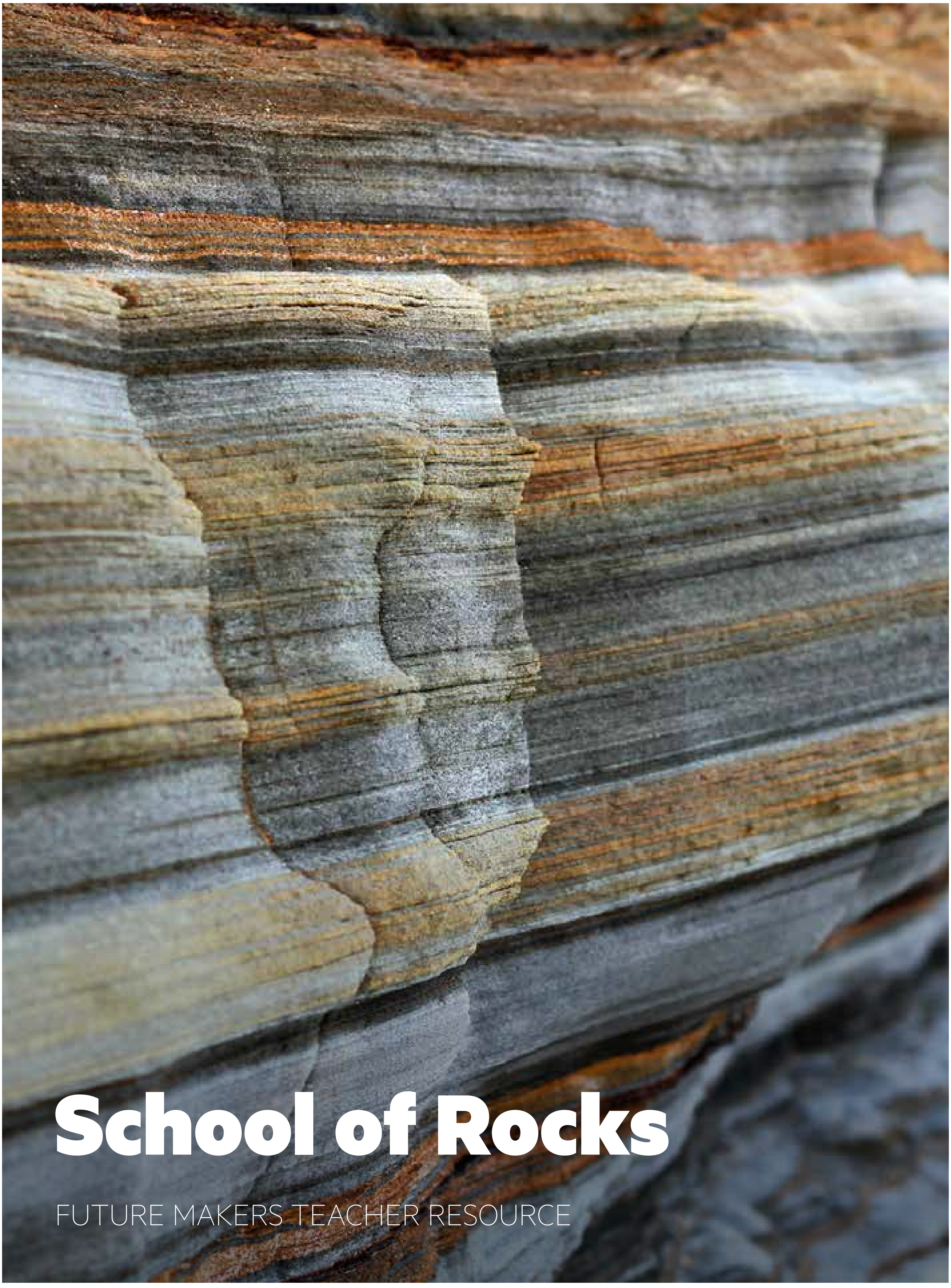


School of Rocks

FUTURE MAKERS TEACHER RESOURCE

Future Makers

Future Makers is an innovative partnership between Queensland Museum and Shell's QGC business aiming to increase awareness and understanding of the value of science, technology, engineering and maths (STEM) education and skills in Queensland.

This partnership aims to engage and inspire people with the wonder of science, and increase the participation and performance of students in STEM-related subjects and careers — creating a highly capable workforce for the future.

This teacher resource is produced by Future Makers, a partnership between Queensland Museum and Shell's QGC business, with support from the Australian Research Council and other parties to ARC Linkage Project LP160101374: The University of Queensland, Australian Catholic University Limited and Queensland Department of Education.

Contents

Workshop Overview

Rocks and minerals have been used by humans and our ancestors for millennia. Within this workshop, students explore the formation of rocks and minerals. They investigate how the properties of rocks and minerals are related to their use and how these naturally occurring materials provide valuable resources for human activity. Students also investigate the effects of volcanic activity, using a real-world example to model one aspect of this type of natural disaster.

Within this workshop you will see examples of stone tools, fossils, minerals and rocks from Queensland Museum collections. Queensland Museum has a legislated responsibility, as defined by the Queensland Museum Act 1970, to collect, research and promote Queensland's natural, cultural and technological heritage. Collections ranging in origin from just days ago to minerals over 3 billion years old provide temporal and spatial evidence of changes occurring in our natural and cultural environments.

Cultural and historical collections provide a tangible link to human innovation and experience. Objects help document how people react to changes as dramatic as epidemics and war, to environmental stress and cultural differences. At the heart of our collection is the material culture of Aboriginal Peoples and Torres Strait Islanders, connecting the deep history of the continent with contemporary life in Australia today.

This workshop has been structured using the 5E's instructional model.
The following topics and concepts are explored in each aspect of the workshop:

ENGAGE	**Mineral Madness Card Game** Explore the chemical composition of minerals by playing the game *Mineral Madness*.
EXPLORE **EXPLAIN** **ELABORATE**	**Mobile Minerals** Explore how minerals and the elements they contain provide valuable resources for human activity, including smartphones. Consider the ethical and environmental issues related to the mining of minerals, and the manufacture and disposal of smartphones.
EXPLORE **EXPLAIN** **ELABORATE** **EVALUATE**	**From Minerals Big Rocks Grow** Observe and analyse three different rocks to determine if a rock is igneous, sedimentary or metamorphic. Transform text to construct a 3D diagram of the rock cycle. Construct and evaluate a model of the rock cycle using everyday materials.
EXPLORE **EXPLAIN** **ELABORATE** **EVALUATE**	**Volatile Volcanoes** Investigate the effects of volcanic activity, specifically in relation to pyroclastic flows.
ELABORATE	**Stone Tools** Consider the properties of a rock to analyse how properties determine use. Examine the *Morah Stone* and investigate the properties of an effective grindstone.
ELABORATE **EVALUATE**	**Time Warp** Analyse a core sample and fossil evidence to explore how environments change and the evidence of these changes.

ENGAGE

Mineral Madness

Teacher Resource

Rocks are made up of minerals. Minerals are naturally occurring inorganic solid substances. There are many thousands of types of minerals found on Earth and quite a few in lunar rocks and meteorites.

Minerals are made up of chemical elements and have a definite chemical composition. Some minerals, such as diamond, gold and sulfur, contain only one chemical element; these minerals are known as native elements. Most minerals are chemical compounds; these minerals contain a combination of chemical elements. It is the specific chemical composition and crystalline structure of each mineral that determines its properties. These characteristics can also be used to classify a mineral into one of several groups, including the native elements, sulphides, oxides, halides, carbonates, sulfates and phosphates.

In this activity, students explore the chemical composition of minerals by playing the game *Mineral Madness. Mineral Madness* is based on the card game 'Rummy' and follows a similar style of play. Within *Mineral Madness*, students identify the chemical formula of varied minerals, before using a periodic table and element cards to form their minerals. Instructions and game cards can be found on the following pages.

After engaging with the game, students could:

- Sort the minerals based on their elemental groups, and research the characteristics of these groups and others not included in the *Mineral Madness* selection of minerals.
- Investigate each mineral, including its date of discovery, who first described the mineral, how it was named, and the historic and current uses of the mineral.
- Explore which minerals form various igneous, metamorphic and sedimentary rocks.

Curriculum Links (Version 8.4)

Science

YEAR 8

Science Understanding

Sedimentary, igneous and metamorphic rocks contain minerals and are formed by processes that occur within Earth over a variety of timescales (ACSSU153)

Science Inquiry Skills

Communicate ideas, findings and evidence based solutions to problems using scientific language, and representations, using digital technologies as appropriate (ACSIS148)

General Capabilities

Literacy

Comprehending texts through listening, reading and viewing

Mineral Madness

Student Resource

Mineral Madness
Game Instructions

Players: 2 – 5 players

Game Components: 16 x mineral cards

48 x element cards

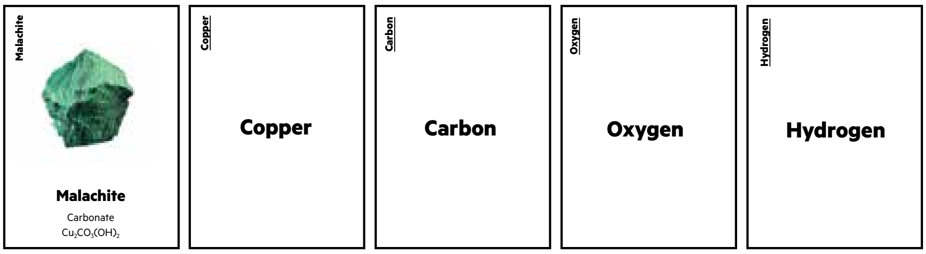
1 x periodic table per player

Objective: Explore the chemical composition of minerals. Pick up and use element cards to form minerals. The first person to use all of the element and mineral cards in their hand is the winner.

Game Play: Select one person to be the dealer. The dealer shuffles and deals the cards to each player. When playing with two, three or four players, each player receives ten cards. When playing with five players, each player receives six cards.

After dealing, the dealer places the remaining cards face-down in a pile in the middle of the group. The dealer flips over the first card to create a discard pile. The person sitting to the left of the dealer plays first.

The first player can either pick up the card on the discard pile or the top card from the main pile. If they can combine their element cards to form a mineral card in their hand, they may do so. One element card may be used to represent elements that appear multiple times in a mineral's chemical formula, for example:



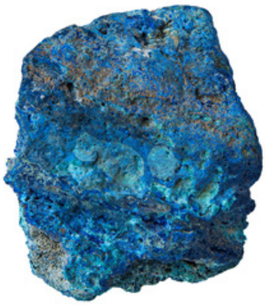
These cards can then be placed face-up in front of the player. The player discards one mineral or element card from their hand, face-up onto the discard pile, to end their turn. Play moves to the next player on the left.

Play continues until one player has no cards remaining in their hand.

Tips: Players can use a periodic table to help identify the chemical elements that form specific minerals.

A wild card can be used to represent any one element.

