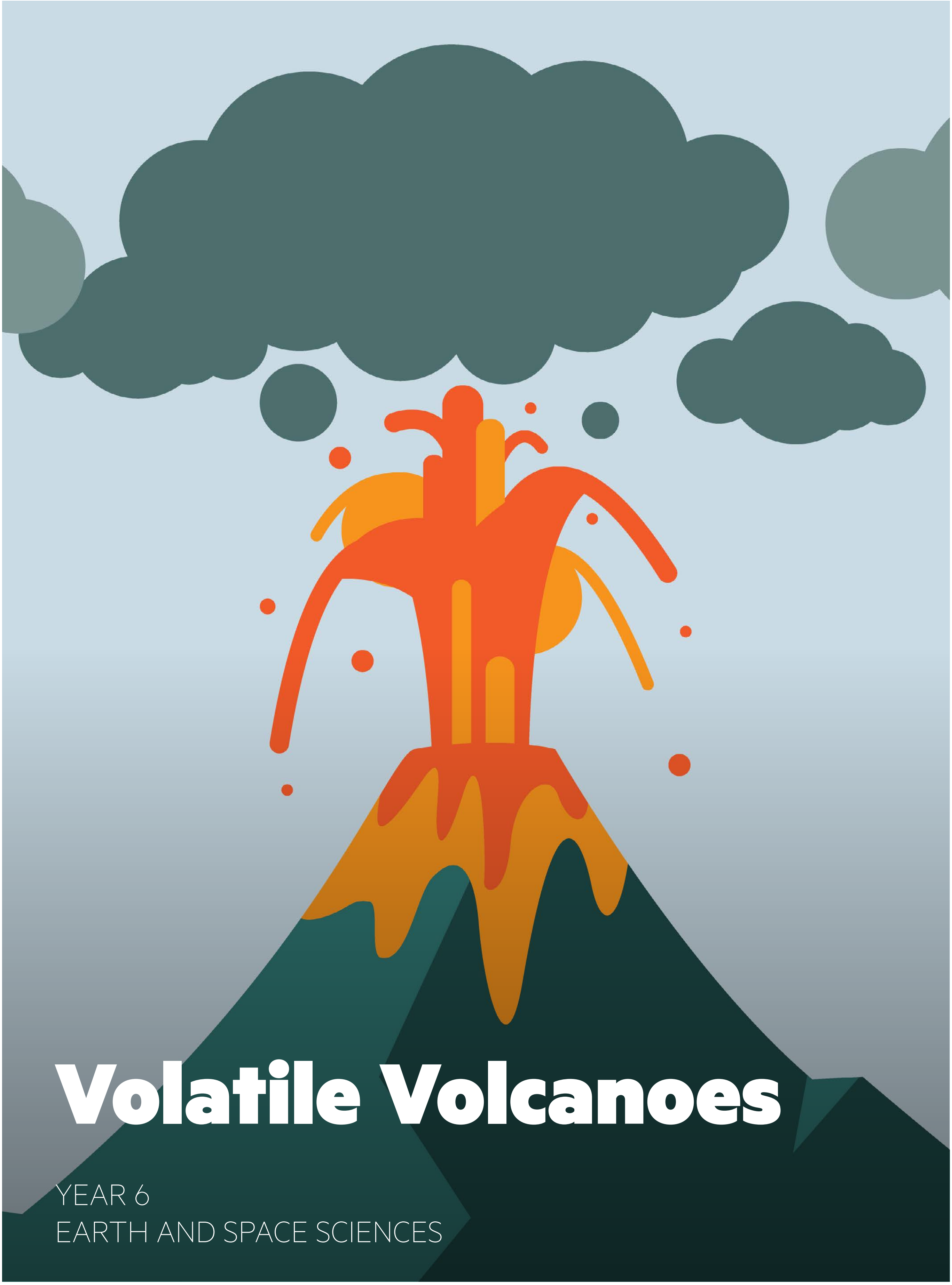


Volatile Volcanoes

YEAR 6

EARTH AND SPACE SCIENCES

Future Makers

Future Makers is an innovative partnership between Queensland Museum Network 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 Network 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.

