Lesson 1-2

Topic: Classifying rocks and minerals

Discovering sedimentary rocks

Lesson concepts

- Sedimentary rocks contain minerals and are formed by processes that occur within the Earth over a variety of time scales
- A range of investigation types including field work and experiments, can be collaboratively conducted ensuring safety guidelines are followed
- A range of representations can be constructed and can be used to represent and analyse patterns or relationships
- Data from investigations can be summarised and scientific understanding can be used to identify relationships and conclusions
- Ideas, findings can be communicated using scientific language and representations

Learning alerts

Be aware of students thinking that weathering and erosion are the same process.

Suggested next steps for learning

Explain to students that weathering is the breaking down of rock into fragments, and erosion is the process of transporting those fragments away by wind, water, ice and gravity.

Science prior knowledge notes

Students learn about the features and identification of sedimentary rocks.

Students begin by revising their understanding of the processes of weathering and erosion. It is important to note the difference between the two, as they are often mistakenly thought to be the same process.

Lesson notes

Students are provided with information regarding the stages involved in the formation of a sedimentary rock. Sedimentary clasts are categorised according to size. Generally they are (from course to fine-grained): cobbles, gravel, pebbles, sand, silt, clay. ('Mud' includes silt and clay.)

The sediment jar models the stage of sedimentation (sediment deposition) in a still body of water.

The images in Step 2 of the lesson provide examples of sediment jars. If students have their own jar to compare, theirs will look more like the image on the left, showing one depositional event where sediment layers form in order of dense, coarse-grained sediment to less dense, fine-grained sediment. The image on the right represents a number of different depositional events separated in time. Each new event begins with layers of coarse-grained sediments and ends with layers of fine-grained sediments.

The suggested **Learning object —** Observe how sediments are deposited provides students with an animation of sedimentation in a moving body of water, and shows the horizontal deposition of sediments as the water slows down and the ability of the body of water to hold the sediment reduces.

The images in the lesson and the **Slideshow 1 —** Common sedimentary rocks provide a common resource for describing and identifying different types of sedimentary rocks. If you have purchased samples of sedimentary rocks, students should observe these as part of this lesson.

The suggested websites are provided as additional resources that may be used in conjunction with **Sheet 1** to complete the information in Table 2.

Slideshow 2 — Interpreting sedimentary layers provides a resource for learning how sedimentary rock layers provide scientists with information about the geological history of a landscape. Explanatory notes are provided in the notes section of slides 9 and 10, so students should view the slideshow in the format that enables them to access these notes.

The geological principles outlined in the slideshow are used in the interpretation of geologic cross-section diagrams.

Practical information

Students have the option of making a sediment jar. This could be done before the lessons, so that it is available for observation during Lesson 1. To make the sediment jar, students require a large glass jar and small amounts of different-sized sediment grains, such as pebbles, gravel, sand and clay. The instructions for making a sediment jar are included in Lessons 1-2.

Prior learning answers

1. a) some wearing away of the original rocks. Some of the granite resists weathering more than the other landscape rocks. This is evident because of the shapes weathering produced compared to the surrounding rocks.

   b) The original granite dome has been weathered by various agents (water, acids, plant growth), and eroded by wind, gravity and water. Because this is a rugged coastal area, much of the sediment has probably been washed down by the ocean and deposited on the ocean floor.

Lesson 1-2 answers

2. No answer required.
3. a) The coarse-grained sediment clasts would be deposited first, such as cobbles and gravel. Why – Due to their mass.
   b) The fine-grained sediment clasts would be deposited last, such as silt and clay. These sediments are commonly referred to as 'mud'. Held in suspension longer due to less mass.
   c) i. Rivers cobbles, gravel, large pebbles, coarse-grained sand
   ii. Lakes coarse to fine-grained sand, silt, clay, fine-grained plant fragments
   iii. Shallow seas fine-grained sand, silt, clay, shells and shell/coral fragments, fine to coarse rock salt crystals
   iv. Deep oceans fine-grained sand, silt, clay, shells and shell fragments

