Chapter 5

Wearing away the Earth

CONTEXT AREA

- Most people think of our Earth as constant and never-changing. This is not true. The Earth changes every day, usually slowly but sometimes very quickly.
- What causes the Earth to change? Are the changes entirely natural? Or have people and our way of life caused it? Why is some farmland being washed or blown away?
- Every minute, land the area of three football fields is being turned into desert somewhere in the world. What can be done about it? What can we do about it?
- This chapter is about how the Earth is being worn flat, where the mud and stones go, and the landforms which they make. More importantly, it is about how to reduce or stop the destruction of our environment.

PRESCRIBED FOCUS AREAS

4.3 identifies areas of everyday life that have been affected by scientific developments

4.4 identifies choices made by people with regard to scientific developments

DOMAINS

KNOWLEDGE AND UNDERSTANDING

4.9 describes the dynamic structure of Earth and its relationship to other parts of our solar system and the universe

4.9.6 the lithosphere

b explain the breaking down of rocks in terms of physical and chemical changes

c relate the formation of landforms to weathering, erosion and deposition

d describe the origins of sedimentary, igneous and metamorphic rocks

SKILLS

4.13 clarifies the purpose of an investigation and, with guidance, produces a plan to investigate a problem

4.14 follows a sequence of instructions to undertake a first hand investigation

4.17 evaluates the relevance of data and information

4.19 draws conclusions based on information available

4.20 uses an identified strategy to solve problems

4.21 uses creativity and imagination to suggest plausible solutions to familiar problems

4.22 completes a variety of individual and team tasks with guidance

VALUES AND ATTITUDES

4.23 demonstrates confidence and willingness to make decisions and to take responsible actions

4.25 recognises the relevance and importance of lifelong learning

4.26 recognises the role of science in providing information about issues being considered and in increasing an understanding of the world around them

4.27 acknowledges their responsibility to conserve, protect and maintain the environment for the future

CONCEPTS

5.1 Wearing away rocks

Rocks look hard and tough. They are used for making roads, important buildings, and monuments. Large rocks can be used to hold back the surf and ocean waves. Rocks seem to last forever. But they don't. They are slowly worn down and washed away. The wearing away of rocks into smaller pieces is called weathering. Weathering can happen in many ways. The causes of weathering have been divided into different groups.

Physical weathering

Physical weathering refers to weathering by non-living things. It includes the effects of heat and cold on rocks, the formation of ice, and the effects of wind and water. Even the size of rocks is important.

Onion-skin weathering

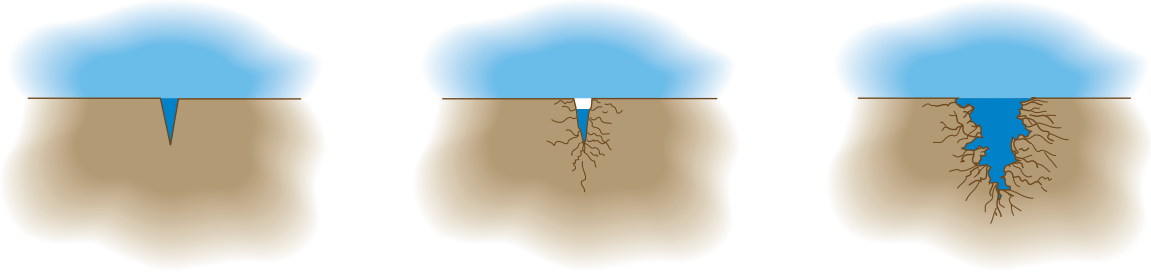
In desert areas, the days are very hot and the nights are freezing cold. This daily heating and cooling affects only the outside of the rock. This is because rocks do not conduct heat very well. Sometimes the outside of the rock can peel off, just like the fleshy parts inside an onion. This is called onion-skin weathering, or spalling. The rocks produced are round and are called tors. (Tors can be made by other types of weathering.)

Physical weathering has formed the Devil's marbles

Tors can be formed by onion-skin weathering

Ice wedging

When water freezes it takes up more space. So when ice forms in a crack in a rock, it pushes hard against the rock around it. This can make the crack larger. The next day, the ice melts and water fills the crack again. That night, ice forms again and makes the crack even larger. The process is repeated many times until part of the rock is split off. This process is called ice wedging.



How ice wedging cracks rocks

EXPERIMENT

AIM: To observe the effects of heating and cooling

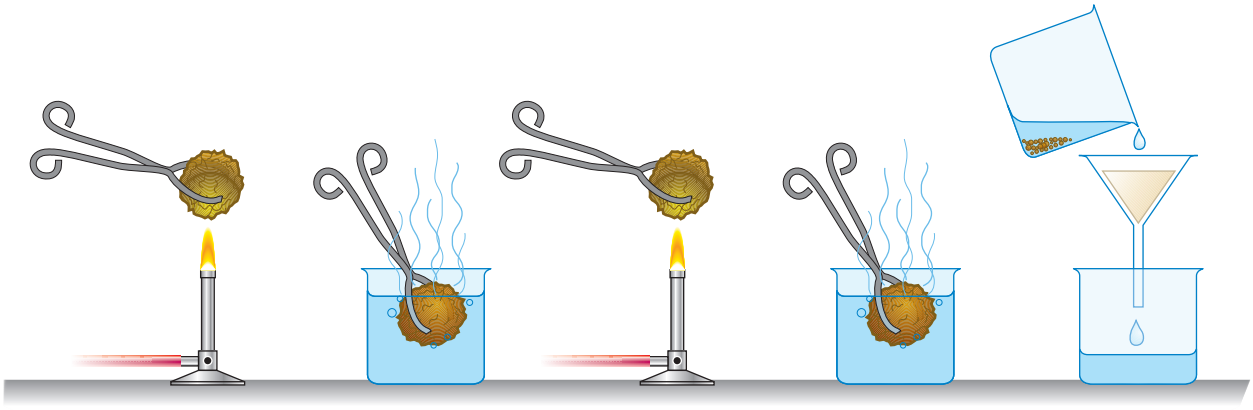
During the day, rocks can be in full sunlight and get very hot. At night they can get very cold. These changes in temperature can cause cracking and peeling of the rock. This is a type of physical weathering. It can be simulated (copied) in an experiment.

Safety glasses are essential in this experiment. Do not stand too close to the rock or the flame. Tiny chips of rock may fly off. As well as eye protection you should have the correct footwear for experiments.

Hold a small piece of rock in some tongs and heat it in the flame of a Bunsen burner for about 30 seconds. Then cool it in a beaker of tap water. Repeat this at least three times.

There should be some fragments from the rock in the bottom of the beaker. Tip out most of the water, and then separate the fragments by filtering them through filter paper. Remove the filter paper and allow it to dry. Open out the filter paper, and examine the fragments of rock using a magnifying glass. Save the fragments for a later experiment.

Write the experiment in your note book. Draw the shape of the rock fragments as part of your report.



Cycles of heating and cooling

CHECKPOINT:

COPY AND COMPLETE

Sometimes the outside of the rock can peel off, just like the fleshy parts inside an _____. This is called _____-____ weathering, or _____. The rocks produced are _____ and are called ____.
When ice forms in a crack, it pushes ____ against the ____ around it. This can make the _____ larger, until part of the rock is _____ off. This process is called ___ _____.

QUESTIONS

1 Look up the meaning of these words from the text: weathering, spalling, tor, ice wedging.

2 Spalling and ice wedging are most effective at the edges and corners of rocks. Draw the usual shape of rocks and boulders formed by these processes.

3 Explain the process of ice wedging, using diagrams and words.

4 Ice wedging is a type of weathering not found on the coast of Queensland. Why?

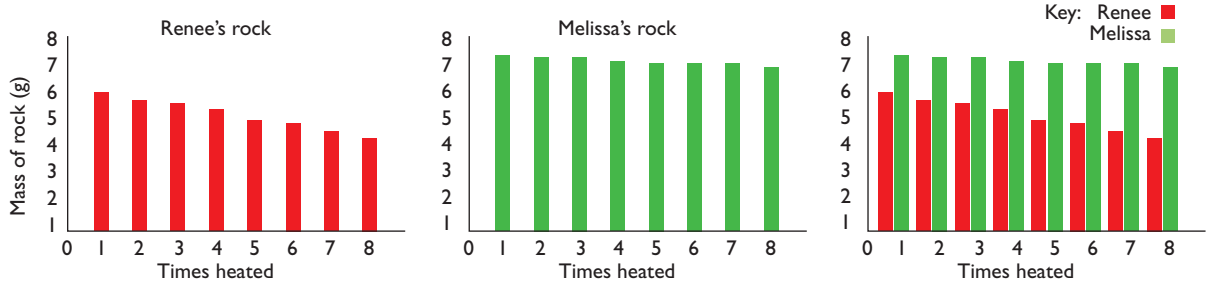
5 Design an experiment to show the effects of water freezing as in the process called 'ice wedging'.

6 Renee and Melissa heated two different rocks and cooled them in water. After each heating and cooling cycle, the rock was dried with a paper towel and hair dryer, then weighed. The process was repeated eight times. Their results are:

Times heated and cooled	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***
Mass of Renee's rock (g)	*5.6*	*5.3*	*5.1*	*4.9*	*4.6*	*4.4*	*4.1*	*3.9*
Mass of Melissa's rock (g)	*7.3*	*7.2*	*7.2*	*7.1*	*7.0*	*7.0*	*6.9*	*6.8*

Graph these results using a column graph. Plot the mass of Renee's and Melissa's rocks separately, then together on the one graph. Use the graphs as a guide. Answer these questions from the graphs.

a Who started with the heavier rock sample?
b Whose rock weathered faster: Renee's or Melissa's?
c After how many heating and cooling cycles would each rock have the same mass?
d Whose rock sample would be best for building a retaining wall? Why did you select this rock?