Azurite



Azurite

Carbonate
$Cu_3(CO_3)_2(OH)_2$

Calcite

Calcite

Carbonate
$CaCO_3$

Chalcopyrite

Chalcopyrite

Sulfide
$CuFeS_2$

Diamond

Diamond

Native mineral
C

Orthoclase Feldspar

Orthoclase Feldspar

Silicate
$KAlSi_3O_8$

Fluorite

Fluorite

Halide
CaF_2

Graphite

Graphite

Native mineral
C

Galena

Galena

Sulfide
PbS

Halite

Halite

Halide
NaCl

Haematite

Haematite

Oxide

Fe_2O_3

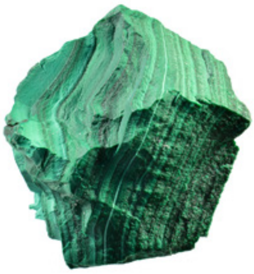
Kyanite

Kyanite

Nesosilicate

Al_2SiO_5

Malachite



Malachite

Carbonate

$Cu_2CO_3(OH)_2$

Pyrite

Pyrite

Sulfide

FeS_2

Quartz

Quartz

Oxide

SiO_2

Rutile

Rutile

Oxide

TiO_2

Talc

Talc

Silicate

$Mg_3Si_4O_{10}(OH)_2$

Copper

Copper

Copper

Copper

Copper

Copper

Carbon

Carbon

Carbon

Carbon

Carbon

Carbon

Carbon

Carbon

Carbon

Carbon

Oxygen

Oxygen

Oxygen

Oxygen

Oxygen

Oxygen

Oxygen

Oxygen

Oxygen

Oxygen

Oxygen

Oxygen

Oxygen

Oxygen

Oxygen

Oxygen

Oxygen

Oxygen

Hydrogen

Hydrogen

Hydrogen

Hydrogen

Hydrogen

Hydrogen

Calcium

Calcium

Calcium

Calcium

Iron

Iron

Iron

Iron

Iron

Iron

Sulphur

Sulphur

Sulphur

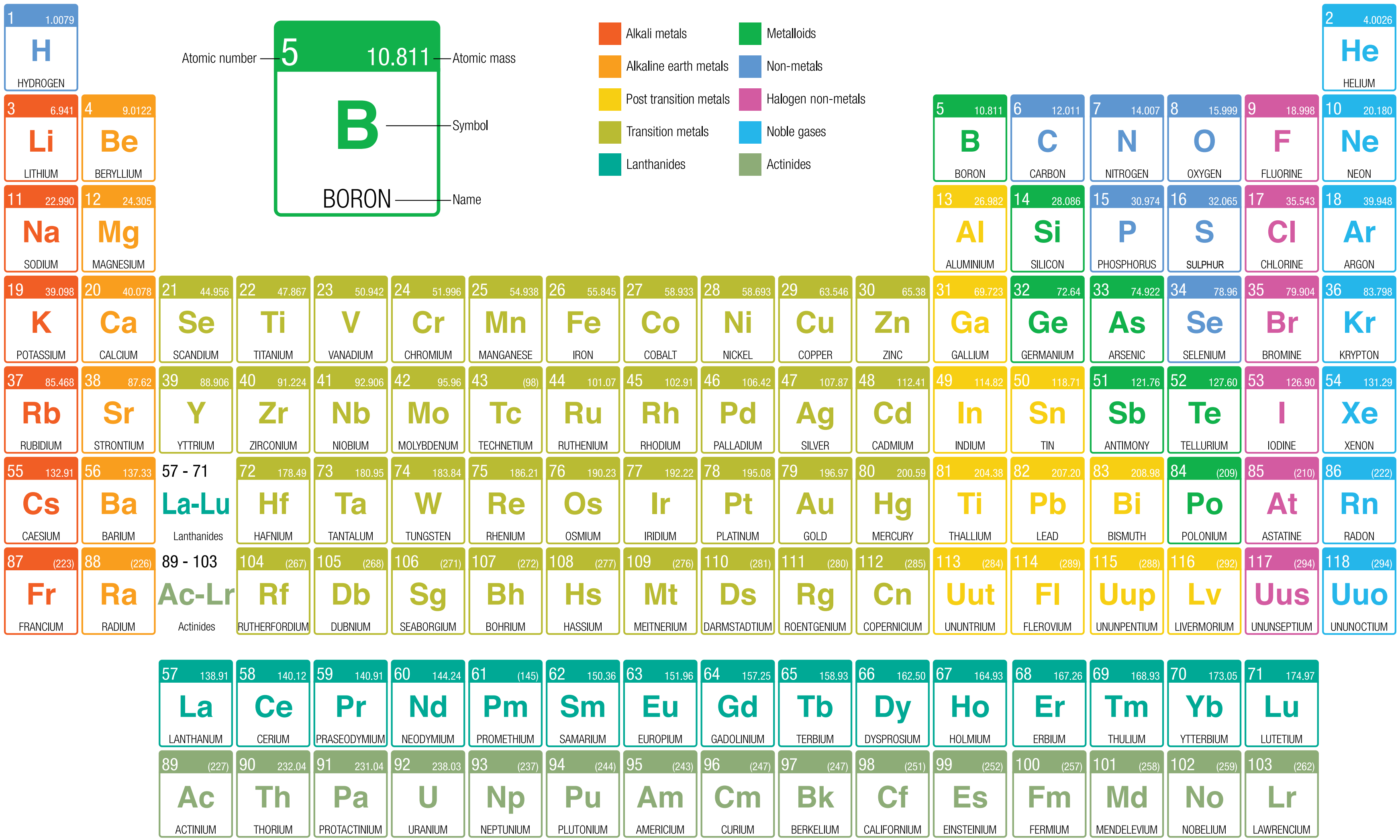
Sulphur

Sulphur **Sulphur**	**Aluminium** **Aluminium**	**Aluminium** **Aluminium**
Potassium **Potassium**	**Silicon** **Silicon**	**Silicon** **Silicon**
Silicon **Silicon**	**Silicon** **Silicon**	**Fluorine** **Fluorine**

Lead **Lead**	Sodium **Sodium**	Chlorine **Chlorine**
Titanium **Titanium**	Silicon **Silicon**	WILD **WILD**
WILD **WILD**	WILD **WILD**	WILD **WILD**

WILD **WILD**	WILD **WILD**	WILD **WILD**

PERIODIC TABLE OF THE ELEMENTS



🟥 Alkali metals
🟧 Alkaline earth metals
🟨 Post transition metals
🟩 Transition metals
🟦 Lanthanides
🟩 Metalloids
🟦 Non-metals
🟪 Halogen non-metals
🟦 Noble gases
🟩 Actinides

1 1.0079 H HYDROGEN																	2 4.0026 He HELIUM
3 6.941 Li LITHIUM	4 9.0122 Be BERYLLIUM											5 10.811 B BORON	6 12.011 C CARBON	7 14.007 N NITROGEN	8 15.999 O OXYGEN	9 18.998 F FLUORINE	10 20.180 Ne NEON
11 22.990 Na SODIUM	12 24.305 Mg MAGNESIUM											13 26.982 Al ALUMINIUM	14 28.086 Si SILICON	15 30.974 P PHOSPHORUS	16 32.065 S SULPHUR	17 35.543 Cl CHLORINE	18 39.948 Ar ARGON
19 39.098 K POTASSIUM	20 40.078 Ca CALCIUM	21 44.956 Se SCANDIUM	22 47.867 Ti TITANIUM	23 50.942 V VANADIUM	24 51.996 Cr CHROMIUM	25 54.938 Mn MANGANESE	26 55.845 Fe IRON	27 58.933 Co COBALT	28 58.693 Ni NICKEL	29 63.546 Cu COPPER	30 65.38 Zn ZINC	31 69.723 Ga GALLIUM	32 72.64 Ge GERMANIUM	33 74.922 As ARSENIC	34 78.96 Se SELENIUM	35 79.904 Br BROMINE	36 83.798 Kr KRYPTON
37 85.468 Rb RUBIDIUM	38 87.62 Sr STRONTIUM	39 88.906 Y YTTRIUM	40 91.224 Zr ZIRCONIUM	41 92.906 Nb NIOBIUM	42 95.96 Mo MOLYBDENUM	43 (98) Tc TECHNETIUM	44 101.07 Ru RUTHENIUM	45 102.91 Rh RHODIUM	46 106.42 Pd PALLADIUM	47 107.87 Ag SILVER	48 112.41 Cd CADMIUM	49 114.82 In INDIUM	50 118.71 Sn TIN	51 121.76 Sb ANTIMONY	52 127.60 Te TELLURIUM	53 126.90 I IODINE	54 131.29 Xe XENON
55 132.91 Cs CAESIUM	56 137.33 Ba BARIUM	57 - 71 La-Lu Lanthanides	72 178.49 Hf HAFNIUM	73 180.95 Ta TANTALUM	74 183.84 W TUNGSTEN	75 186.21 Re RHENIUM	76 190.23 Os OSMIUM	77 192.22 Ir IRIDIUM	78 195.08 Pt PLATINUM	79 196.97 Au GOLD	80 200.59 Hg MERCURY	81 204.38 Ti THALLIUM	82 207.20 Pb LEAD	83 208.98 Bi BISMUTH	84 (209) Po POLONIUM	85 (210) At ASTATINE	86 (222) Rn RADON
87 (223) Fr FRANCIUM	88 (226) Ra RADIUM	89 - 103 Ac-Lr Actinides	104 (267) Rf RUTHERFORDIUM	105 (268) Db DUBNIUM	106 (271) Sg SEABORGIUM	107 (272) Bh BOHRIUM	108 (277) Hs HASSIUM	109 (276) Mt MEITNERIUM	110 (281) Ds DARMSTADTIUM	111 (280) Rg ROENTGENIUM	112 (285) Cn COPERNICIUM	113 (284) Uut UNUNTRIUM	114 (289) Fl FLEROVIUM	115 (288) Uup UNUNPENTIUM	116 (292) Lv LIVERMORIUM	117 (294) Uus UNUNSEPTIUM	118 (294) Uuo UNUNOCTIUM
		57 138.91 La LANTHANUM	58 140.12 Ce CERIUM	59 140.91 Pr PRASEODYMIUM	60 144.24 Nd NEODYMIUM	61 (145) Pm PROMETHIUM	62 150.36 Sm SAMARIUM	63 151.96 Eu EUROPIUM	64 157.25 Gd GADOLINIUM	65 158.93 Tb TERBIUM	66 162.50 Dy DYSPROSIUM	67 164.93 Ho HOLMIUM	68 167.26 Er ERBIUM	69 168.93 Tm THULIUM	70 173.05 Yb YTTERBIUM	71 174.97 Lu LUTETIUM	
		89 (227) Ac ACTINIUM	90 232.04 Th THORIUM	91 231.04 Pa PROTACTINIUM	92 238.03 U URANIUM	93 (237) Np NEPTUNIUM	94 (244) Pu PLUTONIUM	95 (243) Am AMERICIUM	96 (247) Cm CURIUM	97 (247) Bk BERKELIUM	98 (251) Cf CALIFORNIUM	99 (252) Es EINSTEINIUM	100 (257) Fm FERMIUM	101 (258) Md MENDELEVIUM	102 (259) No NOBELIUM	103 (262) Lr LAWRENCIUM	

EXPLORE - EXPLAIN - ELABORATE

Mobile Minerals

Teacher Resource

Within Part 1 of this activity, students investigate how minerals and the elements they contain provide valuable resources for human activity, including the raw materials for equipment we use on a daily basis. Smartphones have been specifically selected to contextualise learning within this activity. These devices are made from a surprisingly large number of elements mined from mineral deposits around the world.

Although smartphones greatly benefit our lives, their manufacture and disposal can be problematic; ethical and environmental issues related to these problems will be explored by students in Part 2 of this activity.

Detailed step-by-step instructions for Parts 1 and 2 of this activity can be seen below. It is recommended that you use these instructions to guide your students through the activity.

Part 1: My Smartphone is Made of What?!

1. Discuss the following with students:
    - Minerals are made of chemical elements.
    - Some minerals and the elements they contain provide valuable resources for human activity. These minerals and elements are used to make a wide variety of objects that we use on a daily basis, including toothpaste, toasters, cars and even smartphones.
2. Introduce the activity to the class: Students will investigate how elements mined from mineral deposits are used to make smartphones.
3. Distribute copies of the periodic table to students. Ask students to predict which element/s might be used to make an average smartphone, using prior knowledge to justify their decisions. Students can also discuss where/how they think these elements are used within a smartphone.
4. Reveal the elements used to make an average smartphone by reading them out loud. Students could circle the corresponding elements on their periodic table as they are spoken. Ask students to identify how many elements are used to make a smartphone (77 of 118).
5. Inform students that these elements are used in varied quantities to make the screen, case, electronics and circuitry, and battery. Students will work in small groups to investigate which elements are used to make these components, where these elements are obtained and how their properties are related to their use.
6. If desired, model how to complete this activity by using the smartphone case as an example response (see following page). Within the 'Reference' column, students may simply record the website/s from which they gathered information or use a referencing system such as APA.

Elements Used to Make an Average Smartphone: Smartphone Case

Element	Mineral Source/s	Element Properties Related to Use	Major Producer/s	Reference
Aluminium	Can include gibbsite, boehmite and diaspore from bauxite ore	Malleable, light weight and strong Highly rust-resistant Non-toxic	Australia – 76% (Queensland, New South Wales, Tasmania, Western Australia, Northern Territory) China – 48% Brazil – 34%	www.ga.gov.au/data-pubs/data-and-publications-search/publications/australian-minerals-resource-assessment/bauxite www.rsc.org/periodic-table/element/13/aluminium

7. Divide students into groups of two to four and assign each group a smartphone component: the screen, electronics and circuitry, or battery. Ask students to circle or underline the component they are working on, before conducting online research to complete the table for their assigned component. Students may then share their findings with other groups who were working on different components (i.e. a group working on the screen, the electronics and circuitry, and the battery may come together to share their information so all have an understanding of how varied elements are used and obtained to make an average smartphone).

Elements Used to Make an Average Smartphone

Aluminium
Antimony
Arsenic
Barium
Beryllium
Bismuth
Boron
Bromine
Calcium
Carbon
Cadmium
Chlorine
Chromium
Cerium
Cobalt
Copper
Dysprosium
Erbium
Europium
Fluorine
Gadolinium
Gallium
Germanium
Gold
Hafnium
Helium
Holmium
Hydrogen
Indium
Iridium
Iron
Lanthanum
Lead
Lithium
Lutetium
Manganese
Magnesium
Mercury
Molybdenum
Neodymium
Nickel
Niobium
Nitrogen
Osmium
Oxygen
Palladium
Phosphorus
Platinum
Polonium
Potassium
Praseodymium
Radon
Rhenium
Rhodium
Ruthenium
Samarium
Scandium
Selenium
Silicon
Silver
Sodium
Strontium
Sulphur
Tantalum
Tellurium
Terbium
Thallium
Thorium
Thulium
Tin
Titanium
Tungsten
Vanadium
Ytterbium
Yttrium
Zinc
Zirconium

Part 2: The Problem with Smartphones

1. Share statistics on global smartphone use with students[1]:

   - 2014 2.6 billion smartphone subscriptions
   - 2015 3.2 billion smartphone subscriptions
   - 2016 3.9 billion smartphone subscriptions
   - 2017 4.4 billion smartphone subscriptions
   - 2018 5.1 billion smartphone subscriptions
   - 2024 7.1 billion smartphone subscriptions (estimated figure)

   NB: The term 'smartphone subscriptions' refers to the number of smartphones in use at the point of survey. A single smartphone subscription may be shared by multiple people. Alternatively, one person may have multiple smartphone subscriptions.

   Students could plot the data on a line graph and/or calculate the percentage increase between each year. Ask students to:

   - Discuss why smartphone use has increased over time.
   - Generate possible explanations for any changes in percentage increase across surveyed years.

2. Ask students to brainstorm issues and implications associated with the worldwide use and manufacture of smartphones; these may relate to ethical considerations, sustainable patterns of living and/or environmental issues. A PMI Chart (plus-minus-interesting) could be used to record student responses.

3. Inform students that they will now work to further investigate the negative issues and implications associated with the use and manufacture of smartphones. Divide students into groups of three or six. From the larger article, Three Ways Making a Smartphone can Harm the Environment, distribute one section (*Catastrophic Mine Waste Spills, Ecosystem Destruction* or *The Most Polluted Place on the Planet?*) to each individual student when working in groups of three, or one section between pairs of students when working in groups of six. (Additionally, if you have sufficient time, students may analyse the full article.)

   Ask students to complete the article analysis for their media article. Students then share their responses to the article analysis task with the larger group.

   Following this, students complete the human impacts place mat, *Analysing Human Impacts*. Students work within their groups to identify what is being done, and what more could be done, to resolve and/or minimise the effects of the issues described in the media article at an individual, community and global level. Students may like to conduct further research to complete this task.

