PEARSON

Science

STUDENT BOOK | VICTORIA

8

Topic 5 The rock cycle

Prior knowledge

Structure of Earth

1 The four main layers of Earth are the crust, mantle, outer core and inner core.

2 Temperature increases from an average of about 25°C on Earth's surface to extremely high temperatures in Earth's centre. Pressure also increases closer to the centre of Earth.

Geological processes

3 Weathering is the process of larger rocks being broken down into smaller rocks. Erosion is the transport or movement of weathered material.

4 Physical or mechanical weathering is the breaking down of rocks into smaller particles through physical processes including wind abrasion, cycles of extreme heat or cold (expansion and contraction), and frost wedging (when water freezes and expands in cracks).

Chemical weathering involves chemicals eating away at rocks, breaking them into smaller particles.

Biological weathering involves the actions of living things such as plant or tree roots breaking rocks apart.

5 Intrusive igneous rocks involve magma cooling very slowly beneath Earth's surface, allowing large crystals to develop. Extrusive igneous rocks form on Earth's surface when lava cools rapidly, resulting in the formation of small or no crystals.

Rocks and minerals

6 **a** igneous rocks

b sedimentary rocks

c metamorphic rocks

7 Students' answers will vary, but a range of resource types could be considered including:

- metals (e.g. gold, copper, silver)
- gemstones (e.g. diamond, sapphire, emerald)
- mineral sands (e.g. rutile, ilmenite, zircon)
- rare earth elements
- energy resources (e.g. uranium)
- fossil fuels/hydrocarbons (e.g. coal, oil, natural gas)
- construction/building materials (e.g. marble, granite, sandstone, limestone, sand, gravel)

5.1 Structure of Earth

Check your understanding

SC1: I can identify the different layers of Earth

a 1: crust; 2: mantle; 3: outer core; 4: inner core

b outer core: liquid; inner core: solid

SC2: I can describe the layers of Earth's internal structure

a The outer core is liquid and is made up mostly of iron and nickel. The inner core is also made up mostly of iron and nickel, but it is solid due to the immense pressure at Earth's centre.

b The outer core is liquid. The mantle is divided into three zones – the lower mantle, the asthenosphere and the uppermost part of the mantle, which is part of the lithosphere. All parts of the mantle are solid.

 ISBN 978 0 6557 1969 4

SC3: I can describe the distribution of heat energy within the internal structure of Earth

The movement of liquid in the outer core distributes heat from the very hot inner core to the cooler mantle and crust. This happens because heat moves from warmer areas to cooler areas.

Lesson review

1. Earth's mantle lies beneath the outermost and thinnest layer, the crust, and above the liquid outer core. The mantle is the thickest layer compared to the other layers.
2. Earthquake P-waves can travel through both solids and liquids in Earth's interior but at different speeds. S-waves are only able to travel through solids, so when they encounter a liquid layer within Earth, they cannot continue.
3. This new layer might have properties intermediate to the solid lower mantle and the liquid outer core. The material may be highly viscous (very thick) with some partially melted rock and some solid rock that behaves plastically. This layer is also likely to be rich in iron as this is found in both the outer core and the mantle.
4. The layers of Earth with the stated characteristics:
   - **a** outer core
   - **b** mantle
   - **c** inner core
   - **d** outer core
   - **e** crust
   - **f** inner core
   - **g** crust
   - **h** crust and uppermost part of the mantle
5. Two sources of heat within Earth's internal structure are primordial heat, retained from when Earth was formed, and the heat generated from radioactive decay.
6. Geothermal energy in the mantle can melt rocks, forming magma. Magma rises to Earth's surface and escapes as lava, forming volcanoes. In volcanic areas, the geothermal heat is close to the surface, which heats underground water. When this hot water rises, it escapes as geysers and hot springs.

5.2 Changes to rocks on the surface of Earth

Check your understanding

SC1: I can describe different types of weathering

Physical weathering breaks rocks into smaller pieces without changing their chemical composition, while chemical weathering involves chemical reactions that alter the rock's composition and break it down.

SC2: I can describe, with examples from Australia, the difference between weathering and erosion

Weathering involves the physical, chemical or biological breakdown of rocks in place, while erosion involves the movement of these weathered materials from one location to another by agents like wind, water or ice.

SC3: I can explain, with examples from Australia, the process of deposition and the land formations produced as a result

Erosion transports weathered materials. Deposition occurs when these materials settle and accumulate in a new location, often due to a decrease in the energy of the transporting medium (i.e. wind, water or ice).