Sample graphs for Renee and Melissa

7 Which types of physical weathering are more common in winter? Which types are more common in summer?

8 Which would weather faster: a solid chunk of rock weighing one kilogram, or small pieces of the same rock with a total weight of one kilogram? Explain your reasons. You can test your answer as a research project.

Chemical weathering

Sometimes the weathering of rocks is caused by chemicals in the environment. This is called chemical weathering. The chemicals in air and water can react with the chemicals in rocks. The newly made chemicals in rocks may be soft like clay. The most important chemicals in weathering are water, oxygen and acids.

Natural acids

There are many natural acids. Natural acids come from the decay of dead plants and animals, and from the rain. These acids are not as strong as the acids in a science laboratory. Some rocks can be slowly dissolved by laboratory acids and natural acids. The rock called limestone is commonly dissolved by rainwater and acids.

Limestone caves

One of the best examples of chemical weathering can be seen in caves. Caves form where limestone rocks are dissolved by acids. The acid and dissolved limestone make a solution, which is then carried away in creeks and rivers. If the water evaporates, then the limestone may crystallise again. Stalactites and stalagmites are formed in this way, when a solution containing limestone drips from the roof of caves and evaporates.

Clay

Clay is made by the chemical weathering of some rock chemicals. It is a natural substance which becomes larger if it gets wet. As clay forms in rocks, it can swell and break apart the grains in the rock. We usually see clay when it is dried and cracked, in dried lake beds.

Biological weathering

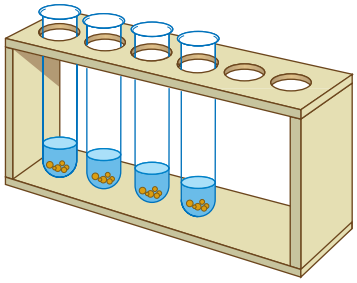
Living things help to break down rocks. Tree roots grow and exert a force which breaks apart giant rocks. Tiny roots can grow between the grains in rocks. All this helps to break rocks into smaller pieces.

Some weathering happens underground. Worms turn the soil over, bringing deep soil to the surface. They also produce acids, which dissolve some rock chemicals. Bacteria and fungi are important in all soils. They help in the breakdown of rocks into soil.

EXPERIMENT

AIM: To investigate the action of acids on limestone

Your teacher will give you four small lumps of limestone, dilute laboratory acid, soda water and white vinegar. (Soda water is carbon dioxide gas dissolved in water.) Take four test tubes and carefully place a piece of limestone into each one. Pour some laboratory acid into one of these test tubes, soda water into another, vinegar into the third, and ordinary tap water into the fourth. The last sample, with tap water, is the control. Observe each piece of rock carefully. Do they all have bubbles? Are all the pieces of limestone reacting?



Procedure for experiment on the action of acids

CHECKPOINT:

COPY AND COMPLETE

The chemicals in ___ and _____ can react with the chemicals in rocks. The most important chemicals in weathering are _____, _____ and _____. There are many _____ acids. The rock _____ is commonly dissolved by _____. One of the best examples of _____ weathering can be seen in _____. Caves form where _____ rocks are _____ by _____. Clay is a natural substance which becomes _____ if it gets wet.

Living things help to _____ ____ rocks. Tree roots ____ and exert a _____ which _____ apart giant rocks. Tiny _____ can grow between the grains in rocks. All this helps to _____ rocks into _____ pieces.

QUESTIONS

1. There are three chemicals in the environment which help weathering. What are they? Where are they found?
2. Where do natural acids come from?
3. Which rock can be dissolved to make caves?
4. What is leaching? What colour are the stains from the leaching of iron in rocks?
5. Cave systems in limestone rocks follow the course of underground rivers. Why is water necessary to make caves?
6. What is biological weathering?
7. How do living things cause rocks to break down?
8. How can tree roots growing under a house cause damage to the house?
9. Clay is formed by chemical weathering, and helps produce physical weathering. Explain both parts of this statement.

REVIEW QUESTIONS

1. What are the three types of weathering?
2. Classify these erosion agents into one of the three types in Question 1:
   - **a** tree roots wedge a rock apart
   - **b** changes in temperature
   - **c** chemicals in rainwater
   - **d** ice forms in cracks
   - **e** salts in urine
3. Which type of weathering causes the following features?
   - **a** limestone caves
   - **b** round boulders called tors
   - **c** tree roots wedging into cracks in rocks
   - **d** rocks changing into clay
   - **e** ice forcing open the cracks in rocks
   - **f** stalactites and stalagmites
   - **g** orange stains down the side of a rock face
   - **h** clay swells in size as it absorbs water
   - **i** ocean spray evaporates, leaving salt crystals to form between the grains of rock

5.2 The effects of weathering

Many people believe that weathering only affects rocks in the mountains, and that weathering does not happen in cities and towns. Weathering happens everywhere. Weathering affects everyone, no matter where they live.

Many road cuttings are carved through rock. When this rock weathers it can fall onto the road, where it is a hazard to vehicles. Many cuttings are sprayed with cement, or have a wire mesh fence to stop the stones and rocks from rolling onto the road. Once cracks have opened in the rock in the cutting, then grass and plants grow which further speed weathering.

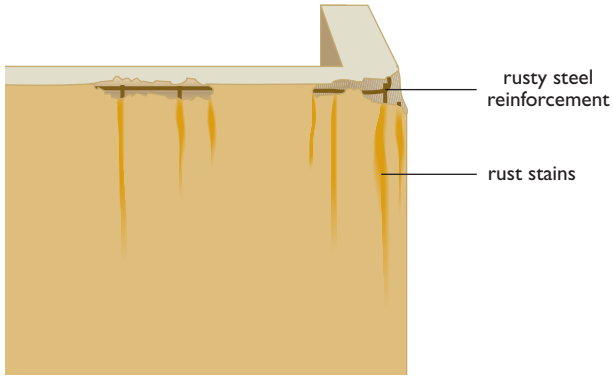
Acid rain

In areas of the world where air pollution is very bad, acid rain is a problem. Acid rain can form when raindrops dissolve pollution and carry it to the ground. If the pollution is acid, then the rain will also be acid. Acid rain is a big problem because it can dissolve limestone and marble statues and buildings, hurt people's eyes, kill plants, and make the water in lakes so acid that even the fish die.

Monuments made from some types of stone can be dissolved by acid rain

Concrete cancer

An unexpected form of weathering happens in buildings. It is commonly called concrete cancer, although it has nothing to do with cancer in people. Many buildings, bridges and pavements are made of concrete, which is reinforced (made stronger) by steel inside it. Sometimes this steel goes rusty and swells. This causes the outside of the concrete to peel off. It looks bad and it weakens the strength of the concrete.



Concrete cancer

You can look for weathering in old buildings near where you live. The bricks will not be as sharp on their edges, and might be faded. Often the mortar has fallen out from between the bricks. Another good place to look is in cemeteries. The headstones are different ages, and will show different amounts of weathering.

In many places around the world, some famous old buildings are weathering. The speed of weathering is increasing because of pollution. The Colosseum in Rome, the Parthenon in Athens and the Taj Mahal in Agra are all weathering faster now than ever before.

Away from cities, there are many old monuments and buildings which are weathering very quickly. The ancient Egyptians built the pyramids 4000 years ago. They have weathered due to wind-blown sand and changes in temperature. But even in the desert, acid rain is weathering these monuments too.

Along beaches and rivers people have built stone barriers and walls. Weathering occurs on these rocks, as grains of sand in the waves chip away at them.

Even the corrosion of steel bridges is a type of weathering in which oxygen and water attack the steel, and rust flakes off.

CHECKPOINT:

COPY AND COMPLETE

Weathering affects _____, no matter where they ____.
Many road cuttings are carved through ____. When this rock _____, it can fall onto the ____, where it is a hazard to _____.
Acid rain can form when _____ dissolve _____. Acid rain is a big problem because it can _____ limestone and marble _____ and _____, hurt people's ____, kill _____, and make the _____ in lakes so ____ that even the ____ die.
In many places around the world, some famous old _____ are _____. The speed of weathering is _____ because of _____.

QUESTIONS

1 Workers who repair roads do not let plants grow on the sides of road cuttings. Why is this?
2 Old buildings and monuments are weathering faster than ever before. Why is this?
3 Explain the process that causes concrete cancer. How can it be reduced in the future?
4 Describe the type of weathering (physical, chemical, biological) that causes the following:
   a weathering of limestone and marble buildings
   b steel reinforcement going rusty
   c rusty steel pushing the surrounding material away

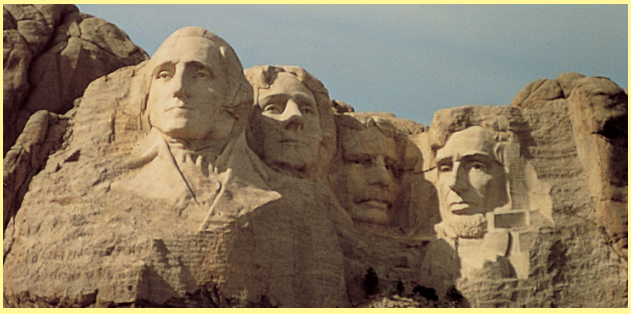
CASE STUDY

Mount Rushmore

The images of four American Presidents have been carved into the top of Mount Rushmore, in the state of South Dakota in the USA. The carvings were done between 1924 and 1941. Each face is 20 m high. That is as high as a five-storey building. In selecting a site for the carvings, Gutzon Borglum, the sculptor, selected a large outcrop of granite rock free from cracks. The faces are on the sunny side of the mountain, where they could be seen easily. But it is the Sun and the cold winters which are causing the faces to weather. The faces are beginning to fall off the mountain.