4-6. no answer required

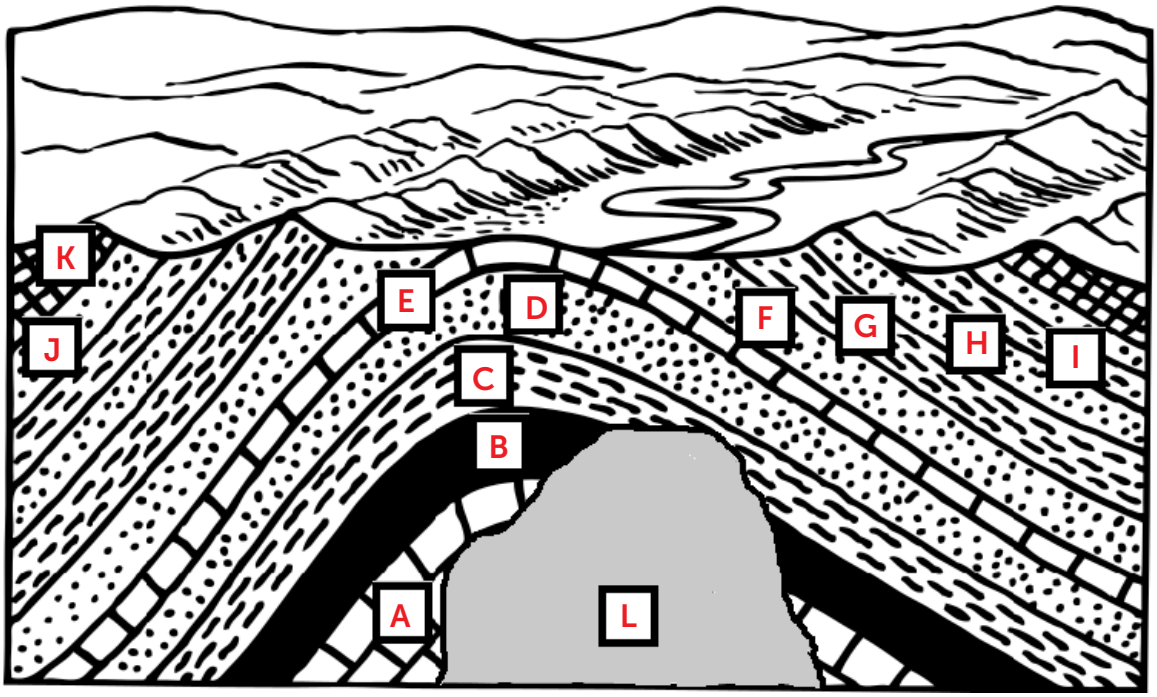
Table 2: Common sedimentary rocks

Sedimentary rock specimen	Observable features	Sedimentary rock name	Features used in key	Places rock might form
1	sample has a rough surface composed of only sand-sized sediment grains	sandstone	formed of sediment grains (1a) grains not coarse (2b) grains sand-sized, sorted (4a)	lakes or shallow seas
2	composed of very fine sediment grains very thin layers present	shale	formed of sediment grains (1a) grains not coarse (2b) grains not sand-sized (4b) sediments i fine layers (5a)	lakes, swamps, shallow seas, deep oceans
3	no sediment grains light coloured adding acid produces bubbles of gas	limestones chemical or biological sedimentary rock	not formed of sediment grains (1b)	shallow seas, deep oceans, caves, springs
4	sediment grains range in size from clay to pebbles composed of mainly large, sharp-edged grains	breccia	formed of sediment grains (1a) grains coarse (2a) grains mostly not rounded (3b)	rock falls along cliffs, colapsed caves, rivers, lakes close to source of rock fragments
5	sediment grains range in size from clay to pebbles composed of mainly large, rounded grains	conglomerate	formed of sediment grains (1a) grains course (2a) grains mostly rounded (3a)	rivers, lakes — rocks transported by water

8,9. no answer required

10. a) All correct except last box - Animal and plant fossils occur in specific vertical order as per fossil record.

b)



c) Layers of sediment that were deposited in horizontal layers have been compressed horizontally, causing them to fold and be pushed up into a mountain. Weathering and erosion by water and wind have worn down through the mountain, forming valleys and smaller mountain ranges, and separating similar rock layers on either side of the river. An igneous intrusion has moved into the sedimentary rock layers beneath the river.

d) The force of the water flowing in the river might further weather and erode the sedimentary layers below the river, deepening the valley and dividing the remaining layers. This process might continue until the igneous intrusion is exposed. As the intrusion will be composed of rock more resistant to weathering, the intrusion will be taller than the surrounding valley.

Reflection

11. Complete the following flow diagram to list and explain the steps in the formation of a sedimentary rock:

Weathering

Pre-existing rocks are broken into smaller fragments or clasts through the action of water, wind, ice, animals, plants and dissolved chemicals.

Erosion

Sediment clasts are transported different distances away from the source through the action of gravity, wind, water and ice.

Sedimentation (sediment deposition)

As the transport medium slows down, its ability to carry the sediment clasts is reduced,. Coarse-grained clasts settle out early, whereas fine-grained clasts can be carried many hundreds of kilometres.

Compaction

As more and more layers are deposited, the underlying layers heat up and the downward pressure of the overlaying layers squeezes the particles together.