 ISBN 978 0 6557 1969 4

Lesson review

1 The three main types of weathering are physical (mechanical), chemical and biological weathering.

2 Physical weathering involves the mechanical breakdown of rocks into smaller pieces without changing their chemical composition. Biological weathering involves living organisms, such as plant roots or lichens, breaking down rocks.

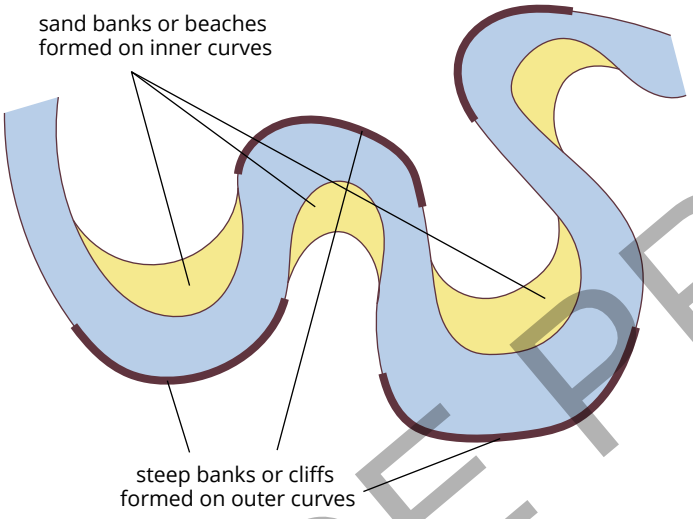
3 Physical weathering breaks down rocks into smaller particles. These particles are then carried away by wind or water in the process of erosion. These two processes can form landscape features such as sand dunes, canyons and gorges.

4 **a** Chemical weathering of the limestone, and physical weathering through the impacts of wind, waves and saltwater crystallisation have broken down the limestone rock into smaller pieces.

b Erosion by wind and by the action of water (rain and waves) have carried away weathered material, gradually sculpting the sea stacks into their current shapes.

c Over time, continued weathering and erosion will likely reduce the size of the Apostles, and more are likely to collapse.

5



6 **a** deposition

b erosion

c deposition

d deposition

e erosion

f erosion

g erosion

 ISBN 978 0 6557 1969 4

5.3 Weathering of rocks

Results

Part A

Test tube	Rock	Liquid	Observations
1	granite	water	no change
2	granite	vinegar	no reaction
3	limestone	water	no change
4	limestone	vinegar	chemical reaction – bubbles formed
5	sandstone	water	water becomes cloudy
6	sandstone	vinegar	slight reaction – a few bubbles formed

Part B

Container	Observations
1 (without water balloon)	no change
2 (with water balloon)	plaster cracked/ broke up

Conclusion

1. The acids in the environment will react with some rocks, including limestone and sandstone. The products of the chemical reaction can then be blown or washed away via erosion. Over a long time, this will remove parts of the rocks.
2. When water seeps into cracks in rocks and freezes, it expands. This expansion can exert enough force to push the rock apart and eventually break it. The smaller particles produced can then be eroded by wind, water, ice or gravity. Over a long time, this will remove some parts of the original rock.

Evaluation

Sample answer:

Chemicals, such as the acid in vinegar, exist naturally in the environment. Temperatures often drop below 0°C, causing water to freeze. Rocks are weathered by these processes in the natural environment, in the same way as shown in this investigation. So, the experiment models the weathering of rocks reasonably well, although the time scales in this experiment are far too short to be realistic.

5.4 Sedimentary rocks

Check your understanding

SC1: I can describe how and where sedimentary rocks are formed

The three main stages of the formation of sedimentary rocks are:

Stage 1 (Deposition): Weathered sediments carried by water, wind or ice are deposited at the bottom of large bodies of water.

Stage 2 (Compaction): Over time, more layers build up and the weight of the upper layers compresses the lower ones, squeezing out water.

Stage 3 (Cementation): Minerals like silica or lime in the water act as a glue, binding the compacted sediments together to form solid rock.

 ISBN 978 0 6557 1969 4

SC2: I can describe observable features of sedimentary rocks

Fossils can be found in clastic sedimentary rocks, where they were preserved within the surrounding clasts (rock fragments). Fossils may also be found in the layers of biogenic sedimentary rocks.