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[1] *Ericsson. (2018). Ericsson mobility reports. Retrieved from* ***ericsson.com/en/mobility-report/reports***

Curriculum Links (Version 8.4)

Science

YEAR 8

Science Understanding

Sedimentary, igneous and metamorphic rocks contain minerals and are formed by processes that occur within Earth over a variety of timescales (ACSSU153)

Properties of the different states of matter can be explained in terms of the motion and arrangement of particles (ACSSU151)

Science as a Human Endeavour

Solutions to contemporary issues that are found using science and technology, may impact on other areas of society and may involve ethical considerations (ACSHE135)

Science Inquiry Skills

Identify questions and problems that can be investigated scientifically and make predictions based on scientific knowledge (ACSIS139)

Construct and use a range of representations, including graphs, keys and models to represent and analyse patterns or relationships in data using digital technologies as appropriate (ACSIS144)

Summarise data, from students' own investigations and secondary sources, and use scientific understanding to identify relationships and draw conclusions based on evidence (ACSIS145)

Communicate ideas, findings and evidence based solutions to problems using scientific language, and representations, using digital technologies as appropriate (ACSIS148)

Mathematics

YEAR 8

Number and Algebra

Solve problems involving the use of percentages, including percentage increases and decreases, with and without digital technologies (ACMNA187)

General Capabilities

Literacy

Comprehending texts through listening, reading and viewing

Composing texts through speaking, writing and creating

ICT Capability

Investigating with ICT

Managing and operating ICT

Critical and Creative Thinking

Inquiring – identifying, exploring and organising information and ideas

Personal and Social Capability

Social awareness

Ethical Understanding

Understanding ethical concepts and issues

Reasoning in decision making and actions

Cross-Curriculum Priorities

Sustainability

Sustainable patterns of living rely on the interdependence of healthy social, economic and ecological systems. (OI.3)

The sustainability of ecological, social and economic systems is achieved through informed individual and community action that values local and global equity and fairness across generations into the future. (OI.6)

Actions for a more sustainable future reflect values of care, respect and responsibility, and require us to explore and understand environments. (OI.7)

Designing action for sustainability requires an evaluation of past practices, the assessment of scientific and technological developments, and balanced judgements based on projected future economic, social and environmental impacts. (OI.8)

Mobile Minerals

Student Activity

Elements Used to Make an Average Smartphone: Smartphone Screen – Electronics and Circuitry – Battery

Element	**Mineral Source/s**	**Element Properties Related to Use**	**Major Producer/s**	**Reference**

Mobile Minerals

Student Activity

Article Analysis

Prediction

Examine the source, date, headline and images. Write three questions you expect to be answered in the article.

First Reading

Underline any words you are unsure about. Use content clues, a dictionary or a group discussion to identify the meaning of these words. Write in replacement words for your underlined words.

Second Reading

Answer the following questions about the article:

1. Summarise the article in the 66 word grid below.

2. What resources are being mined, and why?

3. Who is being impacted by the mining activity?

4. What are the consequences of mining these resources?

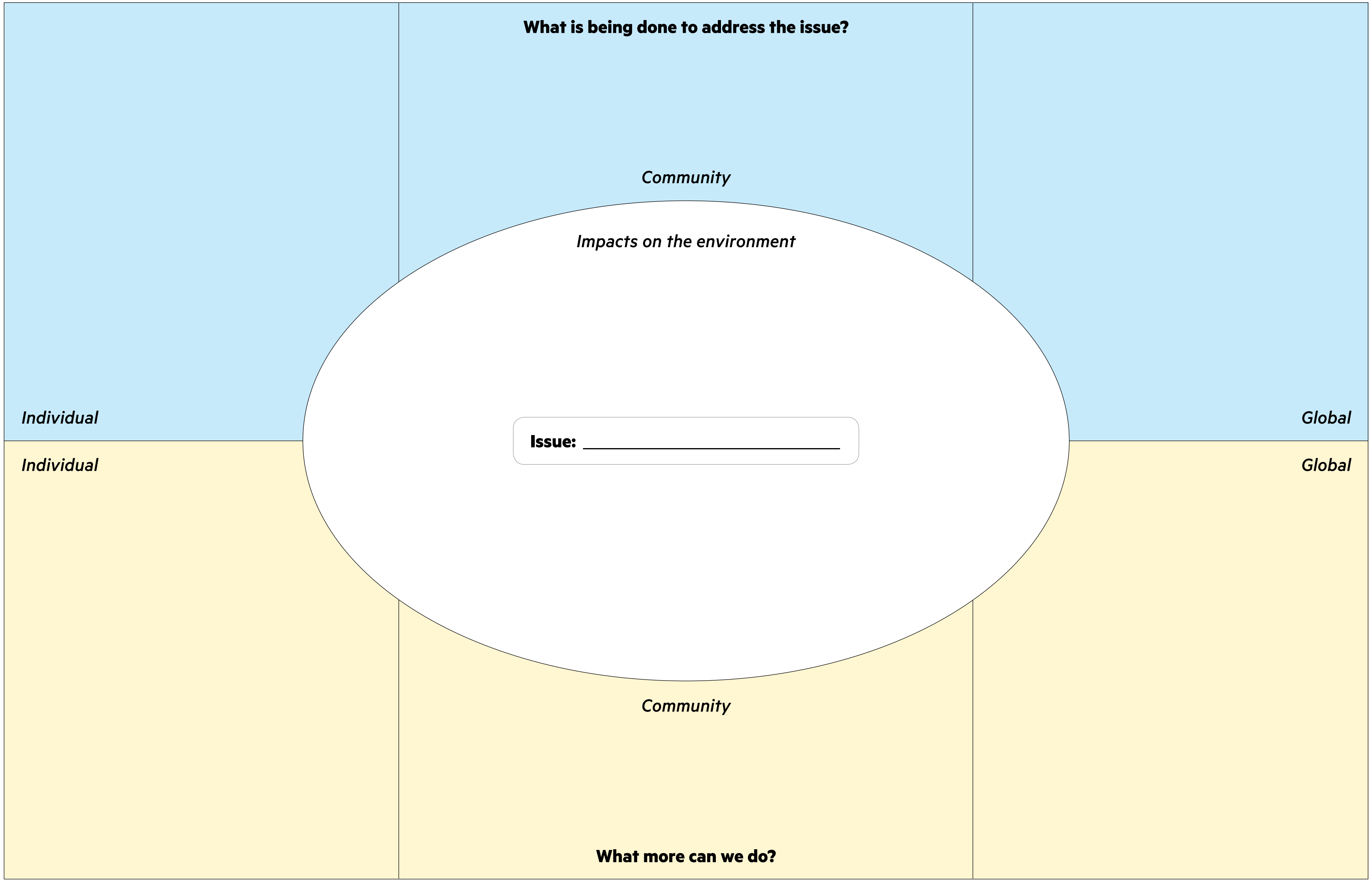
5. Why was the article written?

6. How did this article surprise you?

7. How does this article make you feel?

8. Return to your original three questions. Were they answered in the article?
   If not, how come? How could you find the answers to these questions?

Analysing Human Impacts



EXPLORE - EXPLAIN - ELABORATE - EVALUATE

From Minerals Big Rocks Grow

Teacher Resource

In this activity students will observe the properties of three unlabelled rocks, one of each igneous, sedimentary and metamorphic. They then read a short paragraph about rock types and compare the properties of their rocks with the properties listed in the paragraph. Students use their observations and this paragraph of information to identify which is an igneous, which is a sedimentary, and which is a metamorphic rock. This information will then be used to create a 3D mind-map of the rock cycle. Students will then model the rock cycle and evaluate their model representation.

The Queensland Museum collects rocks, minerals and fossils as a record of Queensland's geological and natural heritage. You may use your own rocks for these activities or borrow Queensland Museum loan kits, including *Fossils, Minerals and Rocks*, or the *Active Earth Kit*. Rocks can also be seen on display in the *Discovery Centre* at Queensland Museum in Brisbane. Photos of rocks have been provided in Appendix 1 for anyone who does not have access to rock specimens.

Reading Rocks

In this activity students will work collaboratively in groups of three to identify rock types. Divide students into groups and then give each student in the group of three a different rock type (igneous, sedimentary and metamorphic).

Students then complete a See-Scan-Analyse activity to facilitate deeper observations of their rocks.

- See: View the rock. Turn it over in your hands to see each side.
- Scan: Look more closely at the rock. What do you notice about the rock?

  Describe the properties of the rock. Students may wish to use words from the *Describing Word Bank*.

  Use a magnifying glass to observe any grains/crystals.

  How does your rock feel? Why does it feel that way?

  Why do you think the rock has these properties?
- Analyse: As a group, compare your rocks. What are the similarities and differences?

Read the information on igneous, metamorphic and sedimentary rocks. Use your observations and this information to determine which rock is igneous, sedimentary or metamorphic, giving reasons.

After students have determined which rock is igneous, sedimentary or metamorphic, you could ask students to create a rock museum in the classroom. Students could bring rocks from home to add to the rock museum. You may wish to share with students the name of their rock so they can identify what minerals the rock is made of.

3D Rock Cycle

Transforming text types requires students to reshape the main ideas of a text into a different form, in the process gaining a deeper understanding of the text. In this activity, students will read a passage of text and use this to create a 3D diagram of the rock cycle using rocks from the first part of this resource, *Reading Rocks* (alternatively you could provide students with a different selection of labelled igneous, sedimentary and metamorphic rocks). Students should read the text once, and then reread while highlighting or making notes. Pencil is recommended when students create their transformation so that they can make changes.

Students should work collaboratively in groups of three, and their 3D rock cycles may be displayed around the room for the duration of the unit. You may also wish to provide students with additional materials to incorporate into their 3D rock cycle, such as small containers of sediment and/or a material to model the magma.

Modelling the Rock Cycle

Models are useful tools in science because they provide visual representations of abstract concepts and help improve explanations and understanding. While models provide valuable tools for learning, it is important for students to understand the strengths and limitations of models to reduce misconceptions.

In this activity, students create a model of the rock cycle using everyday materials, and evaluate their model by comparing it to the rock cycle. You may wish to ask students to create a video to demonstrate how their model represents the rock cycle, or present their model to the class. The rock representations created in this activity could also be added to the *3D Rock Cycle* created in second part of this resource.

Curriculum Links (Version 8.4)

Science

YEAR 8

Science Understanding

Sedimentary, igneous and metamorphic rocks contain minerals and are formed by processes that occur within Earth over a variety of timescales (ACSSU153)

Science Inquiry Skills

Construct and use a range of representations, including graphs, keys and models to represent and analyse patterns or relationships in data using digital technologies as appropriate (ACSIS144)

Communicate ideas, findings and evidence based solutions to problems using scientific language, and representations, using digital technologies as appropriate (ACSIS148)

General Capabilities

Literacy

Comprehending texts through listening, reading and viewing

Composing texts through speaking, writing and creating

Word knowledge

Visual knowledge

Critical and Creative Thinking

Inquiring – identifying, exploring and organising information and ideas

Reflecting on thinking and processes

Analysing, synthesising and evaluating reasoning and procedures

Personal and Social Capability

Self-management

Social awareness

Social management

Intercultural Understanding

Interacting and empathising with others

From Minerals Big Rocks Grow

Student Activity

Reading Rocks

In this activity you will closely observe and analyse three different rocks to determine if a rock is igneous, sedimentary or metamorphic.

- See: View one rock. Turn it over in your hands to see each side.
- Scan: Look more closely at the rock. What do you notice about the rock?

  How does your rock feel? Why does it feel that way?

  Use a magnifying glass to observe any grains/crystals.

  Describe the properties of the rock. You may use words from the *Describing Word Bank*.

  Why do you think the rock has these properties?

Describing Word Bank

smooth rough grains soft sharp layers foliation banding shiny dull crystals

- Analyse: Share your thoughts and rock with your group.

  As a group, compare your rocks. What are the similarities and differences?

  Read the information on igneous, metamorphic and sedimentary rocks in the *Rock Type Table*.

  Determine which rock is igneous, sedimentary or metamorphic, giving reasons from your observations and the information provided.

Rock Type Table

Igneous Rocks	**Sedimentary Rocks**	**Metamorphic Rocks**
Formed from the cooling and solidification of lava or magma. There are two main types of igneous rock. Intrusive igneous rocks form when magma cools slowly below the Earth's surface, often resulting in large, well-formed grains or crystals of different sizes. These crystals may be easily visible as different colours in the rock, e.g. granite. Extrusive igneous rocks are formed when lava cools quickly producing tiny crystals. Some cool so quickly that they form an amorphous glass – a solid that is a consistent colour and smooth texture, e.g. obsidian.	Made from pre-existing rocks or pieces of organic material. These sediments are transported and deposited in water, eventually forming sedimentary rocks through compaction and cementation. Individual sediment grains can often be identified giving the rock a rough texture. Sedimentary rocks may also contain fossils, and distinctive layering from different sediment types. Examples of sedimentary rocks include sandstone and conglomerate.	Formed from existing rocks that are changed due to intense heat or pressure, transforming them into denser, more compact rocks. The extreme conditions often cause the minerals to form parallel layers. Metamorphic rocks may be identified through the banding patterns of these layers, or foliation where metamorphic rocks break easily along parallel sheets. Examples of metamorphic rocks include gneiss and slate.

3D Rock Cycle

Rocks are always changing, however, we might not notice the changes because they often take a really long time and many changes happen underground or underwater. In this activity you are going to use your igneous, sedimentary and metamorphic rocks to create a 3D diagram of the rock cycle to illustrate how rocks change.

1. Place the rocks in a triangle on a large piece of paper (butchers or A3 paper). Cut out the *Rock Type Table* from Part 1 and glue this information onto the paper with the corresponding rock.
2. Read the *Rock Cycle* passage below.

Rock Cycle

Have you ever seen a picture of a volcano erupting? This is how some new rocks are formed! When magma and lava cool, igneous rocks are formed. Weathering and erosion of these igneous rocks (and any other type of rock) causes them to break down into smaller sediments (for example, sand). Under the right conditions of compaction and cementation, new rocks can be formed from the sediments of other rocks. We call these rocks sedimentary rocks because they are made of sediments. If either sedimentary or igneous rocks experience high pressures and temperatures, their properties will change, forming a third type of rock – metamorphic. If it gets too hot however, any rock may melt completely into magma. Cooling of the magma starts the rock cycle again with a new igneous rock!

3. Reread the text and make notes on the main points of the text.
4. Transform the written passage into the 3D visual diagram on your large piece of paper. Use arrows and the *Rock Cycle Word Bank* below, and the text from the rock cycle above, to create a 3D rock cycle diagram. Statements in the word bank may be used more than once.

Rock Cycle Word Bank

heat causes melting
weathering and erosion
compaction and cementation
cooling
heat and pressure
SEDIMENTS
MAGMA/LAVA

5. Take a picture of your 3D rock cycle or draw a diagram in your book.
6. Share your 3D rock cycle with the class.

Modelling the Rock Cycle

Model the rock cycle using everyday materials. Explain how your model represents the rock cycle in the table below. Include an evaluation of the similarities and differences between the rock cycle and model representation.

Comparison of the Rock Cycle and Model Representation

Rock cycle process or object	How it is represented by the model	Similarities	Differences

Volatile Volcanoes

Teacher Resource

The Earth was formed approximately 4.6 billion years ago as a ball of molten rock. In the time since, the outside crust of the Earth has cooled to rock; however, the middle of the Earth, including the core and mantle, are still very hot.

Volcanoes are formed when magma from inside the Earth reaches the surface, causing eruptions of lava, ash and gases. Volcanic eruptions can produce specific types of igneous rocks; they can also significantly affect the Earth's surface and threaten the lives of people who live nearby.

