OXFORD SCIENCE 8

AUSTRALIAN CURRICULUM

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A SPELEOLOGIST (SCIENTIST WHO STUDIES CAVES) PEERS DOWN INTO A GIANT CLOUD-FILLED VOID TO THE FLOOR, MORE THAN 240 M BELOW. CLOUD LADDER HALL IS ONE OF THE LARGEST CAVE CHAMBERS IN THE WORLD. CHONGQING, CHINA

HELEN SILVESTER

OXFORD

SAMPLE

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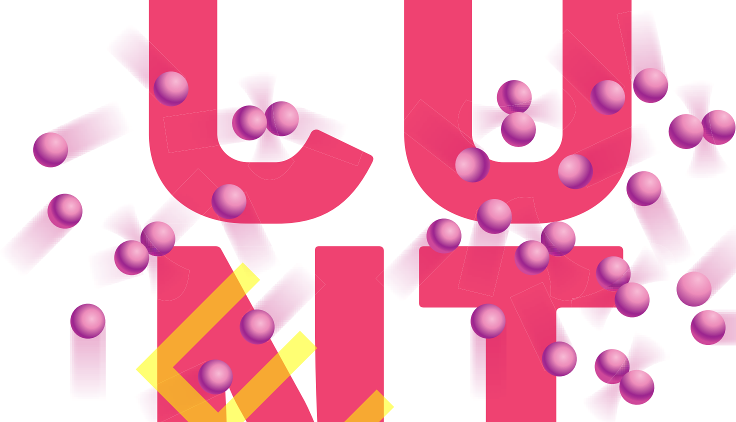

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Using Oxford Science

Oxford Science is a series developed to meet the requirements of the Australian Curriculum: Science across Years 7 to 10. Taking a concept development approach, each double-page spread of Oxford Science represents **one concept** and **one lesson**.

What if?

Student-directed inquiry is encouraged throughout this series using a simple questioning technique. As the series progresses, students discover that their own *What if* questions are actually testable '*if and then*' hypotheses. For example, 'What if *the bubble is touched with a finger*' becomes 'If *the bubble is touched with a finger*, then *it will pop*'.

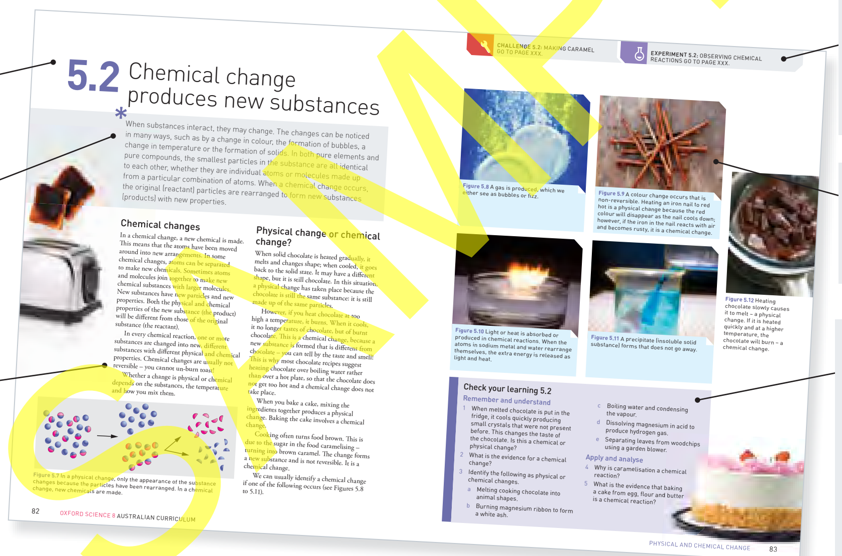
Concept development

Students are given access to the chapter concepts at the start of every chapter. Each double-page spread of this series represents **one concept**. Students explore concepts one-by-one encouraging incremental learning and, by the end of the chapter, complete understanding.

The unit heading introduces the concept.

Each unit begins with a short summary of the concept.

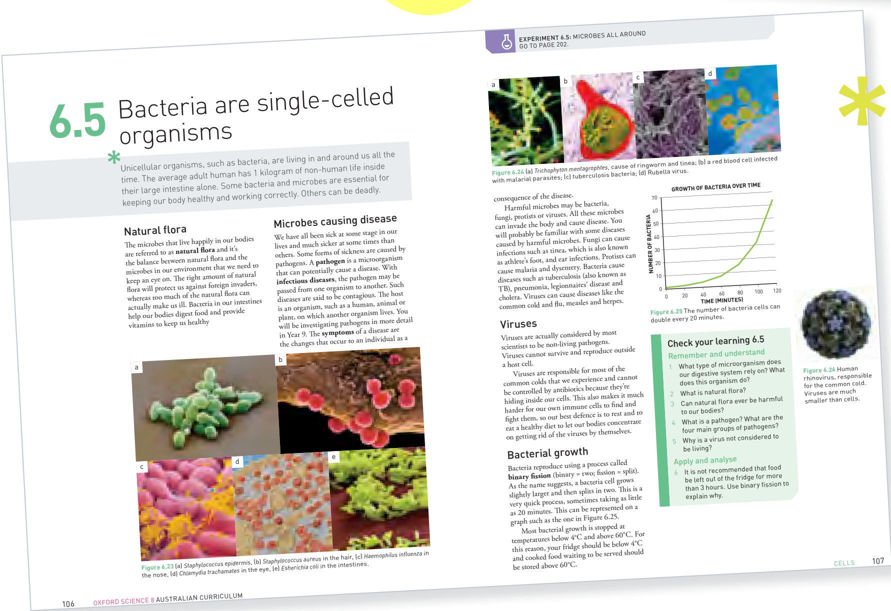
Body text elaborates on the concept in clear and accessible language.



Every spread is linked to one or more experiment, challenge or skills task as a practical application of the concept.

Diagrams and photos are used to illustrate the concept and engage students.

Every double-page spread ends with **Check your learning** questions, allowing students to consolidate their understanding. Questions are graded according to Bloom's Taxonomy – catering for a range of abilities and learning styles.



Accessibility and engagement

Oxford Science has been engineered to be accessible to all science students. We believe that science students are served best when they are free to focus on learning the knowledge and skills of science in simple accessible language, crafted into short sentences. Students will be engaged by the inclusion of stunning photography throughout.

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Science as a human endeavour

Concepts are linked to real-world applications in the highly engaging **Science as a human endeavour** spreads. The **Extend your understanding** questions on this spread are designed to be used flexibly as either homework tasks or as an extended project.

Experiments

Uniquely, experiments are organised at the end of the book in an extended experiments chapter, rather than being confined to each double-page spread. There is a link on most double-page spreads to an experiment, challenge or inquiry task to ensure that practical activites remain aligned to the content.

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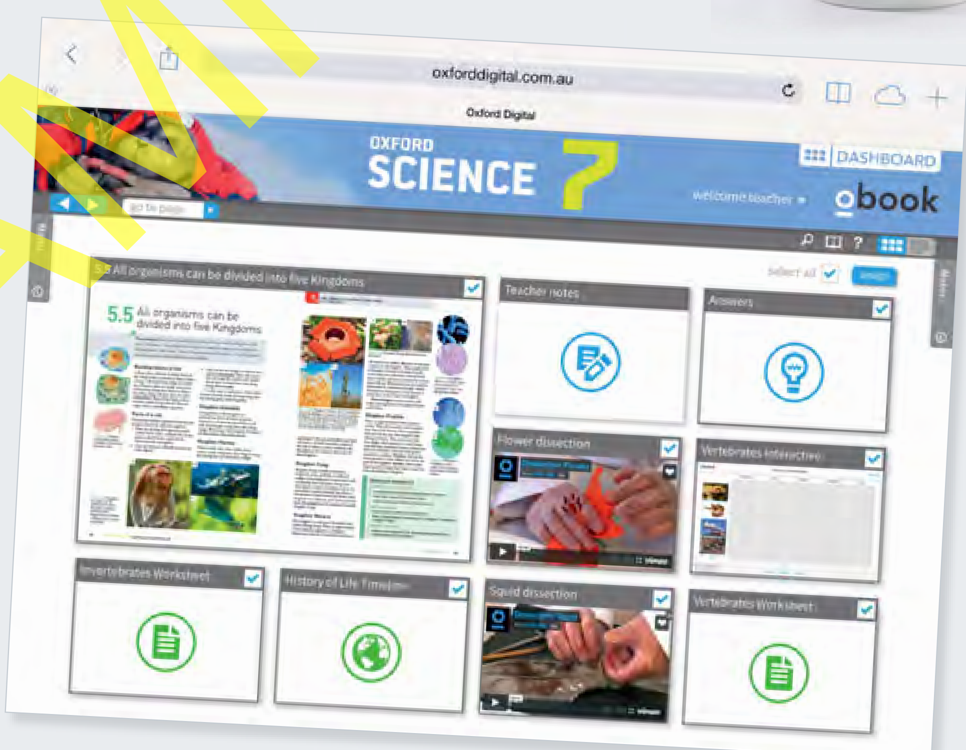
Integrated teaching and learning support

obook assess

obook assess provides an interactive electronic version of the student book in an easy-to-read format. It features multimedia links, interactive learning objects, videos, note-taking, highlighting and bookmarking tools, and live question blocks. **obook** is compatible with laptops, iPads, tablets and IWBs, and also offers page view (in flipbook format) that can be used offline. **assess** provides 24/7 online assessment designed to support student progression and understanding.