To try to stop the weathering, the faces have been mapped. The cracks in the granite rock have been measured. These cracks are where the weathering is happening. Water fills the cracks and freezes at night, which makes the cracks wider. The result is that the faces are beginning to deteriorate. One quarter of George Washington's face could peel off!

In order to preserve the carvings, the largest cracks have been pinned to hold the rocks together. Smaller cracks have been blocked with silicone sealant. The silicone expands and contracts with the rocks, and doesn't stain the rock, yet keeps the water out.



Mount Rushmore, showing the giant carved heads of four American presidents

QUESTIONS

1 Describe what is special about Mount Rushmore.
2 What type of weathering is happening in the cracks?
3 Why have the cracks been filled with silicone?
4 The carvings were made on the sunny side of the mountain so people could see them. But this has speeded up the weathering. Explain why.
5 Steel pins were not used to stop the cracks from widening. Why would steel be a poor choice?

5.3 Erosion

Once rocks have been broken down into smaller pieces, or weathered, they are moved and carried away to somewhere else. The carrying away of rock fragments is called erosion. Erosion happens because of wind, water, surf and ocean waves, ice, and gravity. These are the agents (causes) of erosion.

A roadslip caused by the collapse of the soil

Wind erosion occurs when the wind blows grains of sand and dust. **Water erosion** occurs when moving water washes away stones, sand and mud. **Surf and ocean waves** remove sand from beaches, and wash it along the coast or out to sea. **Ice erosion** occurs when ice in glaciers (frozen rivers) carves away earth and rock. **Gravity** causes landslides and soil creep, which happen when wet earth slips down a steep slope. Wet earth moves because it is heavier and more slippery than dry earth. Soil creep is slow movement, while landslides are large and sudden movements of soil or rock.

How soil creep happens

Wind, water, ice, surf and gravity move the weathered rock fragments. The rock fragments are deposited (put down) in a different location. This is called deposition. The layers of rock fragments which have been deposited are called sediments.

Landslips like this one are common on steep farmland in wet areas

A river drops its sediments when the water slows down. The biggest stones are dropped first, then gravel, then pebbles, then sand, and finally mud when the water is moving quite slowly. This is why most rivers carry mud and silt out into the sea, but not gravel or stones.

Suppose you could stop at any place in the river and look at the sediment. The sediment which was deposited first would be at the bottom. These are the oldest sediments. The newer sediments are at the top. This is always true: the oldest sediment is at the bottom, and the newest sediment is at the top.

Rivers are the most easily seen form of erosion. Television news shows rivers in flood, which can wash away cars and houses. But erosion is happening all the time. The brown colour in river water is caused by mud. Mud is eroded soil.

People who live near the coast will have seen coastal erosion. The surf pounds the beaches, and during big storms the waves can remove lots of sand. The constant pounding of the waves has produced cliffs and headlands.

Coastal erosion

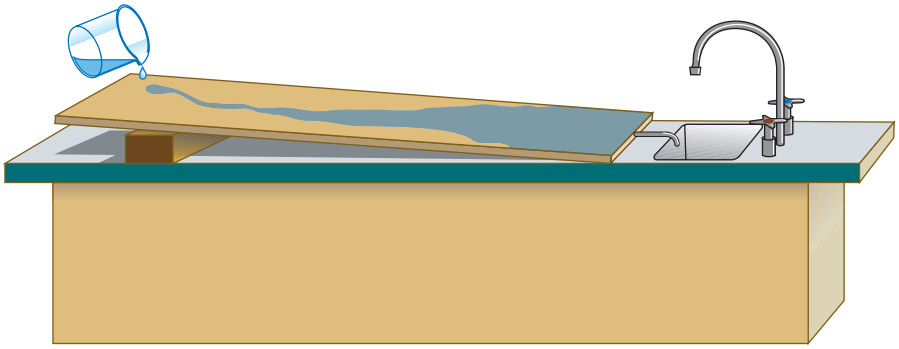
DEMONSTRATION

AIM: To observe a model of water erosion

Your teacher will demonstrate a stream table. This is a large shallow tank which is partly filled with sand and small stones. Water is poured in at the top, and moves over the sand and down the table. The water simulates (copies) the action of a river.

Observe the water flow to answer these questions:

1 Which move further: the large rocks or the small grains?
2 Does the 'river' follow a straight path, or does it curve?
3 Where does most erosion take place?
4 Does this simulate a real river?



Using a stream table

CHECKPOINT:

COPY AND COMPLETE

The carrying away of rock fragments is called _____. Erosion happens because of ____, _____, ____ and _____ waves, ___, and _____. These are the _____ of erosion.
Wind erosion occurs when the ____ blows grains of ____ and ____.
Water erosion occurs when _____ water washes away _____, ____ and ___. Surf and ocean waves remove ____ from _____, and wash it along the _____ or out to ___.
Ice erosion occurs when ice in _____ carves away _____ and ____.
Gravity causes _____ and ____ _____. Soil creep is ____ movement, while landslides are _____ and _____ movements of soil or rock.
____, _____, ___, ____ and _____ move the weathered rock fragments. The rock _____ are _____ in a different location. This is called _____. The layers of rock fragments which have been _____ are called _____.

QUESTIONS

1 What is the difference between erosion and the agents of erosion?
2 Why is the water in flooded rivers always brown?
3 What are the five agents of erosion? Which is the most dominant in your area?
4 Put these words in sequence: erosion, deposition, weathering.
5 In a section of a river, where would you go to look for the largest sediments?
6 Imagine you could stop a section of flooded river.
   a What would you find in the water?
   b If the water was still, and then evaporated, describe what the deposit would consist of, and what it would look like.
7 Where would you go to look for sediments? Set out your answer in a table form, using the headings shown below. Remember to include the five agents of erosion.

Agent of erosion ***Locations of deposits***

5.4 Landscapes caused by erosion

Erosion is the removal of weathered rocks. Erosion is caused by wind, water, surf and ocean waves, ice and gravity. The water can be streams, or flash floods after heavy rain. The wind can be in places such as deserts or on the beach. Each type of erosion produces its own landscape.

River landscapes

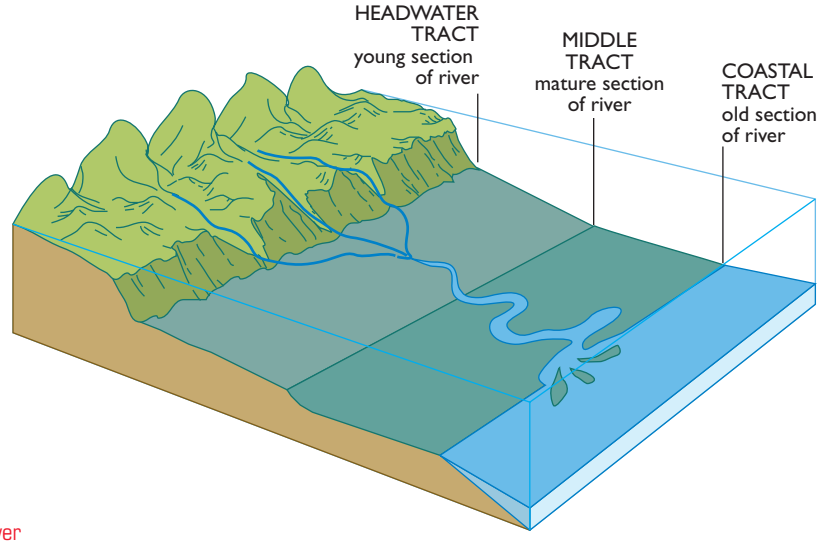
Rivers have their own landscapes. The movement of mud, water and stones creates landforms which are only seen near rivers.

When the slope is steep, the river flows fastest. There might be waterfalls and rapids. Fast-flowing water carries big rock fragments. The fragments are freshly formed and many have sharp corners and edges. This part of the river has V-shaped valleys. It is said to be young and is called the headwater tract.

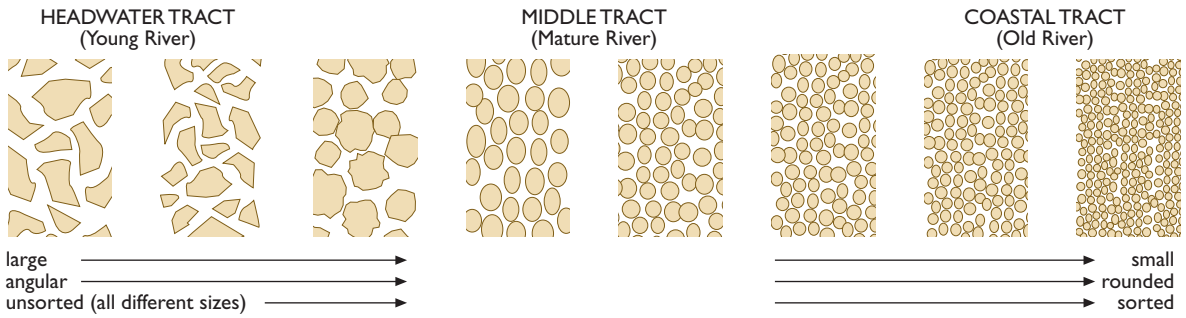
Where the slope is not as steep, the river is slower. The river widens and erodes its banks. Because the water is moving more slowly, it deposits the large stones it is moving. These are deposited in gravel beds. The river is said to be mature, and is called the middle tract.

Where the river valley or plain is nearly flat, the river is slowest. Here only mud and silt are carried by the river. The water is too slow to carry or push sand along. As a result, the river is shallow and sand banks form. This part of the river is said to be old, and is called the coastal tract.

