapes that can be used to identify the minerals. For example, quartz always forms six-sided crystals that are often transparent. Some minerals can be cut and polished to form gemstones; for example, diamonds, rubies, sapphires and emeralds.

Ore/mineral	Metal	Some uses
bauxite	aluminium	drink cans aircraft parts
chalcopyrite (fool's gold)	copper	electrical wires saucepans
galena	lead	batteries fishing sinkers
haematite	iron	steel girders railway lines

Investigate 33 FAST AND SLOW COOLING

Aim

To use a model to represent what happens when crystals grow in cooling magma to form igneous rocks.

Materials

- two 250 mL beakers
- burner, tripod and gauze mat
- stirring rod
- watch glass
- styrofoam box or Esky
- hand lens (optional)
- potash alum (aluminium potassium sulfate)
- **copper sulfate** Toxic

Planning and Safety Check

Read the experiment carefully, then describe to your partner what you will be doing. Include safety precautions in your description.

Method

1 Set up the burner, tripod and gauze mat for heating.

2 One-third fill the beaker with water and heat it.

3 Add a spoonful of copper sulfate (a blue mineral) and a spoonful of alum (a white mineral). Continue heating, and stir until dissolved.

4 Continue adding equal amounts of copper sulfate and potash alum until no more will dissolve. The solution is then said to be *saturated*.

5 Half fill a cold watch glass with the solution and leave it to cool quickly.

6 Pour the rest of the solution into a second beaker and put it in a styrofoam box with the beakers from other groups. Leave it to cool overnight.

7 The next day, pour any remaining solution off the crystals in the watch glass and the beaker. Use the hand lens to examine the crystals Sketch the crystals in each 'rock'.

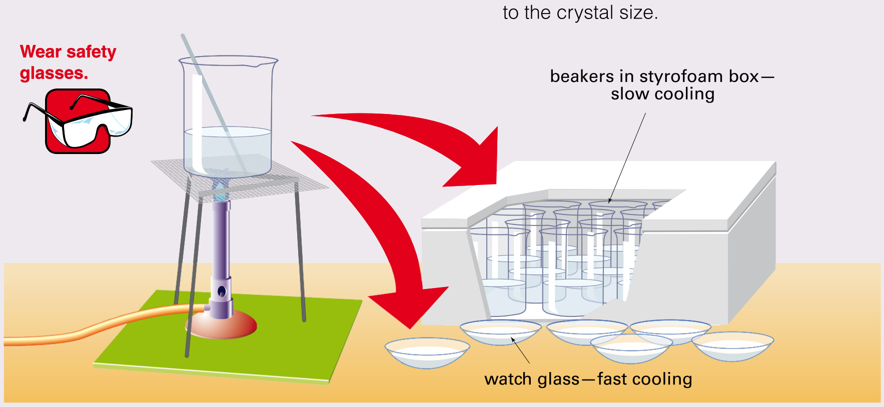
Discussion

1 Which 'rock' has the larger crystals?

2 What does the hot solution in this model represent?

3 Which mineral formed larger crystals—the copper sulfate or the alum?

4 Write a generalisation linking the rate of cooling to the crystal size.



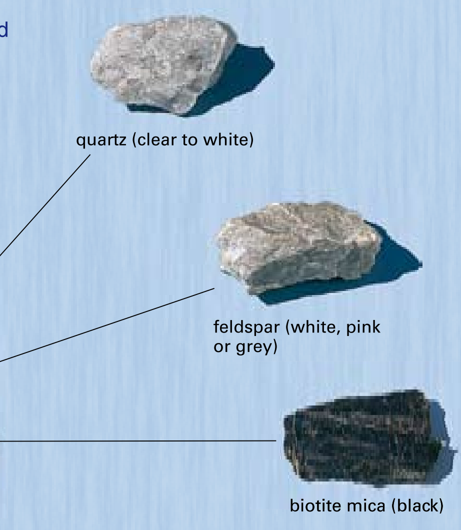
Lab notes

- This investigation probably needs to be done over two lessons. Use the first lesson to saturate the solution and the second to do the fast and slow cooling. An alternative is for you or a lab technician to provide the saturated solution.
- This investigation creates a disposal problem, so please check with your lab technician and do not allow students to wash the copper sulfate or potash alum down the sink.
- Safety glasses are needed, and chemicals should be promptly washed off the skin or wiped off the bench or books if spilt.

Activity

Your teacher will give you samples of various igneous rocks, including granite and basalt. Observe them carefully and see if you can spot the different minerals in them. Use a hand lens or stereomicroscope to take a closer look.

Infer which of the igneous rocks are volcanic (formed on the surface of the Earth). Which are plutonic (formed under the ground)? Explain your answers.



Check!

1 How thick is the Earth's crust? Why is it called the 'crust'?

2 Draw a diagram of a volcano and put these five labels on it:

granite formed here, magma, vent, crater, lava

3 How is basalt formed? Mark where it is formed on your diagram in Check 2.

4 Each of the following words is the correct answer to a question. Write a suitable question for each answer.
- a crust
- b magma
- c igneous rocks
- d plutonic rocks

5 What is the difference between a rock and a mineral?

6 Ask a classmate to check your spelling of the following words. Write the words in your notebook.

basalt, lava, granite, lithosphere, igneous, magma

7 Use the table on page 278 to answer these questions.
- a Which metal is extracted from haematite?
- b Suggest why chalcopyrite is sometimes called fool's gold.
- c Suggest other uses for each of the metals.
- d Use library resources to add two other ores to the table.

8 a How does the speed of cooling affect the size of the crystals in a rock?
- b Why are the crystals in granite much larger than the crystals in basalt?

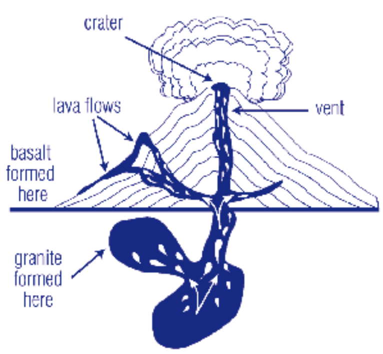
Activity note

When doing this activity, set up a microscope, scratch at the surface of the rocks and try to remove some small grains of rock. View these under the microscope and look at their crystal structure and colour.

Check! solutions

1 The Earth's crust is only about 30 km thick. It is called a crust because it is rather like the crust on a loaf of bread or the shell on an egg.

2



3 Basalt is formed when molten, volcanic rock cools down quickly. As a result, basalt has small crystals. See label on diagram above.

4 Suitable questions are:
- a What is the outermost layer of the Earth?
- b What is the name of molten rock beneath the surface of the Earth?
- c What is the general name given to rocks which form when molten rock solidifies?
- d What type of rocks are formed when molten rock solidifies very slowly well below the surface of the Earth?

5 A rock usually consists of a mixture of several different minerals. A mineral, on the other hand, has a definite chemical composition and is often found as crystals.

6 See spelling given.

7 a The metal extracted from haematite is iron.
- b Chalcopyrite has a yellowy colour and fools think it is gold.
- c Other uses for:
  Aluminium—car motors and alfoil.
  Copper—hot water pipe and alloys.
  Lead—water pipes and in solder.
  Iron—car bodies and railway lines.
- d Some common ones are cassitente (tin), cuprite (copper), magnetite (iron), rutile (titanium), yellowcake (uranium) and spalerite (zinc).

8 a Generally it is true that the faster the cooling of molten rock, the smaller the crystals formed.
- b The crystals in granite are larger than those in basalt because granite is formed by slow cooling of molten rock under the ground, while basalt is formed by rapid cooling on the surface.

challenge

1 How do volcanoes form?

2 The photo below shows a man holding up a boulder made of pumice. Why is pumice so light?

3 The table below shows the temperatures at different depths in a drill hole. Plot a line graph with depth on the horizontal axis, and temperature on the vertical axis. (If you aren't sure how to do this, see page 37.)

Depth (km)	Temperature (°C)
0	20
1	51
2	82
3	112
4	142
5	171
6	201
7	230

a Use your graph to work out how many degrees the temperature rises for each kilometre travelled into the Earth.

b Predict the temperature at the following depths: 1.5 km, 5.8 km, 8 km and 20 km.

4 Why are the crystals in the rocks on the edge of an old lava flow smaller than those in the rocks in the middle of the flow?

5 Lava is sometimes thin and runny, and sometimes thick and sticky. How would this affect the shape of the volcano formed by the lava flows?

try this

1 Make a model of the inside of the Earth showing the different layers.

2 Growing a large crystal:

- Add copper sulfate crystals to hot water until no more will dissolve. Allow the solution to cool almost to room temperature. Pour the solution into a clean beaker, leaving any undissolved solid behind.
- Ask your teacher for a well-shaped copper sulfate crystal. Carefully tie a cotton thread around it. Tie the other end of the thread to a glass rod or ice-cream stick.
- Hang the crystal in the copper sulfate solution as shown. Cover the beaker with aluminium foil or plastic wrap, and put it somewhere it won't be disturbed for a week or so.
- Check the crystal every day to observe its growth.