SC3: I can explain how fossil evidence can be used to predict how and when a rock was formed

Fossils are preserved when organisms are buried rapidly by sediments, protecting them from decomposition. Over time, compaction and cementation of the sedimentary layers occur, and the organism's remains are replaced by minerals and so become fossils.

Lesson review

1 Sedimentary rocks are typically formed in environments such as rivers, lakes and oceans where sediments are deposited over time. Some also form in deserts and caves.

2 **a** Clastic sedimentary rocks are classified based on grain size and shape.

b Examples of biogenic sedimentary rocks include coal, limestone, chert and flint.

c Halite, desert roses and gypsum are chemical sedimentary rocks.

3 Breccia – made up of large sharp-edged clasts cemented together between grains that are often microscopic.

Conglomerate – similar to breccia, but the larger clasts are rounded in shape.

4 Clastic sedimentary rocks are made up of weathered particles (clasts) of different sizes and shapes that have been deposited in layers, and have then undergone compaction and cementation. Examples include sandstone, shale and breccia. Chemical sedimentary rocks formed when dissolved materials precipitated from solution. Examples include gypsum, halite, limestone and desert rose.

5 Limestone is classified as a chemical sedimentary rock when water with dissolved calcium carbonate evaporates, leaving behind a precipitate of limestone (such as when stalactites form). Limestone is more often classified as a biogenic sedimentary rock as it formed in seas and oceans from the remains of living organisms (such as shells and corals).

6 Answers may include:

- *Paradoxides* must have been found across a wide geographic area such as on multiple continents.
- *Paradoxides* must have lived within a short period of time around 500 million years ago.
- *Paradoxides* must have existed in large populations.
- *Paradoxides* must have lived in a marine environment with good conditions for fossil preservation (e.g. rapid sediment deposition).

5.5 Resources in sedimentary rock

Plan

1 Support your search by considering the following advancements: improved seismic imaging, high-resolution electromagnetic imaging, low frequency electromagnetic techniques, and machine learning and artificial intelligence.

2 Support your search by considering hydrocarbons, minerals, groundwater, geothermal energy and rare earth elements.

Design

Student notes may include:

1 Tools to create animations include FlipaClip, Blender, Animatron or Stop Motion Studio.

2 An animation can be engaging and informative if it has the following elements.

- Clear and simple visuals: The visuals in the animation should be clear, simple and easy to understand. The use of colourful and visually appealing graphics can help keep the audience engaged and interested.

 ISBN 978 0 6557 1969 4

- Relevant information: The information presented in the animation should be relevant and accurate. The information should be presented in a clear and concise manner and should be easy for the audience to understand.
- Audio: The use of appropriate audio, such as music or sound effects, can help make the animation more engaging and memorable. The audio should complement the visuals and information being presented and should not distract from the content.
- Interactivity: Adding interactive elements to the animation, such as quizzes or interactive graphics, can help engage the audience and make the information more memorable.
- Consistency: The animation should have a consistent visual style, tone and message. This will help keep the audience focused and engaged and will reinforce the key points.
- Timing: The timing of the animation should be appropriate for the information being presented. The animation should be paced well and should not move too quickly or too slowly.
- Compelling storyline: The animation should have a compelling storyline that flows logically and is easy to follow. The story should be engaging and relevant to the audience, and it should keep the audience interested and focused on the information being presented.

  Incorporating these elements in an animation can be both engaging and informative, helping the audience to understand and retain the information being presented.

3 An animation explaining how imaging techniques can be used to identify different resources beneath sedimentary rock might include the following information.

- Introduction to deep Earth imaging: Start by introducing the concept of deep Earth imaging and why it is important for resource exploration and development. Explain that deep Earth imaging involves the use of various techniques to create images of the subsurface and to gather information about the subsurface structure and composition.
- Seismology: Highlight the use of seismic waves to create images of the subsurface and how the differences in the speed of seismic waves can be used to identify the presence of subsurface reservoirs. Use animation to show how seismic waves are generated and how they travel through the subsurface, highlighting the differences in wave speed that can be used to identify subsurface resources.
- Electromagnetic (EM) methods: Explain how EM methods can be used to detect and map subsurface resources, such as minerals and hydrocarbons. Use animation to show how Earth's natural or induced EM fields can be measured and how this information can be used to identify subsurface resources.
- Application of imaging techniques: Use animation to show how deep Earth imaging techniques are applied in real-world resource exploration and development. Highlight the steps involved in using imaging techniques to identify and map subsurface resources, including the collection and interpretation of data.
- Benefits of imaging techniques: Emphasise the benefits of using imaging techniques for resource exploration and development, including increased accuracy, improved resource identification and evaluation, and reduced exploration risk.