Cementation

Dissolved minerals in the spaces between particles crystallise and grow around the particles, bonding them together.

Extension

12. Represent the steps of formation for a sedimentary rock in the form of a recipe

    OR

    Rewrite a recipe for rocky road in the form of the steps in Q11. What type of sedimentary rock would your rocky road be? What makes you say that? What are the similarities and what are the differences in the rocky road and the identified rock?

    Various answers possible – the point is to get the student thinking of the properties of a rock that make it a rock and the steps in the process of rock formation.

Lesson 3

Topic: Classifying rocks and minerals

Discovering metamorphic rocks

Lesson concepts

- Metamorphic rocks contain minerals and are formed by processes that occur within the Earth over a variety of time scales
- Energy causes change within systems
- Investigation types, including experiments, can be collaboratively conducted ensuring safety guidelines are followed
- A range of representations can be used to represent and analyse patterns or relationships
- Ideas and findings can be communicated using scientific language and representations

Learning alerts

Be aware of:

- students thinking that energy and force are the same thing
- students thinking that pressure and force are the same thing.

Suggested next steps for learning

- Explain to students that energy is needed for a force to be applied.
- Explain to students that a force is a push or pull that changes the motion of an object, and pressure is force spread over a defined area of the object.

Science prior knowledge notes

Students review some of the terminology associated with rock-forming processes covered in previous lessons.

Lesson notes

In this lesson students investigate the processes that lead to the formation of the third family of rocks, metamorphic rocks. They have the opportunity to model the role of heat energy transfer in metamorphic processes. The investigation uses chocolate, which, like rocks, is composed of a number of different crystalline substances, each with its own unique properties. Heating a chocolate while still in its wrapper can produce changes in its chemistry that are observable in its texture, taste, colour and 'snap'.

Students will learn about the two different types of metamorphism in rocks. **Slideshow 3 —** Metamorphism provides a resource for learning how extreme pressure and/or heat lead to the formation of metamorphic rocks. Explanatory notes are provided in the notes section of slide 4, so students should view the slideshow in the format that enables them to access these notes.

Slideshow 4 — Metamorphic match-up provides a common resource for describing and identifying different types of metamorphic rocks, and matching them to their igneous or sedimentary parent rocks. Students should use the slideshow images to complete Table 2 in the lesson.

Practical information

Students need access to two samples of the same individually wrapped chocolate, such as chocolate frogs or similar. One of the samples is heated in hot tap water. Make sure the water is hot and an insulated cup is used to ensure the water remains hot until the chocolate becomes soft.

Personal protective equipment should be worn and adult supervision is required. Students should conduct their own risk assessment, particularly regarding the handling of hot liquids, before starting the investigation. Students are permitted to taste the chocolate as part of this investigation, but they should be reminded that this is a special case and that this component of the investigation should be conducted away from the science work area.

Prior learning answers

Description	Term
type of igneous rocks formed when lava cools quickly and solidifies on the surface	extrusive igneous rock, for example, basalt
type of igneous rocks formed when magma cools slowly and solidifies deep in Earth's crust	intrusive igneous rock, for example, granite
process by which minerals solidify during the formation of a rock	crystallisation
process by which rock fragments are transported away from the source by wind, water, ice or gravity	erosion
process by which sediment grains are 'glued' together	cementation
sediments are deposited in layers called ...	strata

Lesson 3 answers

2. a) both rocks formed of crystals, not grains; no foliation (layering)
   b) marble composed of single coloured mineral, fine-grained crystals, whereas quartzite composed of different coloured minerals, coarse-grained crystals
3. a)

Table 1: Comparison of metamorphic processes

Contact metamorphism	Regional metamorphism
involves high temperature	involves high temperature ad intense directed pressure
occurs in margin of rock in direct contact with hot magma	occurs over vast areas of crust
rock chemically similar to parent rock	rock mineralogy may be different to parent rock
non-foliated, crystalline granular	foliated; crystals may be larger than parent rock
occurs relatively quickly	occurs over millions of years

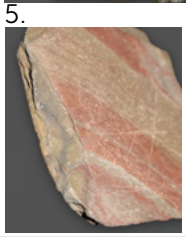
   b) i. Regional metamorphism
   ii. Folding of crust has placed extreme horizontal pressure on the sedimentary layers and also heated the rocks, causing them to metamorphose.
   iii. Contact metamorphism
   iv. Contact with high heat from magma has metamorphosed the area of rock directly touching the hot magma.
4. **Sheet 3 — Chocolate rocks** (see page 11) — if you were able to complete the investigation.

5–6. No answer required.

7.

