Teacher Notes

Themes

- Mineral compositions of our planet (and beyond)
- Earth through the ages
- Signs of ancient life
- Study of geoscience

Key learning outcomes

- Earth was formed 4.5 billion years ago and has been slowly changing ever since
- Earth's history is preserved in the composition and appearance of rocks on its surface
- Life can leave traces of its forms and functions in the chemistry and shapes of rocks
- Geoscience is the study of Earth and all the systems that affect it, and can require knowledge of fields in areas such as chemistry, physics and even computing

Key curriculum areas

- **Science:** Science Understanding (Earth and space sciences, Chemical sciences, Physical sciences)
- **English:** Language; Literature
- **Mathematics:** Measurement; Space
- **Cross-curriculum Priority:** Aboriginal and Torres Strait Islander Histories and Cultures

Publication details

Rocks, Fossils and Formations: Discoveries Through Time

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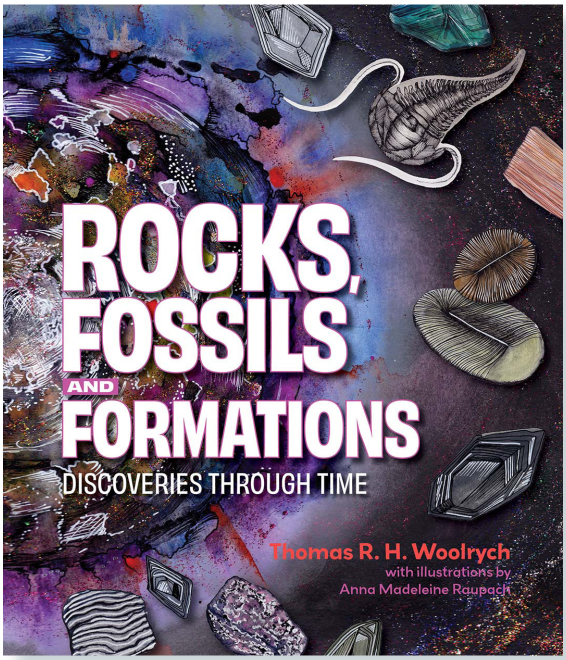

Rocks, Fossils and Formations

Discoveries Through Time

Thomas R. H. Woolrych and
Anna Madeleine Raupach

About the book

Have you ever wondered about those rocks under your feet? How old they might be? How they got their colour and texture? Could they contain some unknown mineral or fossil treasure?

Rocks, Fossils and Formations: Discoveries Through Time is an introduction to geoscience, which uses clues in rocks and the landscape to tell the story of the Earth. It's a story so old and so fascinating that it's almost hard to believe – except that the evidence can be seen all around us!

Come on a 4.6-billion-year-long time travel adventure to explore rocks, minerals and fossils, meet ancient plants and animals, and discover how the continent of Australia was created!

Recommended for

Readers aged 9 to 14 (Years 4 to 8)

PUBLISHING

Teacher Notes

About the author and illustrator

Thomas R. H. Woolrych is a science communicator and exploration geoscientist with a passion for discovering the secrets of the Earth. He enjoys sharing this passion and looking for minerals.

Anna Madeleine Raupach is a multidisciplinary artist based on Ngunnawal, Ngambri country, Canberra. Her practice spans drawing, moving image, installation and digital media to explore expressive interpretations of scientific concepts.

Pre-reading questions or activities

Take students out to visit a part of the school grounds or local community with large amounts of exposed rock. This can be a single formation, natural or artificially landscaped. Discuss with the students how the location came to look that way. What might it have looked like centuries ago? Invite students to imagine what the ground looks like a few metres beneath their feet, or perhaps hundreds of metres underground.

Encourage them to examine the material up close and compare rocks. Discuss whether the rocks might have been transported there by water, wind or even people. Are the large rocks made of smaller pieces? Are they smooth or rough? What colours can they see?

Summarise the excursion by discussing how all of the different features tell a story of the history of the location, one geologists know how to read.

Discussion questions

Science

1. Read the Introduction, with a focus on 'Uniformitarianism vs catastrophism' on page 10 of *Rocks, Fossils and Formations*. Discuss how geologists now understand Earth is 4.54 billion years old, and its surface has been shaped by a mix of sudden catastrophes and slow processes. What evidence helped convince geologists of these facts?
2. Discuss the different features of all of the objects in the Solar System, such as their masses, atmospheres, temperatures, or even how many moons they have. What makes them different? Using information in 'How to build a planet' on page 17, discuss how different planets might have come to have such unique features.

