Rocks and weathering

Before starting this unit, you should already be familiar with these ideas from earlier work.

- You might see rocks in a cliff face or mountainside, but there are also rocks under the ground. Marble is one type of rock. Name two more.
- Soil forms from rocks. Does water flow more quickly through sandy soil or clay soil?
- Particles are arranged differently in solids and in liquids. Summarise these differences in a couple of sentences.
- The pH scale describes how acidic or alkaline a solution is. Neutral solutions have pH 7. What sort of pH does a weak acid have?
- If you leave bowl containing a solution of a salt in water, the water disappears, leaving the salt behind. Where has the water gone?

You will meet these key ideas as you work through this unit. Have a quick look now, and at the end of the unit read them through slowly.

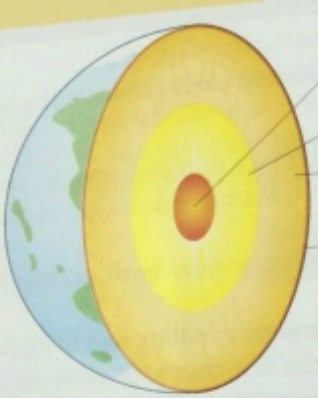
- A **rock** is a mixture of substances called **minerals** that occur naturally in the Earth's **crust**.
- Rock have different **textures** depending on how their mineral particles are arranged. Some rocks are **porous** – they have little spaces in their structure which can hold water.
- Rocks can be worn away or **weathered** by conditions in the environment. **Physical**, **chemical** and **biological processes** wear away rocks. Changes in temperature can weather rocks physically. The acid in rainwater can react with rocks and wear them away chemically.
- Weathered fragments of rock are transported away from where they fall. **Sediment** carried by water can be dropped or **deposited** many miles away.
- Layers of sediment may be deposited on top of each other and become **cemented** together to form new **sedimentary rock**. The remains of dead organisms may fall to the bottom of a sea or lake and form part of the rock. Water evaporating from a lake can also leave behind sedimentary rock, formed from the minerals that were dissolved in it.

A

8G.1 Rocks

What are rocks made of?

What do you know about the Earth, apart from being the planet where you live? For a start it's very old, around 4600 million years. It has a central part called the **core** which is made of iron and a bit of nickel. The core is very hot indeed. Around the core is a hot semi-liquid rock layer called the **mantle**. Covering this is the cooler solid surface layer that we live on. This is the **crust**, made of rocks and minerals.



Rocks and minerals make up the solid outer layer of the Earth.

What is a mineral?

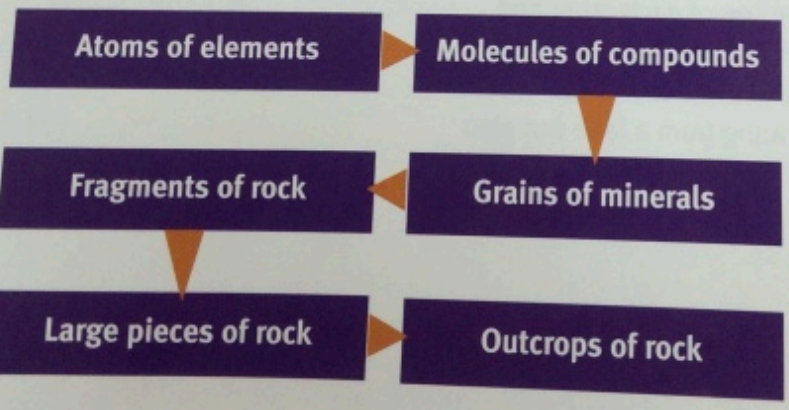
Minerals are the solid substances that make up the Earth's crust. Minerals have a definite composition, a regular structure and are often a single colour. Most minerals are compounds, though a few are elements. The table shows some minerals.

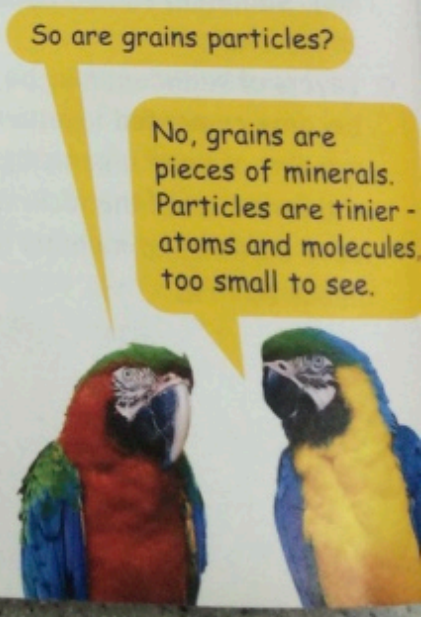
Mineral name	Chemical name	Photo
haematite	iron oxide	
malachite	copper carbonate	
diamond	carbon	
quartz	silicon dioxide	

What is a rock?

A **rock** is a mixture of minerals. The minerals are in little pieces called **grains**. In some rocks the grains are large and you can see them with the naked eye. If a rock has a mixture of grains, it might look multi-coloured or speckled.

Other rocks are crystalline. They have smooth faces which reflect light and so appear shiny. The grains have formed crystals that fit together so you can't see the individual grains.





Classifying rocks – the rock kingdoms

Geologists identify rocks by looking at properties such as colour, hardness, texture, how they split up when hit (cleavage) and their chemical behaviour. Rocks can be made up of many different minerals, so their properties can vary.

The easiest way to classify rocks is by where they have come from. This splits the rock world into three different rock types:

Guess what?

*A **geologist** studies the Earth and its structure, a **seismologist** studies earthquakes and a **palaeontologist** studies fossils.*

Igneous rocks are formed when the molten rock inside the Earth cools and solidifies.

In this piece of granite you can see the interlocking grains of minerals – white feldspar, light grey quartz and dark mica.

Sedimentary rocks are formed from material that is laid down in layers.

*In this sandstone you can see the small rough grains that have settled out from water, loosely **cemented** (joined) together.*

Metamorphic rocks are formed when high temperature and pressure change other rocks.

This schist has a glittering surface, banded layers and small crystalline grains.

Investigating texture

Hannah put a sample of granite into a beaker of water and a sample of sandstone into another beaker of water. The table shows her observations.

Rock	Observation	Inference (conclusion)
granite	no bubbles	Granite does not absorb water.
sandstone	bubbles	Sandstone does absorb water.

Sandstone has a more **porous** texture than granite. In sandstone, the grains do not fit closely together (they do not **interlock**) so there are small gaps which fill with water. Grains interlock more closely in glassy and crystalline rocks than in rough-textured ones.

Language bank

cemented
composition
compounds
crust
elements
grain
igneous
interlock
metamorphic
minerals
porous
rock
sedimentary
texture

1 Copy and complete using words from the Language bank:

The Earth's _____ is made up of rocks. A rock is formed from a mixture of _____. Minerals are usually chemical _____ which have a definite _____. The main rock types are _____, _____ and _____.