If you put a fine net across the river in different places, the sediments trapped in the net would be different in each place. Where the river is fastest, the sediments are angular and some are large. As the river gets closer to the sea, the particles are more rounded. This is because they have bumped together as the water has pushed and bounced them along the river bed. The large sediments have been broken into smaller pieces or left behind in gravel beds.



The three stages of a river



Sizes and shapes of sediments in a river

Coastal landscapes

At the coast, erosion is caused by the surf and wind. It is the surf which erodes beaches and sand dunes. Water has to be moving to be able to carry sand. When the water stops moving, the sand is deposited. This is why sand banks form at river entrances, in harbours and behind islands. Wind blows loose sand into dunes, which may move inland to cover trees, roads and houses.

Sand is always being shifted by water movement at the entrances to bays and inlets

Weathering and erosion can act quickly on some rocks and slowly on others. Even within the same rock, parts of it will weather more quickly than other parts. We say that rocks which do not weather easily are 'hard' or harder than the surrounding rock. Stacks, which are tiny islands left as the coast erodes, are often made of harder rock than the rock around them.

The diagram on the next page shows the major landforms in coastal and river landscapes. Each of these landforms is caused by a different agent of erosion.

EXPERIMENT

AIM: To identify different types of sand grains

If you collected sand from near the sea, and some from near the meanders, and some from further upstream, would all the sand grains look the same?

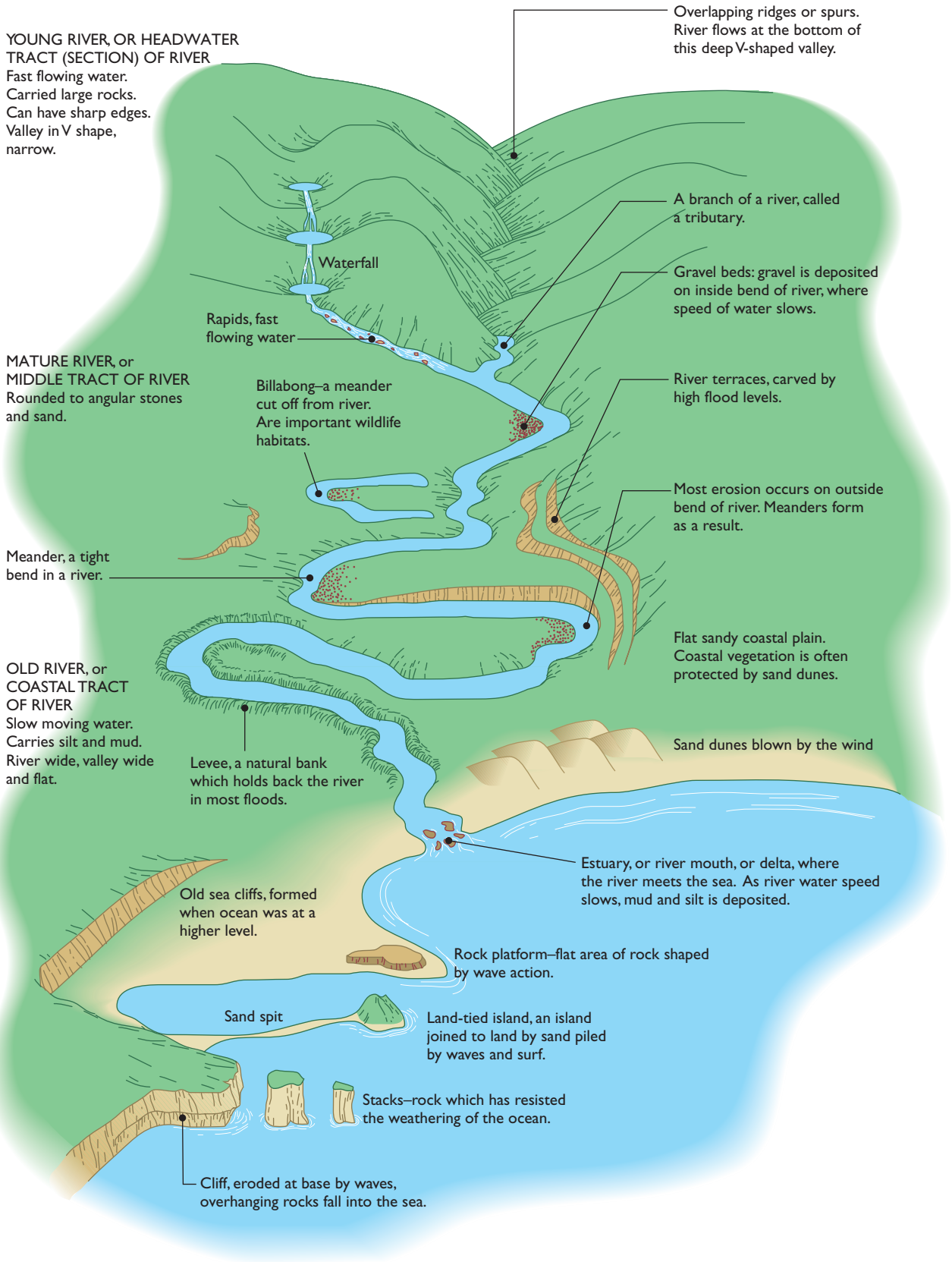
For this you will need some sand, some black cardboard or plastic, and a magnifying glass. Try to get some sand from the ocean or beach, and some from a river inland. If you cannot do this, obtain some packaged sand from a plant nursery or hardware store. Don't forget the rock fragments you collected on filter paper in an earlier experiment.

Look at the grains of sand or rock chips through a magnifying glass. Draw some of them, noting their shape. Infer (guess) which part of the river they came from.

CHECKPOINT:

COPY AND COMPLETE

Rivers have their own _____.
When the slope is steep, the river flows _____. There might be _____ and _____. Fast-flowing water carries ___ ____ fragments. The fragments have _____ corners and _____. This part of the river is said to be _____ and is called the _____ _____.
Where the slope is not as _____, the river is _____. The river _____ and _____ its banks. The water _____ the large _____ it is moving. This part of the river is said to be _____, and is called the _____ tract.
Where the river valley or plain is nearly ____, the river is _____. Here only ___ and ____ are carried by the river. The river is _____ and ____ banks form. This part of the river is said to be ___, and is called the _____ tract.
Where the river is _____, the sediments are _____ and some are _____. As the river gets closer to the ___, the particles are more _____. This is because they have _____ together as the _____ has pushed and _____ them along the river ___.
At the coast, erosion is caused by the ____ and ____. It is the surf which erodes _____ and ____ dunes. Wind _____ loose ____ into dunes.
Weathering and erosion can act _____ on some rocks, and _____ on others. We say that rocks which do not weather easily are '____' or _____ than the surrounding rock.


YOUNG RIVER, OR HEADWATER TRACT (SECTION) OF RIVER
Fast flowing water.
Carried large rocks.
Can have sharp edges.
Valley in V shape, narrow.
Overlapping ridges or spurs. River flows at the bottom of this deep V-shaped valley.
A branch of a river, called a tributary.
Waterfall
Gravel beds: gravel is deposited on inside bend of river, where speed of water slows.
Rapids, fast flowing water
MATURE RIVER, or MIDDLE TRACT OF RIVER
Rounded to angular stones and sand.
Billabong–a meander cut off from river. Are important wildlife habitats.
River terraces, carved by high flood levels.
Most erosion occurs on outside bend of river. Meanders form as a result.
Meander, a tight bend in a river.
Flat sandy coastal plain. Coastal vegetation is often protected by sand dunes.
OLD RIVER, or COASTAL TRACT OF RIVER
Slow moving water.
Carries silt and mud.
River wide, valley wide and flat.
Levee, a natural bank which holds back the river in most floods.
Sand dunes blown by the wind
Estuary, or river mouth, or delta, where the river meets the sea. As river water speed slows, mud and silt is deposited.
Old sea cliffs, formed when ocean was at a higher level.
Rock platform–flat area of rock shaped by wave action.
Sand spit
Land-tied island, an island joined to land by sand piled by waves and surf.
Stacks–rock which has resisted the weathering of the ocean.
Cliff, eroded at base by waves, overhanging rocks fall into the sea.

CHECKPOINT:

QUESTIONS

River landforms

1 What is the main cause of erosion in river valleys?

2 In which tract does the river flow fastest?

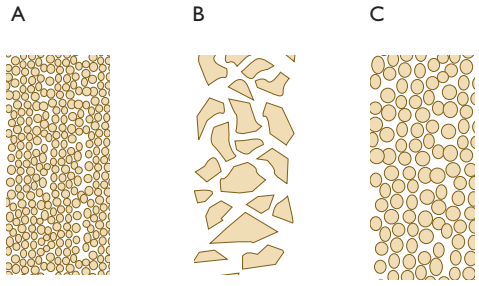
3 In which tract of the river is it able to carry the largest rocks?

4 What is the characteristic shape of the river valley in the headwater tract and the coastal tract?

5 Match the name of the section of river on the left with the tract.

young	*middle*
mature	*coastal*
old	*headwater*

6 Amanda scooped up the rocks in the drawing from three places in the river. Which tract does each come from?



Amanda's rocks

7 Match the words on the left with the meanings on the right.

a	*meander*	*A*	*oxbow or cut-off lake*
b	*estuary*	*B*	*natural bank along the sides of a river*
c	*billabong*	*C*	*river mouth*
d	*levee*	*D*	*section of steep rocky fast flowing river*
e	*rapid*	*E*	*twists and bends in a river*

8 If you were a scientist with a mining company exploring for gravel, in which part of the river would you look?

9 In a flood there is extra water flowing at a higher speed than usual. Suggest how this may change the river.

Coastal landforms

1 What is the main agent of erosion in our coastal areas?

2 Suggest a good location to build a lighthouse. It must be easily seen from the ocean, easily accessible from land, and high above the sea. Use the diagram of river and coastal landforms as a guide.