DASHBOARD

Oxford Science is supported by teaching strategies, lesson ideas, planning tips, assessment advice and answers to all activities. **obook assess** allows teachers to manage their classes by assigning work, tracking progress and planning assessment. Teacher Dashboard is your online lesson control centre, which allows you to instantly preview or assign related teacher resources to deliver incredibly engaging digital learning experiences. Students can also toggle from their obook to the Dashboard to interact with student resources for each topic.

ROCKS AND MINERALS

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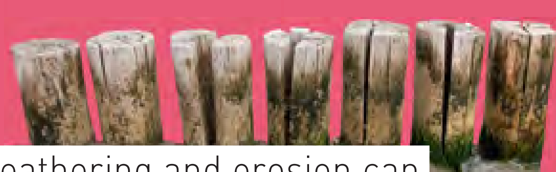

2.8 Weathering and erosion can be prevented

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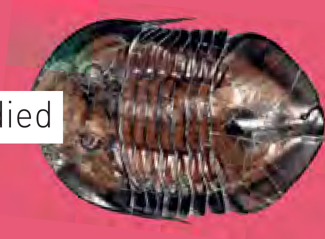

What if?

Rocks

What you need:

selection of different rocks for each group

What to do:

1. Divide into groups of four.
2. Examine each rock carefully. Identify the properties that the rocks have in common and the different features of each rock.
3. Group the rocks according to their similarities. Give each group a name that helps identify the rocks.
4. Record the names and the properties of the rocks on a piece of paper.

What if?

What if another group were given your rocks? Could they use the properties you identified to separate the rocks into the same groups?

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2.1 Rocks have different properties

Rocks don't all look and feel the same. Each rock has characteristics that give clues to its identity, such as its colour or hardness. These characteristics are referred to as **properties**. By making careful observations of a rock's properties, **geologists** (scientists who study rocks) can tell where a rock came from and what has happened to it.

Identifying and selecting rocks

We select rocks for particular purposes because of their properties. For example, granite is selected for kitchen benchtops because it is the hardest building stone, it is not porous (it does not let liquid through), it is not affected by temperature and it is resistant to damage from chemicals.

You can identify rocks first by how they look. Coal is black or dark brown. Pumice and scoria are covered with holes. Conglomerates are made up of individual stones cemented together. Granite is made up of large crystals of the minerals quartz, mica and feldspar.

Geologists also use a range of other properties to help identify rocks, such as colour, layering, weight and the presence of crystals or grains (see Figures 2.1 to 2.5).

Table 2.1 lists some different types of rocks and how they can be identified.

Figure 2.2 Layers in rocks can look very different. Some rocks have different-coloured layers that line up like ribbons. Gneiss usually has alternating layers of colours, often black and white. Sandstone has layers of different-sized grains of sand. Wind or water distributes the sand so that the rock ends up being different shades of the same colour.

Figure 2.1 Weight and density are less if rocks contain large gas holes that were produced when the rock was formed. In pumice, the holes can be the size of a match tip or smaller. In scoria, the holes are often the size of a pea.

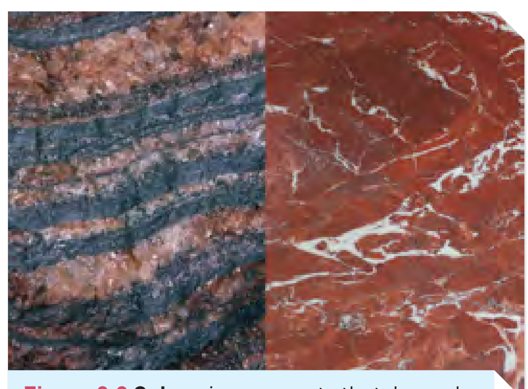

Figure 2.3 Colour is a property that depends on the chemicals in the rocks. For example, some red rocks contain a lot of iron, which has reacted with oxygen in the air ('rusted') to form red iron oxide. Other red rocks don't contain iron, so a rock cannot be identified solely by its colour.

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SKILLS LAB 2.1: IDENTIFYING ROCKS
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Figure 2.4 Crystals are small pieces of organised particles that have smooth sides and sharp edges. They are usually just one colour and often reflect light off their flat surfaces. Crystals in a rock can be different sizes.

Figure 2.5 Grains are small pieces of material. The size of the grain can be used to identify the type of rock. Large grains (larger than a grain of rice) are said to be coarse. Smaller grains that can still be seen with the eye are medium grained. Fine grains cannot be seen without a microscope.

Table 2.1 Rock identification.

ROCK	GRAIN SIZE	HARDNESS	USUAL COLOUR	DENSITY
Basalt	Fine or mixed	–	Dark	2.8–3
Coal	Fine	Soft	Dark	1.3
Conglomerate	Mixed	Hard or soft	–	–
Gneiss	Coarse	Hard	Alternating light and dark bands	2.6–2.3
Granite	Coarse	Hard	Light	2.6–2.7
Limestone	Fine	Soft	Light	2.3–2.7
Marble	Coarse	Soft	Light	2.4–2.7
Obsidian	Fine	Medium	Dark	2.6
Pumice	Fine	Soft	Light	0.6
Quartzite	Coarse	Hard	Light	2.6–2.8
Rhyolite	Fine	Hard	Light	2.4–2.6
Sandstone	Coarse	Hard	Light	2.2–2.8
Schist	Medium to coarse	Medium	Medium	2.5–2.9
Scoria	Fine	–	Dark	0.9
Shale	Fine	Soft	–	2.4–2.8
Slate	Fine	Soft	Dark	2.7–2.8

SAMPLE

Check your learning 2.1

Remember and understand

1 Use Table 2.1 and Figure 2.6 to name these rocks.
   a I am light in colour with a fine grain. I am considered soft.
   b I am light in colour with holes in the surface.
   c I am soft, shiny and dark in colour. I am often used for flooring.
   d I have mixed grains and my colour can vary.

2 What properties are used to identify different types of rocks?

3 Name two different uses for different types of rocks.

4 Why must properties other than colour be used to identify a rock?

5 What branch of science is the study of rocks?

Apply and analyse

6 Pumice has a density of 0.6. Water has a density of 1. Would you expect the pumice stone to float or sink? Explain your reasoning.

Figure 2.6 These are some of the many different types of rocks.

2.2 Rocks are made up of minerals

Rocks are made up of one or more minerals. A **mineral** is a naturally occurring solid substance with its own chemical composition, structure and properties. There are more than 4000 minerals known, but only approximately 150 of these are common.

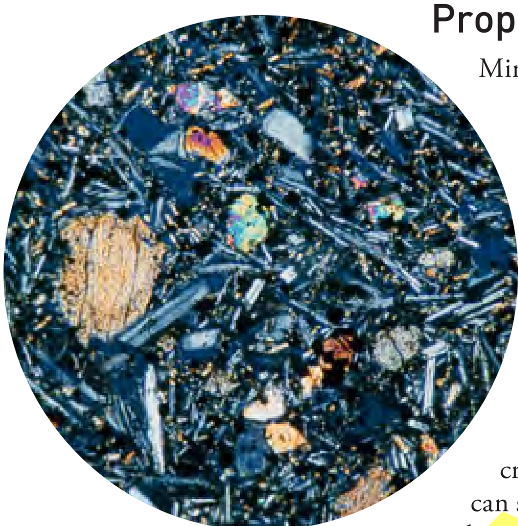

Figure 2.7 The individual mineral crystals of the rock olivine basalt can be seen under a microscope.

Properties of minerals

Minerals are found as crystals.

The structure of a crystal greatly influences a mineral's properties. For example, diamond and graphite have the same chemical composition – they are both pure carbon. Graphite (which is the 'lead' in a pencil) is very soft, whereas diamond is the hardest of all minerals. This difference arises because the carbon particles in a graphite crystal are arranged into sheets that can slide past each other, whereas the carbon particles in a diamond crystal form a strong, interlocking unit.

a

b

Figure 2.8 (a) The carbon atoms in the mineral graphite are arranged in sheets. (b) In a diamond, the carbon atoms are interlocked.

Identifying minerals

To identify minerals correctly, geologists carefully examine the properties of rocks.