2 List these in order of size, smallest first:

rock fragment, atom, molecule, grain.

3 Hannah's two rock samples were the same size and she put each into the same volume of water. After half an hour she noticed the water level in the sandstone beaker was lower. Explain why, including sketches of the grains in your answer.

8G.2 Weathering

M

- How does rain cause rocks to weather?

Gravestones of limestone (left) and slate (right).

These limestone and slate gravestones are about the same age. They don't look it! The writing is less clear on the left-hand gravestone because the limestone has been worn away. **Weathering** is the name we give to the slow breakdown of rocks into smaller fragments.

There are three types of weathering:

- **physical weathering**, also called mechanical weathering, caused by physical factors such as temperature changes
- **chemical weathering**, caused by chemical reactions such as the action of rainwater on certain minerals in a rock
- **biological weathering**, for example, digging animals or growing plant roots can make cracks in rock bigger until bits of rock fall off.

A closer look at chemical weathering

Rocks such as limestone contain the minerals calcite (calcium carbonate) and dolomite (magnesium carbonate). Carbonates react with acids. This is how chemical weathering happens:

1 Rainwater is naturally acidic. This is because carbon dioxide in the air reacts with the rainwater to make a weak solution of carbonic acid. This acid reacts with the carbonate minerals in rocks:

calcium carbonate + carbonic acid → calcium hydrogencarbonate

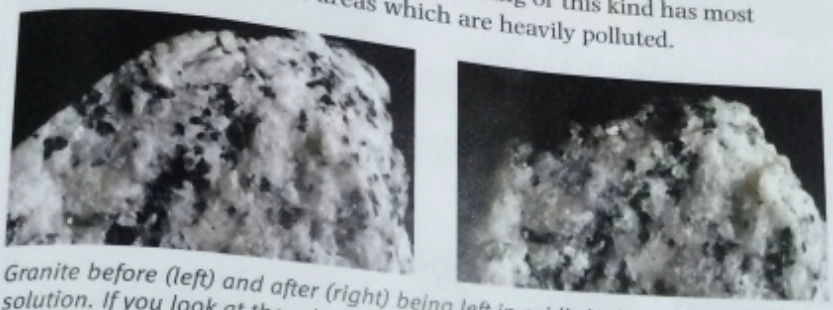
2 Rainwater can become more acidic because of pollutants in the air. For example, burning fossil fuels can produce sulphur dioxide and oxides of nitrogen. These dissolve to form sulphuric acid and nitric acid, which react quickly with the carbonate minerals in rocks:

calcium carbonate + nitric acid → calcium nitrate + carbon dioxide + water

Rainwater is naturally around pH 6, but acidic pollutants from burning fossil fuels lower its pH to make acid rain.

Investigating chemical weathering

Studying the effects of rainwater on rocks could make you very wet and very fed up. Instead we can model the effect of rainwater on rock in the lab by placing a piece of granite in acidic, oxygen-rich water, as shown in the pictures. Chemical weathering of this kind has most impact in warm and wet areas which are heavily polluted.



Granite before (left) and after (right) being left in acidic hydrogen peroxide solution. If you look at the edges you can see it has been weathered. Some of the minerals in the rock, the feldspar and mica, react with the solution. This weakens and softens the structure of the rock.

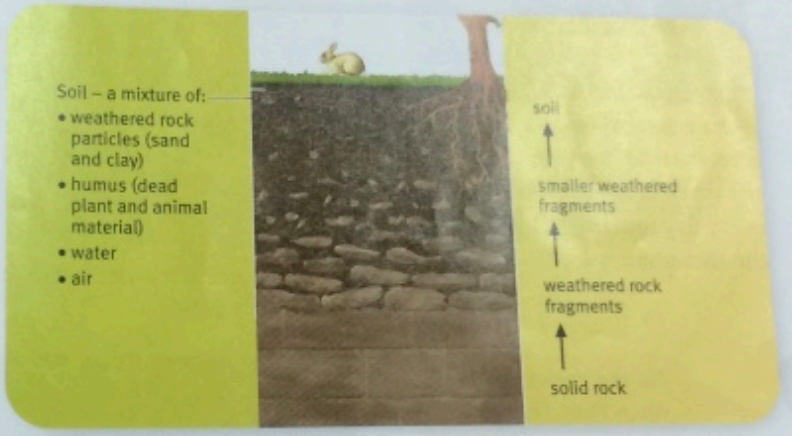
Guess what?

The total amount of weathered rock on the Earth is estimated to be 3×10^{24} kg. (That's 3 with 24 zeros after it – a lot of weathered rock.)

Why is weathering important?

If rocks were not weathered, there would not be any soil for plants to grow in. The picture shows why.

Weathered rock particles, decayed plant and animal matter, water and air mix to form the soil that sustains life on Earth.



The structure of soil varies depending on the rock type that formed it.

1 Copy and complete using words from the Language bank:

_____ is the breakdown of rocks into smaller _____. There are three type of weathering: _____, chemical weathering and biological weathering.

2 a Why is rainwater naturally acidic?
b What makes rain more acidic?

3 a Find out the names of two rocks that can be chemically weathered by natural rainwater.
b Would they be weathered more quickly in a warm moist country or a cold dry country?

4 Briefly describe how soil is made.

Language bank

acid
biological weathering
carbonates
chemical weathering
fragments
grains
minerals
physical weathering
pollutants
soil
weathering

8G 8G.3 Temperature changes and rocks

M

How do changes in temperature cause rocks to weather?

Through each day and night the temperature changes in a natural pattern, which can help to weather rocks into small fragments. This is physical weathering, and there are two types:

- **freeze–thaw weathering**, caused by water freezing and thawing again
- **exfoliation**, caused by the rock heating up and cooling down.

Climbing at night reduces the risk of rock fall, which is more likely as the day warms up.

Freeze–thaw weathering

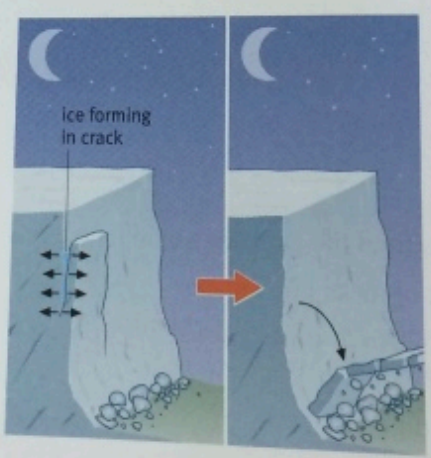
This happens when water is frozen at night and then thaws during the day. When water freezes, it expands. If it is enclosed and can't expand freely, it exerts huge forces on its surroundings. We can see this if we fill a bottle with water and put it in a freezer overnight.

If water finds its way into small cracks or **fissures** in a rock, the same thing can happen. When the temperature falls the water freezes and expands, and the forces are large enough to make the crack bigger. If this happens every day and night, eventually the rock shatters.