In this activity, students investigate the effects of volcanic activity, specifically in relation to pyroclastic flows. Pyroclastic flows are fast-moving 'avalanches' of volcanic rock and ash, suspended in a cloud of hot gas, that rush down the sides of a volcano as part of some eruption processes. Pyroclastic flows are extremely dangerous. Small pyroclastic flows can move at 10 to 30 m/s, while much larger flows can move at up to 200 m/s. Pyroclastic flows are also extremely hot, reaching temperatures between 100 to 800 degrees Celsius. This natural phenomenon can flatten and incinerate everything in its path, making it one of the most destructive effects of volcanic activity.

Students will use a real-world example to:

- Explore pyroclastic flow events.
- Model and investigate the path/s most likely to be taken by pyroclastic flows.
- Develop a natural disaster management plan for villages likely to be affected by pyroclastic flows.

Detailed step-by-step instructions for this activity can be seen below. It is recommended that you use these instructions to guide your students through the activity.

Using Topographic Maps

1. Distribute Mount Merapi topographic map to students. Ask students to make observations about the map. What do students notice about the map? Have students seen a map like this before? If so, when? What does the map show us?
2. Inform students that they are looking at a topographic map. A topographic map shows the varied shapes, heights and slopes of a landscape using lines; these lines are known as contour lines. Contour lines connect points on the land that are the same height above sea level. The height difference, or contour interval, between each line is always the same.

Ask students to:

- Identify the contour interval for this topographic map (40 m).
- Locate areas on the map that are specific heights above sea level (i.e. 1000 metres above sea level, 650 metres above sea level etc.).
- Identify the highest and lowest village/s above sea level.

The closer the contour lines, the steeper the slope. Ask students to:

- Locate places on the map that have a very steep slope.
- Explain what it might mean if the contour lines are farther apart.
- Locate places on the map that have a gradual or smooth slope.

Building Landscapes

3. Students will use the contour lines to build the landscape that is shown on the map. Students can work in groups of four or five to complete this task. Ask students to cut along the main contour lines of their map. You may wish to provide students with a new copy of the topographic map to complete this task.
4. Students then roll out modelling clay to a thickness of approximately 5 mm. They place the cut-out contours on top of the clay and trace the outline of the contour, before stacking the layers from largest to smallest to make the landscape. If working in groups, students can make two or three contour layers each.
5. After stacking, students can even out the layers by making thin rolls or ‘sausages’ from the modelling clay and inserting these into the ‘steps’ between each layer. They can then smooth the layers with the rolls to make the model more life-like. Ask students to describe the model landscape they have created, including landform/s.

Mount Merapi

6. Ask students how they could identify the location of this landform. Students make predictions about the location of this landform using a world map and the provided latitude and longitude. Students can then input these coordinates into Google Maps or Google Earth and zoom out to identify the:
    - Type of landform
    - Its location
    - Characteristics of the surrounding natural and built environment, including types of settlement (Google Street View could be used to complete this task)

7. Ask students to identify Mount Merapi’s volcano type (stratovolcano) using prior knowledge or images of varied volcano types. Provide students with an opportunity to gather and record information about stratovolcanoes, including the physical and eruptive characteristics of these volcanoes. Review findings as a class.

Investigating Pyroclastic Flows

8. Revise and build on students' knowledge of Mount Merapi:
    - Mount Merapi is frequently active.
    - The volcano is known for its highly fatal eruptions. This is related to its classification as a stratovolcano.
    - Mount Merapi produces more pyroclastic flows than any other volcano on Earth.

    Ask students what they may already know about pyroclastic flows. Some students may have read about pyroclastic flows as they completed the previous research activity. Share information about pyroclastic flows with students and view videos of real-life pyroclastic flow events on YouTube.

9. Inform students that Mount Merapi produces more pyroclastic flows than any other volcano on Earth. In fact, 32 of Mount Merapi's 68 historic eruptions have had pyroclastic flow events associated with them[2]. Mount Merapi pyroclastic flows are generally produced by a dome collapse. In 2010 however, pyroclastic flows were generated during explosive eruption phases.

Modelling Pyroclastic Flows

10. Introduce students to the task: Students will investigate the potential impacts of pyroclastic flows on the villages located around Mount Merapi. Students will use the outcome of their investigations to develop a natural disaster management plan for villages that are likely to be affected by pyroclastic flows.

    Students can work in their original groups of four or five to complete the investigation. Provide students with time to respond to the investigation. If desired, student groups could present the outcomes of their investigation to the class. Students who complete this investigation before their peers may:
    - Develop additional designed solutions to protect industry and farmland surrounding the volcano.
    - Research volcanoes that were once active in Queensland, how they formed, when they were active, why they are no longer active and how we know they existed in the past (i.e. evidence of past activity).

11. Compare student results and responses to real-world pyroclastic flow events that occurred throughout late 2010. You may wish to explore these events, their effects and how authorities and other organisations responded to these threats by sharing the following news articles with your class. After reading, students may be provided with an opportunity to reconsider their natural disaster management plan, explaining changes made.
    - Indonesia's Mount Merapi volcano erupts
      ABC News. Published 27 October 2010
    - Indonesia Mount Merapi volcano erupts again Friday
      CNN. Published 16 November 2010
    - Case study: Volcanic eruption – Mount Merapi, Indonesia 2010
      BBC. n.d.

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[2] *Oregon State University. (n.d.). Volcano World: Merapi. Retrieved from* ***http://volcano.oregonstate.edu/merapi***

Curriculum Links (Version 8.4)

Science

YEAR 6

Science Understanding

Sudden geological changes and extreme weather events can affect Earth's surface (ACSSU096)

Science as a Human Endeavour

Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena and reflects historical and cultural contributions (ACSHE098)

Scientific knowledge is used to solve problems and inform personal and community decisions (ACSHE100)

Science Inquiry Skills

With guidance, pose clarifying questions and make predictions about scientific investigations (ACSIS232)

Identify, plan and apply the elements of scientific investigations to answer questions and solve problems using equipment and materials safely and identifying potential risks (ACSIS103)

Decide variables to be changed and measured in fair tests, and observe measure and record data with accuracy using digital technologies as appropriate (ACSIS104)

Construct and use a range of representations, including tables and graphs, to represent and describe observations, patterns or relationships in data using digital technologies as appropriate (ACSIS107)

Compare data with predictions and use as evidence in developing explanations (ACSIS221)

Reflect on and suggest improvements to scientific investigations (ACSIS108)

Communicate ideas, explanations and processes using scientific representations in a variety of ways, including multi-modal texts (ACSIS110)

Mathematics

YEAR 6

Number and Algebra

Select and apply efficient mental and written strategies and appropriate digital technologies to solve problems involving all four operations with whole numbers (ACMNA123)

Measurement and Geometry

Convert between common metric units of length, mass and capacity (ACMMG136)

Design and Technology

YEAR 5 AND 6

Design and Technologies: Knowledge and Understanding

Investigate characteristics and properties of a range of materials, systems, components, tools and equipment and evaluate the impact of their use (ACTDEK023)

Design and Technologies: Processes and Production Skills

Critique needs or opportunities for designing, and investigate materials, components, tools, equipment and processes to achieve intended designed solutions (ACTDEP024)

Generate, develop and communicate design ideas and processes for audiences using appropriate technical terms and graphical representation techniques (ACTDEP025)

Humanities and Social Sciences: Geography

YEAR 6

Knowledge and Understanding

The geographical diversity of the Asia region and the location of its major countries in relation to Australia (ACHASSK138)

Inquiry and Skills

Locate and collect relevant information and data from primary sources and secondary sources (ACHASSI123)

Work in groups to generate responses to issues and challenges (ACHASSI130)

Reflect on learning to propose personal and/or collective action in response to an issue or challenge, and predict the probable effects (ACHASSI132)

Present ideas, findings, viewpoints and conclusions in a range of texts and modes that incorporate source materials, digital and non-digital representations and discipline-specific terms and conventions (ACHASSI133)

General Capabilities

Literacy

Comprehending texts through listening, reading and viewing

Composing texts through speaking, writing and creating element

ICT Capability

Investigating with ICT

Creating with ICT

Communicating with ICT

Managing and operating ICT

Critical and Creative Thinking

Inquiring – identifying, exploring and organising information and ideas

Generating ideas, possibilities and actions

Analysing, synthesising and evaluating reasoning and procedures

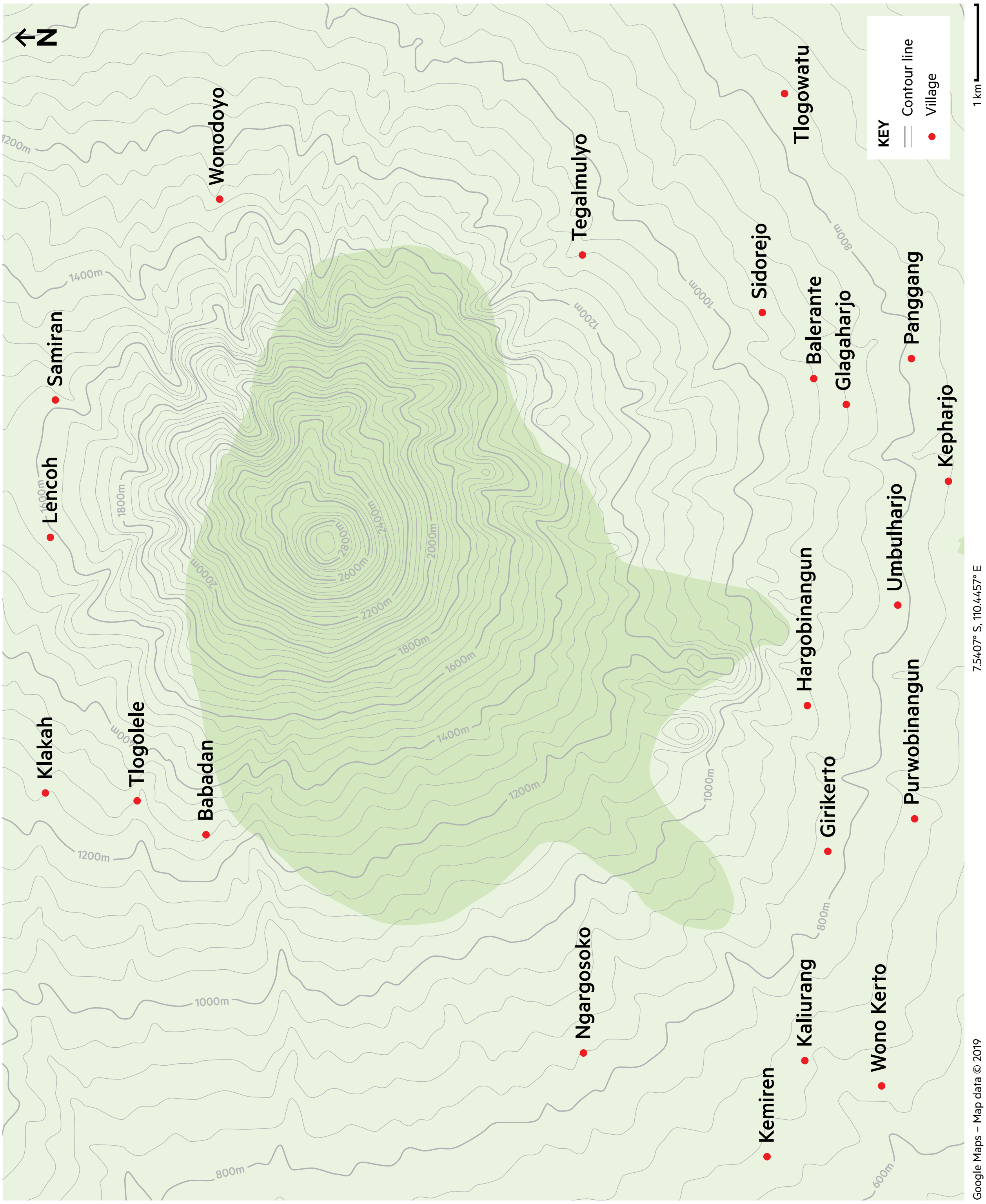
Personal and Social Capability

Self-management

Social management

Topographic Maps

Student Activity



Google Maps – Map data © 2019

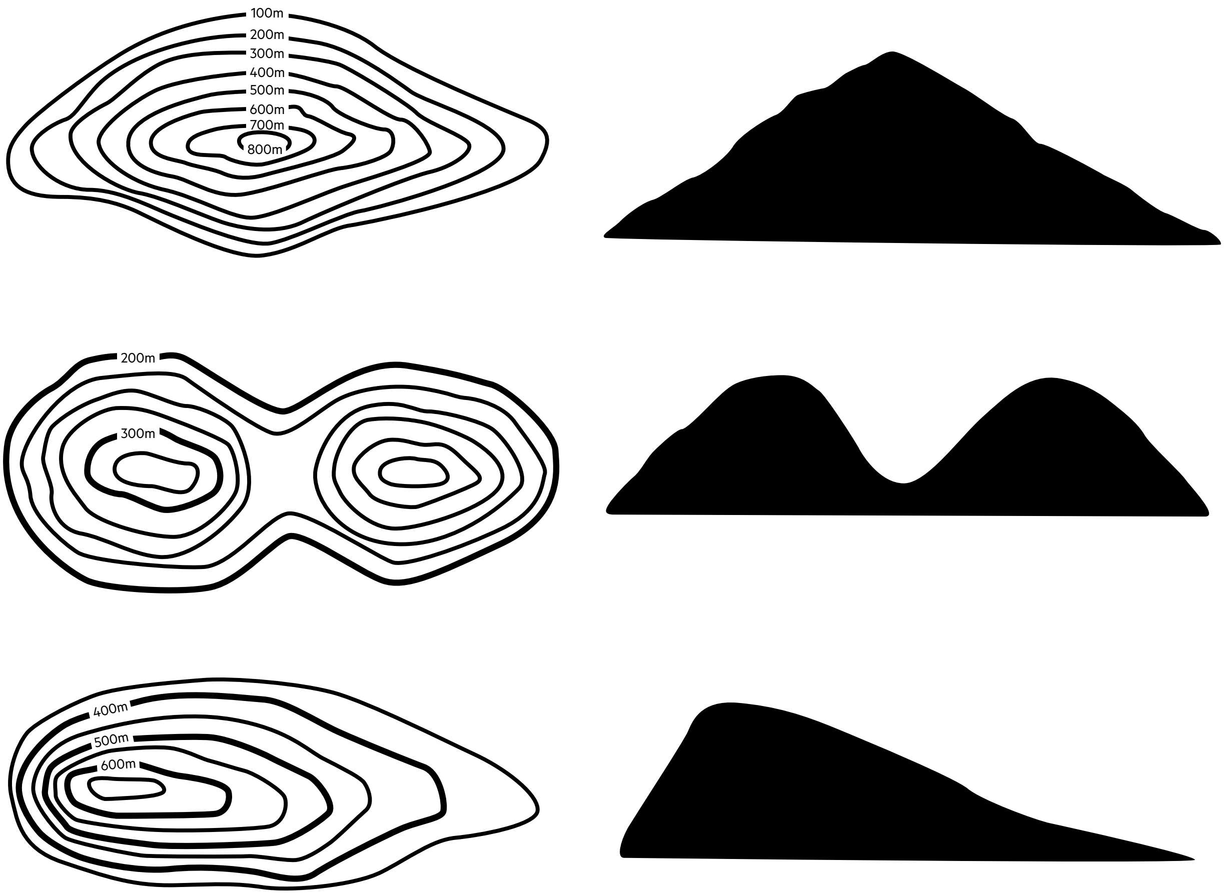
7.5407° S, 110.4457° E

Topographic Maps

Student Activity

Using Topographic Maps

A topographic map shows the varied shapes, heights and slopes of a landscape using lines. These lines are known as contour lines. Contour lines connect points on the land that are the same height above sea level. The height difference, or contour interval, between each line is always the same.