The colour of a mineral is a guide to identifying it, but it cannot be relied on for correct identification. Colour is not a reliable property because many minerals are impure. For example, pure quartz is colourless, but if it contains impurities it can be many colours, such as purple (amethyst), pink (rose quartz) or yellow (citrine). Even in one sample, the colour may vary.

Lustre is the shininess of the surface of the mineral. Some types of lustre are:

> metallic – looks like a shiny new coin
> brilliant – very shiny, like a mirror
> pearly – a bit shiny, like a pearl or fingernail
> dull – not shiny at all
> earthy – looks like a lump of dirt.

Figure 2.9 The lustre of a mineral describes its shininess.

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SKILLS LAB 2.2: TESTING THE HARDNESS OF COMMON SUBSTANCES
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Streak is the colour of the powdered or crushed mineral. This colour can be seen by drawing with the mineral on a footpath. The colour of the line that the mineral leaves behind is its streak. Often the colour of the streak is different from the main colour of the mineral.

Hardness is how easily a mineral can be scratched. Some minerals are so soft that they can be scratched with a fingernail. Other minerals are so hard that they can scratch glass. A hard mineral can scratch a soft mineral and not get scratched itself. Austrian geologist Friedrich Mohs (1773–1839) invented a scale to describe the hardness of a mineral. Mohs gave a hardness number to ten common minerals (see Table 2.2): the softest mineral, talc, has a hardness of 1; the hardest mineral, diamond, has a hardness of 10. These minerals can be used to find the hardness of any other mineral.

A mineral will scratch another mineral with a lower hardness number but not one with a higher hardness number. A mineral will be scratched by another mineral with a higher hardness number but not one with a lower hardness number. So, copper (hardness 3.5) will be scratched by fluorite (hardness 4), but not by calcite (hardness 3). Copper will scratch calcite. Fingernails have a hardness number of 2.5; iron nails and a glass microscope slides have a hardness number of 6.5.

Table 2.2 The Mohs scale of mineral hardness. Every mineral will scratch the minerals above it.

HARDNESS	MINERAL
1	Talc
2	Gypsum
3	Calcite
4	Fluorite
5	Apatite
6	Feldspar
7	Quartz
8	Topaz
9	Corundum
10	Diamond

Cleavage is the tendency of a mineral to break into a number of smooth planes. Minerals that demonstrate cleavage look like thin slabs stuck together.

Mica breaks in one direction into flat layers, like the pages in a pile of papers. Calcite breaks along three cleavage planes: left and right, front and back, and top and bottom.

Several minerals have unusual properties. Some minerals fluoresce in ultraviolet (UV) light: these minerals absorb UV light, which we cannot see, and emit it as visible light, which we can see. Calcite is a transparent mineral. When you look through it, you see a double image.

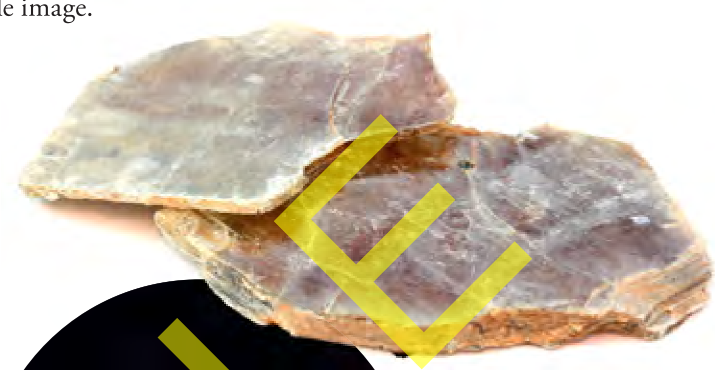

Figure 2.10 Mica has one cleavage plane – it breaks into thin sheets of rock.

Figure 2.11 Calcite is a transparent mineral.

SAMPLE

Check your learning 2.2

Remember and understand

1. Define:
   a. hardness
   b. lustre
   c. streak
   d. cleavage.
2. What does it mean if a mineral has a hardness of 1 on the Mohs scale?
3. Name a mineral that has a Mohs hardness of 10.
4. How would you describe the lustre of gold?

Apply and analyse

5. Obsidian has a hardness of 6 on the Mohs scale and was prized by ancient peoples for its sharp edge. Describe what type of minerals would damage the sharp edge of an obsidian blade.

2.3 Minerals are a valuable resource

Minerals are an important source of metals and other materials. An **ore** is a mineral with a large amount of a useful metal in it. Some minerals, such as iron ore, have to be treated before they can be used. Some important ores and the metals they contain are listed in Table 2.3.

Mineral resources

Australia is rich in mineral resources. It is the world's leading producer of lead, bauxite and alumina, diamonds (by volume), ilmenite, rutile and zircon (and synthetic rutile) and tantalum. It is the second largest producer of uranium, zinc and nickel; the third largest producer of iron ore, lignite, silver, manganese and gold; the fourth largest producer of black coal and copper; and the fifth largest producer of aluminium. Worldwide demand for mineral resources is high, particularly due to increased demand from China as it becomes more and more industrialised.

Table 2.3 Important ores and the metals they contain.

ORE	METAL
Bauxite	Aluminium
Cassiterite	Tin
Chalcopyrite	Copper
Cinnabar	Mercury
Galena	Lead
Haematite, limonite	Iron
Malachite, azurite	Copper
Molybdenite	Molybdenum
Pentlandite	Nickel
Pitchblende	Uranium
Rutile	Titanium
Sphalerite	Zinc

Figure 2.12 Coloured sands indicate the concentrations and types of minerals they contain.

Gold

Australia's mineral resources have always been in big demand. During the 1850s, after gold was discovered in Bathurst, New South Wales, hundreds of thousands of people migrated to Australia to take part in the Gold Rush in Victoria and New South Wales. During this time, Australia's economy boomed. Gold is chemically stable, so it is almost always found as pure gold. This means that it can be collected without having to be smelted or refined. Gold is used in jewellery, in fine wires in electronics, as fillings for teeth and, because of its reflective properties, to protect satellites and spacecraft from solar radiation.

Mineral sands

Australia is an old continent that is rich in mineral sands. Mineral sands are old beach sands with significant concentrations of heavy minerals, such as rutile, zircon and ilmenite. Rutile is a rich source of titanium dioxide, which is used as a pigment in paints, plastics and paper. You may have seen glass jars of mineral sands that are often sold as souvenirs.

Copper

Copper was the first metal to be used by humans. In Australia, copper is found as the mineral chalcopyrite in rocks that are over 250 million years old. Copper is a good conductor of electricity and is used in electrical generators and motors, for electrical wiring and in electronic goods, such as televisions. Copper is also used for water pipes because it does not corrode easily.

Recycling minerals

Earth's mineral resources are finite – they are not renewed. However, they can be recycled. For example, aluminium can be recycled

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EXPERIMENT 2.3: TESTING THE MINERALS IN TOOTHPASTE
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over and over again. A lot of energy is used to produce aluminium from bauxite, but once the metal has been refined it can be recycled indefinitely. Recycling aluminium uses only 5 per cent of the energy needed to produce the same quantity of aluminium from bauxite. So recycling aluminium saves us from having to use coal to produce energy in power stations, which reduces the emission of greenhouse gases into our atmosphere.

Mobile phones and minerals

Many electronic devices such as mobile phones use the minerals niobium and tantalum. These minerals are found in the ore coltan, which is mined in the Congo River Basin in Africa. Unfortunately, this forest region is also home to endangered gorillas and mining is threatening their habitat. Recycling the minerals in old mobile phones helps to reduce the impact of mining on the ecosystem in this region.

MINERALS IN TOOTHPASTE

Toothpaste contains a variety of minerals that perform different roles when cleaning your teeth. Fluorite (calcium fluoride), found in granite and limestone, makes teeth more resistant to decay. Mica reflects light and is used in toothpaste, paints, roofing and rubber products to make them sparkle. Silica, mined from sand, makes the toothpaste thicker and sodium carbonate is used as a whitening agent.

Figure 2.14 Toothpaste contains minerals that help clean your teeth.

Figure 2.13 The minerals in mobile phones can be recycled.