As the ice forms, it exerts a force on the sides of the container which shatters the glass.

So the rocks break up when they freeze.

No, it's the water freezing and expanding then melting again, time after time, that does the damage.



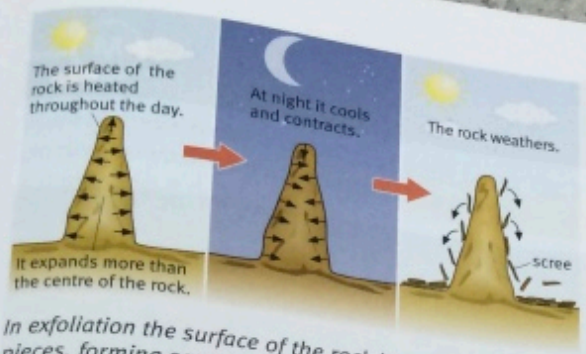
At night the ice makes the crack bigger. During the day more water fills it, and the next night this freezes and makes it even bigger. Eventually the rock breaks up.

Exfoliation

Exfoliation, or onion skin weathering, is another form of physical weathering caused by changing temperatures. Rocks expand when heated by the Sun through the day, and they contract when cooled through the night. If this happens repeatedly to a rock, it can cause the surface to flake and fall off, like peeling an onion.

Guess what?

The forces exerted when water freezes are so strong that they can split open copper or iron pipes. This is why we insulate water pipes and turn off the water to outside taps in winter.



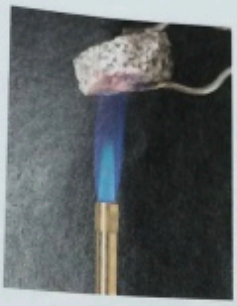
In exfoliation the surface of the rock breaks up into little pieces, forming scree.

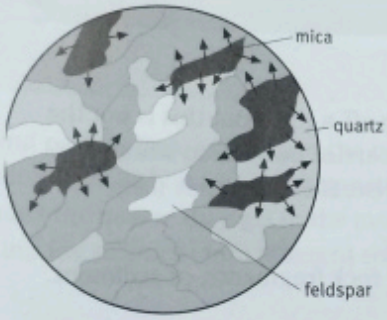
The Screes is a well known scree slope by Wast Water in the Lake District. It has formed by the exfoliation of the rock face above.

Investigating exfoliation

If you heat a sample of granite in a Bunsen burner flame and rapidly cool it in water several times, the rock loses its strength. It is easily broken up by tapping it with a hammer.

Why does the rock break up when it is heated and cooled? It contains grains of different minerals. Each mineral expands and contracts a different amount. This causes forces within the rock which break it up.





The dark mica grains in the granite expand more than the lighter quartz and feldspar. This uneven expansion weakens the structure so much that it can be broken easily with a hammer.

1 Copy and complete using words from the Language bank:

_____ changes throughout the day and night can weather rocks. _____ weathering happens when water in small cracks repeatedly freezes, which makes it _____. Rocks on the Earth's surface are heated and cooled, which causes them to expand and _____. This results in _____ skin weathering, also called _____.

What is scree and how does it form?

In country A the weather is mild and wet. In B it is dry and warm during the day, but very cold at night. In C it is very wet and the temperature can be very high or very low. What kind of weathering will break up the rocks most in A, B and C?

Use the particle theory to explain why rock surfaces expand during the day and contract at night.

Language bank

contract
exfoliation
expand
fissures
fragments
freeze–thaw weathering
grains
minerals
onion skin weathering
physical weathering
scree
temperature

8G.4 Transportation

M

- What happens to weathered pieces of rock?

The Grand Canyon in Arizona, USA, has been formed by the Colorado River cutting through the rock layers. The sides of the canyon show a 2 km deep sediment bed which is over 250 million years old. But how did the sediment get there?

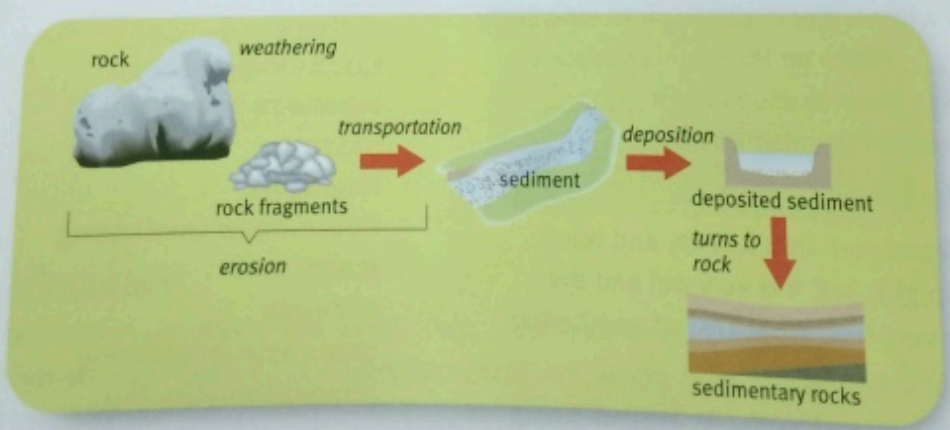
Rivers move rocks

Weathering results in fragments broken off a rock. But this is not the end of the story. The fragments can be carried away from where they were formed, and dropped somewhere else. Here they may form new sedimentary rocks.

Water is especially good at transporting rock fragments, or **sediment**. Rivers can:

- **weather** rocks, as in the Grand Canyon
- pick up sediment and **transport** it to other places
- drop or **deposit** the sediment.