3. Reflect on the kinds of rocks students looked at in the pre-reading activity, and read about the rock cycle on pages 30 to 32. Ask the students to compare the different kinds of rocks with different types of food items. Which foods are built in layers? Which are baked hard and smooth? Which are crumbly? How are each made? Discuss how heat and pressure change not just the things we cook, but rocks as well.
4. Ask students to describe their impression of a fossil. Read ‘First life’ on page 38, including the text ‘What is a fossil?’, and reflect on the low likelihood of fossilisation occurring for any single organism. What might the challenges be in using fossils to understand the history of life on Earth?
5. Strange as it seems, technically speaking, Earth is in an ice age. Read the definition of ice ages on page 54 in the section ‘A global ice house’, and discuss how moving rivers of ice can leave their mark on the landscape. How might global warming leave its own signature on the surface of the planet in the future? Follow on to page 113, reading ‘Humans and the climate crisis’, to inspire further conversation on how we’re leaving our mark on Earth permanently.
6. Read ‘Cold-weather coal’ on pages 78 to 79, noting how the fossil fuels we’ve used for energy in the past 200 years were mostly created during the Carboniferous period. Discuss why there is no large scale natural generation of coal today.
7. Dinosaurs emerged as a new kind of animal around 230 million years ago. Read ‘Dinotopia’ on page 90, and discuss what small changes to reptiles sparked such big changes in animal diversity, eventually leading to the evolution of modern birds. Ask the students to imagine what small changes to a single type of animal today might lead to big evolutionary changes in the future.
8. Australia isn’t regarded as a destination for volcano hunters. But there are still plenty of signs of old, dead volcanos if you know where to look. Read pages 102 to 104, and discuss how Australia’s volcanoes appeared and disappeared over tens of millions of years. How might this extinct chain of volcanoes make Australia’s east coast so different to the continent’s west coast today?

Teacher Notes

English

1. The book's author, Thomas R. H. Woolrych, invites the reader on a 'time travel adventure'. If time travel isn't something people can actually do, why might the author include this feature in a book about science? Does it help the reader, or make it harder for them to learn about geology?
2. Each chapter of the book is set out in chronological order, meaning they are set out according to a sequence of events in time. What are some other ways an author might arrange similar information?

Mathematics

1. Units of time used in the book are counted in millions, or even billions of years. Why don't we see more precise measures, in years or even months and days? For example, why do we say Earth formed 4.54 billion years ago, and not something like 4 billion, 540 million, 236 thousand, 104 years and two days and four minutes?

Aboriginal and Torres Strait Islander Histories and Cultures

1. Read pages 65 to 66 and discuss how geologists think Uluṟu formed. The First Nations people local to the lands Uluṟu is on, the A<u>n</u>angu, pass on accounts with different meanings. What makes geological explanations of Uluṟu useful for us today? Why might other stories about Uluṟu's history be useful to people living on country?

Activities

Science

Conventions of convection

Safety: This activity involves open flames and flammable items. Perform the task in an open space with no other flammable items nearby. Ensure there is a space of at least 2 metres between observers and the demonstration.

Teacher Notes

You will need:

- Tea bags (the ones with tea in stapled paper tubes)
- Ceramic plate
- Matches or lighter
- Scissors
- Open area
- Fire safety equipment (e.g. fire blanket or bucket with water)

What to do:

1. Gently open the tea bag by removing the staple and string and unfolding the paper cylinder. Empty the tea into compost or save to make a cup of tea later.
2. Press the edges of the paper cylinder until it can hold a round tube shape. Place the cylinder on one end so it stands perpendicular to the ground. If it won't stand, try trimming one end of the cylinder with scissors to create a more even edge.
3. Take the class into an open area where the air is still, such as a covered area. Ensure no flammable items are nearby and there is fire safety equipment at hand. Seat the students 2 metres from the demonstration.
4. Place the end of the paper cylinder onto a ceramic plate so it remains upright.
5. Light the top edge of the paper cylinder. It will slowly burn towards its base.
6. Watch the last ring of embers rise from the plate into the air.

What's happening?
Standing upright, the paper cylinder is experiencing a number of forces in balance. Gravity pulls its mass down, while the plate and ground resist the force to hold it up. Air particles push into its sides from without and within. If more particles push – such as in a breeze – the cylinder will fall over.

Lighting the cylinder heats the surrounding air. The particles move faster and harder, spreading out as they bump into each other.

Once the flame reaches the very bottom, and the mass is much lighter, the heated air can push beneath and lift it up. Air that has spread out is less dense, allowing heavier (and denser) air to push beneath, launching the rocket into the air.

This movement of cold, dense air beneath hot 'spread out' air is called convection. With enough heat energy, even rocks far beneath our feet can rise when hot and descend once they've cooled, creating circling currents of molten mineral.