Examples of topographic maps and their corresponding landscapes (not to scale).

Questions

Use the topographic map provided by your teacher to answer the following questions.

1. What is the contour interval for this topographic map?

2. Use your finger to trace an area on the map that is:
    a. 1000 metres above sea level
    b. 680 metres above sea level
    c. 2060 metres above sea level
3. Identify the highest village/s above sea level.
4. Identify the lowest village/s.
5. The closer the contour lines, the steeper the slope. Locate areas on the map that have a very steep slope.
6. Describe what it might mean if the contour lines are farther apart. Locate areas on the map that show this occurrence.
7. Predict what the 3D landform will look like.

Topographic Maps

Student Activity

Building Landscapes

Make a 3D model of a topographic map.

Materials

- Topographic map
- Scissors
- Modelling clay
- Rolling pin
- Modelling tool for cutting
- Toothpicks
- A3 paper

Method

1. Cut along the main contour lines of the map, starting at an elevation of 800 m.
2. Assign two or three of the 11 cut-out contours to each member of your group. Each group member will be responsible for creating a model of their cut-out contours.
3. To make a model of the cut-out contours, place the modelling clay on the paper. Use the rolling pin to roll out the clay to a thickness of approximately 5 mm. Place one cut-out contour on top of the clay. Use a modelling tool to cut the clay around the outline of the contour. Remove the contour layer from the rest of the clay and set aside.
4. Repeat for the remaining cut-out contours until there are 11 contour layers.
5. Stack the contour layers from largest to smallest to make the landscape. Check the original topographic map before stacking to make sure each layer is placed in the correct position.
6. Make thin rolls or ‘sausages’ from the modelling clay and insert these into the ‘steps’ between each layer. Smooth the layers with the rolls using your fingers or a modelling tool. This will help to even out the layers and make the model more life-like. Mark the location of the villages on your model by making indentations in the clay or inserting toothpicks.

Questions

1. Describe the model landscape, including landforms, you have created.

2. How does the landscape compare to your prediction?

Volatile Volcanoes

Student Activity

Mount Merapi

Type of landform:

Location:

Characteristics of the natural environment:

Characteristics of the built environment:

Mount Merapi is a stratovolcano. Mount Merapi is one of Indonesia's most active volcanoes. Its most recent eruption began on 11 May 2018, and has continued until July 2019[3].

All stratovolcanoes (also called composite volcanoes) share similar features and characteristics. You will now conduct research to record information about this type of volcano.

Characteristics of Stratovolcanoes

Diagram:

Physical characteristics:

Formation:

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[3] *Smithsonian Institution – Global Volcanism Program. (n.d.). Mount Merapi: Eruptive History. Retrieved from* https://volcano.si.edu/volcano.cfm?vn=263250#bgvn_201904

Lava viscosity:

Eruption characteristics:

Examples:

Volatile Volcanoes

Student Activity

Investigating Pyroclastic Flows

Pyroclastic flows are fast-moving ‘avalanches’ of volcanic rock and ash, suspended in a cloud of hot gas, that rush down the sides of a volcano as part of some eruption processes.

Pyroclastic flows are extremely dangerous. Small pyroclastic flows can move at 10 to 30 m/s (36 km/h to 108 km/h). Much larger flows can move at up to 200 m/s (720 km/h). Pyroclastic flows are also extremely hot, reaching temperatures between 100 to 800 degrees Celsius.

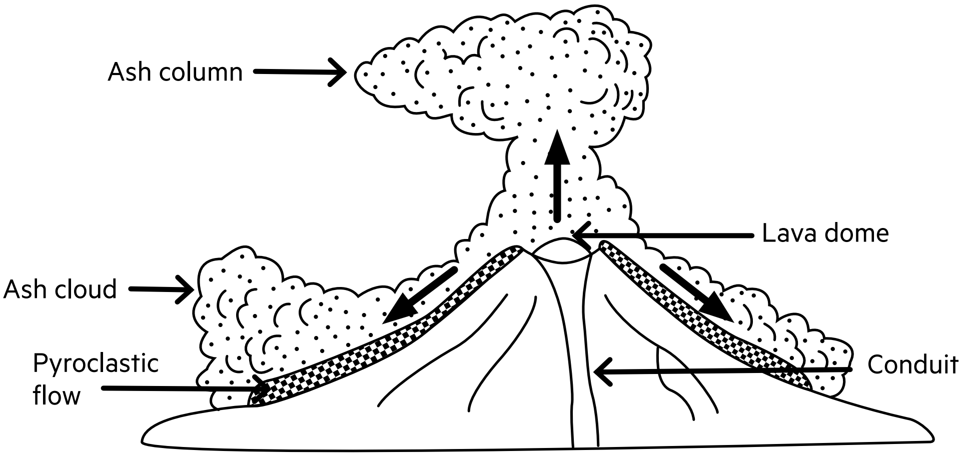
This natural event can flatten and incinerate everything in its path. Pyroclastic flows can therefore be one of the most destructive effects of volcanic activity.

Pyroclastic flows rushing down the side of Mount Sinabung, a stratovolcano in Indonesia.

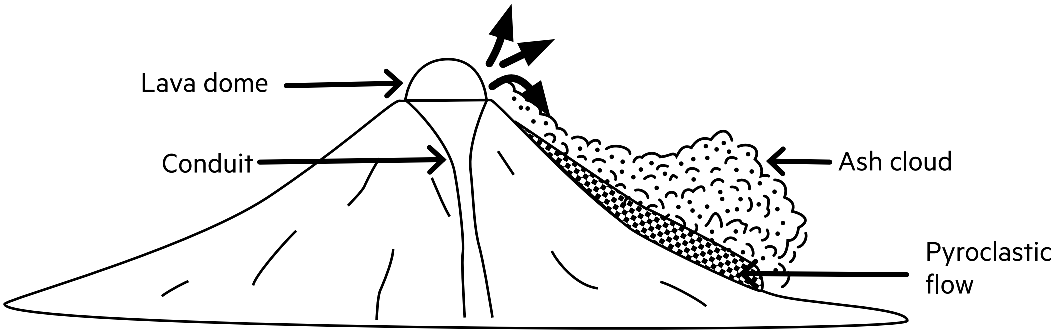
Pyroclastic flows differ to lava flows in a number of ways. Lava flows are characterised by the flow of extremely hot molten rock. Most lava flows can easily be avoided by people on foot as they do not move much faster than walking speed. In contrast, pyroclastic flows do not contain molten rock, but do contain mixtures of volcanic rock fragments, including obsidian and pumice, as well as ash and gas. Pyroclastic flows can move extremely quickly and without sufficient warning can be almost impossible to escape.

Pyroclastic flows can form in three ways:

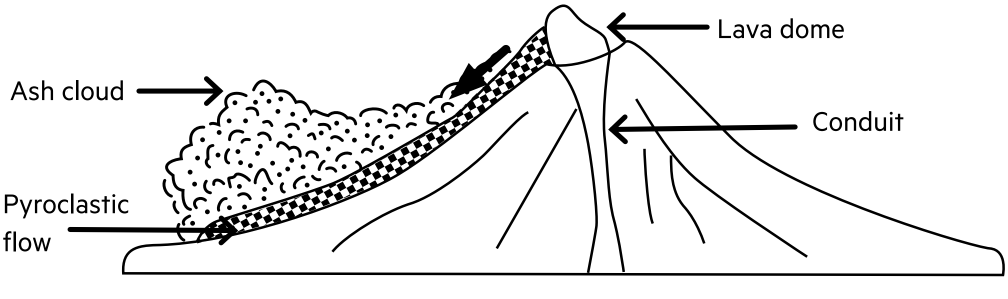
Ash column collapse:
An ash column emerging from the volcano suddenly becomes denser than the surrounding air and collapses. The ash cloud falls back to Earth and rushes down the sides of the volcano.



Dome explosion:
A dome of magma blocks the conduit, the main tube or pathway magma takes to reach the Earth's surface. The dome eventually explodes under pressure, blasting pyroclastic material down one side of the volcano.



Dome collapse:
A dome of magma grows in the crater. The dome grows so large that it eventually collapses under gravity, producing pyroclastic flows that rush down one side of the volcano.



Modelling Pyroclastic Flows

Investigate the potential impacts of pyroclastic flows on the villages located around Mount Merapi.

Develop a natural disaster management plan for villages that are likely to be affected by pyroclastic flows.

Materials

- Mount Merapi model
- Mount Merapi map
- A3 paper
- Pencil
- 250 mL water
- Pipette
- Paper towel
- Recording device, such as a digital camera or iPad
- Coloured pencils

Method

1. Place the model on a piece of A3 paper. Mark the location of any villages that are not shown on the model on the piece of paper.
2. Use a pencil to insert a small hole into the top of Mount Merapi. This hole will represent the volcano's crater.
3. Make a prediction. If pyroclastic flows were to occur, what path/s are they most likely to take down Mount Merapi? Justify your decision and draw the path/s on the map.

4. Fill the pipette with water. The water will represent pyroclastic flows. Place the pipette into the volcano's crater. Holding the pipette vertically and slightly above the plasticine, squeeze the pipette to release the water. Observe where the water flows and draw the path taken by the water on your map. Make sure you use a different coloured pencil to the one used for your prediction. Use a paper towel to dry out the crater.
5. Repeat this process five times, observing and drawing the path the water takes for each trial. You may like to use a recording device to film each trial and then re-watch the footage to help you record results.

Discussion

1. Discuss and explain the results. Were they as predicted? Why/why not?

2. Which villages are most likely to be affected by pyroclastic flows?

3. Evaluate the model.

    a. How could the model be improved?

    b. What other real-life variables could influence the path of pyroclastic flows?

4. Pyroclastic flows travel at an average speed of 30m/s. Use this measurement to determine how long each village in the path of potential pyroclastic flows will have to evacuate when the flows start.

Evacuation times for villages surrounding Mt Merapi

Village	Distance from summit	Time to evacuate

5. Use the outcomes of your investigation and knowledge about pyroclastic flows to develop a natural disaster management plan for local residents. You may like to conduct further online research to complete this task.

Mount Merapi
Natural Disaster Management Plan

Task: Develop a natural disaster management plan to increase the safety of local residents and protect as many lives as possible. You will need to consider three aspects in the development of this plan: a warning system, how residents will be protected from pyroclastic flows and a survival plan.	
Warning system How can you predict a volcanic eruption? How will you inform residents about the likelihood of an eruption and evacuation?	
Protection Develop a designed solution to protect residents from pyroclastic flows.	
Survival plan Steps that will be enacted in the event of a volcanic eruption/emergency.	

ELABORATE

Stone Tools

Teacher Resource

Students have been investigating rocks and minerals, and can identify different types of rocks based on their properties. The properties of an object make it useful for different purposes. For example, you would choose a spoon to eat soup, and a knife and fork to eat steak.

Before people had large-scale manufacturing, many tools were made of stone. You may start this activity with a discussion to gauge background knowledge: How did Aboriginal and Torres Strait Islander People use stone? Students may discuss cutting, grinding, axes etc. They may also conduct research to identify and consider the varieties of stone tools designed and manufactured by Aboriginal and Torres Strait Islander People. How were they used and re-used (for example, tulas, axes, grinding stones and spear heads)? Additional research may be conducted through a visit to Queensland Museum's Discovery Centre to see the stone tools on display, or by searching Queensland Museum Learning Resources to see some of the stone tools in Queensland Museum's collection.

Thousands of years of Aboriginal and Torres Strait Islander research went into the manufacture and improvement of stone tools. Specialty stones and tools could travel hundreds of kilometres from quarry sites. We can identify where a stone tool originated by looking at the elemental composition of the rock used to make the tool, and by comparing this with the composition of quarry sites and rock outcrops.

Aboriginal people were the first Australian botanists, chemists, geologists and zoologists. They developed a deep knowledge of the dangers, possibilities and dynamics of the natural world that enabled Aboriginal people to manage diverse environments for over 60,000 years. It is important to recognise that Indigenous scientific practices have great antiquity, and are carefully embedded within Aboriginal culture. Indigenous science knowledge continues to inform contemporary culture.

Analysing Materials

The properties of a stone determine what it may be used for. In this activity, students will justify what type of stone would be best for making different tools (e.g. cutting tool or grinding tool), and analyse how the properties of stone determine its use. Students may wish to observe and handle different stones when assessing the advantages and disadvantages.

As an additional activity, students could investigate how stone tools were made and try to make their own tool out of a selected stone. If you choose to conduct this activity with students please ensure the risks are carefully controlled. Additionally, making stone tools took thousands of years of research and much practice. Students are unlikely to achieve success, however this can lead into important discussions about the amount of expertise, technology and knowledge required by Indigenous people to make effective tools. You can find some excellent video tutorials online about the production of stone tools.

The *Morah* Stone and Investigating Grinding

The *morah* stone is a grinding and grating tool, used by Aboriginal people in northern Queensland to process toxic seeds and kernels. More information about this amazing tool can be found in the student activity. Students will learn about the *morah* stone using information from Queensland Museum, and then conduct their own investigation to determine what materials may make effective grinding tools and why.