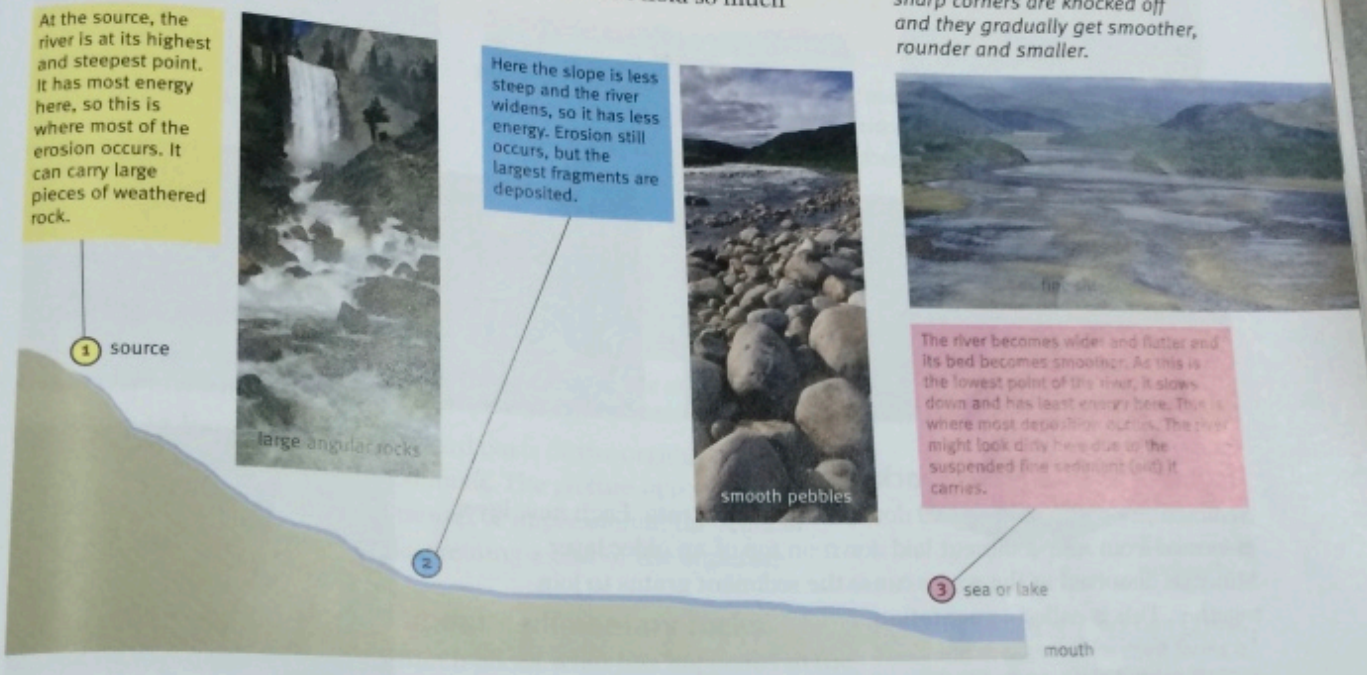
} Weathering a rock and transporting away the pieces is called **erosion**.



It's not just rivers that carry sediment. It can also be transported by **glaciers** (huge frozen rivers), or by the wind, as in a sandstorm.

More about transportation and deposition

How much sediment can a river hold? That depends on how fast it is flowing, or how much energy it has. The more energy the river has, the more it erodes rocks around it, and the larger the load of sediment it carries. Downstream its energy gets less and it can't hold so much sediment, so it deposits it.



A river deposits the larger rocks and pebbles first, and nearer the mouth the small stones, sand and then silt fall to the bottom. The fragments become smoother and more rounded the nearer they get to the mouth. The river is like a giant sieve, sorting the sediment into different sizes along its length.

1 Copy and complete using words from the Language bank:

_____ of rock results in rock fragments. These can be carried away by a river as _____. They get rounder and smoother in the river. Downstream the river has less _____ and it drops the sediment. This is called _____.

2 **a** Why are rock fragments in a river more rounded the nearer they are to the mouth?

b Why do you find larger rock fragments deposited higher up a river, and smaller ones deposited lower down?

3 What do you think would happen to any dissolved materials that are carried in river water when they reach the mouth?

4 In times of heavy rain and flood, what do you think happens to the normal pattern of sediment deposition by a river?

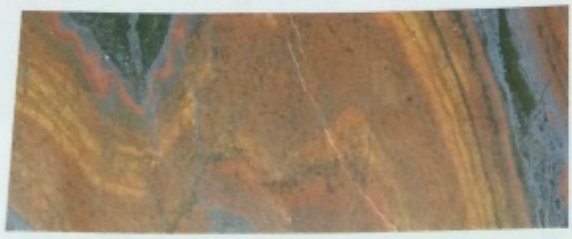
Language bank

deposition
energy
erosion
fragments
glaciers
rivers
sediment
sedimentary rock
transportation
weathering
wind

8G.5 Sedimentary rocks

- Why do sediments form layers?
- How are sedimentary rocks formed?

A river deposits layers of sediment such as sand and silt. The building up of the sediment is called **accumulation**. The deposited layers fix together to form sedimentary rock. This is known as **consolidation**.



There are many types of sedimentary rock, formed from the consolidation of different sediments.

How does sedimentary rock form?

Sedimentary rocks may be laid down in layers or **strata**. Each new layer is formed from new sediment laid down on top of an older layer. Minerals dissolved in the water cause the sediment grains to join together. This is called **cementation**.

Minerals come out of solution under the pressure of the sediment layers above and form cement.

The older, lower beds can be warped and eroded and then newer beds laid down on top of them. Sandstone forms this way.

Other sedimentary rocks are formed by the evaporation of water. For example, a lake with lots of dissolved minerals might dry up. This leaves mineral deposits known as **evaporites**. Gypsum is an example.

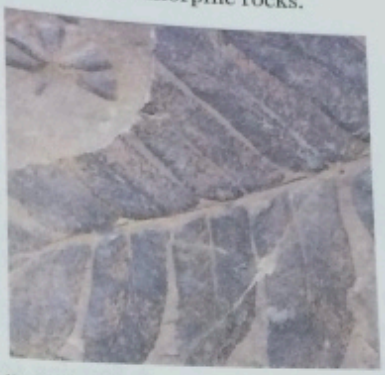
Gypsum is used to make plaster of Paris, a material used for sculpture.

The shells of dead sea creatures became compacted to form this shelly limestone rock.

Sedimentary rocks can form from organic material that was once living. Shelly limestone is an example.

How fossils form

Fossils are the remains of dead plants or animals preserved in rock. They came to rest at the bottom of the sea, for example, and became buried by the accumulation of sediment. We usually see fossils in sedimentary rocks, but they can be present in metamorphic rocks.

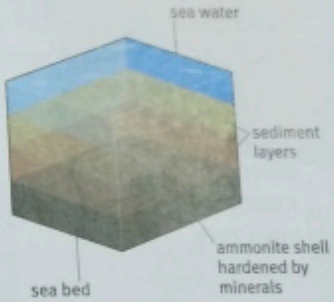


Ammonites, ancient sea creatures, left shell-like fossils. The ancient fern had ridged plant cells which helped it to make a well defined fossil.

Fossilisation happens when the hard parts of the organism are further hardened by minerals in the sediment. The picture opposite shows this. Sometimes body parts leave a mould or impression in the sediment, which is then filled by minerals, creating a cast of the organism.

Guess what?

The rhyme 'She sells sea shells on the sea shore' is about Mary Anning. She was born in Lyme Regis in 1799 and lived until 1847. She collected and sold fossils on the beach to the tourists of the time. Her fossils helped start a new science – palaeontology.



The sediment layers turn to rock, and the ammonite shell forms a fossil as minerals harden it.

Using fossils to find out about sedimentary rocks

Sedimentary rocks can tell us much about what has happened to the Earth during its long history. Geologists have analysed rocks from both sides of the Atlantic Ocean to find out which bits of land were once joined up. If the strata are similar on both sides, and contain similar fossils, they were probably once all the same land mass.

The world as geologists think it was in the Triassic period, about 200 million years ago. There were no maps then (or people)! Geologists have studied rocks and fossils to work out which land masses used to be joined.