Table 2: Types of metamorphic rocks

Metamorphic rock specimen	Foliated (layered) appearance	Texture (crystal size) fine medium or coarse	Colour – mineral con-tent	Metamorphic rock name	Contact or regional	Parent rock name
1. 	Non-foliated	fine-grained	Greyish with many minerals	hornfels	contact	shale

Metamorphic rock specimen	Foliated (layered) appearance	Texture (crystal size) fine medium or coarse	Colour – mineral con-tent	Metamorphic rock name	Contact or regional	Parent rock name
2. 	foliated, banded appearance	Coarse grained	white/grey, black, pink-quartz or feldspars	gneiss	Regional	granite
3. 	non-foliated, crystalline	fine-grained	white — carbonate minerals	marble	Regional	limestone
4. 	non-foliated, crystalline	coarse-grained	pinkish white-quartz	quartzite	contact	sandstone
5. 	foliated	fine-grained	brown to red — clay minerals, micas and quartz	slate	Regional	shale
6. 	well-developed foliation	medium to coarse-grained	grey to orangey brown — sparkly due to high mica content	schist	regional	shale and slate

8. a) For example: I matched the marble with limestone, because they are both whitish and crystalline. They both react with acid, so have carbonated minerals.
   b) Personal response required.
9. a) Hornfels and quartzite would most likely form in the zone marked with 'xxxx', because it marks a confined zone that is in direct contact with hot magma from an igneous intrusion.
   b) compressional forces folding the rock layers

Sheet 3 Chocolate rocks - Answers

Background: Heat and pressure can change the mineral chemistry of rocks. It can also change the texture, or grain size. Like many rocks, chocolate is also a mixture of crystals with different melting points (from 17°C to 37°C). In this investigation you will test the effect of heat on chocolate 'rocks' by comparing heated, then cooled, chocolate squares with unheated chocolate squares (control).

Note: For safety and hygiene reasons, plain milk chocolate in wrappers, such as chocolate frogs, should be used. Taste tests should not be conducted in the science work area — conduct this component of the investigation in an alternative area. Melting the chocolate slowly will achieve better results.

Aim: To observe the effects of heat on chocolate colour and texture.

Materials and equipment

- Two pieces of wrapped chocolate (for example, chocolate frogs)
- Hot water from the tap (less than 50°C) in an insulated cup, (a 'keep' cup would be great)
- Paper towel
- Digital microscope, hand lens or magnifying glass
- Crystal size investigation

Risk assessment

Read through the method, identify risks and complete the risk assessment below. Outline ways you will minimise risk.

Personal safety (Tick which ones apply)

✓ Safety glasses
✓ Hair tied back
✓ Gloves
✓ Closed shoes
✓ Lab coat

Other

✓ Report all spills and breakages to an adult.
✓ Conduct taste tests in an alternative area to the science work area.

What are the risks?	How will you manage them?
Allergic reactions to nuts/chocolate	Wear PPE, including gloves. Do not taste chocolate.
Handling hot water	Handle carefully using oven mitts, and keep movement with hot liquid to a minimum.
Tasting chocolate	Conduct in an area away from science work area.

Fair testing:

Dependent variable (changed variable)	Independent variable (measured/observed variable)	Controlled variables
One chocolate is melted and then re-hardened.	Observable properties — texture, colour, 'snap' and taste	Type, brand and size of chocolate Chocolate individually wrapped Time before comparing samples Tests used for comparison

Results and observations

Chocolate	Physical appearance	Sound and feel	Taste and texture
Sample A Heated	For example: crumbly appearance	doesn't 'snap' as well snaps in a more ragged way	stronger flavour less smooth texture — doesn't have that 'melt in the mouth' feel
Sample B Unheated - control	smooth, glossy, uniform colour	snaps easily and evenly	creamy flavour and smooth texture

Discussion

1. Explain how you ensured that this test was 'fair'.

   Making sure that the two samples of chocolate were identical in all respects at the start of the experiment and that the same tests were used to compare the two samples.

2. How is the heated and re-hardened chocolate different from the control and similar to the control?

   The melted and re-hardened sample has a different colour, texture and taste to the other sample. The chemical composition of the two samples have not been altered, so they both still contain the same chemical compounds.

3. How is melting and re-hardening the chocolate similar to the formation of a metamorphic rock?

   During the formation of a metamorphic rock, extreme heat and pressure result in changes to crystal size and/or arrangement. In the case of the chocolate, the melting and re-hardening also affects the crystal size and texture of the chocolate.

4. What limitations are there in using this as a model for the formation of metamorphic rocks?

   Metamorphic rocks form without melting. There is no change of state from solid to liquid and back to solid again, like the change that happens in the chocolate.