WEBwatch

Go to www.scienceworld.net.au and follow the links to the websites below.

Volcano world

This site has extensive information on volcanoes around the world. It tells you which volcanoes are currently erupting, and you can see movies of eruptions.

Structure of the Earth

Using this site you can explore the various layers of the Earth.

Try this notes

- Seed crystals can be used from Investigate 33 on page 279.
- It is vital that the solution is saturated or you will lose your seed crystals. Check that there is undissolved solute even after vigorous stirring.
- The beaker can be placed inside a stubby holder to slow cooling and get a larger crystal.

Learning experience

Make a crystal garden. You will need sodium silicate solution (waterglass), crystals of cobalt (II) nitrate, iron (III) nitrate or chloride, magnesium nitrate (or sulfate) and manganese (II) sulfate. Prior to the lesson, dilute the sodium silicate solution 1 to 4 with hot water, stirring well. Place the solution into a beaker or jar to a depth of 10–12 cm and allow to stand. Drop in a large crystal of each of the different compounds so that they are evenly spaced at the bottom of the beaker. Cover the beaker and leave it overnight.

A crystal garden of different silicates with different colours will have formed.

Homework

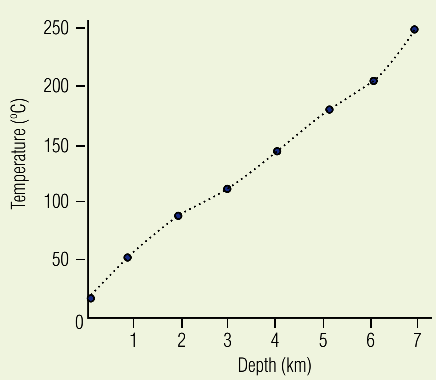
Have students research a mineral or gemstone. They should find out about its properties, abundance, where it is found, its uses and value. They could present this information in the form of a poster or a brochure. Students could find pictures from magazines or jewellery store brochures to make their poster or brochure colourful.

Challenge solutions

1 Volcanoes form when there is a weakness in the Earth's crust and magma is forced out onto the surface of the Earth as lava. A series of eruptions and explosions will usually result in the formation of a cone.

2 Pumice is usually formed when gases cause molten rocks to form a froth. When this solidifies it forms a rock with many air spaces, which means it is very light and will float on water.

3



a The average increase is 30 °C per km.

b At 1.5 km the temperature will be about 66 °C.

At 5.8 km the temperature will be about 195 °C.

At 8 km the temperature will be about 260 °C.

At 20 km the temperature will be about 620 °C.

4 The crystals on the edge of a lava flow are usually smaller because they have cooled more quickly than those in the middle of the flow.

5 You would expect that thin, runny lava would flow further before solidifying and that the volcano formed would therefore be flatter than one formed from thicker and more sticky lava.

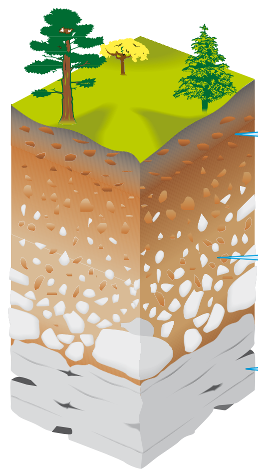
Hints and tips

Every type of rock, no matter what its shape or consistency, weathers over time. Physical weathering can be climate-dependent, causing cracking. This is important in explaining how rocks weather at different rates. Ask the students to suggest places where physical weathering is often quite evident. Weathering is also caused by biological factors such as plants growing in crevasses.

Erosion and weathering are different. Weathering is the slow physical and chemical breakdown of rocks by the action of rain, cold, etc. Erosion is the process by which weathered material is carried away by water, wind and glaciers.

13.2 Earth's changing face

The drawing below shows part of a road cutting Notice that there is solid rock at the bottom, then broken-down rock, and soil at the top. From this, scientists infer that long ago the top must have been solid rock too, but has somehow broken it down into smaller and smaller pieces.



This breaking down of rocks by natural processes is called **weathering**. There are two main types of weathering—*physical weathering* and *chemical weathering*. Most weathering is the result of both physical and chemical processes. Different rocks weather at different rates, depending on how hard they are; and how hard they are depends on what they are made of.

Physical weathering

If you heat a glass rod and put it into cold water, it will crack. This is because the glass on the outside of the rod contracts (gets smaller) while the inside remains the same. Similarly, rocks will crack if their temperature changes quickly. This may occur at night after a hot day, or when rain falls on hot rocks. Eventually the outer layers of the rock crack and may peel off. This process is very common in granite, and eventually rounded boulders are formed.

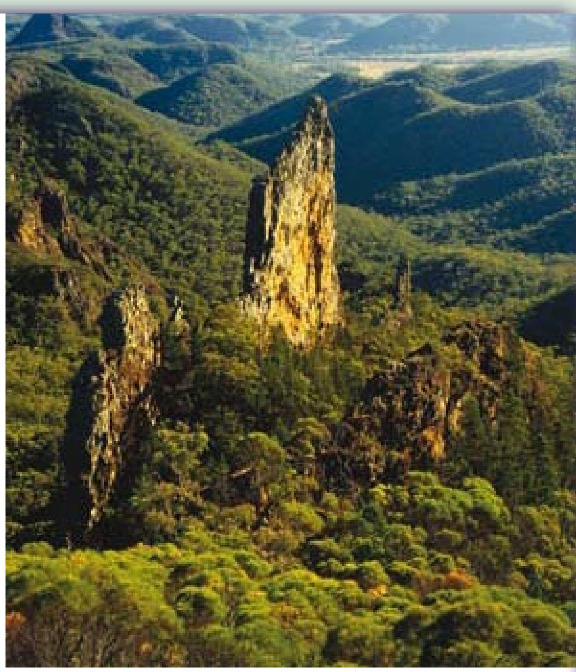


Fig 13 The Breadknife in the Warrumbungles in New South Wales is made of hard volcanic rock. The surrounding softer rock has been weathered away.

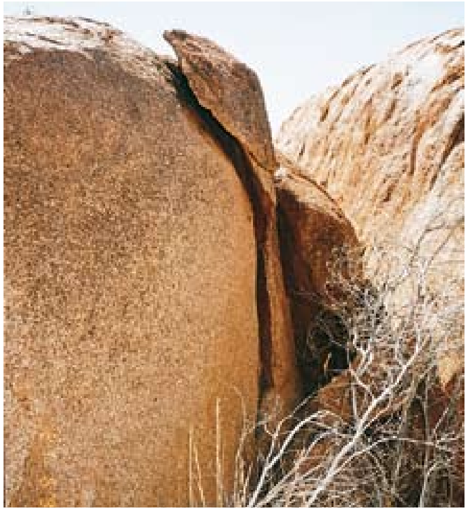


Fig 14 Notice how pieces are flaking off this granite, leaving a rounded boulder.

Learning experience

Rocks in desert environments are subjected to large changes in temperature, from the heat of the day to the extreme cold of the night. Conduct the following simple activity to show how temperature can break down rock.

Heating rocks

Before you attempt this activity, make sure all the people observing this wear safety glasses. It may also be advisable to use a safety screen in case pieces of rock fly off when heating.

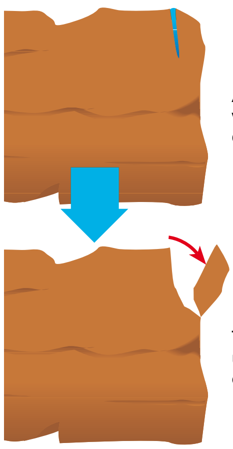
You will need a Bunsen burner, tongs, 250 mL beaker, sandstone and other rock samples. Half-fill the beaker with cold water. Using the tongs, hold the sandstone over the Bunsen flame and heat it for about a minute. Then immerse the rock in the cold water. Repeat this a few times until the rock starts to break up. This procedure can also be used for other rock samples.

Cooling rocks

Soak a piece of soft porous rock such as sandstone in water, then place it into a plastic bag and freeze it. Describe what happens to the rock as it freezes.

In places where the temperature falls below 0 °C, ice can cause weathering by breaking open small cracks and holes in the rocks. How does it do this?

You may have seen a bottle in the freezer burst when the liquid inside freezes. This is because water expands when it freezes. If water in a small crack in a rock freezes, it will eventually split pieces off the rock.



Activity

To get an idea of how water can crack rocks when it freezes, try this activity at home.

Obtain a small plastic bottle with a tight-fitting lid. Fill it to the brim with water and close the lid tightly. Then leave it in the freezer overnight. What happens?

Plants can also cause physical weathering of rocks. Seeds from trees may fall into cracks in rocks and develop into seedlings. As the tree grows, the roots act like a crowbar, wedging the rocks apart.

Fig 16 Over long periods of time, tree roots can break up rocks.

Chemical weathering

Chemical weathering is the chemical breakdown of rocks. There are many different minerals in rocks, and when water and air react with these minerals, the new minerals formed are usually softer. This causes the rock to crumble.