1 Copy and complete using words from the Language bank:

Sedimentary rocks are usually formed in layers or _____.
Deposited _____ is cemented together by minerals in solution.
Some sedimentary rocks are called _____, formed when water evaporates and leaves behind the dissolved _____.

2 What are fossils and why are they important?

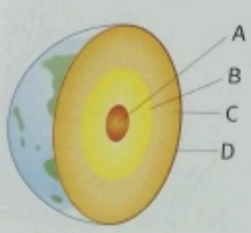
3 The continents have moved to their present positions because of plate tectonics. Find out more about plate tectonics, for example: What is it? Who proposed the idea? Does it affect human life?

Language bank

accumulation
cementation
consolidation
deposited
evaporites
fossils
minerals
sediment
sedimentary rocks
strata

Checkpoint

1 Where in the Earth?



Look at the diagram. Match up each letter A to D with the labels below. Draw a circle round the one that is solid. Put a square box around the one made of rocks.

Labels

outer core
mantle
inner core
crust

2 Match the meaning

Match up each word with its definition.

Words

rock
minerals
texture
grains
porous

Definitions

the size of the grains and how closely they fit together in a rock
a mixture of minerals
compounds and elements that make up the Earth's crust
having spaces between the grains
little pieces of minerals in a rock

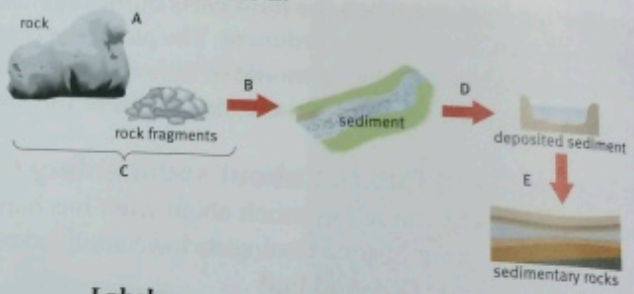
3 Types of weathering

Copy the following processes and write P if it is physical weathering, C if it is chemical weathering and B if it is biological weathering.

a Acidic rainwater reacts with carbonate minerals in a rock.
b Water in cracks freezes at night and expands, then melts during the day, eventually causing rock pieces to break off.
c Tree roots grow into cracks in a rock and cause it to break up.
d The surface of a rock expands in the Sun and contracts at night more than the inside does, causing stress in the rock.

4 Forming sedimentary rock

Sketch this diagram and choose the correct label below for A to E.



Labels

erosion
weathering
cementation
deposition
transportation

5 Moving around

Copy and complete these sentences, unscrambling the words.

Sediment can be carried by water in **svirre** or glaciers.
How much sediment a river can hold depends on how fast it is **niflwog**. A fast river has more energy and can hold more **stemdine**.
As the river **swols nowd** it has less energy and deposits the sediment.

The rock cycle

Before starting this unit, you should already be familiar with these ideas from earlier work.

- Materials are recycled on Earth in processes that can take millions of years. During these processes the particles of matter become combined in different ways. Do you think matter is destroyed when materials change like this?
- Different rocks have different textures. Which is more porous, sandstone or granite?
- Weathered fragments of rock are transported as sediment and deposited to form new sedimentary rock. Can you think of three ways the original rock might have been worn away into fragments?

You will meet these key ideas as you work through this unit. Have a quick look now, and at the end of the unit read them through slowly.

- **Sedimentary rocks** are formed from sediments laid down in layers. The pressure causes minerals to come out of solution and **cement** the grains together. Limestones are formed this way, and there are many different types depending on the mixture of minerals and the environmental conditions where they formed.
- **Igneous rocks** are formed when **magma** or molten rock inside the Earth cools and solidifies. If the cooling happens slowly, the particles have more time to come together and crystallise before the rock solidifies. So slow cooling results in rocks like granite with large crystals; quicker cooling gives rocks with much smaller crystals, such as basalt.
- **Metamorphic rocks** are formed when high temperature and pressure change other rocks deep in the Earth. For example sedimentary limestone may be changed to marble by heat and pressure.
- These three types of rock have different properties. Some have big crystals or grains; others are glassy or have small crystals. Some are porous and some are denser than others. Some have fossils and some have bands or layers in the rock. These characteristics help us decide what type of rock it is and how it formed.
- All these rocks are constantly being recycled and changed from one form to another over millions of years in the **rock cycle**. Energy is transferred in the rock cycle.

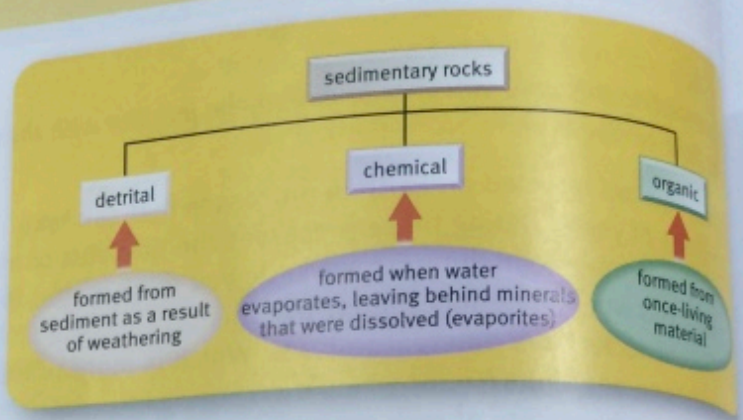
8H.1 Limestone

M

Are all limestones different?

You know that there are different sedimentary rocks, such as limestone or sandstone. Sedimentary rocks may be formed in one of three ways:

- from the cementation of sediment layers – **detrital rocks**
- minerals left behind when water evaporates (evaporite rock) – **chemical rocks**
- from once-living materials – **organic rocks.**

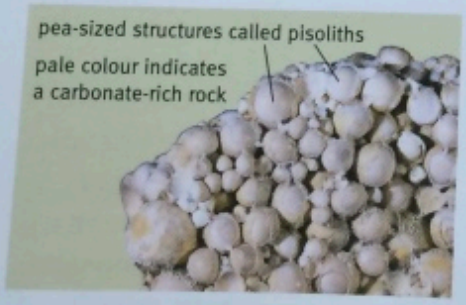


Looking at limestones

There are lots of different types of limestone. Limestone rock can be formed in any of the three ways listed above, so limestone can have a variety of properties. Like all rocks it is a mixture, and its composition will vary depending on how it was formed.

Limestone breccia forms from fragments of other rocks (it is a detrital limestone). It is found near areas of weathering such as the base of a cliff.

Pisolitic means 'like a pea'.