Fossil features

You will need:

- Modelling clay
- PVA glue
- A small shell, bone or toy dinosaur

What to do:

1. Press the modelling clay out onto a flat, hard surface. Ensure it is at least 5 centimetres thick throughout.
2. Take one of the objects and press it into the modelling clay just enough to leave a clear impression. For the toy dinosaur, the student can choose to press in its footprints or a section of its body.
3. Fill the impression with PVA glue until it is just overflowing.
4. Leave the modelling clay in a cool, dry spot where it won't be disturbed.
5. Wait two to three days and check the glue. If it appears completely dry, carefully peel the glue from the impression.
6. Compare the glue model with the original object. What is the same? What is different?

What's happening?

Fossils are objects that tell us something about the features of an organism that lived in the distant past. In many cases, they are rocks that contain an impression of some part of the organism, such as its feet, teeth or bones.

Often, the impression will be filled by other minerals as the original material decays away. Bones and teeth eventually dissolve, with the cavity they leave slowly filling again with other dissolved minerals to create a rock that looks like the bone or tooth.

Footprints and even skin impressions can also be filled by sediment or other materials, preserving their shape and texture. Scientists who study them might fill them with latex or other hardening liquids to preserve the imprint and capture all of their features for future study.

Sedimentary principles

You will need:

- 4 different colours of plasticine
- A flat surface
- A rolling pin
- A clock or watch with seconds
- A blunt knife (a butter knife will do)

What to do:

1. Choose a colour of plasticine and press it out until it is fairly flat and around 2 to 5 centimetres thick.
2. Repeat this for the other 3 colours of plasticine.
3. Stack the 4 flat layers in a clear sequence, taking care to make it clear which colour was on the table first and which was placed most recently. Note the exact time to the second for each stacking.
4. Use a blunt knife to cut through the stack of plasticine. Pull the two halves apart to see the colours inside. Which is the deepest? What time was it placed down? Which represents the 'oldest' layer, set down first? Which is the most recent?
5. Separate the two stacked halves by moving one across the room. Suggest to the students that one half is now in North America, the other is now in Africa. Does this movement change their order? Ask the students the same questions as in step 4.
6. Press firmly the sides of one of the stacks so it bends slightly in the middle. Use the diagram on page 47 of the book as a guide to what this 'fold' might look like. Ask the students the same questions as in step 4.

What's happening?

Each layer of plasticine represents a different period of sediment being deposited and pressured into becoming a rock. In actual rock formations, layers of sedimentary rock can be not only different shades and colours, they can contain different sized grains and even different fossils or other materials.

The law of superposition states layers of sedimentary rock are deposited in a sequence, with deeper layers deposited before shallower layers. This can be used to give rocks a relative age that correlates with depth.

Sediments also always settle flat, like the plasticine. They can be folded, broken apart, and even flipped. But they always form horizontally, telling geologists how the landscape might have looked when the sedimentary rock was first deposited.

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English

Rocking recipes

Share with the students some recipes for popular foods, discussing the format of the text. Ask them why they think it is structured the way it is. Why are the ingredients listed as they are? Why are the steps numbered?

Ask the students to choose a type of metamorphic rock from the book, and read about its formation. What sedimentary rock is it made from? How is the sedimentary rock itself formed?

Instruct them to use the format of a recipe to explain how their choice of metamorphic rock is formed (including the sedimentary rock it forms from).

Mathematics

Popcorn half-life

You will need:

- A bag of popcorn kernels
- A paper bag
- A microwave
- Kitchen scales
- Pencil and paper
- Graph paper
- Ruler

What to do:

1. Weigh out 30 grams of popcorn kernels and place them into a paper bag.
2. Put the paper bag and popcorn kernels into a microwave and set its power on high. Set the timer for five minutes and press start.
3. When the first kernels pop, note the time. Let the microwave progress for 15 seconds and then press stop.
4. Let the popcorn cool for 20 seconds.
5. Open the microwave and take out the bag. Remove the popped corn and weigh the remainder. Remove this number from 30 grams. Write down the answer and label it 'Popcorn popped at X seconds', where X is the number of seconds on the microwave timer.

6. Repeat the process from step 1, only this time let the microwave progress for 30 seconds in step 3.
7. Repeat the process again, each time adding 15 seconds to the timer until no more popcorn kernels are left to pop.
8. Create a line graph comparing the time taken for kernels to pop in seconds, with the weight of popcorn kernels popped.

What's happening?

In spite of all being so similar, some popcorn kernels take longer to build up steam and pop than others. Not that you can tell by looking at them. But the longer you wait, the fewer unpopped kernels you will find.

Even if you had 100 grams of popcorn instead of 30 grams, the shape of the line you drew on your graph would look more or less the same. In both instances, after a certain amount of time, half the popcorn would have popped. Wait that time again, and again, half the remainder would have popped.