You may have noticed that most rocks are brown on the outside. This is because iron is present in many minerals, and it reacts with the oxygen in the air to form brown iron oxide (rust), which is relatively soft.

iron + oxygen → iron oxide

If you chip a piece off some weathered rock you will notice that the unweathered rock inside is a different colour.

Hints and tips

Chemical weathering is caused mainly by water and air. An example of chemical weathering is acid rain dissolving limestone.

Learning experience

To reinforce chemical weathering, conduct this small demonstration. Fill one beaker with water and another with soda water. Place a small piece of limestone in the water and observe what happens. Place another piece of limestone in soda water and observe. Ask students to write an inference to explain their observations. What is it in the soda water that dissolves the limestone?

This activity can be done at home.

Learning experience

Ask the students to come up with places familiar to them that show evidence of both types of weathering. What do they think caused the weathering?

Ask the students to infer what sand and sediment are, and why areas near water contain a lot of this type of material.

Fig 17 Three pieces of granite. The piece on the left has not been exposed to the weather. The middle piece has been weathered (notice its brown colour). The piece on the right has been weathered to small pieces.

Igneous rocks such as granite often contain cracks and joints. Water seeps into these cracks and some of the minerals in the granite change, causing the rock to crumble. Physical weathering occurs at the same time, forming rounded boulders, and sometimes balancing rocks, as shown below.

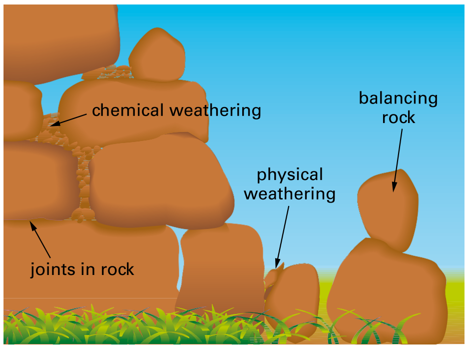


Fig 18 Weathering in granite—see the balancing rock on page 275

A special type of chemical weathering occurs with limestone, which is made of calcium carbonate. Carbon dioxide in the air reacts with moisture in the air or with rainwater to form carbonic acid.

carbon dioxide + water → carbonic acid

Limestone reacts with carbonic acid (and other acids). So when this acidic water seeps into cracks in limestone it can dissolve quite large amounts of limestone, eventually turning the cracks into caves and arches. The Jenolan Caves near Sydney and the Chillagoe-Mungana Caves in North Queensland were formed in this way.

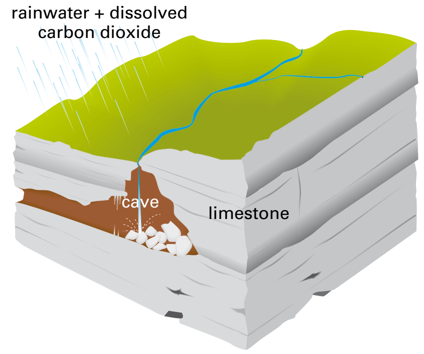


Fig 20 A beautiful shawl formation in the Chillagoe-Mungana Caves

Open the **How limestone caves are formed** animation on the CD. Working with technology

Hints and tips

- There are many commercial DVDs available showing the processes of rock erosion. Ask your school librarian for assistance. Your SOSE department may also have relevant resources.
- Organise an excursion to any local caves which have stalactites or stalagmites. Stalactites and stalagmites occur in limestone caves and are formed when the dissolved calcium carbonate comes out of solution as carbon dioxide escapes from the water dripping into the caves. Stalactites hang downward while stalagmites grow up.

Animation

Students should view the animation **How limestone caves are formed** on the CD.

Homework

Get students to research how stalactites and stalagmites are formed, the difference between them, where in Australia they can be found, and any other interesting information.

Erosion

Weathering is the process by which rocks are broken down. **Erosion** is the movement of soil and other weathered material from one place to another. The main agents of erosion are wind, water and ice. The eroded material is deposited (dumped) somewhere else as **sediment**. Erosion is a natural process, but human activity often causes it to occur more quickly.

Wind erosion

Dust storms are common in dry areas such as deserts. The sand grains carried by the wind can wear away (weather) rocks, often smoothing them and causing spectacular landforms such as the Pinnacles in Western Australia (see page 275). Fertile topsoil can be carried away by the wind if there is no vegetation to cover it and hold it in place.

Wave erosion

The action of the sea on coastal areas removes large amounts of weathered rock and sand, depositing it in other areas. The Twelve Apostles on Victoria's south-west coast (see page 275) are spectacular examples of coastal erosion. The soft rocks have been eroded by the sea, leaving the harder rocks, called sea stacks. Four of these have already collapsed and the rest will eventually fall as the sea wears their bases away. The action of the sea is also responsible for the removal of sand from beaches. The eroded sand is often carried by currents and deposited on other beaches.

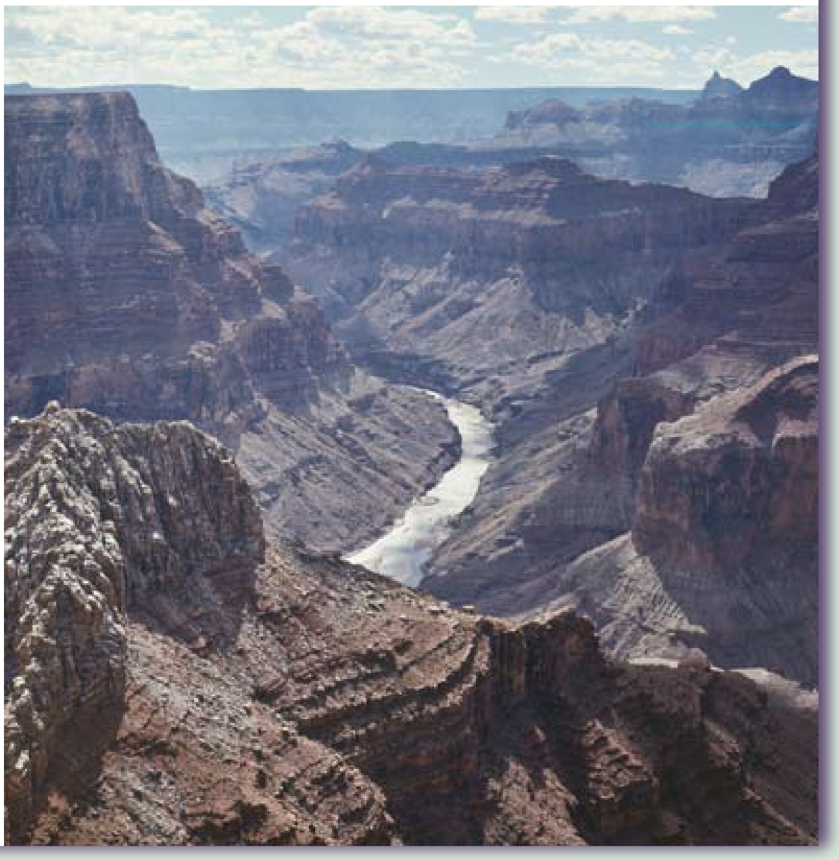
Running water erosion

Running water is the most effective agent of erosion. Water running down any slope can carry soil with it. A fast-flowing river in flood can carry huge boulders, as well as pebbles, sand and soil. A spectacular example of erosion by a river is the Grand Canyon in the USA, where the Colorado River has carved a groove in the Earth 450 kilometres long and an average of 1.6 kilometres deep! It has been estimated that this has been going on for about 30 million years.

Glacier erosion

If you visit New Zealand you may see a *glacier*. This is a huge 'river of ice' moving down a valley. It moves rocks, just like a river, only very slowly.

Fig 21 The Grand Canyon, USA



Hints and tips

Acid rain occurs when sulfur dioxide and nitrogen dioxide released by factories and cars are absorbed by moisture in the air. Acid rain contributes to the weathering of both natural carbonate rocks and man-made objects, such as statues and buildings. Ask students to research what acid rain is and how it has damaged the environment.

When CO_2 dissolves in water in the atmosphere, the resulting acidic solution has a pH of about 5.5. So acid rain has been described as having a pH lower than 5.

Learning experience

Have students complete the following writing task. Imagine you are a rock particle. Write a story about the adventures that take place as you are weathered, eroded and moved so that you are finally located in another place. What eventually happens to you?

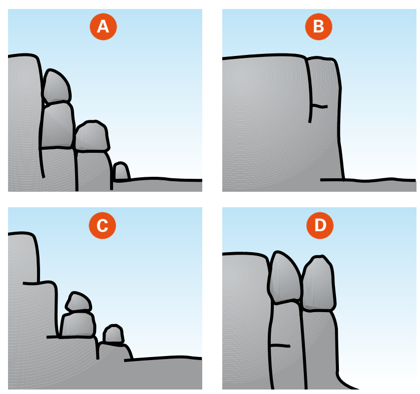
Check!