3 Many people have built their homes near the edges of beaches, but this is no longer allowed. Why?

4 Why do small sandy or muddy islands form around the entrances to rivers?

5 Headlands have vertical cliffs on the part that faces the ocean. How do these vertical faces form?

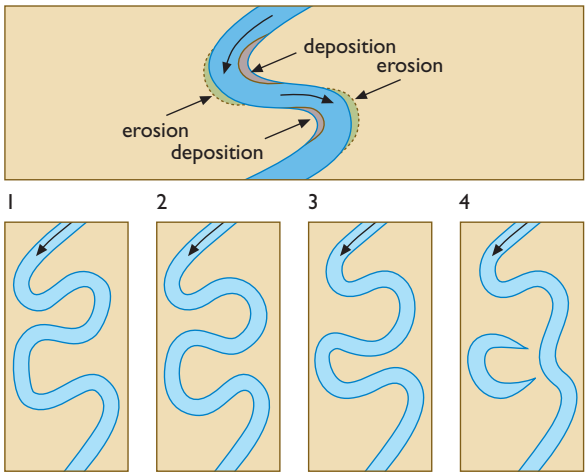
General questions

1 How is the size of particle which is able to be carried in a river related to the speed of the water?

2 How is the shape of the particle in a river related to the distance it has travelled?

3 A grain of sand, which was once part of a rock in the mountains, ends up as part of a sand bar at the mouth of a river. Describe its journey down a river, using as many names of landforms as you can. Write its journey using point form.

4 Use the diagrams to explain, in words, how meanders and billabongs form.



5 Sand spits are strips of sand which form behind islands that are close to the land. Sometimes they join the islands to the land. Why do sand spits form?

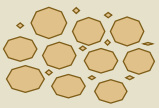
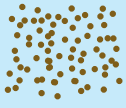
5.5 Rocks made by erosion

Weathering is when rocks are worn down and broken into smaller pieces. Erosion is the removal of weathered rocks by ice, wind or moving water. When the speed of the wind or water slows, the fragments sink to the bottom. This is called deposition. The fragments of rocks that sink to the bottom are called sediments. Sometimes the fragments can be cemented (glued) together naturally to make new rocks. These rocks are called sedimentary rocks, because they have been made from sediments.

Sedimentary rocks

A river carries mud, tiny stones and gravel, as well as sand. These sediments are deposited at different places in the river, depending on the speed of the water. Different types of sediments make different types of rocks, which have different names.

The largest sediments, such as gravel and rocks, form a rock called conglomerate. Normal grains of sand form sandstone. Mud and silt form rocks called mudstone and siltstone. The name shale

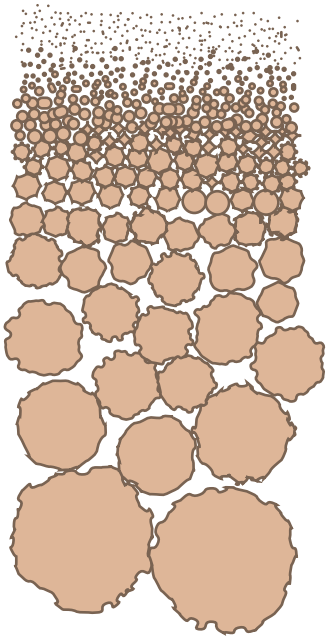
TRACT	HEADWATER	MIDDLE	COASTAL
STAGE	YOUNG	MATURE	OLD
SEDIMENTS	GRAVEL STONES	SAND	MUD, SILT
NAME OF ROCK	CONGLOMERATE	SANDSTONE	SHALE
ILLUSTRATION			

Naming rocks in sediments

Top: conglomerate rock

Middle: shale

Bottom: sandstone



Graded sediments

refers to any sedimentary rock which is made of small grains of sand, clay, silt or mud. Sandstone and shale may form layers when the sand and mud is being deposited. Sedimentary rocks are found in deep thicknesses. The deposition which formed them must have lasted millions of years.

Heavy rains or floods can wash away sandbanks and river banks. Where the river suddenly slows the heaviest rocks are deposited first. The heaviest rocks are the biggest. The lightest grains are the smallest and these are deposited last. Sediments made of rocks and grains arranged like this are said to be graded. In graded sediments, the largest rocks are at the bottom and the smallest grains are at the top.

Many sedimentary rocks, such as sandstone, have coloured layers in them. The layers come from different-coloured sand and silt that washes down the river. Not only does each rock have layers, but the rocks themselves can make layers. You can see these layers in road cuttings and excavations. Some layers of rocks extend for many kilometres in road cuttings.

The formation of rocks from sediments is very slow. The layers are squashed by the weight of the sediments on top of them. This forces out the air bubbles and some water, and squeezes the grains together. Chemicals in water in the ground seep through the sediments and cement the grains together. The process of making rocks is called lithification. The chemicals in the rock are different from the ones in the sediments the rock was made from.

CHECKPOINT:

COPY AND COMPLETE

Weathering is when rocks are ____ down and broken into _____ pieces. _____ is the removal of _____ rocks by ice, ____ or moving _____. When the speed of the wind or water _____, the fragments _____. This is called _____. These fragments of rocks are called _____. The fragments of _____ rocks can be _____ together. These rocks are called _____ rocks.

The largest sediments, such as _____ and _____, form the rock called _____. Sand forms _____. The name _____ refers to any _____ rock which is made of small grains of ____, ____, ____ or mud.

In _____ sediments, the largest _____ are at the bottom and the _____ grains are at the ___.

Many _____ rocks have _____ in them. Not only does each ____ have _____, but the rocks themselves make _____. You can see these layers in road _____ and _____.

The formation of rocks from _____ is very slow. The process of making rocks is called _____.

QUESTIONS

1 What is the meaning of erosion, sediment, and deposition?

2 Draw the rocks or grains in conglomerate, sandstone and shale.

3 What are graded sediments? How are they formed?

4 In a rock cutting of sandstone, where would you find the oldest part of the rocks?

5 How do grains of sand get cemented together to make sandstone?

6 Place these words in the correct time sequence: deposition, lithification, erosion, weathering.

7 Write a description of how you would describe to a friend—over the telephone—how to tell the difference between conglomerate and sandstone.

8 Lithification is the process of turning sand and sediments into rock. Explain the changes that happen.

5.6 Some unusual sedimentary rocks

Dead plants that settle to the bottom of swamps are slowly dried and compressed to make the rock we call coal. Coal is an excellent fuel. It contains large amounts of chemical energy. It is mined in large quantities in New South Wales and Victoria. Most of our coal is sold to other countries for making steel, but some is burnt in power stations to provide our electricity.

Dead coral and broken shells can accumulate in the seas near reefs. The rock which forms from them is called limestone. Limestone made from broken shells is called shelly limestone. Limestone made entirely from coral is called coral limestone.

This sample of limestone shows sun coral

When shallow seas, bays or salt lakes dry up, the salt in the water crystallises. Deposits of salt are called halite, or rock salt. In Europe and America, ancient deposits of salt are buried deep under layers of rock. This underground salt is mined using explosives, backhoes and bulldozers.

Where would you go to see sedimentary rocks being made today? You would look in places where deposition is occurring. River estuaries, lakes, and shallow seas are all places where sedimentary rocks could be forming. Coral limestone is forming near coral reefs, and coal is forming in swamps.

What can rocks tell you about their past? If you find some sandstone in a road cutting, it must have been formed in a lake or river. This means that, long ago, that part of the Earth was in a river or lake. If you find coral limestone in a quarry, you know that, long ago, this was a warm tropical area near a coral reef.

Sedimentary rocks contain other clues about their history. Some rocks contain fossils. Fossils are the remains or impressions of living things

Fenestella fossil

which have been preserved in the rock. Rocks which have formed from sediments in the sea have fossils of shells and coral. Rocks made from sediments on the land have fossils of leaves in them. Mostly only the hard parts of animals, such as shells and bones, make fossils. Many fossils are of plants and animals which are now extinct.

Geologists study rocks to learn about the past. The history we discover from rocks is called geological history.

Fossils are often found when shale is split

EXPERIMENT

AIM: To compare sedimentary rocks

Your teacher will have some sedimentary rocks for you to look at. Each rock will have a different number but no name. Name each rock (with reasons) and decide how or where it was formed and its history, in a table with the following headings:

Rock number	Name of rock	Reasons for naming it	History of the rock

EXPERIMENT

AIM: To make an artificial rock

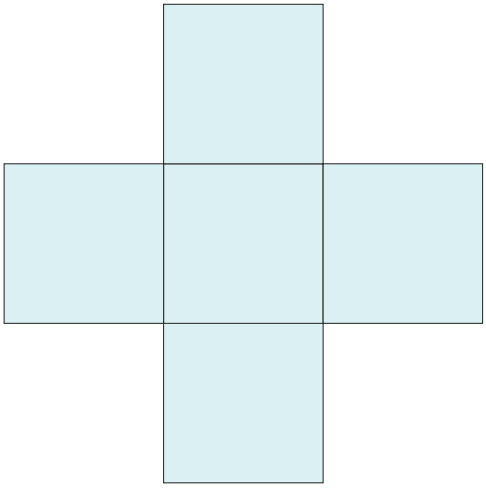
Note: You must wear protective eyewear when heating the chemicals in this experiment.

Make a small box from some manila cardboard, and tape the edges. Pour in some sand, which is either damp or dry, but not wet. Do not squash the sand into the box.

Put 10 cm depth of sodium thiosulfate (also called hypo) in a test tube. Gently heat it until the crystals dissolve, then heat for another 10 seconds with the Bunsen burner on low heat. (Do not boil the molten chemical, as this may ruin your experiment.) Pour the chemical into the sand. Seal the box and leave it for at least a day to give the hypo time to set properly. Clean up and continue with your classwork.