  Throughout the animation, use clear, simple visuals and explanations to help the audience understand the concepts and techniques being discussed. Additionally, consider incorporating real-world examples and case studies to make the information more relatable and relevant.

4 Headings to consider include introduction, seismology, electromagnetic methods, application of imaging techniques and benefits of imaging techniques.

Improve

1 Answers may include considerations about receiving positive feedback received from the teacher and peers about the presentation and information within their animation.

2 Answers may include considerations about whether the animation conveyed key messages about recent advancements in deep Earth imaging techniques.

3 Answers may include considerations about whether there was any key information missing.

 ISBN 978 0 6557 1969 4

4 Answers may include considerations about reviewing the headings to see if they conveyed all information clearly, inclusion of more graphics or use of more up-to-date information and examples.

Evaluate

1 Answers may include statements such as: in this inquiry, we were investigating the various resources that can be found in sedimentary rock using deep Earth imaging techniques.

2 Answers may include statements such as: the skills that I used in this inquiry included research, analysis, creativity and communication.

5.6 Igneous rocks

Check your understanding

SC1: I can describe how and where igneous rocks are formed

Intrusive igneous rocks form below the ground from cooling magma. Extrusive igneous rocks, in comparison, form above the surface from cooling lava.

SC2: I can describe observable features of igneous rocks

a This porphyritic rock started to cool beneath the ground, but then it erupted to the surface where it cooled rapidly.

b The rock will contain crystals of different sizes: larger crystals formed slowly underground, while smaller or microscopic crystals formed rapidly after the eruption above ground.

SC3: I can explain the role of heat energy in the formation of igneous rocks and compare how quickly or slowly processes can occur

Heat energy in lava is rapidly absorbed by the surrounding environment and so the lava cools very quickly.

Lesson review

1 Intrusive igneous rocks form from magma that cools slowly beneath Earth's surface, resulting in large crystals. In contrast, extrusive igneous rocks form from lava that cools quickly on the surface, resulting in small or no crystals.

2 A rock with large, visible crystals is likely an intrusive igneous rock, formed by the slow cooling of magma beneath Earth's surface, allowing large crystals to develop.

3 **a** Observable features of igneous rocks include crystal size, texture and mineral composition.

b Slow cooling allows large crystals to form, resulting in a coarse-grained texture, while rapid cooling results in small crystals and a fine-grained texture.

c Intrusive igneous rocks have coarse-grained textures with large crystals, while extrusive igneous rocks have fine-grained textures with small or no crystals.

d Colour is important for identifying igneous rocks as it provides information about the rock's mineral composition.

e As the rock contains crystals of varying sizes, it is likely to be a porphyritic igneous rock.

4 Heat energy (from primordial heat in the core and radioactive decay) melts rock to form magma, which then cools and solidifies to form igneous rocks. The rate of loss of heat energy (cooling rate) determines the texture and crystal size of the igneous rock.

5 **a** This bubbly-textured rock specimen is most likely to be an extrusive igneous rock.

b The molten material from which it formed is most likely to be lava as the small grains indicate that it cooled rapidly on the surface.

c Heat energy would have been lost rapidly to the surrounding environment.

d The likely cause of the bubbly texture is bubbles of gas trapped as the lava cooled rapidly.

e The igneous rock is likely to be either pumice or scoria.

 ISBN 978 0 6557 1969 4

5.7 Metamorphic rocks

Check your understanding

SC1: I can describe how and where metamorphic rocks are formed

The three types of metamorphism are:

- regional – heat and pressure
- contact – mainly heat
- dynamic – mainly pressure.

SC2: I can describe examples of specific metamorphic rocks and their parent rock

a The parent rock of gneiss is shale (also known as mudstone).

b The stages of metamorphism to form gneiss are: shale → slate → schist → gneiss.

c Gneiss is a foliated metamorphic rock.

SC3: I can explain the role of heat energy and force in the formation of metamorphic rocks and compare how quickly or slowly processes can occur

Strong shear forces apply high levels of pressure to the rock. This high pressure will result in the formation of foliated metamorphic rocks.

Lesson review

1 Metamorphic rocks typically form deep within Earth's crust where high temperatures and pressures cause existing rocks to change physically and chemically.

2 Contact metamorphism occurs near igneous intrusions where rocks are heated by nearby magma, affecting a small area. Regional metamorphism occurs over large areas due to tectonic forces that generate high pressures and temperatures, often associated with mountain building.