More on the *morah* stone and the processing of poisonous plants can be seen in the *First Scientists* display in the Discovery Centre on Level 4 of Queensland Museum in Brisbane. A *morah* stone can also be found in a Queensland Museum loan kit Aboriginal Science: Rainforest. You can see examples of other stone tools in the Queensland Museum collection by searching ‘stone tool’, ‘grindstone’, ‘axe’, ‘tula’ etc. on Queensland Museum Learning Resources.

In this activity, students will conduct an investigation to assess the potential for materials to be used for grinding. Students may develop their own investigations or you may wish to supply set materials. For example, students could use sandpaper with different grit to grind a chestnut or 1 cm^3 piece of raw potato to investigate the effect of surface roughness. We would not recommend students use Zamia Palm, Black Bean or Cycad seeds due to their toxicity.

The scientific report should be specific to the materials and investigation students have selected, and they should control variables for a fair experiment.

NB: Should you find an artefact or quarry site there are a couple of very important things to keep in mind. Firstly, do not move the artefact. Artefacts always reveal the most information when their context is recorded as well, including their exact location and associated geological layer. The next thing to do is to contact the Department of Aboriginal and Torres Strait Islander Partnerships *on 13 74 68 or enquiries@datsip.qld.gov.au, so their trained staff can help manage and document the discovery.*

NB: When studying rock artefacts, archaeologists use the term stone rather rock. In this activity we will use similar terms to archaeologists, hence the use of the word stone. Stone tools may also be referred to lithics or geological resources.

For further information on *morahs* please see the following:

Field, J., Cosgrove, R., Fullagar, R., and Lance, B. (2009). Starch residues on grinding stones in private collections: A study of *morahs* from the tropical rainforests of NE Queensland. In Archaeological Science Under a Microscope: Studies in Residue and Ancient DNA Analysis in Honour of Thomas H. Loy (pp. 228–238). Retrieved from http://press-files.anu.edu.au/downloads/press/p123961/pdf/17.pdf

Curriculum Links (Version 8.4)

Science

YEAR 8

Science Understanding

Sedimentary, igneous and metamorphic rocks contain minerals and are formed by processes that occur within Earth over a variety of timescales (ACSSU153)

Science as a Human Endeavour

Science knowledge can develop through collaboration across the disciplines of science and the contributions of people from a range of cultures (ACSHE226)

Science Inquiry Skills

Identify questions and problems that can be investigated scientifically and make predictions based on scientific knowledge (ACSIS139)

Collaboratively and individually plan and conduct a range of investigation types, including fieldwork and experiments, ensuring safety and ethical guidelines are followed (ACSIS140)

Measure and control variables, select equipment appropriate to the task and collect data with accuracy (ACSIS141)

Construct and use a range of representations, including graphs, keys and models to represent and analyse patterns or relationships in data using digital technologies as appropriate (ACSIS144)

Summarise data, from students' own investigations and secondary sources, and use scientific understanding to identify relationships and draw conclusions based on evidence (ACSIS145)

Reflect on scientific investigations including evaluating the quality of the data collected, and identifying improvements (ACSIS146)

Use scientific knowledge and findings from investigations to evaluate claims based on evidence (ACSIS234)

Communicate ideas, findings and evidence based solutions to problems using scientific language, and representations, using digital technologies as appropriate (ACSIS148)

Design and Technologies

YEAR 7 AND 8

Design and Technologies Knowledge and Understanding

Analyse ways to produce designed solutions through selecting and combining characteristics and properties of materials, systems, components, tools and equipment (ACTDEK034)

Design and Technologies Processes and Production Skills

Critique needs or opportunities for designing and investigate, analyse and select from a range of materials, components, tools, equipment and processes to develop design ideas (ACTDEP035)

Select and justify choices of materials, components, tools, equipment and techniques to effectively and safely make designed solutions (ACTDEP037)

Independently develop criteria for success to evaluate design ideas, processes and solutions and their sustainability (ACTDEP038)

Cross-Curriculum Priorities

Aboriginal and Torres Strait Islander Histories and Cultures

Aboriginal and Torres Strait Islander communities maintain a special connection to and responsibility for Country/Place. (OI.2)

Aboriginal and Torres Strait Islander Peoples' ways of life are uniquely expressed through ways of being, knowing, thinking and doing. (OI.5)

Stone Tools

Student Activity

Analysing Materials

Stone has been used to make tools by people and our ancestors for many millennia. Over thousands of years people have refined methods for making tools from a variety of stone, and developed different tools to do different jobs and respond to changing needs (for example, increasing population, changing trade networks, and changing environments and social and cultural customs). Stone artefacts provide useful clues that can tell us about the lives of people who manufactured, traded and used them. For example, individual tools can be tracked back to their quarry sites sometimes hundreds of kilometres away, providing information about trade and travel.

Effective rock types (stone) for the manufacture of different tools

Type of Tool	Properties Required	Rock Type	Justify how you selected the rock type

Additional activity: Create a stone tool out of a material you selected in the above table.

The *Morah* Stone and Investigating Grinding

How do the properties of a stone tool determine their use?

The *morah* stone is no ordinary rock. To the Aboriginal people of the northern Queensland rainforest, this stone technology aided their ability to survive, sustain themselves and prosper. This is because the *morah* stone was used to process toxic plants such as the Zamia Palm (*Lepidozamia hopei*), Black Bean (*Castanospermum australe*) and Cycad (*Cycads media*). The Bama people knew about the toxicity of these plants and, through scientific processes, discovered how to extract the toxin from them. The *morah* stone was invented as an aid in extracting toxins from the seeds of the toxic plants.

The *morah* stone is a specialised grooved grindstone formed from slate, a smooth, flat metamorphic rock. Slate has a low water absorption index. This is important because when toxic seeds are ground using the *morah* stone, toxic materials are not absorbed by the rock and will not contaminate other food. Slate is also fireproof, has a level of resistance to breakage and is easily portable. It is a very handy tool. Most *morahs* have roughly parallel incised grooves running across the grinding surface perpendicular to the axis of the stone. These grooves or incisions would most likely have been made with a sharp, hard rock such as quartz or granite, a pointed bone or piece of sharp coral. The grooves increased the friction for grinding, and helped to separate the plant pulp and liquid.

Seeds or kernels were placed on the incised *morah* stone and the *moogi*, usually a harder stone, was placed on top. A rolling pushing and pulling motion was used to grate and grind the seeds or kernels using the *moogi*. This motion across the stone over the incised grooves facilitated the efficient breakup of the starchy kernels to create a powder which could then be used to make a type of damper or bread. Before this powder could be used however, it was placed in a basket in running water to leach the remaining toxins from the material.

How do we know which seeds were processed? The residue analysis from some *morah* stones found in northern Queensland revealed the specific types of seeds which were ground down. Food sources such as the Zamia seeds provided a high carbohydrate, protein and energy diet as well as being low in fat. Six species of toxic plant sources in the rainforest provided and formed part of the Bama people's staple food source, and they were cultivated in groves to increase the production of food resources. This readily-available, high-energy food source allowed Bama people to settle on a more permanent basis in the rainforest.

Questions

1. What were the properties of *morahs* that made them useful for processing toxic seeds?

2. Write the procedure used to process the toxic seeds.

3. What kitchen tools could we use today to complete this process?

More on the *morah* stone and the processing of poisonous plants can be seen in the *First Scientists* display in the Discovery Centre on Level 4 of Queensland Museum. Here you can learn more about the Indigenous cultivation of the land to grow important food sources, and the engineering of bicornual baskets.

You can see examples of other stone tools in Queensland Museum's collection at Queensland Museum Learning Resources. You may wish to try search terms such as 'flake', 'grindstone' or 'axe'.

Additionally, you can learn more about the work of Nick Hadnutt, an archaeologist at Queensland Museum, in the ABC article, Archaeology more down to earth than high adventure of Indiana Jones.

The *Morah* Stone and Investigating Grinding

Investigating Grinding

The grooves were made in the *morah* stone to increase the friction as seeds were pushed across the surface, making the stone more effective for grating and grinding seeds and kernels.

In this activity, you will design and conduct your own experiment to investigate how the properties of materials affect their ability to be used as an effective grinding tool.

Structure of a Scientific Investigation

Aim: Statement about what the experiment will do. Often this statement starts with to investigate or to determine. For example, *to investigate how the surface roughness of a material affects the ability to grind a piece of coconut.*

Introduction: Give background information on the topic being investigated, and explain the purpose of the experiment and how it will be conducted.

Hypothesis: Write an educated prediction as to the outcome of the experiment. This must incorporate the independent variable and the dependent variable. Remember to justify the hypothesis by giving reasons for why the particular prediction was made.

Variables: Include an independent variable (variable that is purposely changed), a dependent variable (variable that is measured), and at least five control variables (variables that are kept the same for a fair experiment).

Materials: List all equipment used in the experiment, include number and amounts.
E.g. 4 x 250 mL beakers.

Method/ Procedure: List the steps taken to conduct the experiment. Remember, there should be enough detail for someone else to pick up the method and conduct the exact same experiment, and the method should be written in past tense.

Risk Assessment: What safety considerations must be made before, during and after this experiment? Include AT LEAST five hazards and how to minimise them.

Results: Include both qualitative observations and quantitative data. Record the results in a table. Use Microsoft Excel to graph the results, and briefly summarise the observations in a paragraph.

Discussion: Analysis of results and experimental design.

- Describe what the results found. Include data in the analysis.
- Explain if the results support or do not support (refute) the hypothesis.
- How do the results compare with the information in the introduction?
- Give possible reasons for why the results occurred. Include background knowledge, and an explanation for any inconsistent or unexpected results.
- What problems were encountered and how could these be overcome in future investigations?
- Evaluate the experiment and results:
  - Were the results fair? (Were all the control variables kept the same throughout the experiment?)
  - Were the results reliable? (Has the experiment been repeated many times with similar results?)
  - Were the results accurate? (Were the measurements precise?)
- Suggest how the experiment could be improved in the future.
- Explain future experiments that would be useful for collecting further information, and answering unknown questions.
- Where is this experiment useful or important to real life?

Conclusion: Summarise the experiment and the results. Was the hypothesis supported or refuted?

References: List all sources in a consistent format and include in-text referencing in the introduction and discussion.

ELABORATE - EVALUATE

Time Warp

Teacher Resource

Our Earth is constantly changing. In this activity students will explore these changes, and the evidence left behind.

Going Forward

The formation of rocks, minerals and resources depend largely on environmental conditions, and the forces and energy available. In *Time Warp: Going Forward* students will analyse images of different environments and predict the type of rock and/or resource that will form. There may be multiple answers considered correct as many rocks are formed in similar environments, and small differences in environments can result in the formation of very different rocks. For example, the volcanic environment can result in the formation of many igneous rocks, as well as sedimentary tuff. As a result, it is very important that students justify their answers.

This activity can be completed following the introductory video of Zana Williams, a geologist from Shell's QGC business. This video will introduce how some common rocks and resources are formed. You may wish for students to complete *Time Warp* to demonstrate their existing knowledge, or complete it as research task.

Reproducing the Past

Core samples are used by geologists to evaluate available resources in a given area. The five metre core sample in this activity has been donated by Shell's QGC business. It is a small section of a larger 435 metre core produced from a site between Chinchilla, Dalby and Tara in the Western Downs, Queensland. This area is part of the Walooon Subgroup Coal Measures, an area of coal laid down during the Jurassic Period, 201 to 145 million years ago. In the formation of this coal, trees and plant material died, fell to the ground, and were gradually compressed. Under the immense pressure, the decomposing vegetation would first be converted into peat then eventually coal. It takes approximately 30 metres of decomposing vegetation to form one metre of coal!

In this activity students will analyse the core sample, and use information provided from the core sample to infer what the environment was like in the past, and how it changed over time.

Time Warp: Fossil Evidence

We can learn much about past environments by looking at rocks; however fossils are required to help us understand life on Earth throughout geological time. Through fossils, scientists at Queensland Museum, and throughout the world, can extrapolate information on climate, feeding relationships, evolution and more. We can learn how living things responded to change in the past to predict the impact of human and natural changes on our environment today. As we head toward a human-induced mass extinction event, past extinction events can also provide warning signs for the future.

In this activity students will reconstruct the layers of sedimentary rocks using the fossil record to determine the order of the layers. It is recommended that students start with the current period – the layer containing humans. They then identify the layer that has the most common fossils to the current day to find the next layer of rock, and so on. You may check student answers by comparing the order of their sedimentary rock layers against the geological timescale. Remind students that like a core sample, the most recent fossils and most recent layer of sedimentary rock will be at the top, and the oldest rock will be at the bottom of their layers.

You may wish to share the video of Dr Espen Knutsen, a palaeontologist at Queensland Museum as he discusses his experiences in palaeontology and how he got there. Further information on the geological and fossil history of Queensland can be found in *Lost Creatures* on Level 2 at the Queensland Museum in Brisbane, as well as in our loan kits. Additionally, the book, In Search of Ancient Queensland showcases Queensland's unique landscapes, fascinating geology and incomparable fossils.