In your next science lesson, remove the block of artificial rock from the box. Is it a convincing piece of sandstone? What would happen if you left it in the rain?

This experiment is suitable for making other rocks, such as coarse sandstone or conglomerate. Plaster of Paris is another cementing agent. Ask your teacher if you can make other 'rocks'. Compare the strengths of different cements.



CHECKPOINT:

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Dead plants that _____ to the bottom of _____ are slowly _____ and _____ to make the rock we call _____. Dead _____ and broken _____ can accumulate in the _____ near _____. The rock which _____ from them is called _____.

Deposits of _____ are called _____, or _____ salt.

River _____, _____, and shallow _____ are all places where _____ rocks could be forming.

Fossils are the _____ or _____ of living things which have been _____ in the _____. The history we discover from _____ is called _____ history.

QUESTIONS

1 Describe what is in these rocks: coal, rock salt, coral limestone, shelly limestone.

2 What are fossils? What can they show us or tell us about the Earth's history?

3 What is the history of sandstone which has fossil leaves in it?

4 What is the history of shale that has ripple marks from waves in it?

5 In which environments could a rock with a worm trail have been formed?

6 What can you infer about the geological history of an area where you find shelly limestone and coral fossils?

7 What type of rock would be forming, at present, in these locations?
- **a** river mouth with sand banks
- **b** dry dusty desert of stones
- **c** a swamp with trees
- **d** muddy creek, slow moving water
- **e** tropical coral reef
- **f** dead sea shells washed up on a beach

EXTRA QUESTIONS

1 Copy and complete the table below. The information to complete it is given in the text.

Type of sediment	*Sedimentary rock formed*
sand	.....
gravel	.....
mud and silt	.....
shells and coral	.....
remains of plants	.....
salt from dried lake or sea	.....

2 Write sentences that use these words in the correct way: weathering, erosion, deposition, sedimentary rocks, sediments.

5.7 How to beat erosion

Erosion costs many billions of dollars each year. Valuable farmland is washed into rivers, where it forms sand banks at the river mouth. Soil from farms is blown away, sometimes being carried hundreds of kilometres onto cities or into the ocean. Beaches and dunes are being washed into the sea. Erosion affects people, and something has to be done to control it.

On the farm

In rural areas there are large open paddocks, long rivers and many creeks. There are many places where erosion can occur. Water erosion washes away valuable soil and crops. Gullies can wash away large parts of paddocks. Wind can blow away loose topsoil.

Erosion costs farmers a lot of money. Eroded land does not grow crops and pasture as well as productive land. Animals do not grow as fat or healthy. Farmers have to buy fertiliser for their land and extra feed for their animals. Farmers now prevent erosion by ploughing their land in a different way, planting trees and preventing the run-off of water which erodes gullies.

Desertification occurs when land in a dry area loses its vegetation cover and becomes desert. The topsoil, which is high in nutrients, is blown away and plants cannot grow in the subsoil that is left. Desertification is a problem in the semi-arid regions of Australia.

Land degradation is the name given to the change in land from being productive and valuable, into land which is worthless because it cannot grow crops or pasture. Many government groups, and community groups such as Landcare and Dunecare, are aiming to save our land and beaches from erosion and degradation.

In the city

Even in cities, people are trying to stop erosion. In new housing estates and near new roads, barriers are placed across creeks and gullies to slow the speed of water. This catches the sediments so they are not washed into rivers and lakes.

In cities, erosion is stopped by having tar roads and using stormwater drains and underground pipes to carry waste water away. In some suburbs, creeks have been turned into concrete drains to prevent erosion of their banks. Rocks slow the speed of water in drains and this also reduces erosion.

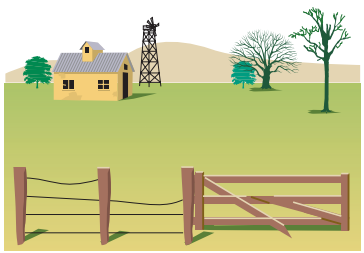
In new housing estates, road cuttings are sprayed with grass seed mulch, or covered with wire netting or hessian. Water courses have barriers put in them. Mud, sand and gravel get caught behind the barriers.

At the beach

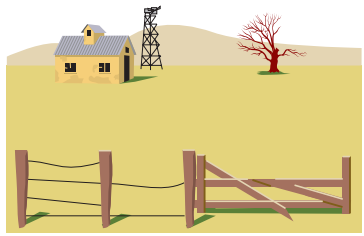
Beaches are constantly changing. Storms wash away lots of sand, and it is put back in times of normal weather. Beaches have less sand on them in winter than in summer. The sand is moved up and down the beach by the surf. Sometimes the surf takes more sand than it deposits on the beach.

Most of the sand on the beach comes from rivers. When a river slows, it might deposit its load of sand and silt. Where it meets the sea a river can silt up and become shallow. Fishing boats and recreational boats cannot safely use that part of the river. People have constructed breakwaters to keep the rivers open to boats. Even with breakwaters, river entrances can become silted.

Overgrazing by cattle removes the grass



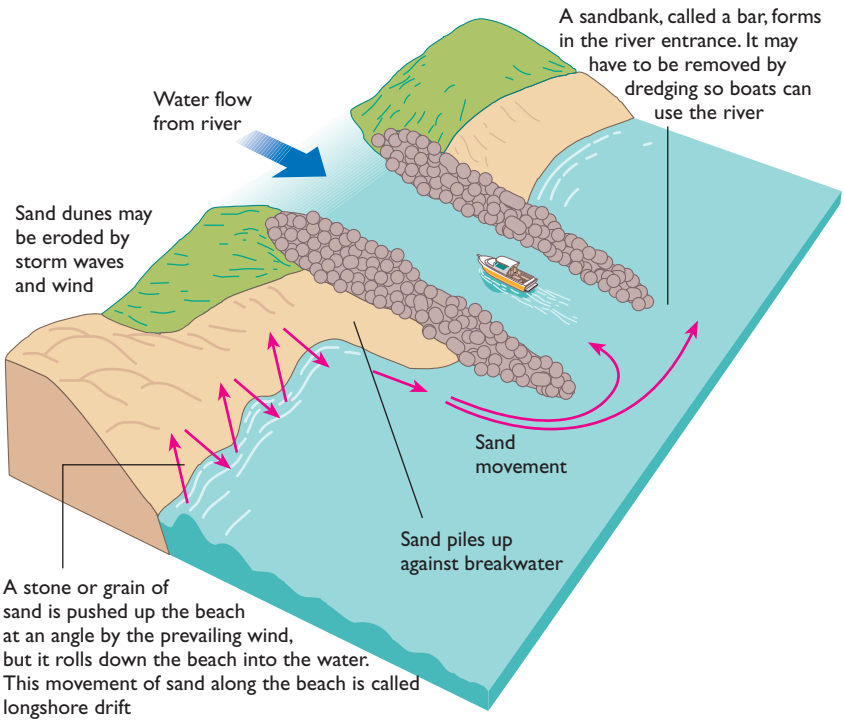
Drought and wind remove the topsoil



Leaving unproductive desert-like land

This shows one way that desertification can happen

Bank erosion



Some features of beach erosion

CHECKPOINT:

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Erosion costs many _____ of _____ each year. Valuable _____ is washed into _____, where it forms _____ banks at the _____ mouth. Soil from farms is _____ away, sometimes being carried _____ of _____ onto _____ or into the _____. _____ and _____ are being washed into the sea.

Land degradation is the name given to the _____ in land from being _____ and _____, into land which is _____. Groups such as _____ and _____ are aiming to save our ____ and _____ from _____ and _____.

Beaches are constantly _____. Where it meets the ___ a river can ____ up and become _____. People have constructed _____ to keep _____ open to boats.

QUESTIONS

1 What is the meaning of these words: erosion, desertification, overgrazing, breakwater?

2 Why are some road cuttings covered with hessian? What would happen if it they were not covered? What happens to the hessian—does it last forever, or does it degrade?

3 How can erosion be stopped in cities?

4 Why have breakwaters been built at the entrances to many rivers on the NSW coast?

5 Explain why rivers silt up at their estuary.

6 The photograph above shows erosion along a riverbank. Propose methods that could be used to prevent or reduce further erosion.

EXTENSION QUESTIONS

I Design an experiment using a stream table (see section 5.3) to show how to reduce water erosion.

2 Design an experiment using a hair dryer and sand to show how to reduce wind erosion.

5.8 Under our feet

What is under our feet? What is in the earth that we walk on? Firstly there is dirt, although its correct name is soil. There are also lots of living things, and water, and below everything is solid rock.

Soil is more than the dirt in which plants grow. It provides all the nutrients that plants need to grow, and holds them in the ground. Soil is essential for growing most of our food plants. It is very important, yet most people take it for granted.