Radioactive atoms are much the same in how they decay, or lose part of their atomic structure. Like the popcorn, it's impossible to tell which atoms will break apart at any one moment. But some elements will decay faster than others on average, taking less time for half of the atoms in a rock to break apart than other elements.

We say they have shorter 'half-lives', which is a term used to describe the time taken for half of a sample of radioactive material to decay. Once that time has passed, it will take the same time again for half of the remainder to decay ... and so on, until there's barely any traces of radioactivity left.

Australian curriculum links (Primary) (Version 9.0)

Year level	Learning area: Science	Other learning areas
Year 4	**Science Understanding: Physical sciences** • Identify how forces can be exerted by one object on another and investigate the effect of frictional, gravitational and magnetic forces on the motion of objects (AC9S4U03) **Chemical sciences** • Examine the properties of natural and made materials including fibres, metals, glass and plastics and consider how these properties influence their use (AC9S4U04)	**English** • Understand past, present and future tenses and their impact on meaning in a sentence (AC9E4LA09) • Recognise similar storylines, ideas and relationships in different contexts in literary texts by First Nations Australian, and wide-ranging Australian and world authors (AC9E4LE01) **Mathematics** • Interpret unmarked and partial units when measuring and comparing attributes of length, mass, capacity, duration and temperature, using scaled and digital instruments and appropriate units (AC9M4M01)
Years 5/6	**Science Understanding: Earth and space sciences** • Describe how weathering, erosion, transportation and deposition cause slow or rapid change to Earth's surface (AC9S5U02) • Describe the movement of Earth and other planets relative to the sun and model how Earth's tilt, rotation on its axis and revolution around the sun relate to cyclic observable phenomena, including variable day and night length (AC9S6U02) **Chemical sciences** • Compare reversible changes, including dissolving and changes of state, and irreversible changes, including cooking and rusting that produce new substances (AC9S6U04)	**English** • Understand how to move beyond making bare assertions by taking account of differing ideas or opinions and authoritative sources (AC9E5LA02) • Explain how texts across the curriculum are typically organised into characteristic stages and phases depending on purposes, recognising how authors often adapt text structures and language features (AC9E6LA03) • Identify authors' use of vivid, emotive vocabulary, such as metaphors, similes, personification, idioms, imagery and hyperbole (AC9E6LA08) **Mathematics** • Choose appropriate metric units when measuring the length, mass and capacity of objects; use smaller units or a combination of units to obtain a more accurate measure (AC9M5M01) • Describe and perform translations, reflections and rotations of shapes, using dynamic geometric software where appropriate; recognise what changes and what remains the same, and identify any symmetries (AC9M5SP03)

Australian curriculum links (Secondary) (Version 9.0)

Year level	Learning area: Science	Other learning areas
Years 7/8	**Science Understanding: Physical sciences** • Investigate and represent balanced and unbalanced forces, including gravitational force, acting on objects, and relate changes in an object's motion to its mass and the magnitude and direction of forces acting on it (AC9S7U04) **Earth and space sciences** • Investigate tectonic activity including the formation of geological features at divergent, convergent and transform plate boundaries and describe the scientific evidence for the theory of plate tectonics (AC9S8U03)	**English** • Identify and describe how texts are structured differently depending on their purpose and how language features vary in texts (AC9E7LA03) • Understand how layers of meaning can be created when evaluating by using literary devices such as simile and metaphor (AC9E8LA02) • Identify and explore ideas, points of view, characters, events and/or issues in literary texts, drawn from historical, social and/or cultural contexts, by First Nations Australian, and wide-ranging Australian and world authors (AC9E7LE01) **Mathematics** • Represent objects in 2 dimensions; discuss and reason about the advantages and disadvantages of different representations (AC9M7SP01)
All	**Cross-curriculum Priority: Aboriginal and Torres Strait Islander Histories and Cultures** • *A_TSIC2I*: First Nations Australians' ways of life reflect unique ways of being, knowing, thinking and doing.	

Related books from CSIRO Publishing

- *AmAZed! CSIRO's A to Z of Biodiversity* (https://www.publish.csiro.au/book/7984)
- *How to Survive on Mars* (https://www.publish.csiro.au/book/8011)
- *The Encyclopedia of STEM Words: An Illustrated A to Z of 100 Terms for Kids to Know* (https://www.publish.csiro.au/book/8084)

Other CSIRO resources

CSIRO has developed and delivered a broad range of high-quality STEM education programs and initiatives for nearly 40 years. Our programs aim to inspire the pursuit of further STEM education among students and the community, to equip the emerging workforce with tomorrow's skill sets, and to strengthen collaboration between industry and classrooms across Australia. For more information visit: https://www.csiro.au/en/Education

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