1 Which of the following are true and which are false? Correct the ones that are false.
  a Rocks usually have cracks and holes in them.
  b Air and water cause chemical weathering.
  c Weathering is a rapid change.
  d Granite dissolves slowly in acidic water to form caves.
  e Water takes up less space when it freezes.
  f Plant roots can crack rocks.

2 How do sudden temperature changes cause weathering of rock?

3 Limestone dissolves slowly in rainwater. Explain in your own words how limestone caves are formed.

4 The diagrams below show four stages in the weathering of a granite cliff.
  a Put them in the correct order.
  b How long do you think this weathering would take—weeks, years, hundreds of years, or thousands of years?



5 Clear water flowing down a river becomes muddy after rain. Why is this?

6 Granite is formed deep inside the Earth but there are many places where this rock can be seen at the surface. Suggest a reason for this.

7 Why do different rocks weather at different rates?

8 When limestone dissolves, what happens to the dissolved material?

9 A geologist has set up two measuring stations 150 km apart on a river. In a gorge in the mountains the river carries 200 million tonnes of sediment each year. Downstream it carries only 10 million tonnes per year. Infer what happens to the rest of the sediment.

10 Mt Crookneck, one of the Glasshouse Mountains in Queensland, is about 26 million years old. It is made of a volcanic rock called trachyte. Write an inference to explain its present-day shape.

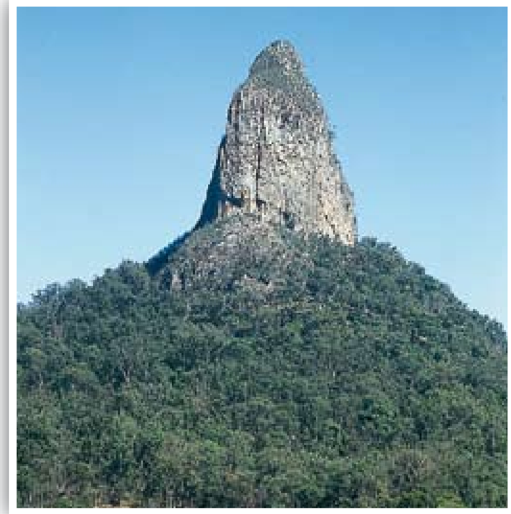


Fig 23 Mt Crookneck, Glasshouse Mountains

11 a In what ways has human activity increased erosion by the sea?
  b How can beach erosion by wave action be prevented or reduced?

12 Look back to your inferences for Getting started. If necessary rewrite them using what you have learnt in this section.

Check! solutions

1 a True
  b True
  c False. Weathering is usually a very **slow** process.
  d False. **Limestone** dissolves slowly in acidic water.
  e False. Water expands and takes up **more** space when it freezes.
  f True. In particular the roots of plants.

2 Sudden temperature changes cause rapid expansion and contraction of the outside of rocks. This causes the outside of the rock to break away, leaving a rounded shape.

3 As rain falls through the air it dissolves small amounts of carbon dioxide to form a very weak acid. As this water seeps through the soil and rocks this very weak acid dissolves some of the limestone to form large underground spaces called caves.

4 a The correct order of the diagrams is B, D, A, C.
  b Usually weathering is a very slow process taking thousands of years.

5 Flowing water becomes muddy after rain because it is carrying small particles of soil. This process is called erosion. These particles are deposited when the water slows down or stops flowing.

6 The reason that granite can be seen at the surface of the Earth is because the surface rocks have been weathered and carried away by wind or water.

7 Rocks weather at different rates because some are hard and some are soft.

8 The dissolved material will be carried away in flowing water and perhaps deposited somewhere else as part of the rock cycle.

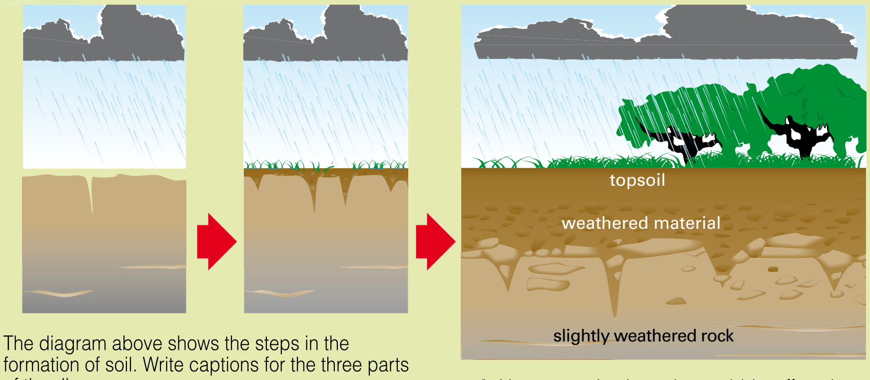
9 Sediment is insoluble material. It will be deposited in the gorge between the two stations.

10 The best inference is that the rhylolite was formed in the vent of a volcano when lava solidified. After that the outside of the volcano was eroded away leaving the hard core.

11 a Human activity has increased sea erosion by removing sand dunes and by removing vegetation which stabilises the sand near the shore.
  b Beach erosion can be reduced by re-planting vegetation, replenishing sand supplies and building barriers (‘groynes’) along the beach to prevent long-shore drift.

12 The answer depends on what the student wrote at the start.

challenge



1 The diagram above shows the steps in the formation of soil. Write captions for the three parts of the diagram.
2 Why is soil in one place different from that in other places?
3 Fig 25 below shows Wave Rock in Western Australia. It is made of granite.
   a Write an inference to explain how it was formed.
   b Can you suggest another inference?
   c Could you test which inference is correct? If so, how?
4 How can animals such as rabbits affect the rate of weathering and erosion of soil and rocks?
5 Many water reservoirs in agricultural areas of Australia are becoming filled with sediment washed in by streams flowing into them. What action could be taken to help overcome this problem?
6 Do weathering and erosion occur on the Moon? Explain your answer.

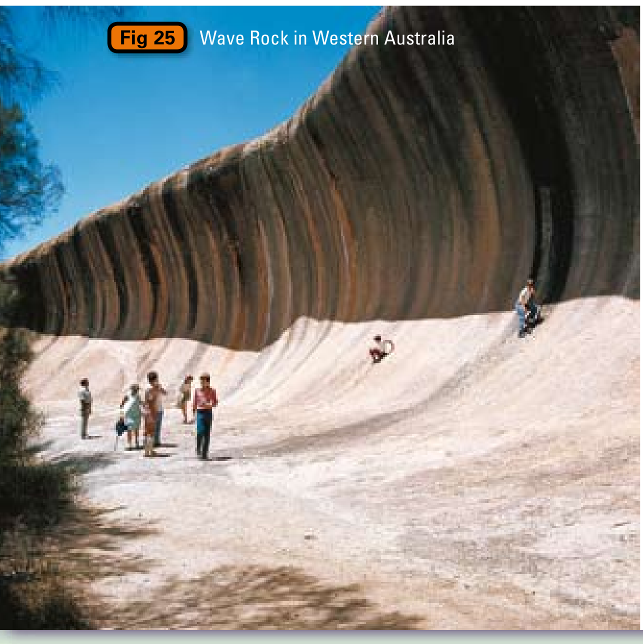


Fig 25 Wave Rock in Western Australia

try this

1 The brown colour of rocks is due mainly to iron oxide. This is formed when iron in the rocks reacts with air and water. Here is a way to show how this happens.

   Put some steel wool (or iron filings) in a jar, and pour in enough sand to just cover it. Sprinkle water on the sand each day. Examine the jar after about a week.
2 Look at Fig 20 on page 284. What are these cave formations called? Use a library to find out how they were formed.

Challenge solutions

1 Suitable captions would be:
   A: Rain and changes in temperature cause weathering of rocks.
   B: Small particles of rock are deposited on the surface and plants grow causing further changes.
   C: More particles of rock are deposited and larger plants grow.
2 Soil is different from one place to another because it has different 'parent' rock and different weather conditions.
3 a A possible inference is that this was formed by the action of running water.
   b Another possible inference is that it was formed by the action of wind carrying sand particles.
   c One way to test these would be to set up an experiment in the laboratory. For example, you could take a small piece of the rock and add it to some very weak acid and carefully weigh it to see whether it dissolves.
4 Rabbits can affect the rate of weathering by digging burrows, which expose rocks, and by eating vegetation, which holds soil together.
5 One thing that can be done to overcome this problem is to have a settling pond before the reservoir to gather the sediment. Steps could also be taken to reduce erosion in the catchment area.
6 It is possible that the temperature changes on the Moon cause some weathering, and very recent evidence suggests that there is ice in some of the deep craters. There is no erosion because there is no movement of air or water.

Animation

Students should view the animation **How sedimentary rocks are formed** on the CD. Alternatively, the animation could be viewed using a data projector.

Hints and tips

Bring in some sample sedimentary rocks. Allow students to touch and look at the rocks, then draw and label them in their books.