Recipe for making soil

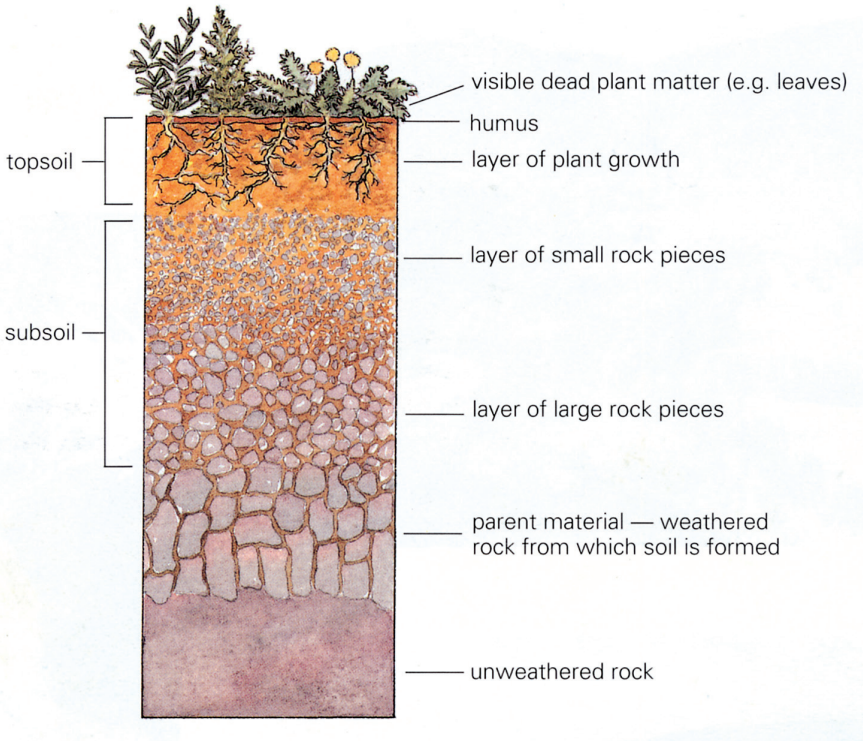
You cannot make soil, but if you could, a list of the ingredients would look like this:

1. Parent rock. The fragments from weathered rocks make up most of the soil.
2. Climate. Rainfall and temperature help weather the parent rock. Minerals are leached (washed out) and deposited again deeper in the soil.
3. Living things. Tree roots can reach deep into the ground. Soil is the home of many types of bacteria and fungi. Humus is the remains of living things in the soil.
4. Landforms. Soil at the top of hills is thin, but it is well drained and has lots of air pockets. The soil in gullies is deeper and not well drained, and it has fewer air pockets.
5. Time. A long time is needed for the processes mentioned above to take effect.

If you dig deep into the soil, you will notice that it changes as you dig down. Soil consists of different layers. The layers are formed by the movement of minerals by water. Each layer is called a horizon, or soil horizon. The complete soil, with all the horizons, is called a soil profile. Soil profiles depend on lots of factors, such as rock type, climate and time.

Water in the ground

If you dig a deep hole into the soil, you might find that the hole fills with water. Water is always present in the ground. This water is called ground water. It lies in the tiny spaces between the grains of sand and fragments of rock which make up the soil. Water which lies on the surface of the ground, such as in swamps, creeks, and puddles, is called surface water. The top of the ground water is called the water table.



A soil profile, showing the different layers

Acid sulfate soils

Acid sulfate soils are found near the sea, in low-lying or swampy areas. They occur around the east, north and west coast of mainland Australia. They contain the chemical iron sulfide as a part of the clay layer deep in the soil.

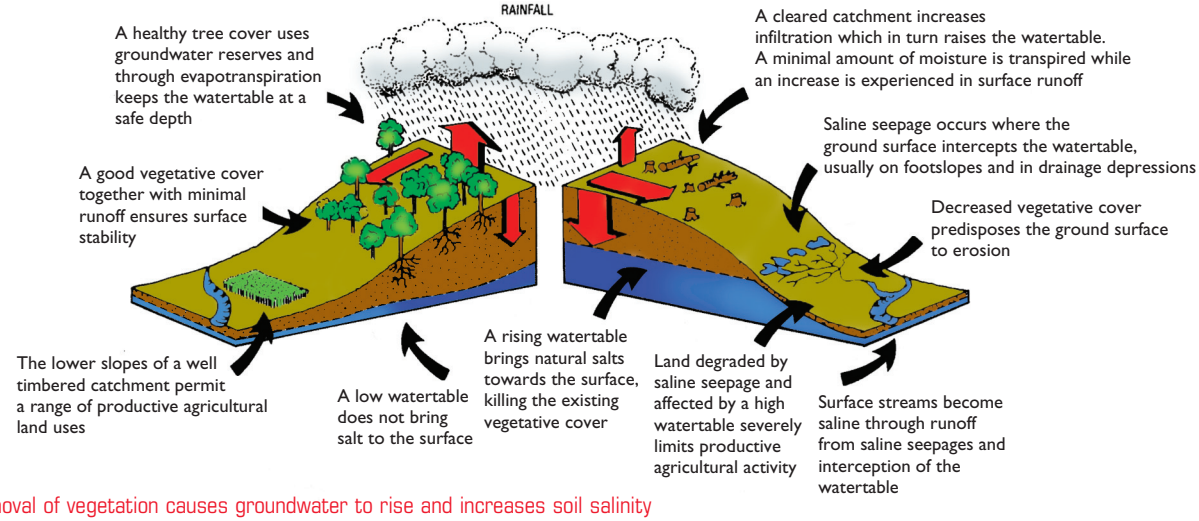
In natural conditions, the water table covers the clay layer. Air cannot reach it, because it is covered by water. When people drain the swamp and plant grasses for cattle, the water table is lowered. Air reaches the iron sulfide clay layer, and chemical weathering takes place. Oxygen in the air reacts with the iron sulfide, forming sulfuric acid. When it rains, the sulfuric acid is washed into streams or the sea. The acid kills fish and seaweed. It even corrodes concrete and steel pipes. Some acid stays in the soil, where it stops some types of grasses from growing.

Soil salinity

Salinity means saltiness. In some places in Australia the soil salinity is so bad that plants cannot grow. Deep rooted trees soak water from deep in the soil. This water evaporates from their leaves. This keeps the ground water deep below the surface.

When the trees are cut down and removed, the ground water rises. This is because there are no trees to remove it, and more water can percolate down from above. Ground water has many salts dissolved in it. When the ground water reaches the surface the water evaporates and the salt remains behind. This is like the crystallisation process in the laboratory. The salt can be seen as a white shiny layer over the soil.

Soil is very important to our society. It is needed to produce our food including crops, fruit and vegetables. Soil also supports the grass and pasture that is eaten by farm animals. Yet people do not look after our soil. Soil is under threat from erosion, desertification and salinity.



Removal of vegetation causes groundwater to rise and increases soil salinity

CHECKPOINT:

COPY AND COMPLETE

Soil provides all the _____ that plants need to ____, and holds them in the ground. Soil is _____ for growing most of our ____ plants.

Soil consists of different _____. Each layer is called a _____. The complete soil, with all the horizons, is called a ____ _____.

Water is always _____ in the ground. This water is called _____ water. Water which lies on the surface of the ground is called _____ water.

Salinity means _____. In some places in Australia the _____ is so bad that _____ cannot grow. When the groundwater reaches the surface the _____ evaporates and the _____ remains behind.

QUESTIONS

1 What are the five things needed to produce soil? Why can't we make soil?

2 On building sites, the holes dug for the foundations often fill with water. Explain why this happens.

3 What is the water table?

4 What are acid sulfate soils? Why can they kill fish?

5 What is soil salinity? What causes it? What are its effects?

6 What threats face our soil? What can be done to reduce or overcome them?

Review and Research

Review Questions

1 Match each word with its meaning.

weathering	*carrying away of rock fragments*
spalling	*ice freezing in a crack in rock, and forcing the crack larger*
ice wedging	*rock fragments which have been deposited*
acid rain	*wearing away of rocks*
erosion	*saltiness*
sediments	*rain, snow, ice, fog which is acidic*
salinity	*onion skin weathering, where the outside of rocks peels off*

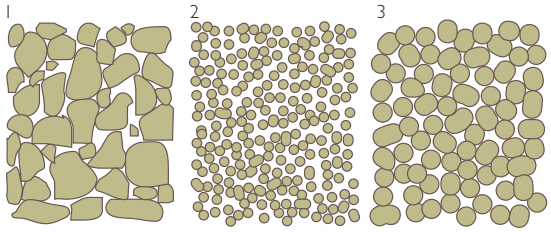
2 Describe an experiment you have done which shows the effects of heating and cooling on the weathering of rocks. Include:
- **a** an explanation of what you did
- **b** a diagram of what you did
- **c** the results of the experiment.

3 Amanda put a plastic soft drink bottle in the freezer and later found that the bottle had split open.
- **a** Why did the bottle split open?
- **b** Explain how freezing temperatures help in the weathering of rocks?

4 Complete the table to compare and contrast the young river and the old river for each of the following.

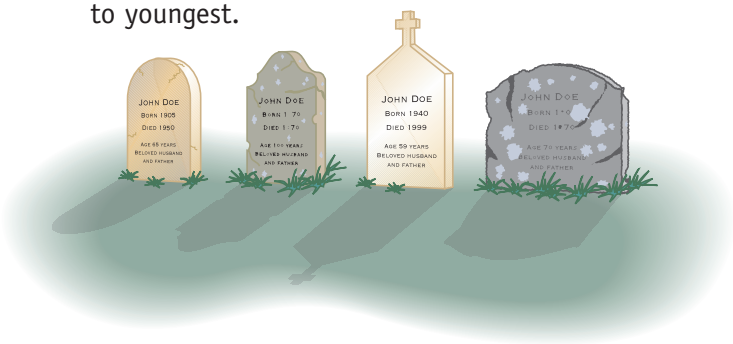
Feature of river	***Young river***	***Old river***
speed of water in river	.....	.....
size of stones in the river	.....	.....
amount of saltiness	.....	.....
width of river valley	.....	.....

5 Match the shape of the river stones with their location. Give reasons for your answers.
- **a** headwater tract
- **b** middle tract
- **c** coastal tract



6 The drawing below shows a natural rock formation. Explain the sequence of events, from unweathered rocks to boulders. What name would you give the boulders?

7 These drawings show a group of tombstones from a cemetery. Rank them in age from oldest to youngest.



8 The photograph shows a landslip beside a road.
- **a** Describe the causes of landslips.
- **b** How would you advise landowners to prevent landslips?