3 A rock subjected to high pressure but relatively low temperature might be a foliated metamorphic rock such as slate.

4 Quartzite forms from the parent rock sandstone under conditions of high temperature and lower pressure, resulting in a non-foliated rock type. Schist forms from the parent rock shale or mudstone through high levels of pressure and temperature, resulting in a foliated rock type with visible crystals.

5 **a** Heat energy causes the recrystallisation of minerals, changing both the mineral composition and texture of the rock.

b Pressure causes minerals to align, creating a foliated texture with parallel layers, bands or cleaves.

c Non-foliated rocks form mainly from recrystallisation due to heat, while foliated rocks form under both heat and pressure, leading to mineral alignment.

d Foliation and small grain-size indicate that this rock was formed (mostly) under pressure. Therefore, this rock is most likely to have undergone dynamic metamorphism.

6 Slate is suitable for construction and decorative purposes because it is a hard foliated rock, has a fine grain, and has very strong cleavage lines that allow it to be split into thin, flat, yet durable sections.

 ISBN 978 0 6557 1969 4

5.8 The source of metamorphic rocks

Try yourself

Classifying rocks

Thinking	Working
Does the rock have crystals?	No, go to 6.
Is the rock non-crystalline and is it made of clasts (pieces or chunks)?	Yes, *Sedimentary, clastic* – go to 7.
Does the rock have large clasts?	Yes, go to 8.
Are the large clasts rounded?	Yes, the clasts are rounded. The rock is *Sedimentary, clastic*, e.g. conglomerate

Results

Task 1

Sample results:

Rock number	Description	Classification	Rock name
1	light colour interlocking crystals	igneous intrusive felsic	diorite

Task 2

Results should show the parent/metamorphic rocks correctly matched with relevant descriptions and the metamorphic rocks correctly identified with correct reasoning.

Sample results:

	Parent rock	Description	Metamorphic rock	Description
Pair 1	limestone	light colour no interlocking grains sedimentary rock	marble	light colour interlocking grains crystalline
Pair 2	shale	dark colour no interlocking grains soft sedimentary rock	slate	dark colour foliated hard feels smooth can't see crystals
Pair 3	shale	dark colour no interlocking grains soft sedimentary rock	schist	dark colour foliated can see crystals without a magnifier
Pair 4	granite	light colour interlocking crystals igneous rock	gneiss	light colour foliated hard can see crystals without a magnifier

 ISBN 978 0 6557 1969 4

	Parent rock	Description	Metamorphic rock	Description
Pair 5	sandstone	light colour gritty texture – very fine grains, can't see with the magnifier soft sedimentary rock	quartzite	light colour can see crystals without a magnifier feels gritty

Note: It is also possible that students may have determined that shale is the parent rock for gneiss, depending on the colour of the gneiss sample.

Rock name	Reasons you have decided it is metamorphic	What changes occurred to make it metamorphic?
Marble	crystals had formed compared to its parent rock	large amounts of heat will have been applied to produce the crystals
Slate	appears to have some foliation and has cleaves	pressure applied to create the banding
Schist	appears to have some foliation and has crystals	large amounts of heat and pressure
Gneiss	appears to have some foliation and has crystals	large amounts of heat and pressure
Quartzite	crystals have formed	large amounts of heat

Conclusion

Conclusions should discuss how the dichotomous key was used and the process for determining parent/metamorphic rock relationship.

Sample answers:

Task 1

I was able to classify the rock samples by analysing the colour and texture of each of the rocks and using a dichotomous key to determine what type of rock it is. I recorded relevant observations to use the dichotomous key, such as whether the rock had interlocking crystals, if it had clasts or not and the size and shape of the visible grains. I combined my observations with research on the internet to determine the names of some of the rocks by comparing the sample with online images.

Task 2

For each pair, I was able to determine the parent/metamorphic rock relationship by identifying key features of each rock. My observations included looking for crystallisation and any obvious foliation in either of the rocks which would suggest that the rock had undergone a period of high temperature and/or heat, which would result in a metamorphic rock. I paired this with identifying features in the parent rock which may make it sedimentary or igneous; for example, the fine grains in limestone.

Evaluation

Answers may include:

- modification to the dichotomous key
- visual sorting of rocks by their own classification criteria.