13.3 The rock cycle

Sedimentary rocks

Streams carry large amounts of weathered material (sediments). The size of the sediments being carried depends on the flow rate of the stream. The largest sediments are deposited first. For example, gravel quickly settles to the bottom unless the stream is flowing very quickly down a steep slope. The next to settle is the sand. Near the mouth of the stream the water moves very slowly. Here the smallest sediments settle out, making the banks muddy.

Look at Fig 26 below. The sediments carried by the river have entered the sea. Eventually they will settle to the bottom, the largest sediments first and the smallest sediments last. This also happens when rivers flow into lakes.

Fig 26 The sediments deposited at the mouth of this river will eventually turn into sedimentary rocks.

Sea water contains dissolved minerals that can soak into the sediments and cement them together. The sediments are also compressed (pressed down) by the tonnes of material on top of them. Eventually the sediments turn into **sedimentary rocks**.

Over millions of years, these sedimentary rocks can be pushed up above sea level by the movements in the lithosphere. You can usually see the sediment layers in these rocks.

Open the **How sedimentary rocks are formed** animation on the CD.

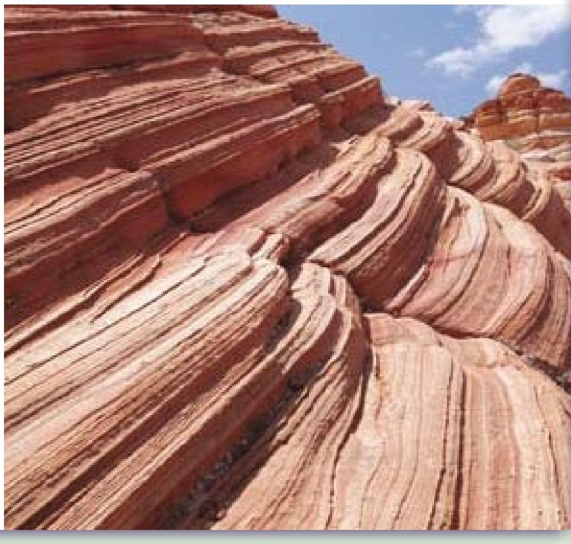
Working with technology

Types of sedimentary rocks

Different types of sediments produce different types of sedimentary rocks. For example, sand-sized sediments eventually produce *sandstone*. *Shale* (or mudstone) is a fine-grained sedimentary rock formed from mud. Like sandstone it is often layered, and often contains fossils. If rounded pebbles and stones are deposited and cemented together with sand, clay and other minerals, a rock called *conglomerate* (con-GLOM-er-it) is formed.

Not all sedimentary rocks are formed from deposits of weathered rocks as a result of erosion. *Limestone* is mostly formed from deposits of the remains of organisms such as shellfish, corals and certain microscopic plants. For this reason limestone usually contains fossils. *Coal* is formed from the remains of dead plants that are buried by other sediments before they can decay. Over millions of years the weight of the overlying sediments compacts the partially decayed plant material. This compacting process increases the temperature of the material and squeezes out water. Eventually coal is formed.

Fig 27 Layers can usually be seen in sedimentary rocks.



Learning experience

Ask students to fill a large plastic softdrink bottle with equal quantities of pebbles, sand and clay soil. Break the soil up using a mortar and pestle if necessary. Shake the bottle to mix the contents. Place tap water in the bottle so that it covers all the contents. Ask students to again shake the bottle then let it sit while they observe what happens to the contents. Ask students which particles settled first and why. Leave the bottle overnight and observe any changes from the previous day. Students can then draw diagrams of the contents of their bottles.

Learning experience

Sandstone is formed by the cementing of small particles with clay. This process tends to occur under water, so let students observe what happens to clay when it dries out. Mix some clay and sand with some water in a container. Make 2 small clay balls and place each onto a piece of filter paper. Flatten each ball. Place one filter paper in the sunshine to dry slowly, and place the other in the school kiln or in a drying oven.

Investigate

34 SEDIMENTARY ROCKS

Aim

To investigate the formation of sediments and sedimentary rocks.

Planning and Safety Check

Read both parts carefully and plan when you will do them. In Part B you will need to work out the details yourself.

PART A
Settling of sediments

Materials

- sediment (mixture of dried mud, sand and gravel)
- clear plastic bottle with lid

Method

1 Half fill the bottle with a mixture of mud, sand and gravel. Fill the rest of the bottle with water.

2 Put the lid on the bottle and shake it. Then stand it on the bench and observe what happens.
Record the following data:
- About how long did it take for the first sediment to settle?
- What is the depth of sediment in the bottom of the bottle after 5 minutes? How much of the water is almost clear?
- Can you see any layers in the sediments? Draw a sketch.

Let the sediments settle overnight.

Discussion

1 Which sediments settled first (clay, sand or gravel)? Why?

2 Did all the sediments settle eventually? How do you know?

3 What is the relationship between the settling time and the size of the sediments? Write a generalisation.

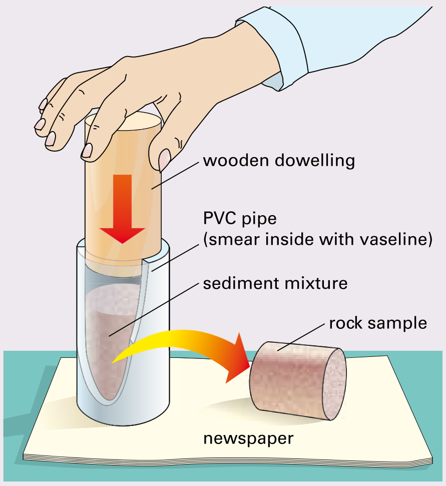
PART B
Making rocks

Materials

- sand, gravel and clay
- a range of cements, eg plaster of Paris, cement powder, PVA glue.
Use the Method below to make a full list of the equipment you will need.

Method

1 Make a sample of sandstone rock, as shown.



2 Experiment with the proportions of sand, clay and gravel to make different sorts of rocks. How would you make shale or conglomerate? You can also try different types of cement. For example, clay and a little water makes a good cement.

3 Leave your rock samples to dry for a few days then examine them closely. Use a hand lens if you like. How hard is the rock? How does it break?

4 Write a full report of your investigation.

Lab notes

- This investigation needs a bit of forward planning to make up pipes and dowels. Another possibility is to use large plastic syringes. Cut off the ends and lubricate the insides with petroleum jelly.
- The investigation can be very messy, so do it outside or cover the benches with newspaper. Provide a brush and tray to sweep up the debris.
- Don’t leave cement or plaster of Paris mixtures in the pipe too long or they will be very difficult to remove.
- Do not allow students to put soil or other solids in the sinks.

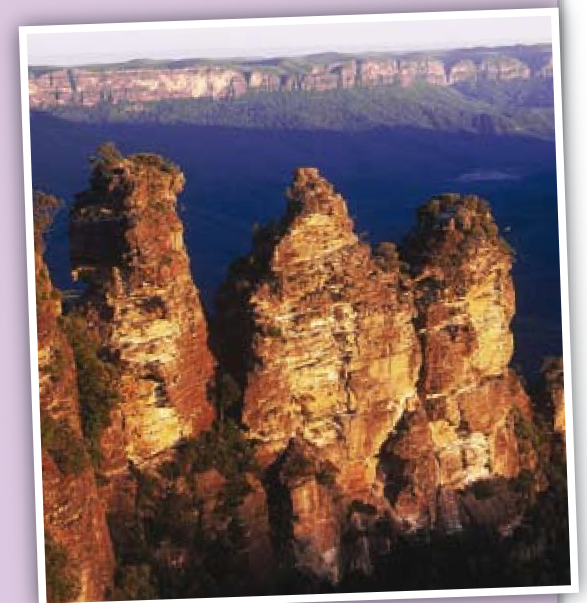
Hints and tips

- Uluru is composed of arkose, which is a coarse-grained sandstone.
- Kata Tjuta (the Olgas) are composed of a conglomerate, with pieces of granite and basalt cemented together by sand and mud.
- Karlu Karlu (the Devil's Marbles) have been formed by weathering and erosion of granite to form massive rounded boulders.
- The Organ Pipes in Victoria are a set of basalt columns as straight and regular as organ pipes. They were formed when the lava from a nearby volcano cooled.

A dreamtime legend

Different cultures have different ways of explaining the world around them. Aborigines have many legends to explain various landforms throughout Australia. For example, there is a Dreamtime legend to explain the origin of The Three Sisters in the Blue Mountains.

There were three beautiful giant sisters who fell in love with three brothers from a neighbouring tribe. Marriage was forbidden by tribal law so the brothers decided to take the maidens by force. The large tribal battle that followed forced the medicine man to turn the sisters into stone. He intended to restore them after the danger had passed, but he was killed in the battle and nobody has been able to break the spell and turn the three sisters back to their original form.



Using what you have learnt in this chapter, how would you explain the formation of The Three Sisters?

What are the differences between your explanation and the Aboriginal explanation?

Your teacher may be able to arrange for an Aboriginal person to describe a legend about your local area.