Curriculum Links (Version 8.4)

Science

YEAR 8

Science Understanding

Sedimentary, igneous and metamorphic rocks contain minerals and are formed by processes that occur within Earth over a variety of timescales (ACSSU153)

Science Inquiry Skills

Construct and use a range of representations, including graphs, keys and models to represent and analyse patterns or relationships in data using digital technologies as appropriate (ACSIS144)

Communicate ideas, findings and evidence based solutions to problems using scientific language, and representations, using digital technologies as appropriate (ACSIS148)

General Capabilities

Literacy

Comprehending texts through listening, reading and viewing

Composing texts through speaking, writing and creating

Word knowledge

Visual knowledge

Critical and Creative Thinking

Inquiring – identifying, exploring and organising information and ideas

Identifying, exploring and organising information and ideas

Reflecting on thinking and processes

Analysing, synthesising and evaluating reasoning and procedures

Time Warp

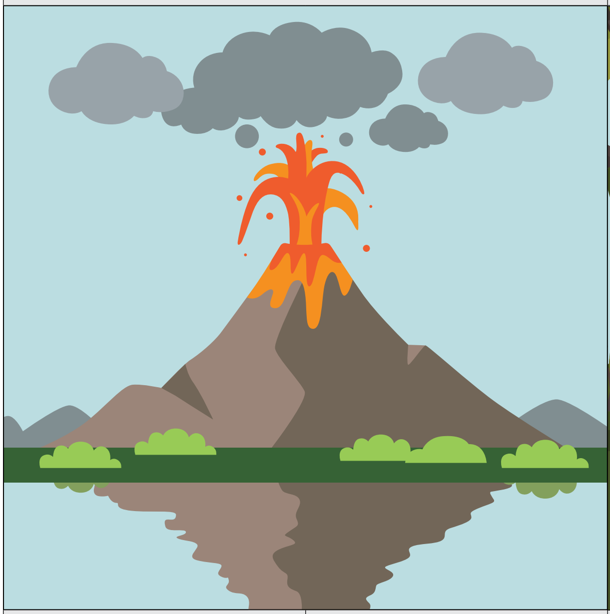
Student Activity

Time Warp: Going Forward

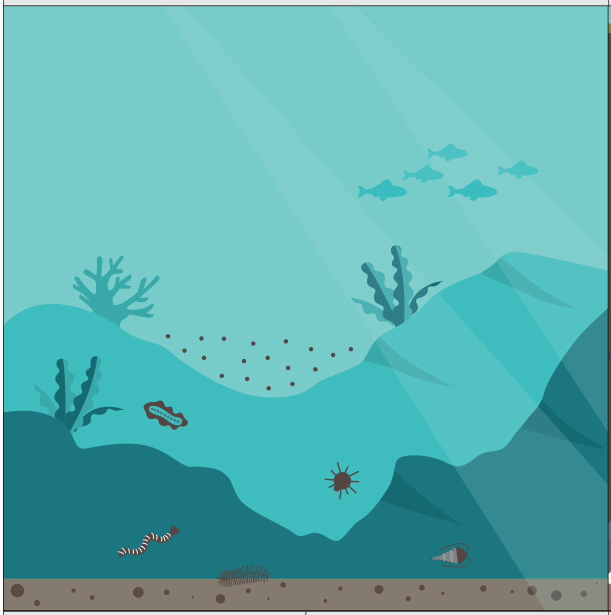
The history of environments and life on Earth can be told through rocks. Over millions of years, sediments such as sand and silt are laid down and compressed to form sedimentary rock layers. These rock layers preserve a record of ancient landscapes, climates and life. The types of rock formed also tell stories about the environment, for example: was the land volcanically active?

Below you will find images of different environments. Analyse the image and predict what rock and/or resource may be formed from the environment. Remember to give reasons for your answers.

What rock and/or resource would be formed in this environment?

<table>
<tr><th colspan="2">Volcanic Environment</th><th colspan="2">Swamp</th></tr>
<tr><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Rock/Resources Formed</td><td>Formation Time</td><td>Rock/Resources Formed</td><td>Formation Time</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Justification</td><td colspan="2">Justification</td></tr>
<tr><td colspan="2"></td><td colspan="2"></td></tr>
</table>

What rock and/or resource would be formed in this environment?

<table>
<tr><th colspan="2">Shallow Ocean</th><th colspan="2">Fast Flowing River</th></tr>
<tr><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Rock/Resources Formed</td><td>Formation Time</td><td>Rock/Resources Formed</td><td>Formation Time</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Justification</td><td colspan="2">Justification</td></tr>
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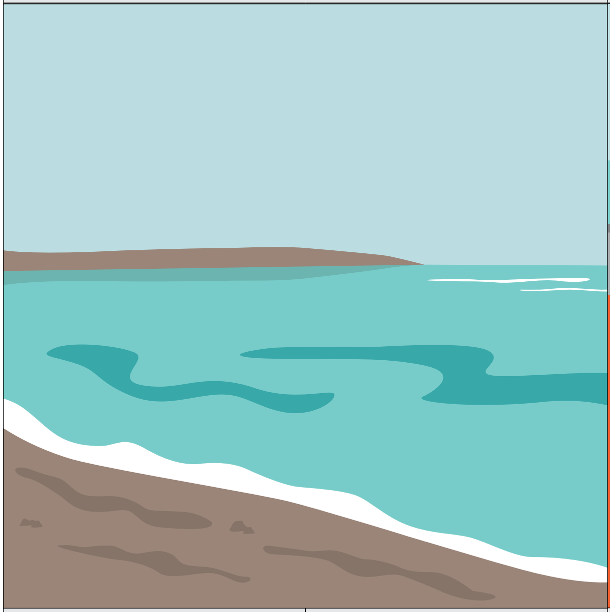
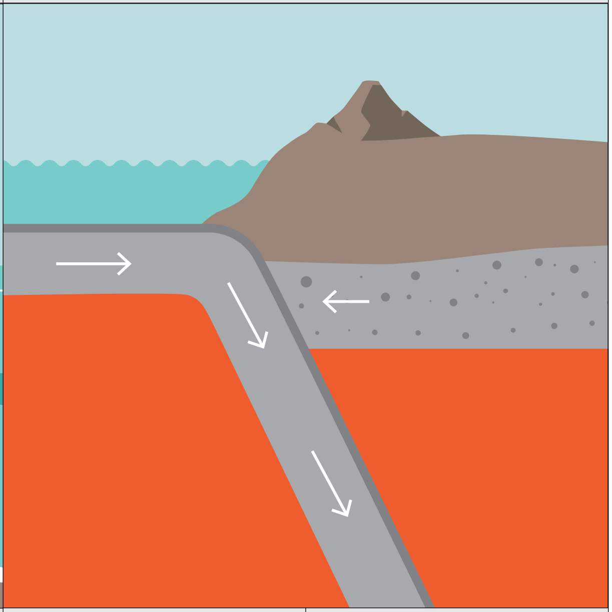
</table>

What rock and/or resource would be formed in this environment?

<table>
<tr><th colspan="2">Low Energy Lake</th><th colspan="2">Subducting Plate Boundary</th></tr>
<tr><td colspan="2"></td><td colspan="2"></td></tr>
<tr><th>Rock/Resources Formed</th><th>Formation Time</th><th>Rock/Resources Formed</th><th>Formation Time</th></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><th colspan="2">Justification</th><th colspan="2">Justification</th></tr>
<tr><td colspan="2"></td><td colspan="2"></td></tr>
</table>

Time Warp: Reproducing the Past

We are going back in time to see how an Australian environment has changed throughout history. Rock core samples can show us the depositional environment at the time a rock was formed; for example, coal is formed in a swampy, anoxic environment with lots of trees present. Mudstone forms in drier environments with more fine sediment and less organic material, and sandstone is formed when there is a higher energy accumulation to transport larger sediment.

To the right is a picture taken in the Western Downs, Queensland. We are going to analyse a rock core sample extracted from this area to examine the changes in the environment through time. The rock sample and expertise were generously donated by Shell's QGC business.

Present day environment near the core sample site in the Western Downs, Queensland.

1. Describe the present-day environment by examining the image above.

2. Analyse the rock core sample to explain how the environment changed throughout time.
   a) Observe the core sample.
   b) Draw a key to identify each rock type found in the core.
   c) Complete the chart below to show how the rocks change throughout the 5 m core sample (please note this is a section of a much larger core sample). Use your key to show each rock type in the chart.
   d) Label the rocks throughout the core.
   e) Infer the environment that existed in this location when each rock was formed, and describe how the environment changed through time.
   f) Choose one section of the core and draw a diagram of the environment at the time the rock was formed.

Rock Type **Core Sample** **How was the rock formed?**

Describe the environment at the time of rock formation.

Scale 1:10

Rock Type **Core Sample** **How was the rock formed?**

Describe the environment at the time of rock formation.

Scale 1:10

3. Contrast the changes you identified throughout the core, with the present environment shown in the picture. How was the environment different?

4. Approximately 30 metres of debris is compressed over hundreds of millions of years to create 1 metre of coal.

   Explain if the present environment shown in the picture will create resources such as coal, oil and/or gas in the future? Give reasons for your answer.

5. 300 million years have passed and humans of the future have taken a core sample in the area shown in the picture. What might you see in the section of the core sample relating to the present day?

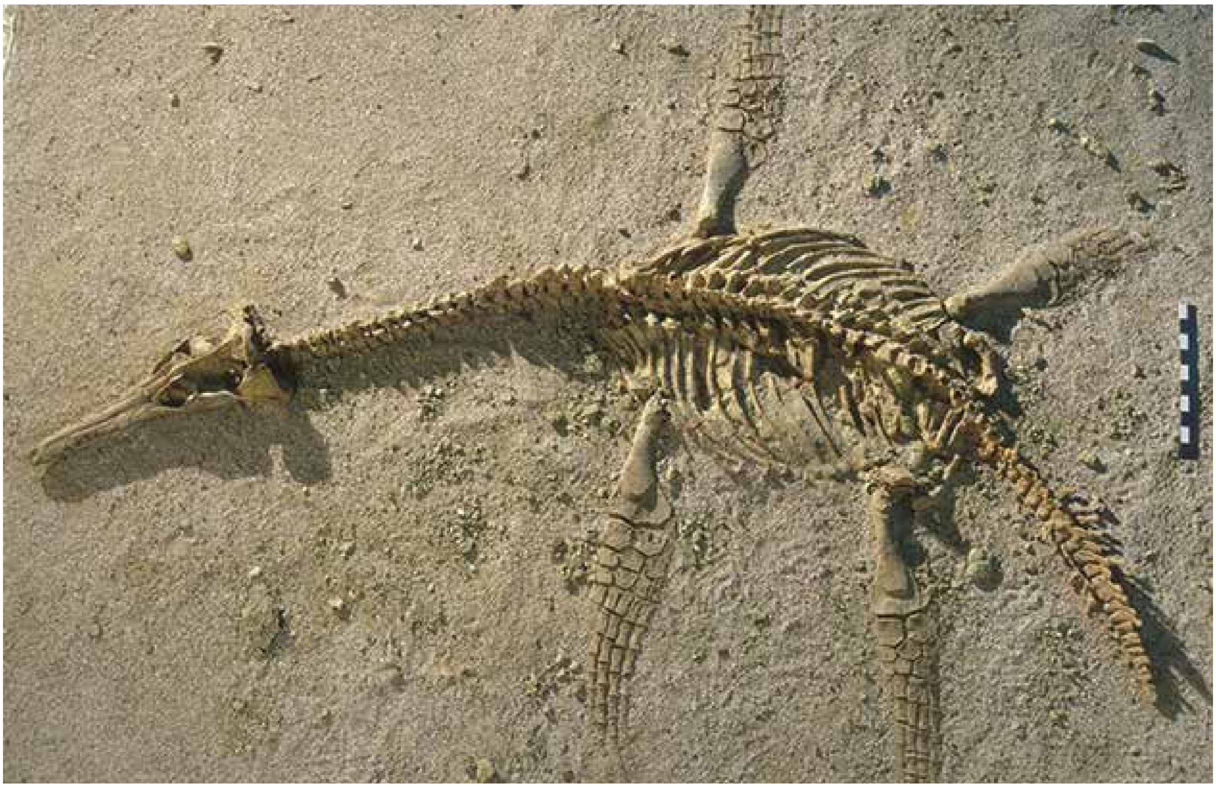
6. In 300 million years, future civilisation is completing a core sample to learn about life during the 21st century. Where would you recommend they take the core, and why?

Fossil Evidence

Fossils are the preserved remains, impressions or traces of plants, animals and other life forms. Queensland's fossil record stretches across some 1.65 billion years and it is preserved almost entirely in sedimentary rocks. The history of the Earth's surface can be told by looking at the fossils that have been found from different time periods. It is through the study of the fossil record that scientists can trace the evolution of life.

Over millions of years, sediments such as sand and silt were laid down and compressed to form sedimentary rock layers. These rock layers preserve a record of ancient landscapes, climates and life forms. Fossils are found in many, but not all, sedimentary rocks, including limestones, sandstones, shales and mudstones. They are not found in igneous rocks and rarely in metamorphic rocks. Due to the long timeframes, weathering and erosion has obliterated much of the fossil record across Australia, however the records that we do have are internationally important due to our unique flora and fauna.

Explain why fossils are found mostly in sedimentary rocks, sometimes in metamorphic rocks and never in igneous rocks.



The Richmond Plesiosaur, discovered in 1990, is the most complete fossil of its type in Australia. Due to weathering and erosion it is rare to find such a complete fossil specimen. The Richmond Plesiosaur is from the Great Inland Seas of Queensland 100 – 150 million years ago. It is likely that it was very old when it died because these are traces of arthritis in its neck and thorax identified as the bones are irregular and rough, rather than smooth healthy bone. There is also a bite mark in the hind quarters that shows signs of healing. QMF18041, QM, Jeff Wright

Dating Rocks

Scientists at Queensland Museum use two methods to determine the age of rocks – direct and indirect dating. Direct dating uses natural radioactive isotopes to determine the exact age of rocks and fossilised materials. Some isotopes in rocks and minerals are unstable and decay at a consistent rate. The amount of each isotope is measured and from this the age of the rock can be calculated. However, sedimentary rocks are not as reliable for radioactive dating because they consist of recycled fragments of other rocks so only provides direct dates of the source/parent rock.

Indirect dating uses fossils found within a rock and the position of a rock in its geological sequence to provide a relative estimate of age. Scientists often determine the correct sequence of sedimentary rock layers using the fossils found within them. They compare the fossils to figure out if two layers are from the same geologic time period, or if one layer is older than the other.

Certain genus of Ammonite are used as index fossils and can be found in rocks of the same age around the world. It is through fossils such as these that global and regional correlations in time and evolution can be made. Queensland Museum, Peter Waddington

Task

Reconstruct the layers of sedimentary rock below, which contain a selection of ancient Queensland fossils. These fossils tell a story about what the landscape was like in ancient Queensland and how it has changed over time. The Queensland time periods represented in this activity are indicated on each layer.

Instructions

a. Cut out the six (6) layers.

b. Based on the fossils in the images, put the layers in correct order with the most recent time period at the top, and the oldest at the bottom. Clue: The most recent layer includes humans.

c. Decide which layer comes next by looking closely at the life-forms. It will have some of the same life-forms as the older layer but will also include some new ones. Hint: Life-forms do not disappear for a layer then reappear. Why?

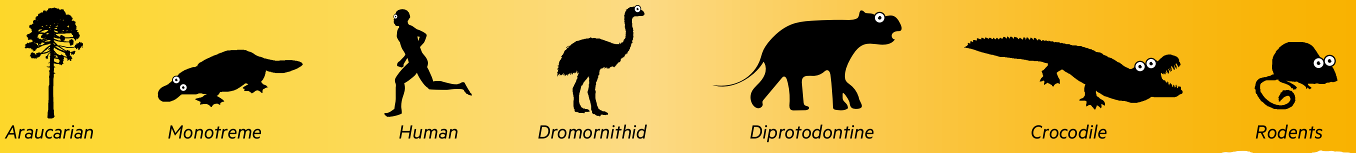
d. Once you have the layers in order from newest to oldest, stick them down in order and check your answers.