 ISBN 978 0 6557 1969 4

5.9 The rock cycle in action

Check your understanding

SC1: I can compare the formation of different types of rock within the rock cycle

a igneous → sedimentary: weathering, erosion, deposition, compaction and cementation

b sedimentary → igneous: melting to form magma then crystallisation/cooling

c metamorphic → igneous: melting to form magma then crystallisation/cooling

d sedimentary → metamorphic: heat and/or pressure

e metamorphic → metamorphic: heat and/or pressure

f metamorphic → sedimentary: weathering, erosion, deposition, compaction and cementation

SC2: I can predict how environmental changes will affect a rock's structure based on the rock cycle

Answers may include any two of:

- increased rates of wind erosion
- increased deposition of wind-blown sediments
- less rainfall may reduce rates of physical and chemical weathering
- less sediment will be moved by rivers
- less erosion will occur in waterways as their flow rate falls
- less vegetation on the surface will allow more weathered material to erode.

SC3: I can predict and explain locations where specific types of rocks are found

The most abundant rock types in Australia are igneous and sedimentary.

Lesson review

1 The five stages involved in the formation of sedimentary rock are weathering, erosion, deposition, compaction and cementation.

2 Heat can melt existing rock to form magma and lava. When these cool and become solid, igneous rocks are formed. When rocks are subjected to heat but do not melt, changes to the rock such as the formation of new crystals occur, producing metamorphic rocks.

3 In a tropical climate with intense rainfall, igneous rocks undergo more intense physical, chemical and biological weathering due to the high availability of water. High rainfall also results in significant erosion by water. In a desert climate, physical weathering from temperature fluctuations and wind erosion are likely to dominate. Wind becomes the primary agent of both weathering and erosion.

4 1: magma; 2: igneous rocks; 3: sediments; 4: sedimentary rocks; 5: metamorphic rocks

5 **a** In a volcanic region, you would expect to find igneous rocks like basalt and pumice.

b These rocks form from the cooling and solidification (or crystallisation) of magma or lava.

c In a river delta, you would find sedimentary rocks like sandstone and shale, formed from the accumulation and compaction of sediments carried by the river.

d Uplift can bring all three types of rocks – igneous, sedimentary and metamorphic rocks – to the surface, where they are subjected to weathering and erosion, eventually forming new sediments and sedimentary rocks. Pressure created by the uplift can cause rocks to metamorphose. Uplift may bring molten magma closer to the surface which may trigger volcanic eruptions and the formation of new igneous rock.

6 Australia is considered an old landscape because there is little to no formation of new igneous or metamorphic rocks. Weathering, erosion and deposition are the major geological processes occurring in Australia. Rocks are broken down and transported by rivers to the ocean, where they contribute to beach formation. This abundance of sand is why Australian beaches are often regarded as some of the best in the world.

 ISBN 978 0 6557 1969 4

5.10 Mineral resources in Australia

Design

Sample research design plans:

Investigation Area 1 – Research question	**Sources of information**
Why do First Nation Australians quarry for rocks and minerals?	Internet, textbooks, other reference books
Which First Nations group/s are we researching?	Internet
How do they quarry for rock and minerals?	Internet
What do they do with the rocks and minerals obtained?	Internet
What are some other examples of mining by First Nations Australians?	Internet
How do they leave the site when they are finished?	Internet

Investigation Area 2 – Research question	**Sources of information**
When did the new settlers begin mining in Australia?	Internet, textbooks, other reference books
What minerals were being mined?	Internet, textbooks, other reference books
Who carried out the mining and where did they come from?	Internet, textbooks, other reference books
How did the mining impact Australian society?	Internet, textbooks, other reference books
What examples are there of the impact of mining on Australian society?	Internet, textbooks, other reference books

Investigation Area 3 – Research question	**Sources of information**
How is mining carried out now compared to 20th and 19th century mining operations?	Internet, textbooks, other reference books
Why have mining operations changed?	Internet, textbooks, other reference books
How has Australian society influenced mining practices?	Internet, textbooks, other reference books
What examples are there of Australian society influencing mining practices?	Internet, textbooks, other reference books

 ISBN 978 0 6557 1969 4

Conduct

Sample answers:

1 Why do First Nation Australians quarry for rocks and minerals?

2

Research notes	Source information
Traditionally, First Nations people used stone implements (tools) to gather and process their food, while ochre was, and still is, used in art and ceremonial practices.	*Mining by Aborigines – Australia's first miners, Prime Facts, Feb 2007,* <https://www.mininghistory.asn.au/wp-content/uploads/mining-by-aborigines.pdf>
Stone was quarried from rocky outcrops to make chipped or ground stone tools for many different purposes.	<https://www.firstpeoplesrelations.vic.gov.au/fact-sheet-aboriginal-quarries>
Ochre was also mined for painting and decorating bodies, artefacts, rock paintings and for use in ceremonies.	<https://austhrutime.com/ochre_mining.htm>
One of numerous examples of traditional mining practices are the Tasmanian First Nations people who quarried particular stone outcrops and collected stones from riverbeds and coastal zones to create a sophisticated set of tools.	< https://www.aboriginalheritage.tas.gov.au/cultural-heritage/aboriginal-stone-artefacts>

3 Traditionally, First Nations Australians quarried for rocks to make tools. They also mined ochre to use the coloured mineral for painting and decorating their bodies, artefacts, rock paintings and for important ceremonies.

Research for the other two topics could identify:

- How the discovery of gold in Australia brought immigrants from all over the world to mine, as well as building communities to support the miners. Examples include the Victorian and Western Australian gold rushes and mining for other resources such as opal and copper.
- More recent attitudes towards mining which consider the environment and the protection of First Nations Culture. Towns are no longer created by the discovery of minerals and instead workers FIFO (Fly In and Fly Out), which has an impact on families and communities. The destruction of Juukan Gorge in Western Australia by Rio Tinto and the Queensland government's recent decision to block plans for Australia's largest thermal coal mine, are examples of society prioritising environmental and cultural concerns over the economic benefits of mining. At the same time, some First Nations Peoples such as the Gumatj Corporation have taken a proactive role by establishing their own mining companies and mining operations.

Improve

1-3 Answers should focus on areas such as how well the group collaborated, whether the research question was addressed sufficiently, the suitability of the chosen presentation method and whether appropriate references were included.

Evaluate

1-3 Answers may include: deeper understanding of the different perspectives around mining; an understanding of how culture influences scientific knowledge; an appreciation for the complexity of policy issues; and an increased respect for First Nations perspectives on land use.

 ISBN 978 0 6557 1969 4

Topic review

Remember

1 **a** A: crust; B: mantle; C: outer core; D: inner core

b The outer core is liquid.

c Scientists know about the composition of Earth's internal layers because of the behaviour of earthquake waves. P-waves travel at different speeds through solids and liquids. S-waves are only able to travel through solids.

2 Erosion involves the movement of weathered rock particles by agents of erosion (i.e. wind, water, gravity or ice). Deposition is the settling of weathered and eroded rock material to form sediment.

3 Common features of sedimentary rocks include layers (strata), fossils and grain size variation.

4 Answers may include:

- Mount William Stone Hatchet Quarry by the Wurundjeri people
- Wajarri people's mining of ochre at Wilgie Mia in Western Australia
- Mount Difficult Grampians Quarry (Victoria) associated with the Djab Wurrung and Jardwadjali people
- Lake Mungo (New South Wales) with its area of significance for stone tool manufacturing to several First Nations groups, including the Ngiyampaa, Mutthi Mutthi and Paakantyi people
- Brewarrina quarry along the Barwon River which is culturally significant to the Ngemba people
- Gumatj Corporation who own and operate their own bauxite mine in the NT
- The Arrernte people's ongoing use of the ochre pits in Tjoritja/West MacDonnell ranges

Understand

5 The lithosphere is a rigid layer made up of the crust and the very top layer of the mantle. The lithosphere is broken up into segments called tectonic plates. The asthenosphere is a layer in the mantle just below the lithosphere. It is also solid, but the rock can move very slowly.

6 **a** A dichotomous key is a tool used for identification, offering two choices at each step to help classify organisms or objects such as rocks.

b An intrusive igneous rock has crystals that are visible to the naked eye. A clastic sedimentary rock has clasts (particles) of various sizes, such as sand or mud, cemented together.

7 Acid rain is a type of chemical weathering agent. It reacts with the minerals in granite, particularly on the rock's surface, weakening it and causing it to break down into smaller pieces over time.

8 Regional metamorphism is large-scale metamorphism where rocks are altered by high heat and high pressure conditions. Dynamic metamorphism is smaller scale metamorphism where rocks are altered mainly due to high levels of pressure. Contact metamorphism also occurs at a smaller scale where rocks are altered mainly by heat.