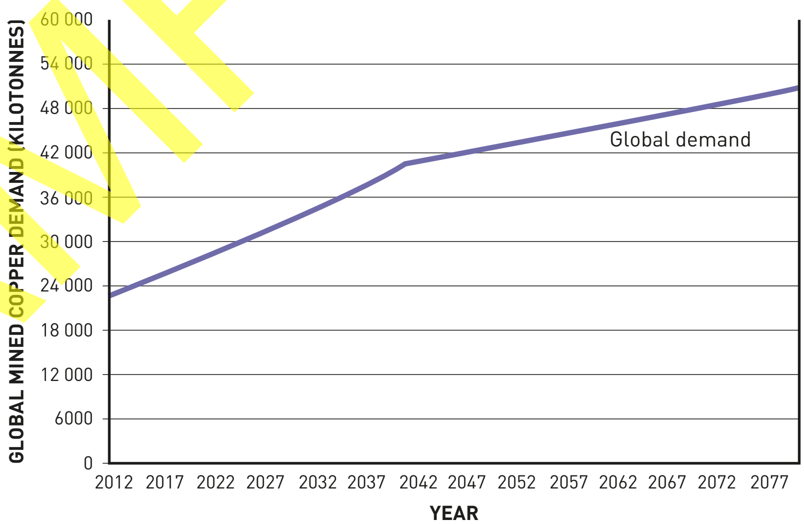

Figure 2.15 Global demand for mined copper is projected to continue to increase.

Check your learning 2.3

Remember and understand

1 What is a mineral?
2 What is an ore?
3 Name two uses of copper.
4 What are five of Australia's most important minerals?

Apply and analyse

5 Use the graph in Figure 2.15 to describe how the global demand for mined copper will change after 2042. Suggest a reason for this change in demand.

SAMPLE

2.4 Igneous rocks develop from magma and lava

Rocks are broadly classified according to how they are formed. The three main types of rocks – igneous, sedimentary and metamorphic – form in different ways. **Igneous rocks** form when magma and lava from volcanic eruptions cool and solidify.

Magma and lava

The term 'igneous' comes from the Latin word *ignis*, which means 'fire'. The hot, molten rock inside the Earth is called **magma** and its temperature can be more than 1200°C. The magma chamber under a volcano is the source of molten rock for the volcano (Figure 2.16).

In a volcanic eruption, the red-hot magma rushes out onto the surface of the Earth as **lava**. The cooler conditions at the Earth's surface help to solidify the lava quickly. Igneous rocks also form from magma under the ground. These igneous rocks look quite different from those formed on the Earth's surface because they cool much more slowly.

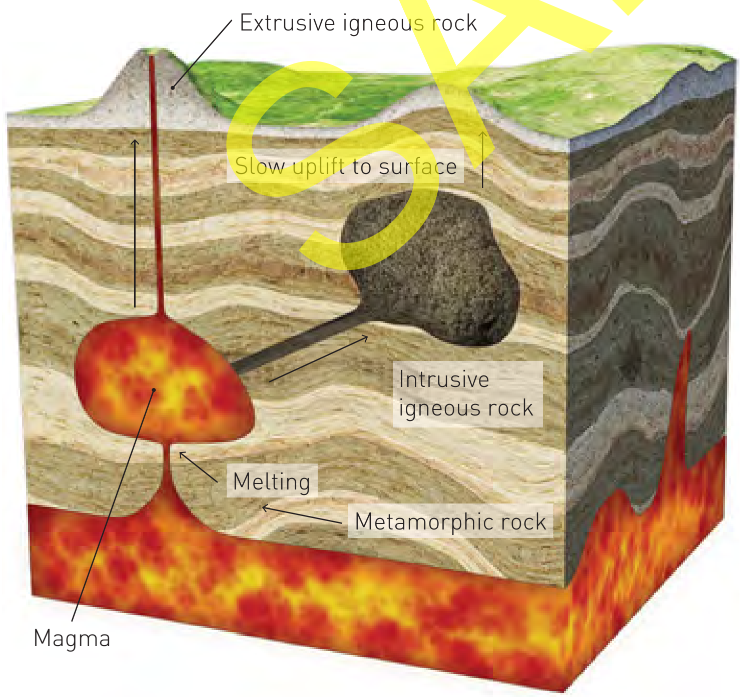

Figure 2.16 Igneous rocks are formed from volcanic magma.

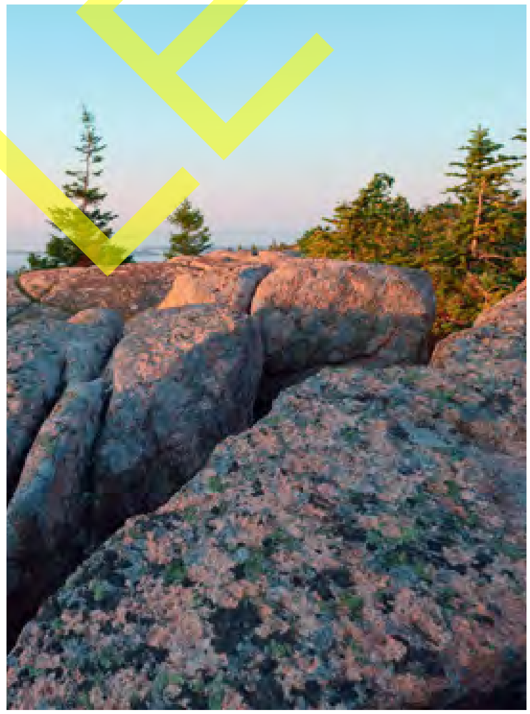

Figure 2.17 Granite is an intrusive igneous rock.

Intrusive igneous rocks

Intrusive igneous rocks form slowly beneath the surface of the Earth when magma becomes trapped in small pockets. These pockets of magma cool slowly underground (sometimes for millions of years) to form igneous rocks. The longer it takes for lava to cool, the bigger the rock crystals that grow. Intrusive igneous rocks have large crystals locked together. Granite is an intrusive igneous rock in which the crystals can be seen with the naked eye. Although formed underground, intrusive igneous rocks reach the Earth's surface when they are either pushed up by forces in the Earth's crust or uncovered by erosion.

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EXPERIMENT 2.4: WHAT AFFECTS CRYSTAL SIZE?
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Extrusive igneous rocks

Lava cools much more quickly on the surface of the Earth. This causes it to form **extrusive igneous rock**. Because the lava is cooling much more quickly than the magma underground, the crystals that are formed are small. Sometimes, the lava cools so quickly that no crystals are formed. For example, pumice has no crystal structure. Pumice forms when hot, gas-filled lava cools very quickly. The many tiny holes in pumice are formed by volcanic gases escaping from the cooling lava (see Figure 2.18). It has so many holes that it is extremely light and can float on water. Pumice stones are used to scour hard skin from feet, and powdered pumice is found in some abrasive cleaning products.

Figure 2.18 Pumice contains many holes, which make it light enough to float on water.

The different forms of basalt

Magma can solidify into many different igneous rocks, which can vary in appearance. This is because of how igneous rocks form and what they are made of.

Basalt is the most common type of rock in the Earth's crust. Most of the crystals in basalt are microscopic or non-existent because the lava cools so quickly that large crystals do not form.

We commonly think of basalt as the building product bluestone. However, basalt can look different depending on the type of volcanic eruption that produced it and how quickly it cooled. Scoria is a type of basalt that is full of bubble holes. The lava was filled with gases when it began to cool and the holes in the scoria are where the gas bubbles once were. Scoria is a light rock that is often used for garden paths and as fill in drainage trenches.

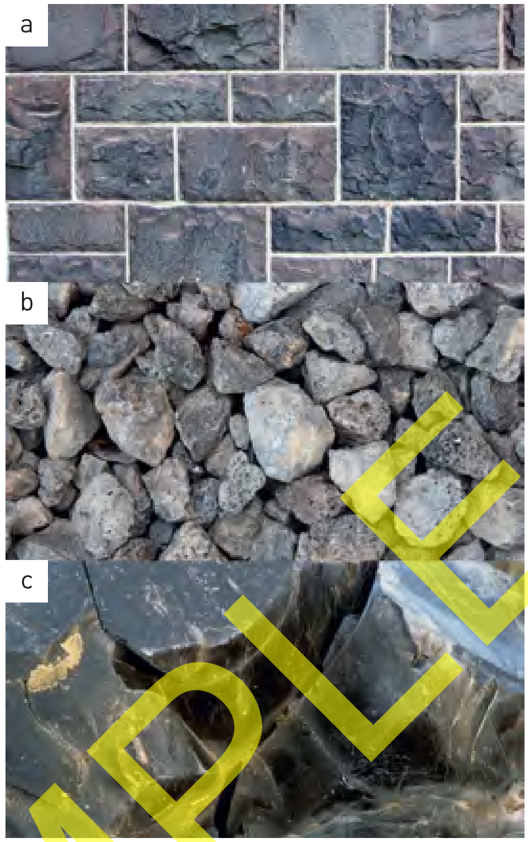


Figure 2.19 Basalt comes in different forms: (a) bluestone, (b) scoria and (c) obsidian.

Obsidian is a smooth, black rock that looks like glass. It is formed when lava cools almost instantly and forms no crystals. Obsidian is used to make blades for surgery scalpels; the resulting blades are much sharper than those made from steel.

Check your learning 2.4

Remember and understand

1. What does the term 'igneous' mean?
2. How do igneous rocks form?
3. What type of rock is produced by magma that cools deep below the Earth's crust?
4. Name an igneous rock that would float on water.