A roadside landslip

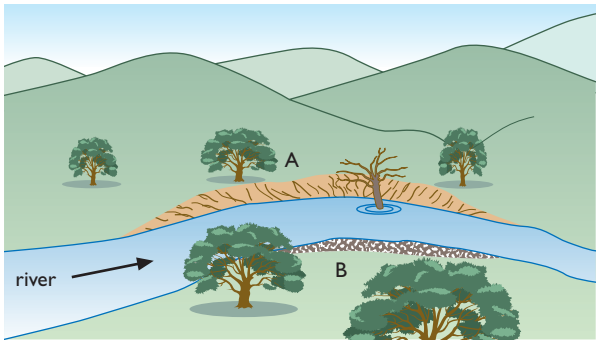
- **c** Why is it important to prevent landslips along the sides of roads?

9 This photograph shows some rocks set into concrete near an inlet into an underground storm water drain.
   a Suggest a reason for the stones.
   b The grate over the hole stops people and animals from falling into the drain, and also acts as a filter or sieve. What would it filter?

A storm water drain

Thinking questions

1 Ben and Mi-su have purchased a large block of land in the country, which has a river flowing through it. They want to build a home near the river. Which location, A or B, is better? Give an explanation.



2 This photograph shows erosion. List as many ways as you can to reduce erosion.

Erosion causes damage to vegetation

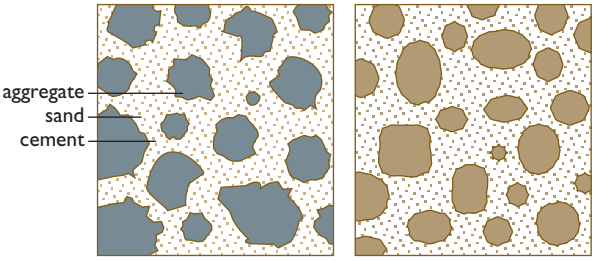
3 This photograph shows severe gully erosion. To prevent further erosion, the farmer has decided to place some large rocks in the gully and plant trees nearby. How will this help prevent further erosion? How will the trees help prevent soil salinity?

Gullies can be badly eroded if the trees and shrubs are removed

4 This photograph shows a creek in a housing estate. Identify the erosion control measures.

Drainage in housing estate

5 The drawing below shows a sample of broken concrete and conglomerate.

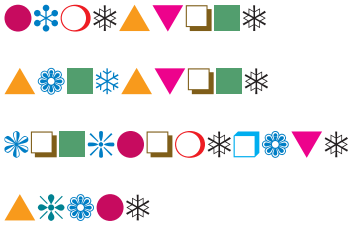


A comparison of concrete and conglomerate rock

a How is concrete made?
b How was the conglomerate formed?
c What is one important difference in the aggregate in concrete and conglomerate?
d How could you make concrete which looked more like conglomerate?

6 Written in code are the names of four common sedimentary rocks. Each symbol stands for a different letter. Solve the code, then decode the message. It is a type of weathering.

Four rocks



Secret Message

Word check

acid sulfate
breakwater
chemical
coal
conglomerate
degradation
delta
deposition
desertification
drought
dune
erosion
estuary
fragment
geological
graded
horizon
landforms
landscape
limestone
lithification
physical
profile
salinity
sandstone
sedimentary
sediments
shale
simulate
stagnant
staining
stalactite
stalagmite
tor
unproductive
weathering

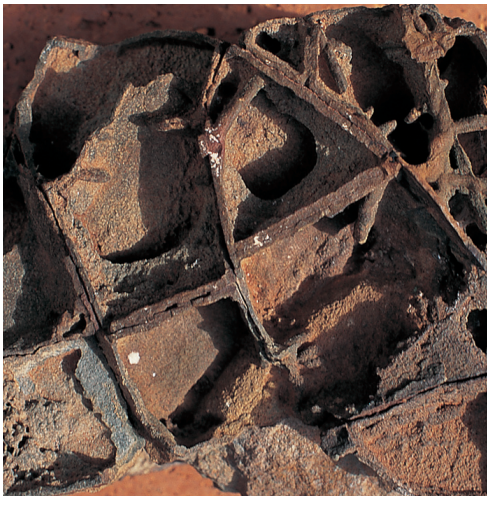
Concept map

Draw a concept map of the ideas in this chapter.

Research Question

1 These photographs show two unusual forms of weathering. The form on the left is called honeycomb weathering and is found in sandstone rocks. The weathering on the right shows that this rock has weathered more slowly where a chemical has seeped along the joints. Suggest how each type of weathering could have happened.

Honeycomb weathering



Hard joints in rock resist weathering

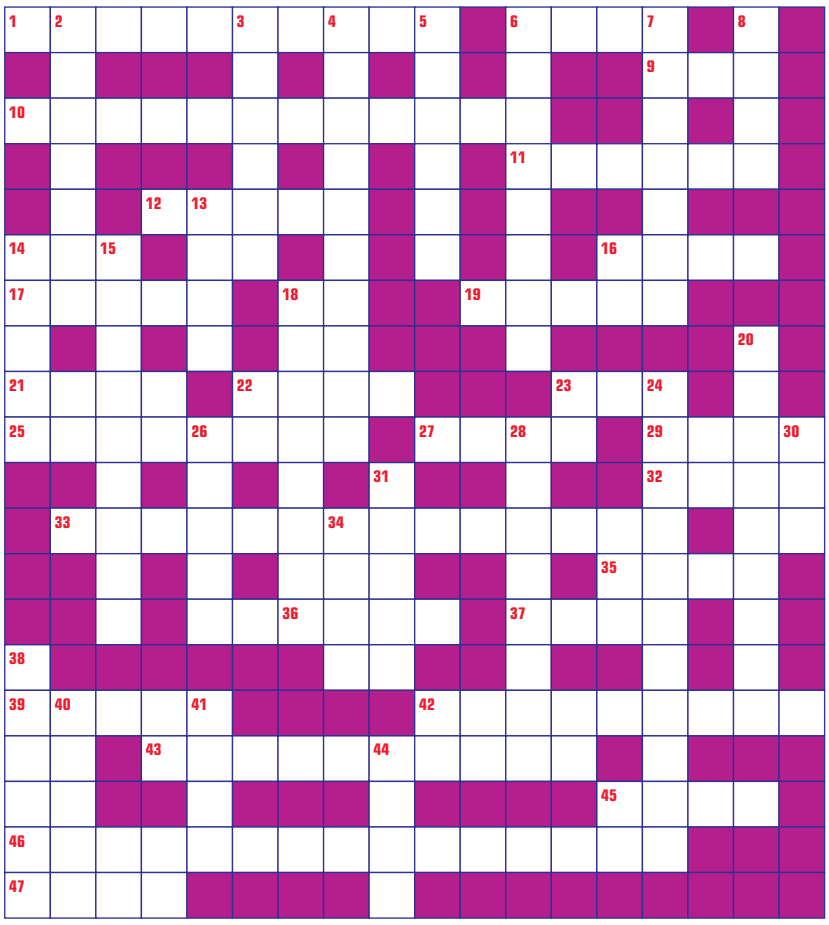
Crossword

Across

1 Wearing away rocks (10 letters)
6 Underground hole formed by the dissolving of limestone by rainwater (4)
9 A small ocean (3)
10 The rock formed from sediments of gravel in a fast flowing river (12)
11 Word that describes the middle tract of a river (6)
12 You can tell ____ in a river sediments were found because of their size and shape (5)
14 Means to steal from someone (3)
16 Rusty coloured chemicals leached from rocks contain this (4)
17 _____ skin weathering is where the outside of the rock peels off (5)
19 Means made of lots of sand (5)
21 You can ____ where in a river sediments were found because of their size and shape (4)
22 Weathered rock fragments found along the coast, such as beaches and sand spits (4)
23 Eroded soil carried by a river (3)
25 Shorter name for onion skin weathering (8)
27 Orange-coloured iron chemical which forms on iron (4)
29 Sign above the door where people walk out (4)
32 Means departed, left, used up (4)
33 Process in buildings where steel mesh inside concrete swells and causes the outside to peel (8,6)
35 A lot of information (4)
36 Grows into a plant with roots and leaves (4)
37 Weathered rock fragments found on the beach and spits (4)
39 These are released by plants and animals in biological weathering (5)
42 A branch of a river (9)
43 A rock formation hanging down from the roof of a cave (10)
45 Holds plants in the ground and provides the water and nutrients they need to grow (4)
46 Process of turning land into desert (15)
47 Onion-____ weathering (4)

Down

2 The carrying away of rock fragments (7)
3 Carried away by wind and water (6)
4 Weathering where ice expands in cracks (3,7)
5 Rounded river rocks, found in middle tract of river (6)
6 Form of weathering using water and oxygen (8)
7 Mouth of a river (7)
8 Causes most of the physical weathering on the coast (4)
13 You can write with a right and left one of these (4)
14 Parts of plants which help in biological weathering (5)
15 River meander that is cut off from the river (9)
18 S-shaped bends in a river (8)
20 This falls from the sky, dissolving pollution and causing erosion (8)
24 Process where land is changed from being productive and valuable to being worthless (11)
26 Means in your nearby area (5)
28 Joins a land tied island to the shore (4,4)
30 Smallest number made of two digits (3)
31 Raised bank along the edge of a river which contains flood waters (5)
34 Roots of one of these can exert a great force to split rocks (4)
38 Parts of the river where the water flows fastest (6)
40 A stream that is smaller than a river (5)
41 Means to mix a liquid, best done with a stirring rod (4)
44 A small part of a rock which has been chipped off a bigger rock (4)



SOLUTION: PAGE 229