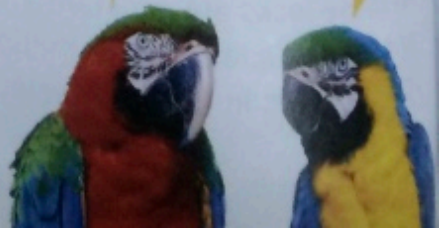


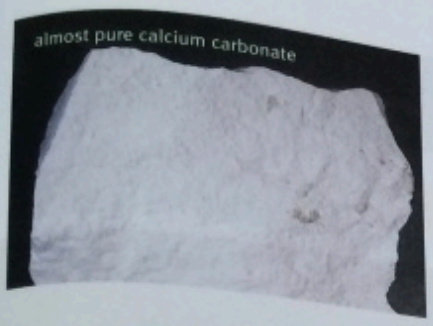
Pisolitic limestone is a chemical sedimentary rock. The rounded structures form when calcite ***precipitates*** *from water (when it falls out of solution). This kind of limestone is formed in shallow seas which provide ideal conditions for precipitation to occur.*

This crinoidal limestone was formed in ancient seas from sea creatures rather like starfish and sea urchins. It is therefore an organic limestone. The remains of sea creatures are in a matrix of calcite.

Crinoidal?

The little sea creatures that formed it were called crinoids.





Chalk is another organic sedimentary rock. It is powdery with very fine grains. Chalk formed from the remains of micro-organisms, so it often contains fossils. It is very pure, and probably formed at a time when the land was dry and there was little erosion by water.

How much carbonate is in limestone?

Limestone contains calcium and magnesium carbonates, which react with acid. The more carbonate there is in a rock sample, the more acid it will react with. There might be sediment made from sand (silicon dioxide) in limestone, and this does not react with acid.

- George and Perminder ground up three different types of limestone. They placed 10 g of each into separate beakers.
- They added hydrochloric acid from a measuring cylinder until they couldn't see any more bubbles of carbon dioxide.
- They then filtered the mixture to collect any unreacted rock. They left this overnight to dry and weighed it the next day.
- They used their results to work out how much of each original rock sample was carbonate.

Limestone sample	Acid used (cm^3)	Mass of rock left over that didn't react with acid (g)
A	98	0.2
B	95	0.5
C	92	0.8

Which rock sample contained the most carbonate?

The rock cycle

1 Copy and complete using words from the Language bank:

Limestones can be made from _____, from a solution evaporating or from organic material. They contain metal carbonates including _____ carbonate and _____ carbonate. These react with acid to produce _____ gas.

2 Name the three different types of sedimentary rock.

3 Calculate the percentage of carbonate in each limestone sample A, B and C above.

Language bank

calcite
calcium carbonate
carbon dioxide
cementation
chemical rocks
detrital rocks
evaporite
hydrochloric acid
limestone
magnesium carbonate
matrix
organic rocks
precipitate
sediment

8H.2 Igneous rocks

O Where do igneous rocks come from?

Imagine being inside an erupting volcano at temperatures over 1000 °C, as it throws red-hot molten rock or **magma** high into the air. This is what happens when igneous rocks are formed.

The word igneous comes from the Latin word meaning 'fire', as igneous rocks form from cooling magma. When magma reaches the Earth's surface it is called **lava**.

Mount Pinatubo in the Philippines erupts, blasting lava and ash from its mouth. The ash settles and the lava cools and solidifies, forming new igneous rocks.

Types of igneous rock

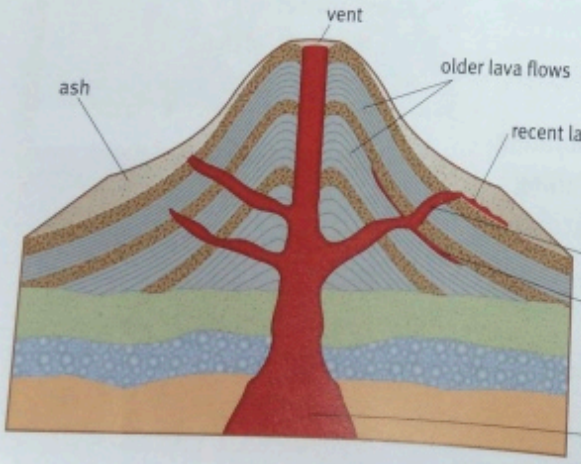
Sometimes magma cools below the Earth's surface. This might happen in a volcano's side-vent (**dyke**). Sometimes liquid magma flows between rock strata and solidifies there, forming a **sill**.

Guess what?

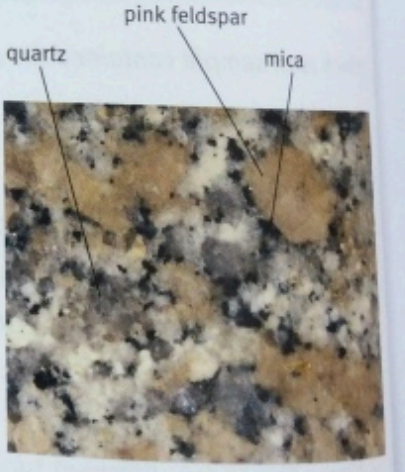
Most volcanoes run on a belt on the Pacific Ocean called the Ring of Fire.

The molten rock is deep in the Earth, insulated from the cooler surface. This means it cools slowly. As it gradually solidifies, the mineral crystals have time to grow large before the rock becomes totally solid. Rocks formed like this are called **intrusive igneous rocks**.

Other igneous rocks are formed on the surface of the Earth, so the lava cools quickly. There is no time for large crystals to form so these rocks have very small crystals or a glassy type of structure. Rocks formed like this are called **extrusive igneous rocks**.

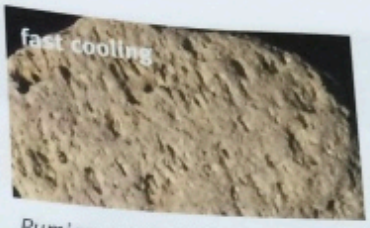


Anatomy of a volcano.



This sample of pink granite was formed slowly, deep in a dyke. It has large crystals, up to about 5 mm.

Obsidian is glassy; no crystals visible.



Pumice: gas bubbles, visible.

Basalt: very fine crystals.

Investigating cooling rocks

We can model slow and fast cooling using salol (a waxy solid). We melt it and put some on a hot slide and some on a cold slide to cool.

The salol cooled more slowly on the warm slide (A). Here the particles had more time to come together to form large crystals before it all turned solid. The crystals are smaller on the cold slide (B).

Different densities

Igneous rocks have different compositions depending on the rock that melted to form them. For example, granites are usually rich in minerals that contain silica. Gabbros have more iron-containing minerals.

Silica-rich rocks have a lower density than iron-rich rocks. To identify an unknown igneous rock, finding its density gives some clues.

1) Weigh the rock to find its mass.

2) Find its volume:

Archimedes can

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

volume

Divide the mass of a rock by its volume to find the density. This gives a clue to the minerals inside.

1 Copy and complete using words from the Language bank:
Igneous rocks form from cooling _____ or lava. They can be _____, which means they formed on the surface of the Earth, or _____, which means they formed underneath the Earth's surface.