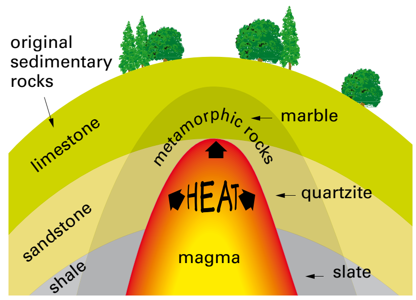
Metamorphic rocks

All rocks can be altered in some way by the effects of *heat* and *pressure*. Rocks that have been changed in this way are called **metamorphic** (met-a-MOR-fik).

1 Most metamorphic rocks are formed during mountain building, when the Earth's crust is pushed up and down by movements in the upper mantle. Enormous pressures cause the rocks to fold and twist, and tremendous heat is generated. Chemical changes produce new minerals, and the metamorphic rocks formed are harder than the original rocks.

Fig 30 Pressure and heat produced in the folding of rocks can produce metamorphic rocks.

2 Another way metamorphic rocks form is when magma is forced up into the Earth's crust. The rocks in contact with this magma become very hot and are slowly changed to metamorphic rocks, as shown below.



Learning experience

Get the students to research other rock formations in Australia and to present their information as a brochure. They could investigate Dreamtime legends associated with their chosen rock formation, give the Aboriginal explanation and the scientific explanation for their formation, identify the type of rock etc.

Learning experience

Set up a display of metamorphic and sedimentary rocks so students can look at them and compare the metamorphic rock to its related sedimentary rock.

For example:
shale → slate
coal → graphite → diamond
(Explain that coal, graphite and diamond are all made of carbon. Different conditions of heat and pressure produce the three different products.)

The rock cycle

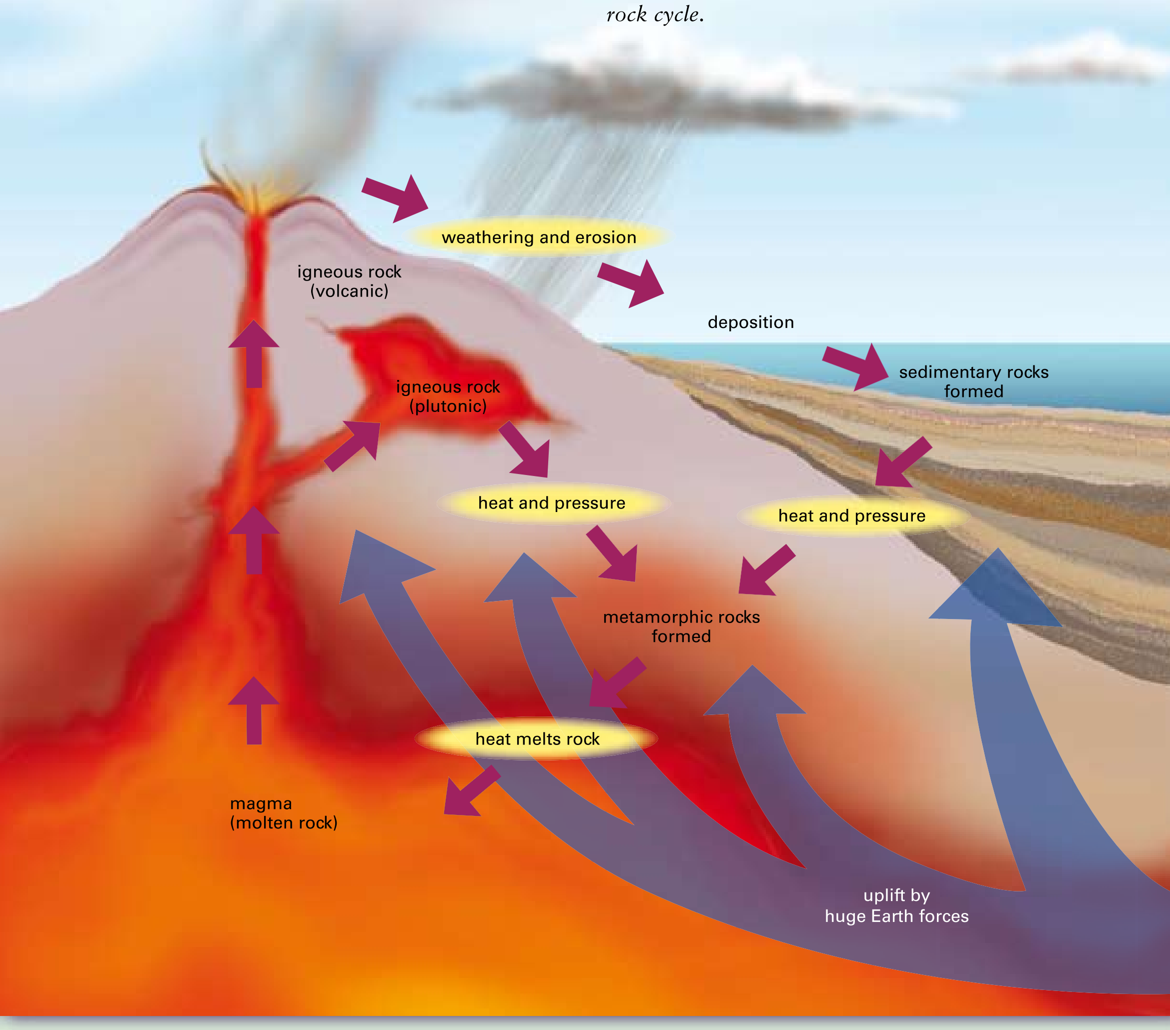
To summarise, there are three types of rocks.

1 Igneous rocks are formed from magma.
2 Sedimentary rocks are formed from sediments.
3 Metamorphic rocks are formed from other rocks by heat and/or pressure.

Over millions of years, the Earth's rocks are constantly changed. Magma from deep within the Earth rises to the surface, and cools to become igneous rock. These igneous rocks are weathered and eroded to form sediments, which form sedimentary rocks.

As layers of sedimentary rocks build up, the bottom layers sink deeper and deeper into the Earth's crust, where the temperature and pressure are greater. When this happens they can be changed into metamorphic rocks. If the temperature is high enough, they may melt to produce magma again. They may also be uplifted by huge Earth forces pushing the rocks upwards to form mountains.

The Earth's surface is constantly being worn down and uplifted by mountain-building forces. As this happens the rocks are changing from one form to another. The whole process is called the *rock cycle*.



Learning experience

Set up a class display, illustrating what has been researched and taught during this chapter about the rock cycle. Divide students into groups and get each group to set up a display wall about their given subject area. The groups could be:

- the Earth and its structure and volcanoes
- igneous rocks
- sedimentary rocks
- metamorphic rocks
- weathering and erosion.

As you move your way around the room from display to display, the rock cycle story is explained. You could assign one group to write a narrative connecting the displays.

Lab notes

- Spread the rocks around the room and arrange for students to circulate, with a few minutes at each one.
- A container such as a plastic ice-cream container should be available for the rocks that are acid tested. The rocks can be washed for a minute or so with water containing some washing soda. This way another class can use the rocks at a later time.

Investigate
35 LOOKING AT ROCKS

Aim

To observe a variety of igneous, sedimentary and metamorphic rocks.

Materials

- variety of rocks or rock kit
- hand lens
- table knife or metal spatula
- dilute **hydrochloric acid** Corrosive

Planning and Safety Check

Draw up a data table in which to record the properties of the rocks.

What safety precautions will be necessary?

Method

Look closely at the rock samples.

Record your observations in the data table, under the following headings.

General appearance—Note properties like shape, layering, presence of fossils. A simple sketch may help.

Colour—Note the colour.

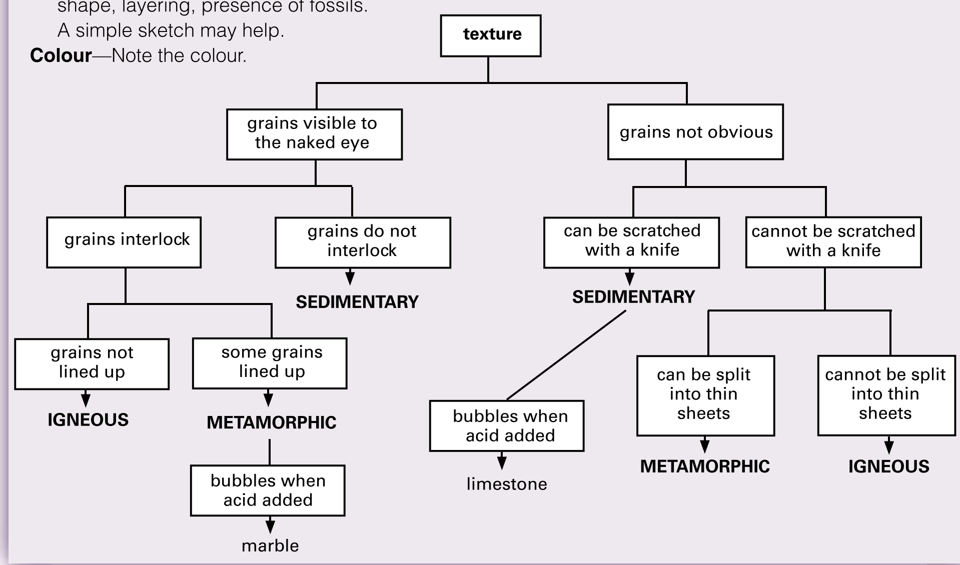
Hardness—Use a table knife or metal spatula to see if you can scratch or split the rock.