Apply

9 **a** Answers may include: beaches, sand dunes, spits, rocky headlands, rocks, cliffs, sea stacks, sea arches, caves or wave cut platforms.

b Environmental factors in a coastal area that contribute to weathering include wind abrasion, wave action, rainfall, salt crystallisation, algal growth and extremes of temperature.

c Weathering breaks down coastal rocks into smaller particles. Erosion transports the particles by wind, waves, currents and tidal action, leading to the formation of erosional and depositional landforms such as beaches, spits, sand dunes and sea stacks.

 ISBN 978 0 6557 1969 4

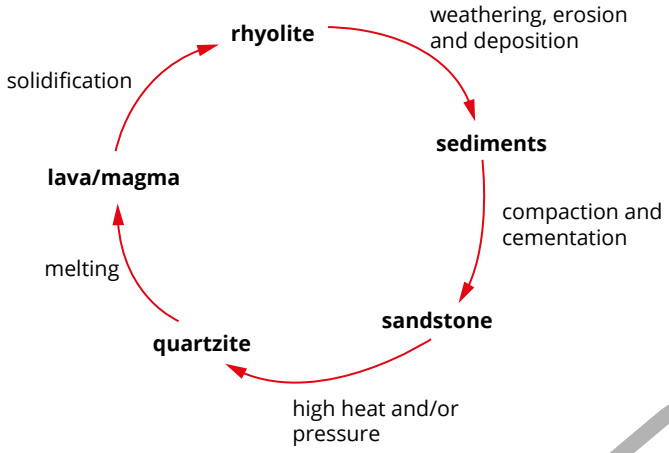
10 a Pumice is an extrusive igneous rock as it formed from lava that reached Earth's surface.

b Molten rock in the form of lava reached the surface at an undersea volcano. The lava cooled and solidified rapidly as it entered the ocean water, trapping bubbles of gas as it did so. These bubbles made the rock very light, so it was able to float on the surface.

c The pumice was broken down into smaller pieces by the physical weathering effects of waves, wind and salt crystallisation as it travelled across the ocean. The organisms living on the pumice could also have caused biological weathering.

d The pumice that washed up on Australia's beaches is sediment deposited by waves.

11 Sample diagram:



Analyse

12 a The presence of the fossilised trilobite suggests that the sedimentary rock formed in a marine environment, such as a shallow sea or ocean floor.

b The species of trilobite would have died and was rapidly buried in sediments that formed sedimentary rock. At some stage uplift brought the sedimentary layers to Earth's surface. Weathering and erosion have exposed the fossils in the desert of Algeria.

c To be useful as an index fossil, an organism had to live for a relatively short period of time, live across a wide area, and be very abundant (large populations) to increase its chances of fossilisation. As this is a newly discovered species, it seems to be rare and, therefore, is very unlikely to meet the criteria. Therefore, this species is not useful as an index fossil.

13 The igneous rock has quite large crystals, which indicates that it is an intrusive igneous rock. This means it cooled very slowly from magma beneath Earth's surface, allowing the growth of large crystal to form.

14 a 1: shale/mudstone; 2: schist; 3: marble; 4: quartzite

b A: shale/mudstone; B: limestone; C: sandstone

c Rock 1 (shale/mudstone) is a soft sedimentary rock with fine grains. Gneiss is a metamorphic rock that has undergone extreme heat and pressure conditions. It will be very hard, has foliations, and the crystals have formed into bands which are visible.

Extension: Research task

15 Sample answer:

Diamonds are composed entirely of carbon. Four processes are believed to be responsible for the formation of natural diamonds that have been found at or near Earth's surface. The first, and most commonly occurring process is believed to occur in the mantle where there are the very high temperatures and pressures that diamonds require to form. Diamonds are stored in this part of the mantle until they are brought to the surface by rare volcanic eruptions known as kimberlites. These eruptions carry up unmelted chunks of rock—called xenoliths—that contain the diamonds. These xenoliths are what miners extract during diamond mining.

 ISBN 978 0 6557 1969 4

Other theories include diamonds forming at high temperature and high-pressure sites such as in subduction zones, at asteroid impact sites, or brought to Earth by meteorites.

Rocks containing diamonds can be dated. The majority are believed to have formed more than 542 million years ago. In contrast, the earliest land plants appeared on Earth for the first time about 450 million years ago, and the plants from which sedimentary coal formed didn't exist until nearly 100 million years after diamonds were created in the mantle. Additionally, coal forms in the crust, where the temperature and pressure are too low for diamonds to form. Therefore, diamonds are very unlikely to have formed from coal.

 ISBN 978 0 6557 1969 4