Apply and analyse

5. The ancient civilisations that discovered obsidian had a competitive advantage over those who didn't. Explain why.

SAMPLE

2.5 Sedimentary rocks are compacted sediments

Sedimentary rocks are formed when loose particles are pressed together (compacted) by the weight of the overlying sediments. Sediments are rock particles, such as mud, sand or pebbles, that are usually washed into rivers and eventually deposited on the riverbed or in the sea. Sediments can also come from the remains of living things, such as plants and animals.

Sediment

Over thousands or even millions of years, sediments form thick layers on the riverbed or sea floor. Pressure from the overlying sediments and water squeezes out air and any gaps in the bottom layer. Over time, the compacted sediments become sedimentary rocks.

The names of some sedimentary rocks are clues to the sediments that formed them – sandstone, mudstone, siltstone and conglomerate are all types of sedimentary rock. Sandstone is made up of sand deposited in environments such as deserts and beaches. Conglomerate is a mixture of all sizes of rocks that have become cemented together.

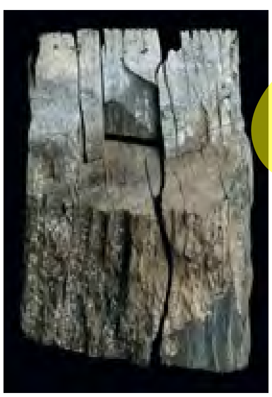
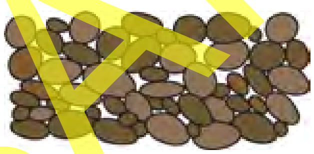
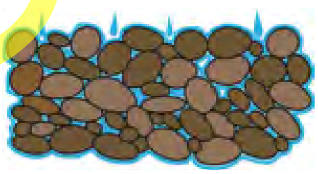


Figure 2.20 Shale (or mudstone) is the most common sedimentary rock. Shale is a fine-grained sedimentary rock made up of clay minerals or mud. This specimen clearly shows the layers of sediments that were compacted to form this rock.

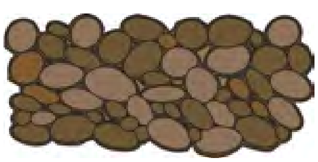
Sediments are deposited in layers called beds.



The grains of sediment in lower layers begin to squash together.



Chemicals that are dissolved in the water can soak into the sediments.



The chemicals help cement the grains together once the water has evaporated.

Figure 2.21 Sedimentary rocks form over long periods of time.

Figure 2.22 Sandstone is a popular building material. This ancient temple of Abu Simbel in Egypt was carved directly into the sandstone rock.

Figure 2.23 Conglomerate rocks have grains of different sizes. The sediments for these rocks were deposited in fast-flowing rivers during flooding or by glaciers.

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EXPERIMENT 2.5: MAKING SEDIMENTARY ROCKS
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Biological rocks

Sedimentary rocks are not always formed from the sediments of minerals or other rocks. The remains of living things also break down and are deposited as sediments. Shells and hard parts of sea organisms break down and are deposited in layers on the ocean floor. Eventually, they become cemented together under pressure to form limestone.

The compaction of dead plant material can also help form sedimentary rocks. For example, coal is formed from dead plants that were buried before they had completely decayed. Pressure from the layers above can change the plant material into coal or oil.

Chemical rocks

Chemical sedimentary rocks form when water evaporates, leaving behind a solid substance. When seabeds or salt lakes, such as Lake Eyre in South Australia, dry up, they leave a solid layer of salt behind. If the layer of salt is compressed under the pressure of other sediments, it may eventually form rock salt.

Limestone caves

When groundwater passes over limestone, it can dissolve calcium carbonate from the limestone. When the water evaporates, it leaves behind the calcium carbonate. Various rock formations in caves are formed by this method.

The amazing long strands of rock found on cave floors and ceilings are composed of calcium carbonate from the limestone ceiling of the cave. A stalagmite grows from the floor towards the ceiling (they 'might' reach the ceiling one day) and a stalactite grows down from the ceiling (they hold on 'tight'). If these formations meet in the middle, then they form a column.

Stalagmites and stalactites form when limestone rocks are dissolved by acids in water. The acid and dissolved limestone form a solution that drips through the ceiling of the cave and is deposited on the stalagmites and stalactites, gradually increasing their width and length. It is important that visitors to limestone caves do not touch the stalactites and stalagmites because they are generally still forming. Oil from skin can interfere with stalagmite and stalactite formation.

Figure 2.24 Coal is formed from dead plant material.

Figure 2.25 Stalagmites and stalactites form in limestone caves.

Check your learning 2.5

Remember and understand

1. How do sedimentary rocks form?
2. How do stalactites and stalagmites form?
3. How do chemical sedimentary rocks form?

Apply and analyse

4. A student claims that sandstone is made up of sand. Do you agree or disagree? Explain.
5. What do plants have to do with coal?

SAMPLE

2.6 Metamorphic rocks require heat and pressure

Metamorphic rocks are formed when other types of rocks are changed by incredible heat and pressure inside the Earth. When igneous, sedimentary or even metamorphic rocks are heated to extreme temperatures by magma, or when they are placed under extreme pressure from the layers of rocks above them, they can change into different types of rock.

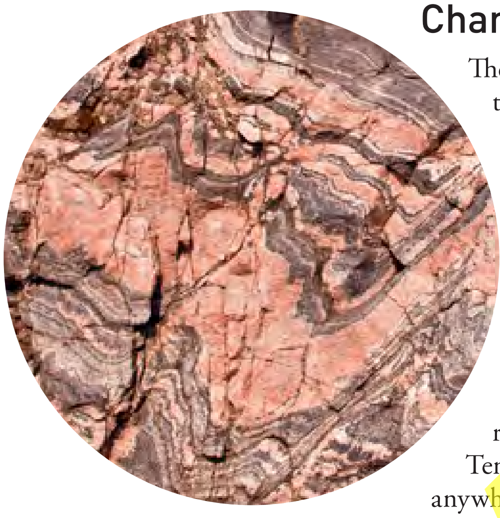

Figure 2.26 Foliation occurs when rock is subjected to uneven pressure.

Change in appearance

The combination of high temperatures and pressures causes differences in the appearances of the metamorphic rock. (Metamorphism means 'change in form'.) As you go deep underground, the temperature gradually increases. Miners in the West Wits minefield in South Africa, who work up to 3.9 kilometres below ground, report temperatures as high as 60°C. Temperatures can get much higher anywhere magma intrudes.

The pressure of the earth above the rock also contributes to the different appearance of metamorphic rocks. Bands can occasionally be seen in metamorphic rocks formed under high pressure. Sometimes the pressure is uneven, causing the rock crystals to twist. This is called **foliation**.

Change in the minerals

Metamorphic rocks also change chemically. Some metamorphic minerals (sillimanite, kyanite and garnet) only form at high temperatures and pressures. They are called **index minerals** because they can tell us the history of what happened to the minerals – the temperature and pressure they were exposed to. Other minerals, such as quartz, can withstand the high temperatures and pressures and can sometimes be found in metamorphic rocks. The heat and temperature can cause some crystals to change their size and shape.

Recrystallisation occurs when the crystals are squeezed together so tightly that they partially melt and form fewer, but larger, crystals. For example, when granite is squeezed under high pressure, the crystals change and the rock gneiss is formed (see Figure 2.27).

Metamorphic rocks are stronger than the original material because the particles have been fused together under great pressure or heat.

a

b

Figure 2.27 When granite (a) is subjected to high heat or pressure, it can change into the metamorphic rock known as gneiss (b). The bands on gneiss show that the crystals have been squeezed together under immense pressure.