Grain size—This is the size of the rock fragments (in sedimentatry rocks) or the size of the crystals (in igneous rocks). The terms usually used to describe grain size are *fine*, *medium* and *coarse*.

Texture—The size, shape and arrangement of the fragments or crystals in the rock. Note whether they interlock as in granite (see the photo on page 280) or whether they are separate grains held together by finer material.

Reaction with acid—Add a drop of dilute hydrochloric acid to see if it produces bubbles of carbon dioxide gas. (*Teacher note:* You will need to arrange things so that students are not handling rocks with acid on them.)

Classification—Use the key below to see if you can classify each sample as igneous, sedimentary or metamorphic. You may also be able to classify rocks you have collected yourself.



WEBwatch

Use the internet to research the following commonly used rocks:

- dolerite
- granite
- limestone
- marble
- pumice
- quartzite
- sandstone
- shale
- slate.

Record your information in a table under these headings:

- type of rock (sedimentary, igneous or metamorphic)
- properties
- how it was formed
- how it is used.

For two useful websites go to www.scienceworld.net.au and follow the links to:

Stupid page of rocks

List of rocks

Granite kitchen bench

A bluestone wall

Cutting limestones slabs in a quarry (Mount Gambier)

Sandstone arches at the University of Queensland

Hints and tips

Develop a concept map with the students to illustrate the uses of rocks. You may like to draw a giant map on the board and get each student to add a word and linking sentence.

Learning experience

The actions of human beings have increased the rate of weathering and erosion, with devastating effects on our environment. Research how people have increased the rate of weathering and erosion—clearing land for agriculture, in housing, building and mining, in changing our coastlines etc.

Learning experience: rocks board game

Ask students, working in pairs, to design a board game about rocks. The game must contain facts and information they have learnt in this chapter. It should provide learning experiences for others whose knowledge of rocks is limited. The board game should be about A3 in size, and should have a name, be colourful and fun to play.

Once completed, students can play other students' games, then evaluate and critique them.

Check!

1 These four stages in the formation of a sedimentary rock are mixed up:

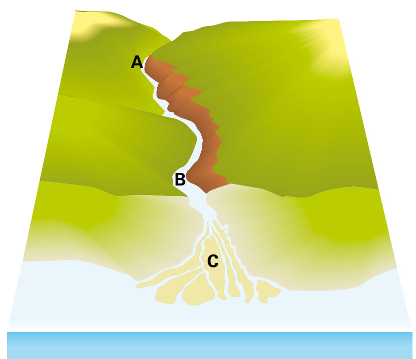
cementing and compressing — weathering
deposition (settling) — erosion

Put them in the correct order.

2 a List the following sediments in the order in which they would settle in water that has been vigorously shaken in a bottle:

coarse sand — fine sand
clay — gravel

b Suppose you found sediments that had been deposited at A, B and C in the diagram below. Which sediments would be gravel, which mud, and which sand? Explain your answer.

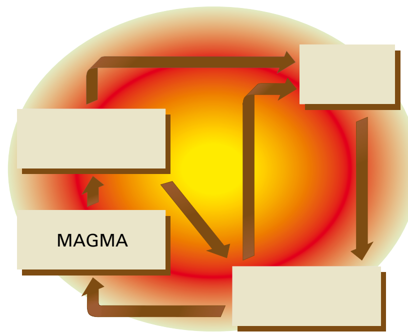


3 How could you tell the difference between sandstone and conglomerate? Draw a diagram to show the difference between the two rocks.

4 Which type of rock is formed as a result of:
a weathering and erosion
b heat and pressure
c melting and cooling?

5 Where does all the force come from to squeeze sediments together to form sedimentary rocks?

6 Copy the rock cycle diagram below. Then use the diagram on page 291 to add the names of the rock types and label the arrows.



7 Name three igneous, three sedimentary and three metamorphic rocks.

8 a How can granite be changed into a sedimentary rock?
b Can a metamorphic rock be changed into an igneous rock? How?

9 The photo below shows an open-cut coal mine.
a Why is coal called a fossil fuel?
b What effect does coal mining have on the environment?

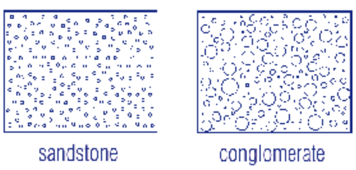
Check! solutions

1 The four stages in the formation of sedimentary rocks are: weathering, erosion, deposition and cementing, and compressing.

2 a The order in which they would be deposited (from the bottom) is gravel, coarse sand, fine sand and then clay.

b You would find gravel at A because it was deposited first, then sand at B and mud at C because it was deposited last.

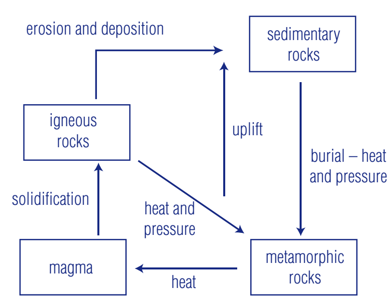
3 The best way to tell the difference is by carefully observing the size of the grains. In sandstone they will be visible but fairly uniform in size whereas in conglomerate there will be some pebbles, some sand and some fine clay.



4 a Weathering and erosion usually form sedimentary rocks.
b Heat and pressure usually form metamorphic rocks.
c Melting and cooling form igneous rocks.

5 The pressure which squeezes sediments together comes from the weight of material above.

6



7 Some igneous rocks are granite, basalt and pumice. Some sedimentary rocks are sandstone, conglomerate, limestone and shale. Some metamorphic rocks are marble, slate and quartzite.

8 a Granite is an igneous (or plutonic) rock. It can be changed into a sedimentary rock over millions of years. First of all it must be physically weathered into smaller particles and then eroded and deposited. This is part of the rock cycle.

b A metamorphic rock can be changed to an igneous rock if it is heated to the temperature at which it melts and then cooled and solidified.

9 a Coal is called a fossil fuel because it consists of dead plant remains ('fossil') and can be burned to produce heat energy ('fuel').

b The mining of coal can lead to erosion and spoil the landscape. The burning of coal produces gases which cause air pollution and global warming.

challenge

1 Many buildings were once built from stone. Why are buildings rarely made of stone now?

2 Which rock would be best to build a small bridge across a stream? Explain your choice.

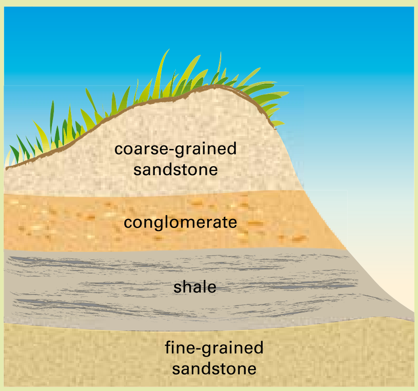
3 Suggest why marble is usually found in regions of heavily folded sedimentary rocks.

4 Sandstone and quartzite are both made of the mineral silicon dioxide (sand), but quartzite does not weather as quickly as sandstone. Suggest a reason for this.

5 Why don't the continents disappear as they are continually worn down by weathering and erosion?

6 The cliffs in the Blue Mountains are up to 500 metres high. Geologists infer that it took about 20 million years for the sedimentary rocks in these cliffs to be formed on the ocean floor. Calculate the average depth of sediment deposited each year.

7 Mary found a cliff-face with four different layers, as shown.

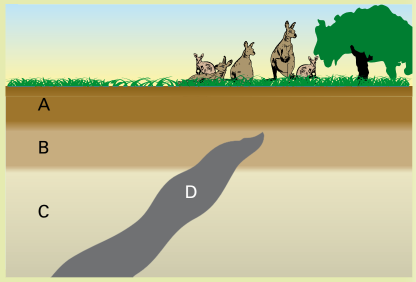


a Suggest why the sediments in the layers are different sizes and colours.

b Which layer was most likely formed during a period of floods? Explain your inference.

c Which layer was most likely formed when the area was swampy? Explain your inference.

8 A, B and C in the diagram below are sedimentary rocks and D is a plutonic igneous rock. Which of these four rocks would be the oldest? Which would be the youngest? Explain your answer.



9 Imagine you are a piece of rock that has recently come from a volcano. Using the rock cycle on page 291 describe your 'life' over the next few million years.

try this

Collect as many different kinds of rocks as you can. The best places to look are where bare rocks are exposed—on hillsides, cliffs, quarries, building excavations, rocky gullies, stream beds and road cuttings. To get a good specimen you will need to break off a piece of rock about the size of a clenched fist with a geological hammer. Warning: When chipping rocks always wear safety glasses to protect your eyes.