2 Explain the difference between magma and lava. Which one cools to form extrusive igneous rock?

3 Why do intrusive igneous rocks have larger crystals than extrusive ones? Use the word 'particle' in your answer.

4 Typical rock densities: granite 2.75 g/cm^3; gabbro 3.0 g/cm^3.
a Jo measured the mass and volume of a rock: mass 364 g, volume 120 cm^3. Is it granite or gabbro?
b Explain this difference in density between granite and gabbro.

Language bank

crystals
dyke
erupt
extrusive igneous rocks
igneous rocks
intrusive igneous rocks
lava
magma
salol
sill
volcano

8H.3 Changing rocks

M

What is different about metamorphic rocks?

You might think that once igneous or sedimentary rocks have formed, they stay there. But heat and/or pressure can change these solid rocks into new forms, called **metamorphic rocks**. The baking and squeezing may change the rock only slightly, or if conditions are extreme the rock may become quite different.

*The wavy bands or **foliation** shown in this metamorphic rock have been caused by conditions of high pressure. This can happen when some parts of the Earth's crust collide or move past each other.*

Comparing rock types

The table shows the main differences between sedimentary, igneous and metamorphic rocks.

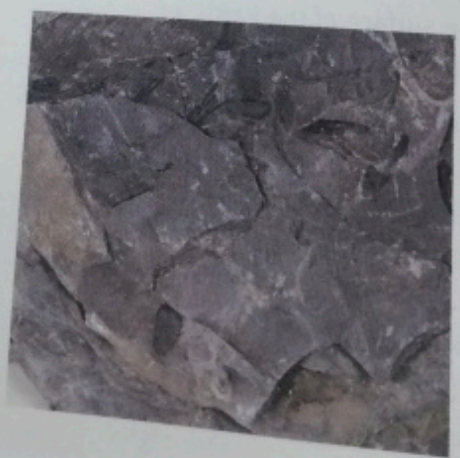
Rock type	Sedimentary	Igneous	Metamorphic
Structure	platy or layered, with grains that may be poorly held together	crystalline with interlocking minerals firmly held together	often sugary, particles may be aligned or random
Fossils present?	fossils very common	no fossils present	remains of fossils possible, but rare
Bedding	flat beds often present unless rock has been folded	random arrangement of crystals	often have wavy bands called foliation
Porosity	often porous	non-porous	varies, but often less porous than sedimentary rocks

Examples of metamorphic rocks

Generally, the higher the temperature and pressure, the larger are the grains in the metamorphic rock.

Slate forms from sedimentary shale or clay in conditions of low temperature and low pressure. The fine grains in slate are too small to be seen by the naked eye.

Slate forms from ...



... shale.

In slate the grains are fine and the layers are more defined and less flaky than in shale.

Marble forms from sedimentary limestone and chalk. Blue marble is almost completely calcite (calcium carbonate) but it may contain dolomite (magnesium carbonate). It forms when limestone is strongly heated at low pressure.

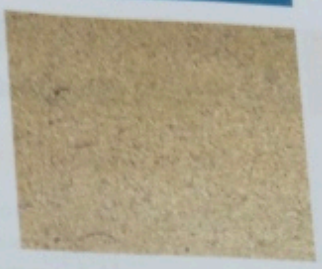
Metaquartzite forms from sedimentary sandstone. When sandstone is heated its appearance becomes paler and more sugary, with a finer and more even texture. Metaquartzite is not as porous as the sandstone that formed it.

Where do metamorphic rocks form?

How do these conditions of heat and pressure that change rocks come about? Hot magma can find its way up into cracks in the crust, wedging them open to form an **igneous intrusion**. The heat may cause rocks in contact with it to metamorphose, for example, shale forming slate and limestone forming marble.

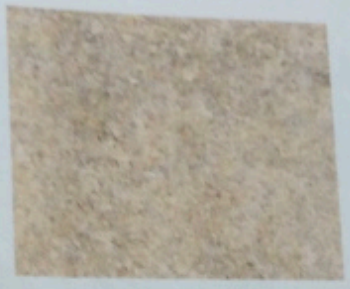
The deeper the rocks, the more pressure they are under, from all the rock above them. Rocks may be heated by an igneous intrusion nearby.

Marble forms from ...



... limestone.

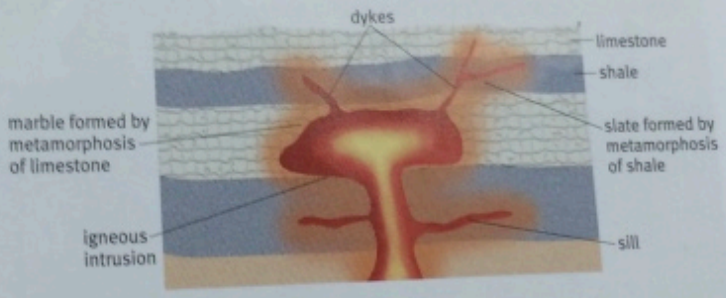
The heat destroys the original limestone structure and gives the rock a new texture.



Metaquartzite forms from ...

... sedimentary sandstone.

In metaquartzite the grains are large and held together loosely.



1 Copy and complete using words from the Language bank:
Conditions of _____ and _____ can cause some rocks to change even though they may be solid. The rocks formed are called _____ rocks. These rocks may have wavy bands called _____.

2 Write out the correct statements below about metamorphic rocks.
a They are formed of distinct layers or bands.
b Their crystals may be aligned.
c They are less porous than the sedimentary rock that formed them.

3 Why are fossil samples found in metamorphic rocks often distorted?

4 Gneiss forms under high pressure and temperature. What kind of grain structure will it have? Explain your answer.

Language bank

dyke
foliation
fossils
heat
igneous intrusion
limestone
marble
metamorphic rocks
pressure
shale
sill
slate