SAMPLE

EXPERIMENT 2.6: MAKING A METAMORPHIC ROCK
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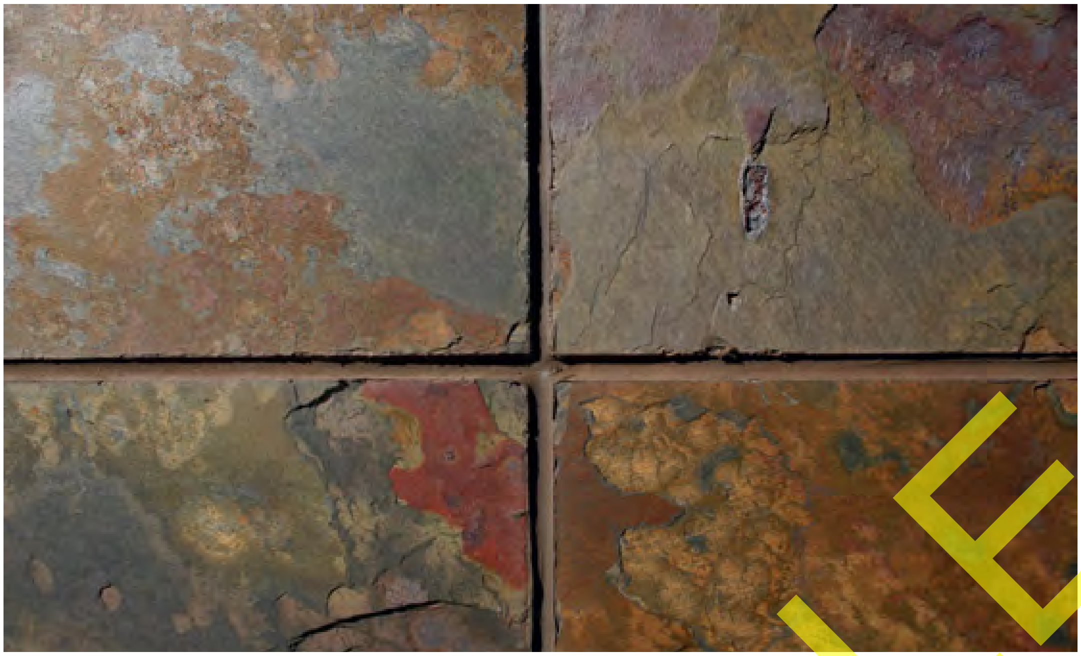

Figure 2.28 Slate cleaves easily into flat sheets because of its flat, parallel crystal structure. This makes it a useful material for floor and roof tiles and as the base for billiard tables.

Figure 2.29 The Taj Mahal in India is made of marble, the metamorphosed form of limestone. With its dense composition and beautiful patterns, marble is also a popular material for sculptures and kitchen benchtops.

Check your learning 2.6

Remember and understand

1. How do metamorphic rocks form?
2. Where do metamorphic rocks form?
3. A student claimed that a rock had to be igneous because it had quartz crystals. Are they correct? Explain.
4. Describe a foliated rock.

Apply and analyse

5. Which type of rock is stronger: sandstone or marble? Explain your reasoning.

SAMPLE

2.7 The rock cycle causes rocks to be re-formed

The **rock cycle** is an ongoing process that describes the formation and destruction of the different rock types. **Weathering** is the breaking down of rocks and minerals through the movement of water and animals, and the extremes of temperature. **Erosion** is the movement of the sediment to another area.

Physical weathering

Mechanical, or physical, weathering occurs when a physical force is applied to a rock. It includes the breakdown of rocks by non-living things.

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 an onion skin. This process is called **onion-skin weathering** and the round rocks produced in this way are called **tors**.

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

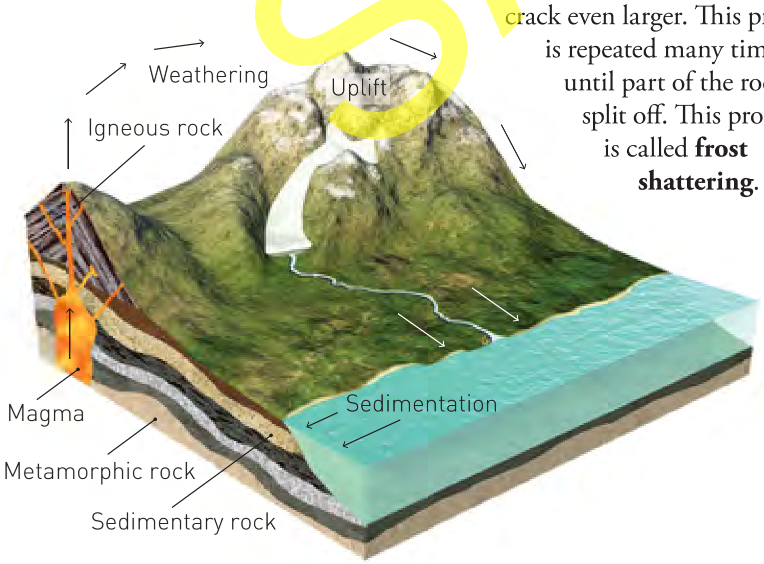

Figure 2.30 The rock cycle.

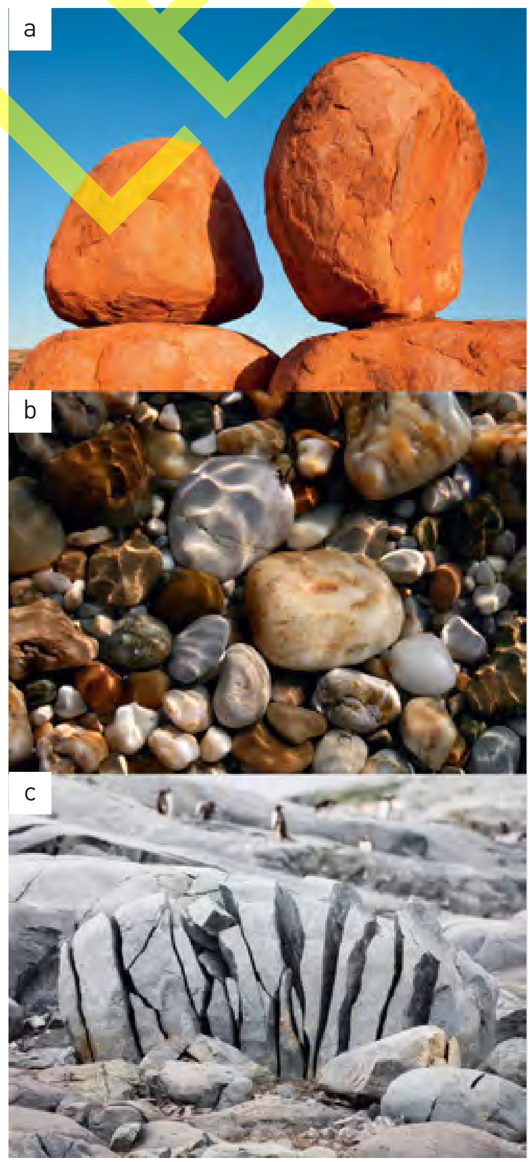

Figure 2.31 Physical weathering can include (a) onion-skin weathering, (b) abrasion in moving water and (c) frost shattering.

SAMPLE

SKILLS LAB 2.7: MODELLING THE ROCK CYCLE
GO TO PAGE 165.

Chemical weathering

Chemical weathering changes the minerals in the rock. Carbon dioxide in the air mixes with the water to form a weak acid rain (a much weaker acid than vinegar). When the acid rain falls on rocks such as limestone, a chemical reaction changes the minerals in the rock and the minerals are washed way (eroded). You can see evidence of this type of weathering in old statues.

Figure 2.32 Chemical weathering can be caused by acid rain.

Biological weathering

Biological weathering can start with a seed falling into a crack in the rock. Soil in the rock encourages the seed to grow. As the roots grow, they push on the cracks in the rock, eventually causing the rock to break.

Over time, the large rocks are broken down into smaller rocks, which are broken down into sediment. The sediment is carried by wind and water to an area where it accumulates. Gradually, the sediment becomes buried under many layers, re-forming as sedimentary rock.

Heat and pressure

As more layers form on top of the sedimentary rock, it is put under pressure. Over time the layers sink deeper to where the temperatures start increasing. Increased temperature and pressure causes physical and chemical changes in the rock, transforming it into metamorphic rock. If the temperature continues to rise, the rock will melt, turning it into its liquid form, magma.

Magma is also put under great pressure, causing it to seek any available space. Gradually it makes its way to the surface where it can cool as igneous rock. Over time it is exposed to wind and water. The cycle continues.