Note the difference between the weathered surface of the specimen and the unweathered rock inside. Label each specimen, and make a note of where you found it. You could use the key on page 292 to help you identify your rocks.

Did you find any sedimentary rocks? Can you tell whether they are sandstone, conglomerate or shale? If you think a sedimentary rock may contain fossils, try to split it along the layers. Fossils are common in limestone.

Did you find any igneous rocks? Basalt is very common. It is grey-coloured and its crystals are too small to see. Granite (page 280) is also common and often forms round boulders. It has large crystals in it.

Challenge solutions

1 Stone has been used for thousands of years for buildings because it has been readily available and easy to use. However, it does weather and becomes unsightly and unstable. Different materials are used today because they are cheaper and easier to use and do not require so much skilled labour.

2 The best type of rock to use will not dissolve in water and will be able to support heavy loads. For these reasons granite is often used.

3 Marble is formed when the sedimentary rock limestone is subjected to great pressure and heat. Heavy folding of rocks usually indicates massive earth movements which produce these great pressures and heat.

4 Quartzite is a metamorphic, crystalline rock where the particles of sand have been fused together by heat and pressure. This explains why it is more resistant to weathering.

5 They do, but very slowly. In addition, earth movements push the crust up and in some parts of the Earth new rocks are formed by volcanic eruptions.

6 The average depth of sediments deposited each year can be calculated by dividing the depth by the time:

$$= \frac{500\ 000 \text{ mm}}{20\ 000\ 000 \text{ years}}$$

$$= \frac{1}{40} \text{ mm per year}$$

7 a The sediments are different sizes and colours because they came from different places at different times and were formed by different methods of erosion.

b The layer formed during a flood is probably conglomerate because larger particles need fast flowing water to carry them.

c The layer likely to have been formed in a swamp is the shale because it is made from very fine particles which are deposited slowly.

8 The oldest rock is C because it is at the bottom of the sedimentary sequence. It is unlikely that rock D was formed after A otherwise the magma may have come to the surface.

9 In your story keep in mind that rocks are cycled and recycled and that they may be sedimentary, metamorphic or igneous at various stages. Eroded particles may also be transported over long distances.

Main ideas solutions

1 molten
2 magma, lava
3 igneous
4 ores
5 weathering
6 erosion
7 deposition, sediments
8 metamorphic
9 cycle

MAIN IDEAS

Copy and complete these statements to make a summary of this chapter. The missing words are on the right.

cycle
deposition
erosion
igneous
lava
magma
metamorphic
molten
ores
sediments
weathering

1 The inside of the Earth is very hot, and in parts it is _____.
2 Molten material below the Earth's surface is called _____. Where the magma breaks through the surface in a volcano, it is called _____.
3 _____ rocks are formed by the cooling and hardening of molten rock.
4 Rocks are formed from minerals. _____ are minerals from which metals can be extracted.
5 _____ is the slow breaking down of rocks into smaller and smaller pieces. It may be physical or chemical.
6 _____ is the process by which weathered materials are carried away, mainly by water.
7 Sedimentary rocks are formed by the processes of weathering, erosion and _____, followed by the cementing together and hardening of _____.
8 _____ rocks are formed from other rocks by heat and/or pressure.
9 Rocks can be changed from one type to another over millions of years. This is called the rock _____.

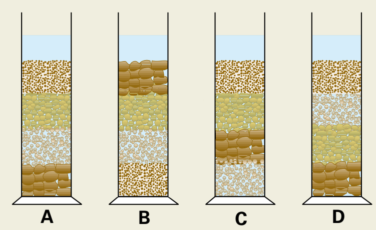
Try doing the Chapter 13 crossword on the CD. Working with technology

REVIEW

1 Which of the following are rocks and which are minerals?
a basalt
b bauxite
c calcite
d marble
e pumice
f quartz
g sapphire

2 Granite is a rock:
A containing crystals big enough to see
B made up mostly of dark minerals
C formed by the cooling of a lava flow
D made up of layers of different colours.

3 A soil sample containing different-sized grains was mixed with water in a jar. After the mixture settled, four layers could be seen. Which one of the diagrams shows the correct order in which the layers probably formed?



Review solutions

1

rocks	minerals
basalt	bauxite
marble	calcite
pumice	quartz
	sapphire

2 A

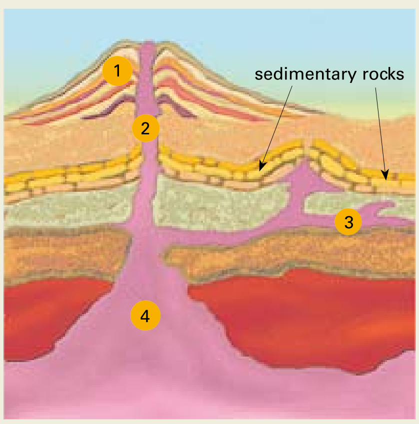
3 D

REVIEW

4 Just below the crust of the Earth is the:
A mantle
B inner core
C outer core
D atmosphere.

5 You want to find out whether an igneous rock has been formed by slow or rapid cooling. Which of these properties of the rock would you need to observe?
A hardness
B shape
C colour
D crystal size

6 The diagram below is a cross-section of an extinct volcano.
a Where would you expect to find igneous rocks with the smallest crystals? Why?
b Which of the following rocks would you most likely find at 4?
A granite
B pumice
C basalt
D sandstone
c Are the rocks at 3 volcanic or plutonic?
d Copy the diagram and mark on it where you are likely to find metamorphic rocks.
e Why are the layers of sedimentary rocks not horizontal?



7 The surface of the Earth is covered by many different landforms. These were formed by:
A erosion
B movements inside the Earth
C volcanoes
D all of the above.

8 Put these five stages of the weathering and erosion of granite into the correct order:

boulder	gravel	fine sand
coarse sand	solid rock	

9 Explain in your own words the difference between lava and magma.

10 You are a rock sculptor and have been given the job of making an outdoor sculpture of Australia's first president.
a What properties would the rock you use for the sculpture need to have?
b Suggest which rock you would use.

11 Use your knowledge of the rock cycle to explain the sequence of events which could over millions of years change a rock exposed near the top of a mountain into metamorphic rock. Describe the changes needed and draw a diagram.

12 A mesa is a flat-topped land form. Many mesas in Australia are capped with basalt or other hard rock, as in the photo below. Use diagrams to explain the flat-topped shape.

Check your answers on pages 306–307.

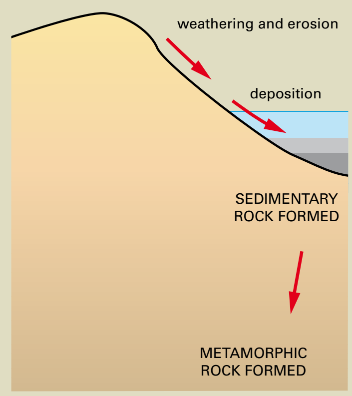
7 **D**

8 solid rock → boulder → gravel → coarse sand → fine sand

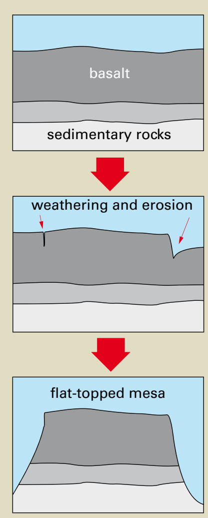
9 Magma is molten rock under the Earth's crust before it reaches the surface. Lava is molten rock after it reaches the surface.

10 **a** Since you have to carve the rock you would not want it to be too hard. Since the sculpture has to sit out in the weather you would not want it to weather too easily.
b Using information from your internet research on page 293, the best rock to use is probably **marble**. (Granite would be too hard, and limestone would probably weather too easily.)

11 Firstly, the rock would be weathered and eroded. The sediments would then be deposited in the ocean or a lake and changed into sedimentary rock. As this sedimentary rock is buried under other rock layers, it could be changed by heat and pressure into a metamorphic rock. See the diagram below.



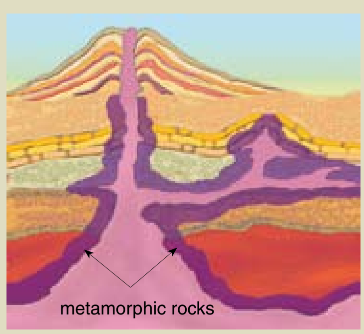
12 Basalt does not weather as easily as most sedimentary rocks. It also prevents the rocks under it from being weathered and eroded. This is why a flat-topped mesa is sometimes formed, as shown.



4 **A**

5 **D** See pages 278–279.

6 **a** **1**—since the rocks here cooled most rapidly.
b **C**
c **Plutonic**—since they formed below the surface.
d The rocks around the magma would be changed to metamorphic rocks as shown on the right.



e The layers of sedimentary rock are not horizontal because they have been pushed up by the magma.