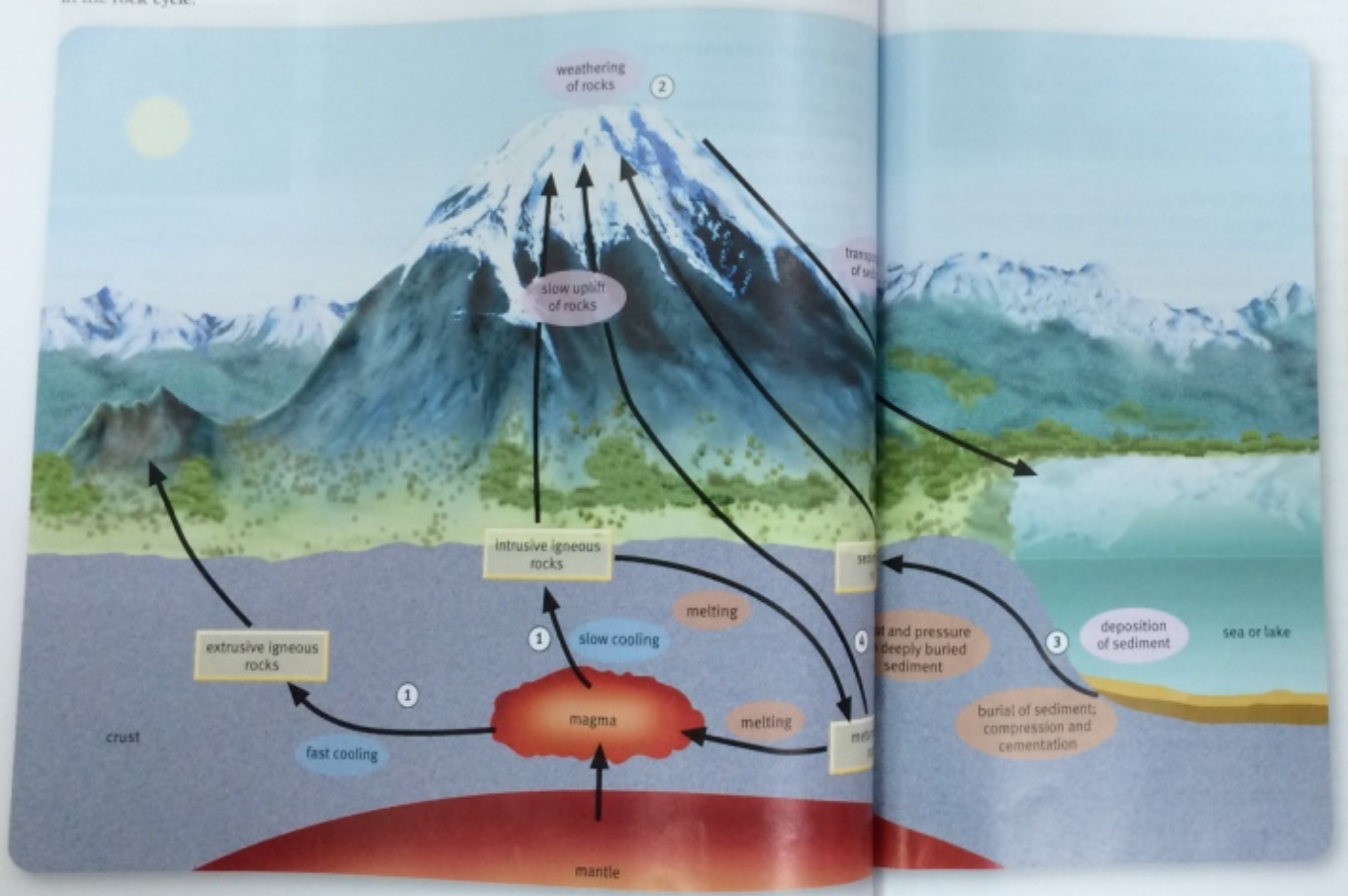
8H.4 The rock cycle

M

What is the rock cycle?

Metamorphic rock may form from igneous or sedimentary rock, but even this is not the end of the story. There is a continual process in which rocks are recycled over many years into new rocks. The three types of rock are linked together by processes that constantly supply and transform the Earth's materials. These processes are summarised in the rock cycle.

The rock cycle.



The important processes of the rock cycle are these:

1. Magma cools to form both intrusive and extrusive igneous rocks.
2. All rock types may be weathered, by physical, biological or chemical means. The weathered sediment may be transported by wind, water or ice. It may later form sedimentary rock.
3. Sedimentary rocks form from deposited sediment or from solutions. They are usually compressed and the particles cemented together.
4. Metamorphic rocks can form from all rock types, especially igneous and sedimentary, when they are changed by heat or pressure or both.

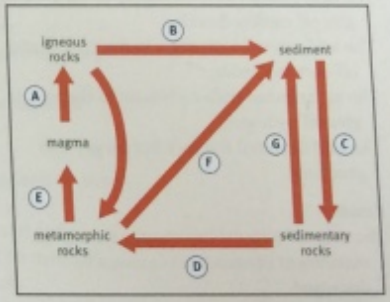
Language bank

cementation
compression
crystals
cycle
deposition
igneous
metamorphic
sediment
sedimentary

1 Copy and complete using words from the Language bank:

The _____ cycle links together the processes that form and change rocks. It is a _____ process in which old rocks are transformed into new ones.

2 Copy the flow chart below and write labels for A to G. Use the large rock cycle to help you.



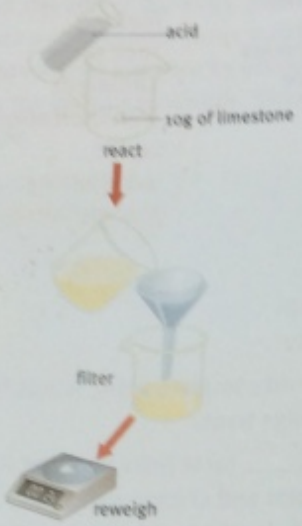
3 Weathering erodes rocks into small fragments or sediment. Why then has the Earth's surface not been weathered until it is completely flat?

4 The Earth is sometimes described as being 'dynamic'. What do you think this means in terms of rock formation?

Checkpoint

1 How much carbonate?

Look at this experiment to find out how much carbonate is in a type of limestone.



Choose the correct description and result below for this experiment.

Descriptions

The acid reacted with carbonate in the rock to give off carbon dioxide.

The acid reacted with oxide in the rock to give off carbon dioxide.

The acid reacted with carbonate in the rock to give off hydrogen.

The acid dissolved the rock but no gas was produced.

Results

The mass of rock did not change during the experiment because rocks cannot be destroyed.

The mass of rock was greater after the experiment because carbon dioxide had been added.

The mass of rock was less after the experiment because the carbonate had reacted with the acid.

The mass of rock was less after the experiment because acid is like rainwater.

2 Forming igneous rocks

Match up the beginnings and endings to make complete sentences. Use a different colour to write each sentence.

Beginnings	Endings
Magma is ...	... molten rock on the Earth's surface.
Lava is ...	... slowly inside the Earth.
Intrusive igneous rocks form ...	... molten rock inside the Earth.
Extrusive igneous rocks form ...	... quickly on the Earth's surface.

3 It's your choice

Copy and complete the following sentences, choosing the correct words.

Deep in the Earth, heat and/or pressure can change existing rocks into new **metamorphic** / **igneous** / **intrusive** rocks.

Rocks may be heated by nearby hot **magma** / **slate** / **lava** finding its way into cracks underground.

Marble / **sandstone** / **shale** is a metamorphic rock that is formed from limestone or chalk.

4 True or false?

Decide whether the following statements are true or false. Write down the true ones.

a The rock cycle formed the rocks we see today.

b The rock cycle is no longer happening because the Earth is no longer hot enough to change rocks.

c Sedimentary rocks are formed by deposition and cementation.

d Igneous rocks can be weathered to form sediment and so can end up as part of sedimentary rocks.

e Metamorphic rocks are only formed from lava.