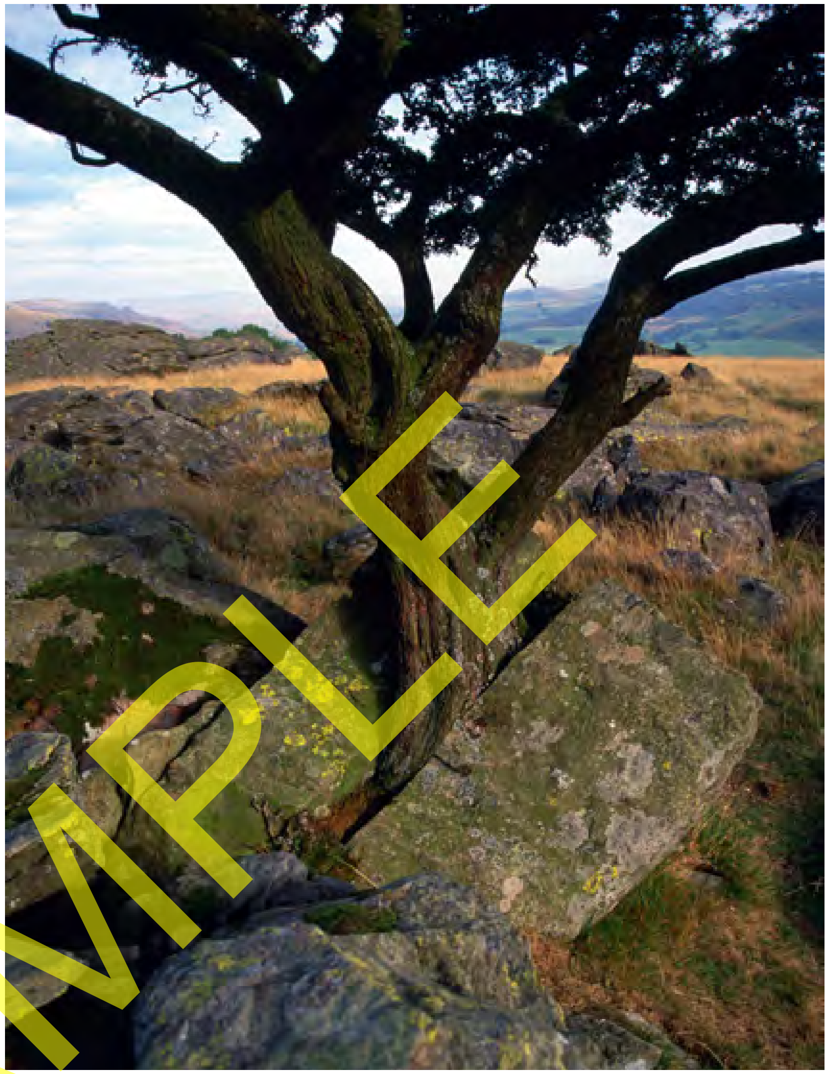

Figure 2.33 Biological weathering can be caused by plant roots.

Check your learning 2.7

Remember and understand

1 Describe the different stages in the rock cycle. Use the rock cycle diagram in Figure 2.30 to assist you.

Apply and analyse

2 Write a creative story of the 'life of a rock'. Rocks change with time, as do humans. However, unlike humans, rocks are never truly 'born', nor do they 'die' – they can move through the rock cycle, covering the same stage many times in many different ways. What life does your rock experience?

SAMPLE

//SCIENCE AS
A HUMAN ENDEAVOUR//

2.8 Weathering and erosion can be prevented

*

Humans are very good at changing their environment to suit their needs. However, this has changed the rate of rock weathering and erosion. This has resulted in flooding and poor food production. Soil erosion engineers are helping to solve this problem.

Preventing erosion

The population of Australia has been steadily increasing for many years and as a result we have needed to build more houses and grow more food. Building houses means building roads and footpaths around the houses. Instead of trees and grasses lining a riverbank, footpaths and roads can be built right up to the edge of the water flow.

The roots of plants interlace the soil, helping it resist the movement of wind and rain. If plants are removed, then the topsoil will erode.

Rain falling on concrete paths and roads is not absorbed into the soil. Instead, it flows off the road and carries away further soil layers. This can slowly remove the support beneath the built structures, causing them to collapse. The loose soil and rocks can trigger damaging mudslides. Engineers are responsible for developing ways to solve this problem.

Figure 2.34 Australia's population has increased dramatically since the beginning of the 20th century.

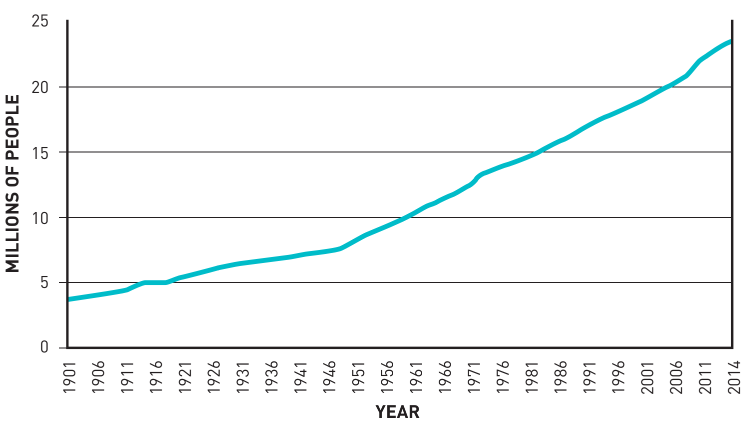

Figure 2.35 Footpaths, roads and roofs affect how water moves around the land.

Figure 2.36 Soil erosion can lead to many problems.

SAMPLE

CHALLENGE 2.8: PREVENTING SOIL EROSION
GO TO PAGE 166.

Engineering solutions

Figure 2.37 Engineers try to minimise erosion by controlling the flow of water with dams and levees.

Figure 2.38 Groynes are built on beaches to remove some of the energy of the waves. They protrude from the beach and trap the sand, preventing its erosion.

Figure 2.39 Terraces may be built to allow water to follow a set path that is protected from erosion by man-made structures such as drains, or by plants. This reduces the force of the water, making it less likely to cause damage.

Figure 2.40 New products have been developed that allow water to move through instead of contributing to run-off. This allows the water to be absorbed into the soil and join the groundwater.

Figure 2.41 Temperature erosion causes materials such as concrete to crack. Footpaths have grooves in them to allow for their expansion during hot weather.

Figure 2.42 Regular cleaning prevents the build-up of moss and pollution that might contribute to biological or chemical erosion.

SAMPLE

Extend your understanding

1 What is the difference between weathering and erosion?
2 Name two ways erosion can affect food production.
3 What does a soil engineer do?
4 How could an engineer prevent erosion of soil by water?
5 Find an area near your school that has been affected by erosion. Suggest a way that you could prevent further erosion.

//SCIENCE AS A HUMAN ENDEAVOUR//

2.9 Rocks are studied by geologists

Planet Earth is 4.5 billion years old. The events on Earth are recorded in the rocks. From about 570 million years ago, the ancestors of the different plants and animals that now populate Earth evolved. The remains of some of these life forms are captured in the rocks as fossils. Fossils allow specialist geologists, known as **palaeontologists**, to build up a picture of Earth's long history.

What are fossils?

Fossils are the remains (or imprints) of animals or plants preserved in rock.

A fossil is evidence of life in the past. Fossilised evidence may be found in many forms, but usually consists of the hard parts that remain after decay – bones, teeth and shells. Sometimes, softer parts of an organism are preserved and even footprints or impressions of organisms are considered fossils. Palaeontologists study these remains to find clues about ancient life.

How do fossils form?

Fossils are usually only found in sedimentary rocks. These rocks are formed by the deposition of layers of sediments, such as mud, silt or sand. Any organism trapped in the mud and silt can eventually become part of the rock through the process of fossilisation. The fossils can be uncovered when the rocks are broken apart or weathered away. This process can take millions of years.

Extremely old rocks contain fossils of simple animals, whereas slightly younger rocks have fossils of animals with shells. Rocks that are younger still have fossils of fish. Only the newest rocks have fossils of mammals. The variety and complexity of life has increased as the Earth has become older.

Figure 2.43 Broome in Western Australia is the site of many trace fossils such as these footprints.

Figure 2.44 If the conditions are just right, soft body parts can be fossilised.

SAMPLE

CHALLENGE 2.9A: USING EVIDENCE TO DEDUCE
GO TO PAGE 166.

CHALLENGE 2.9B: RECONSTRUCTING ANIMALS
GO TO PAGE 167.

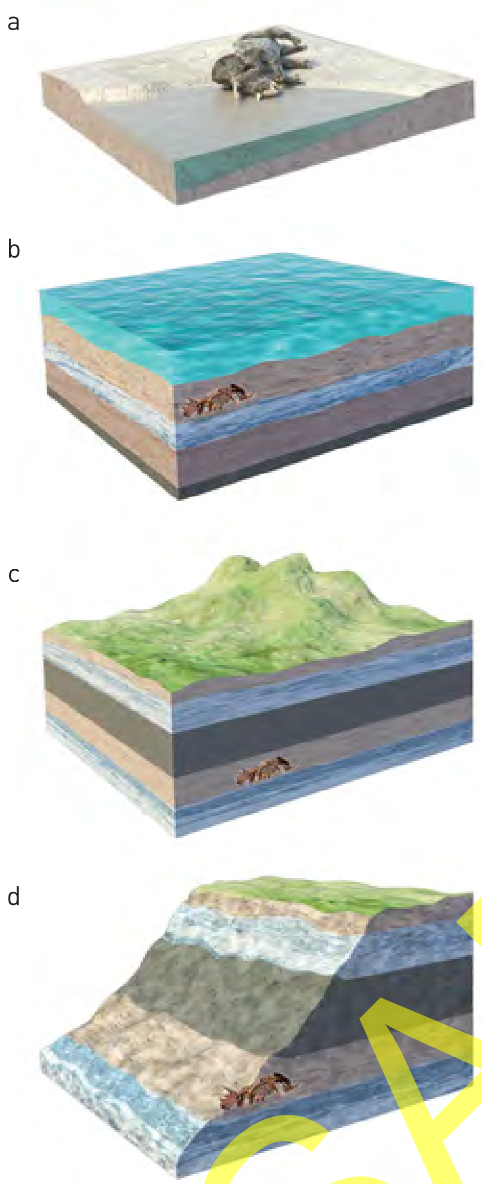

Figure 2.45 Formation of a fossil. (a) If an organism dies near water, it has a greater chance of being covered by sediment. (b) The sediment protects the body from predators and weathering. (c) Over millions of years, more sediment is deposited and the remains are gradually transformed into sedimentary rock. (d) Years of geological movement, weathering and erosion may eventually expose the fossil.