More incredible Queensland fossils and stories can be found in *Lost Creatures* on Level 2 at Queensland Museum in Brisbane.

Jurassic Period

Cretaceous Period

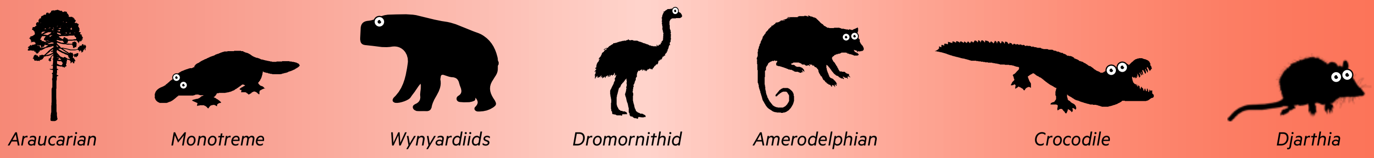
Quaternary Period



Triassic Period

Neogene Period

Palaeogene Period



1. What do the fossils found in each of these layers tell you about the landscape of ancient Queensland?

2. Starting from the top, why are there so many differences between layer 1 & 2, and between layer 3 & 4? What might have happened during these time periods?

3. What can we learn from fossils that we cannot identify from studying rocks?

4. Examine the fossils in each layer. What can you learn about the evolution of living things in Queensland from these fossils?

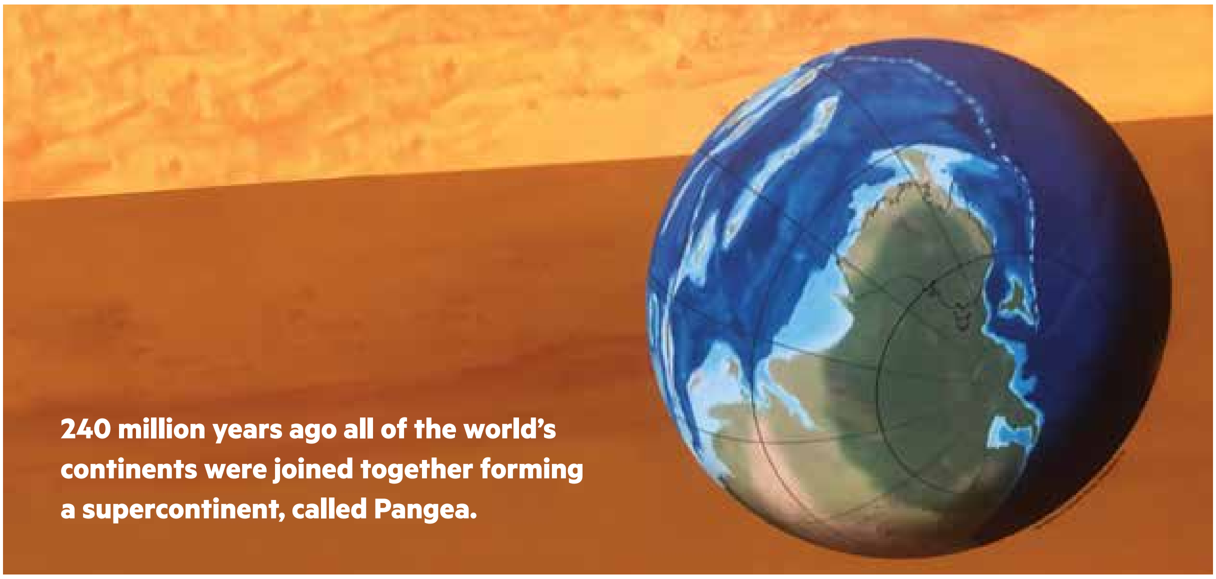
5. Read the *Changing Surface of the Earth* below, and plot the major time periods and conditions of Queensland on a timeline.

The Changing Surface of the Earth

Queensland has a diverse and complex geology that reflects the varying origins, many environments and different time periods that have helped shape the state's modern topography. Most of the world's major divisions of geological time are represented in the rocks and landforms that occur across Queensland, with the exception of the Archean Era (3800-2500 million years ago). During this very ancient time period, the Earth's crust began to stabilise and the primordial atmosphere and earliest oceans came into being.

Triassic Period—Queensland

252–201 million years ago



240 million years ago all of the world's continents were joined together forming a supercontinent, called Pangea.

The Triassic Period was the beginning of the Age of Dinosaurs and it was marked by continuing climatic and environmental change. On a global scale, the climate varied from hot and dry at the beginning of the Triassic to warm and wet in the later stages. However, Australia experienced cooler conditions because it was further south than it is now.

At this time, Australia was part of Gondwana and was joined to Africa, South America, Antarctica and India. In the early Triassic, erupting volcanoes continually reshaped the eastern edge of Gondwana. Inland, vast rivers flowed across the endless plains dotted with lakes.

During the late Triassic, extensive wetland areas formed in what is now northern New South Wales and south-east Queensland and there were also forests of conifers, cycads and ferns. Some of Australia's major coal deposits were formed within this ancient environment.

The first dinosaurs are known from this time and footprints of these animals have been found in eastern Australia. Amphibians and fishes lived in the lakes and streams and strange creatures who were the ancestors of mammals walked the land.

Jurassic Period—Queensland

201–145 million years ago

150 million years ago Australia was connected to Antarctica forming part of a new supercontinent, called Gondwana.

Gondwana was made up of the present day continents of Australia, New Zealand, Antarctica, South America, India, Africa and Madagascar.

A Time for Giants!

Australia still looked very different from the continent we know today. It remained part of the supercontinent of Gondwana, but Africa and South America started to break away.

The warm Jurassic climate and massive networks of fast-flowing rivers carrying sediment through deep valleys created a rich covering of vegetation throughout Australia. Thick pine forests with an understory of ferns and cycads sheltered dinosaurs and other animals.

Horsetails, ginkos and other plants were common. Dinosaurs were the dominant life form.

Cretaceous Period—Queensland

145–66 million years ago

105 million years ago Africa and India have split away from Gondwana leaving Australia and South America connected to Antarctica.

The Great Inland Seas

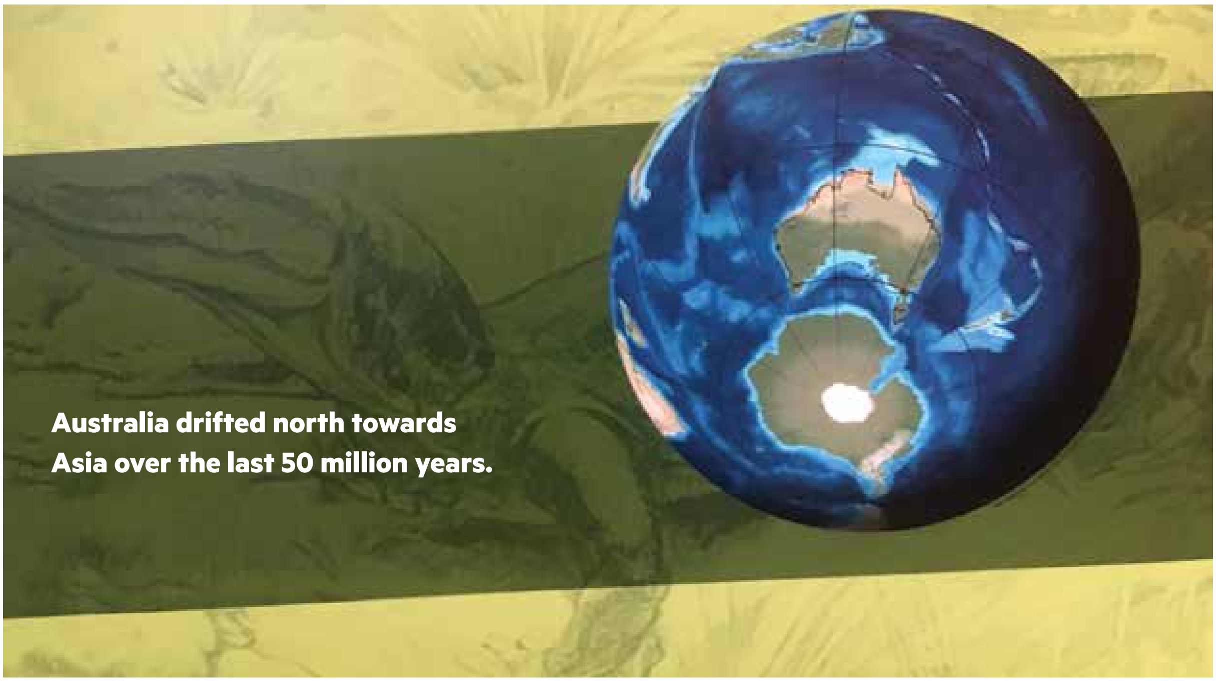
Australia was still well south of the equator, at latitude 55°S, but was slowly travelling north and rotating in an anti-clockwise direction. Violent volcanic eruptions and movements in the Earth's crust were tearing eastern Gondwana apart.

At different times during the Cretaceous Period, eastern Australia was inundated by five separate inland seas. The largest inland sea, about 110 million years ago, covered one-third of the land mass. The shallow waters of the inland seas supported marine reptiles, turtles, sharks and other fish. Giant squid up to 4m long roamed the depths and other squid-like animals such as ammonites, belemnites and nautiloids darted through the cool waters.

Beneath the surface, a wide muddy sea floor stretched for hundreds of kilometres. Conditions were poor, but clumps of sponges, marine plants and oyster-like bivalves, with crabs and lobsters scuttling in between, managed to survive. At the edges of this great sea, dinosaurs browsed on vegetation and pterosaurs hunted for fish. Occasionally, after they died, the bodies of these terrestrial animals were washed into the sea. Today they are found as fossils in the rocks of the Great Artesian Basin.

Palaeogene Period—Queensland

66–23 million years ago



First large mammals appear — 66–56 million years ago

Oligocene extinction event — 56–34 million years ago

Mammals are dominant — 34–23 million years ago

The mass extinction of 66 million years ago marks the end of the dinosaurs and the emerging dominance of mammals. Survivors of this catastrophic event include the mammals, lizards, snakes, frog and crocodiles, and the last surviving group of dinosaurs – the birds.

Australia's final separation from Antarctica occurred during the Palaeogene, as Australia began its slow transit north toward Asia. As an island, our species evolved into animals unlike anywhere else on Earth. This includes unique species of kangaroos, emus and koalas.

The journey north to our present position took millions of years and formed a new southern seaway, the Southern Ocean. Tectonic forces in the east caused buckling along the edges of the Australian continent, lifting the crust by a few hundred metres. A small subsidence to the west also resulted in a series of shallow depressions, including the formation of the Lake Eyre Basin.

Deep weathering and erosion in western Queensland occurred during this period due to high precipitation levels and a warm, humid climate. This resulted in the formation of most of Queensland's opal deposits. Opal is Australia's principal gemstone, with more than 95% of the world's precious opal originating from the rocks of the Great Artesian Basin. In Queensland's south-east this was also the period of peak volcanism.

Neogene Period—Queensland

23–2.6 million years ago

Grasses become widespread — 23–5.3 million years ago

Human ancestors (Hominids) appear — 5.3–2.3 million years ago

The Neogene Period marked the great drying of Australia. During this period Australia had moved significantly northwards to the mid latitudes. The Australian continental plate crashed into Southeast Asia where massive tectonic upheaval forced New Guinea out of the Pacific Ocean, causing a rain shadow effect over inland Australia. Climate change forced rainforests to retreat to the eastern seaboard, reducing this habitat greatly in size. Animals had to adapt to these changing conditions or face extinction.

As the interior of the continent began to dry out, open forests of eucalypts, acacias, casuarinas and grasses began to adapt to the new conditions and flourish. These adaptations can be seen in the way plants have developed strategies to conserve water and avoid water loss. The opening up of new grassland habitats allowed enormous new species to evolve: the megafauna.

Quaternary Period—Queensland

2.6 million years ago — present

Ice Age begins — 2.6 million years ago

Earliest humans appear — 2.6–0.0117 million years ago

Humans are dominant and Ice Age ends — 0.0117 million years ago – present

Extreme climate variability marks the Quaternary Period. Due to alternating ice ages and interglacial periods the climate cycled between moist and arid conditions, and this resulted in rapid changes to ecosystems across the continent.

The unstable conditions impacted most severely on rainforests, which remained greatly reduced and continued to be further overtaken by dry-adapted woodlands and grasslands. Plants and animals had to adapt to environments that were more prone to fire. The semi-arid climate and dry inland areas that are now so typical of much of the modern Australian continent developed in just the past few million years.

However, the Australian climate, and therefore the environment, is not static and is continuing to respond to natural and human influences on both global and local scales. We rely on these environments for survival; extinctions and environmental changes today may impact on human survival into the future.

Appendix 1: Rock Images for From Minerals Big Rocks Grow

Object-based learning is ‘a mode of education which involves the active integration of authentic or replica material objects into the learning environment’[4] and is used to prompt investigation and promote student inquiry. At Queensland Museum we use objects for learning whenever possible. For these activities, you may borrow Queensland Museum loan kits, including Fossils, Minerals and Rocks, or the Active Earth Kit.

Rocks may also be purchased from scientific suppliers such as Mad about Science, Crozcare Geological Supplies or Haines Educational. It is important to ensure all rocks are free from asbestos and asbestos-like materials. For more information please see the safety alert on asbestos samples in minerals from the Queensland Department of Education.

If you cannot get access to rocks for the activities in School of Rocks, images of rocks have been provided for analysis.

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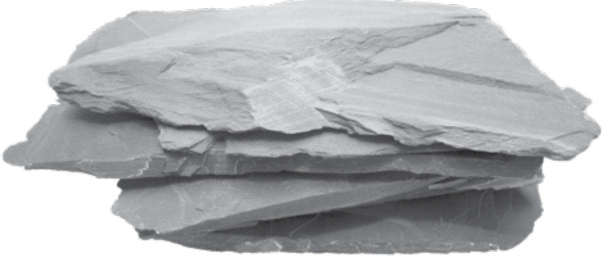
[4] *Jamieson, A. (2016). Object-based learning: A new mode in Arts West. Retrieved from* https://arts.unimelb.edu.au/articulation/editions/2016-editions/december-2016/object-based-learning-a-new-mode-in-arts-west

Igneous

Sedimentary

Metamorphic



Appendix 2: Core Sample

The actual size rock core sample can be accessed on Queensland Museum Learning Resources. Search 'rock core sample' to find this resource.

Notes

QGC | FUTUREMAKERS | QUEENSLAND MUSEUM Queensland Government