Comparative dating

Geologists can place rocks and fossils into a date order. They work this out from the different layers of sediment in rocks. When layers of sand or mud are deposited, the oldest sediments are at the bottom. Newer, or younger, sediments are deposited on top (see Figure 2.46). Working out the age of rocks as being younger or older than rocks of known age is called **comparative dating** or relative dating. It is comparative because we are comparing the old with the new, the bottom layers with the top.

Different rocks that are the same age have the same type of fossils in them. These fossils are called **index fossils**. They are used to find rocks of the same age.

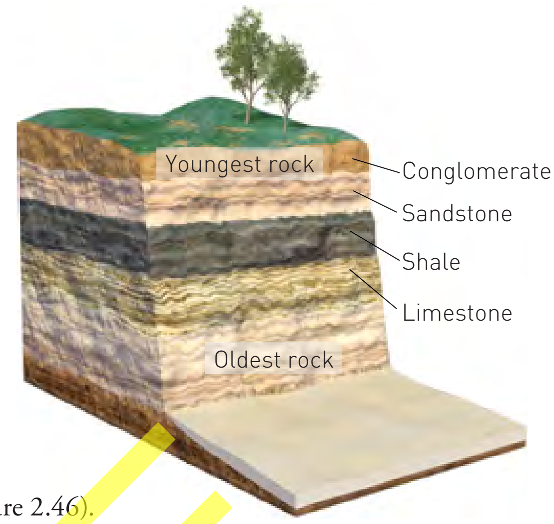

Figure 2.46 Comparative dating is used to determine the age of rocks and fossils.

Radioactive dating

The actual age of a fossil, measured in millions of years, is found by looking at the amount of radioactivity left in rocks. For example, uranium (U) is a radioactive substance found in many rocks. It decays to lead (Pb) at a known rate. So, as rocks age, the amount of uranium decreases and the amount of lead increases. The age of rocks can be calculated by comparing the amounts of uranium and lead they contain. This is called **radioactive dating**.

The oldest rocks on Earth have been dated at 4500 million years. This method has been checked using different radioactive atoms. This age is the same as that of meteorites that crash to Earth, as well as that of Moon rocks brought back to the Earth by astronauts.

Figure 2.47 This trilobite fossil has been dated to 500 million years ago. The fossils of some trilobites are the size of beetles, whereas others are the size of dinner plates.

Extend your understanding

1. What are fossils?
2. How are fossils formed?
3. What can fossils show us or tell us about the Earth's history?
4. What are geologists who study fossils called and what sorts of things do they do as part of their job?
5. How do scientists find out how old a rock is?

SAMPLE

Remember and understand

1 Copy and complete the following sentences.
   a An _________ is a mineral with a large amount of useful metal in it.
   b _________ rocks are formed when loose particles are pressed together by the weight of overlying sediments.
   c _________ rocks are formed when other types of rocks are changed by heat and pressure inside the Earth.
   d _________ rocks form when magma and lava from volcanic eruptions cool and solidify.

2 Define:
   a lustre
   b streak
   c hardness.

3 What is the difference between magma and lava?

4 How do geologists identify minerals?

5 Why is colour not a reliable guide for identifying minerals?

6 What properties of gold made it valuable to early civilisations, such as the Incas of South America?

7 How would you tell the difference between intrusive and extrusive igneous rocks?

8 Cave systems in limestone rock follow the course of underground rivers. Why is water necessary to form caves?

9 Explain why only simple fossils are found in the oldest types of rocks, whereas younger rocks have fossils of mammals.

10 Design a flow chart of how fossils are formed.

Apply and analyse

11 Why do sedimentary rocks form at the Earth's surface?

12 Why does pumice have no crystal structure even though it is a rock?

13 Explain the difference between weathering and erosion.

Evaluate and create

14 If you were a palaeontologist searching for fossils, which types of rocks would you look for? Explain.

15 A kitchen scourer can be used to clean stainless steel cutlery, but this type of scourer should not be used to clean silver-plated cutlery. Explain why.

16 Explain a way to remember which way stalactites and stalagmites grow.

17 Why should we recycle minerals? What minerals can be recycled? What forms can they be used in once they have been recycled?

18 Some famous works of art are made of marble. What are the properties of marble that make it ideal for sculpture? What are some of the properties of marble that may not make it appropriate for all works of art?

Critical and creative thinking

19 Some people say that Australia is a huge quarry. This is because Australia mines so many minerals and sells them. Working on your own, list the advantages and disadvantages of mining and selling minerals. Join with a classmate and combine your lists. Then join with another group and prepare another list containing the three best reasons for mining and the three best reasons against mining.

20 Look at Figure 2.48, which shows the Twelve Apostles. Use this image to describe how these rocks were formed. Prepare a poster to show how the rocks were formed and would have changed over time. How will they look in 1000 years' time?

21 Imagine you are a geologist who is going to discover minerals in a remote part of Australia. You will need to take a test kit to help you identify the minerals you find. What items should go into your kit to allow you to test for streak, hardness and so on?

SAMPLE

Figure 2.48 The Twelve Apostles, located off the coast of Victoria.

Research tasks

22 Choose one of the following topics for a research project. Some questions have been included to help you begin your research. Present your report in a format of your own choosing.

a Formation of oil

Oil is formed from the compression of dead marine-plant material in mud over millions of years. Oil is made up of hydrocarbons, which are lighter than rock and water, so it often migrates up through porous rock towards the Earth's surface.

- What is an oil reservoir?
- What conditions are needed for an oil reservoir to form?
- How is an oil field formed?
- In what other forms is oil found?

b Gemstones

- Which gemstones are found in Australia?
- Which gemstones are dug up by recreational fossickers?
- What do the gemstones look like?

c Extraction of metals

Metals are extracted from ore using a variety of methods. Some are heated, some are purified using electrical energy, and some are extracted using chemical processes. Why are different metals extracted using different chemical or electrical processes? Find out how some metals are extracted, such as copper and aluminium, and design a poster that shows the process of extraction.

SAMPLE

KEY WORDS

2

cleavage
number of smooth planes a mineral breaks along

colour
property of rocks and minerals used to identify them

comparative dating
determining the age of rocks by comparing them to rocks of known age

crystal
small, organised particle in rocks, which has smooth sides and sharp edges

erosion
movement of sediment to another area

extrusive igneous rock
rock formed at the Earth's surface by quickly cooling lava

foliation
occurs when rock is subjected to uneven pressure

fossil
remains (or imprint) of an animal or plant preserved in rock

frost shattering
process of weathering in which repeated freezing and melting of water expands cracks in rocks so that eventually part of the rock splits off

geologist
scientist who studies rocks

grain
small rock particle; grain size can be used to identify rock type

hardness
how easily a mineral can be scratched; measured on the Mohs hardness scale

igneous rock
rock formed by cooling magma and lava

index fossil
fossil found in different rocks, that can be used to determine age of rocks

index mineral
a mineral that only forms under a particular temperature and pressure; used to determine the history of the mineral

intrusive igneous rock
rock formed underground by slowly cooling magma

layer
property of rocks used to identify them

lava
hot, molten rock that comes to the surface of the Earth in a volcanic eruption

lustre
shininess

magma
hot, molten rock inside the Earth

metamorphic rock
rock formed from other rock that has experienced intense heat and pressure

mineral
naturally occurring solid substance with its own chemical composition, structure and properties

onion-skin weathering
weathering of rock where the outside of the rock peels off

ore
mineral containing a large amount of useful metal

palaeontologist
scientist who studies fossils

property
characteristic

radioactive dating
determining the age of rocks by comparing the amounts of uranium and its decay product lead

rock cycle
process of formation and destruction of different rock types

sedimentary rock
rock formed from compacted mud, sand or pebbles, or the remains of living things

streak
colour of powdered or crushed mineral

tor
round rocks produced by onion-skin weathering

weathering
breakdown of rocks and minerals by movement of water and animals, and extremes of temperature

weight
property of rocks used to identify them

SAMPLE