EXPLORE - EXPLAIN - ELABORATE - EVALUATE

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.

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

Curriculum Links

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 men al 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

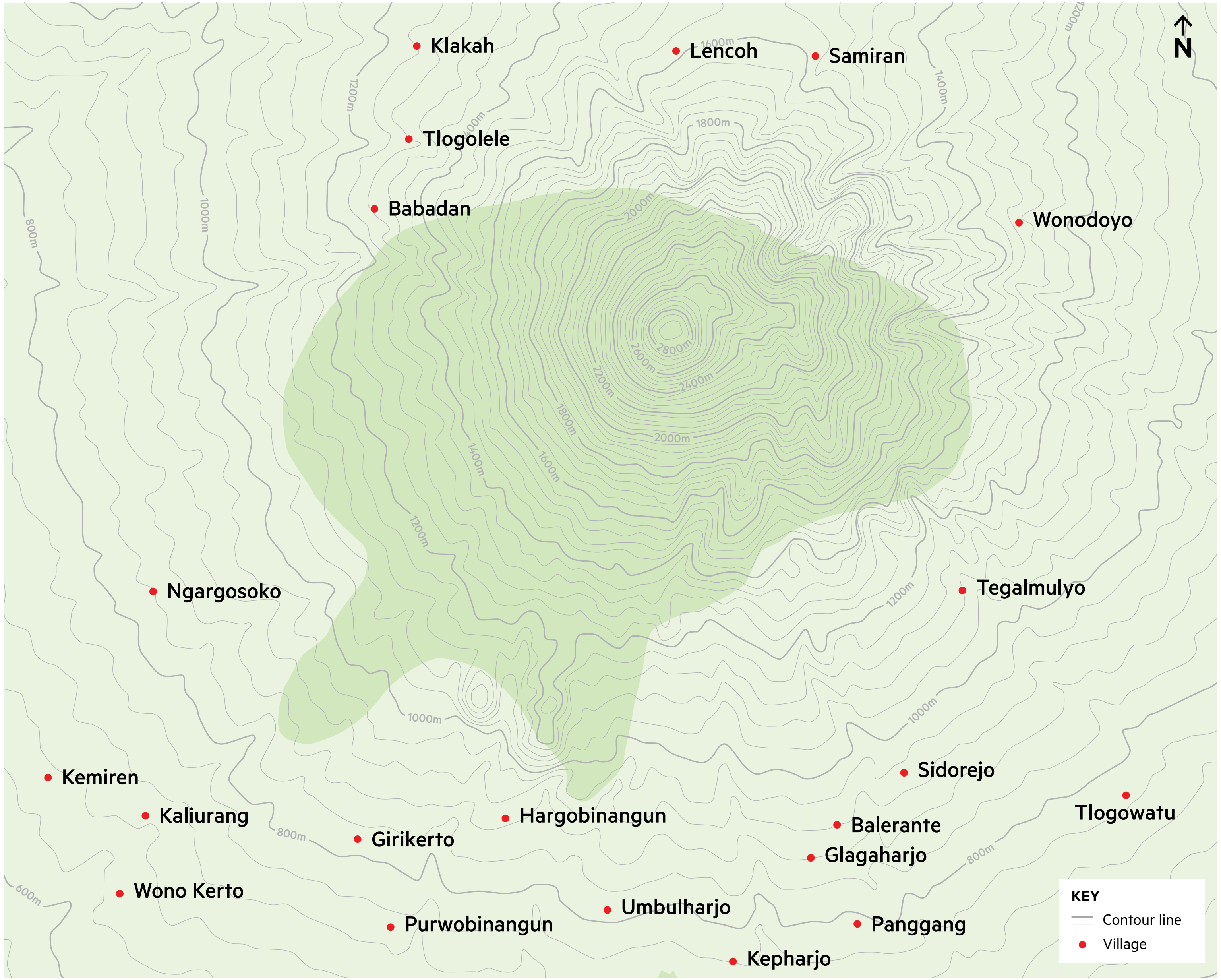
Personal and Social Capability

Self-management

Social management

Topographic Maps

Student Activity



Google Maps – Map data © 2019

7.5407° S, 110.4457° E

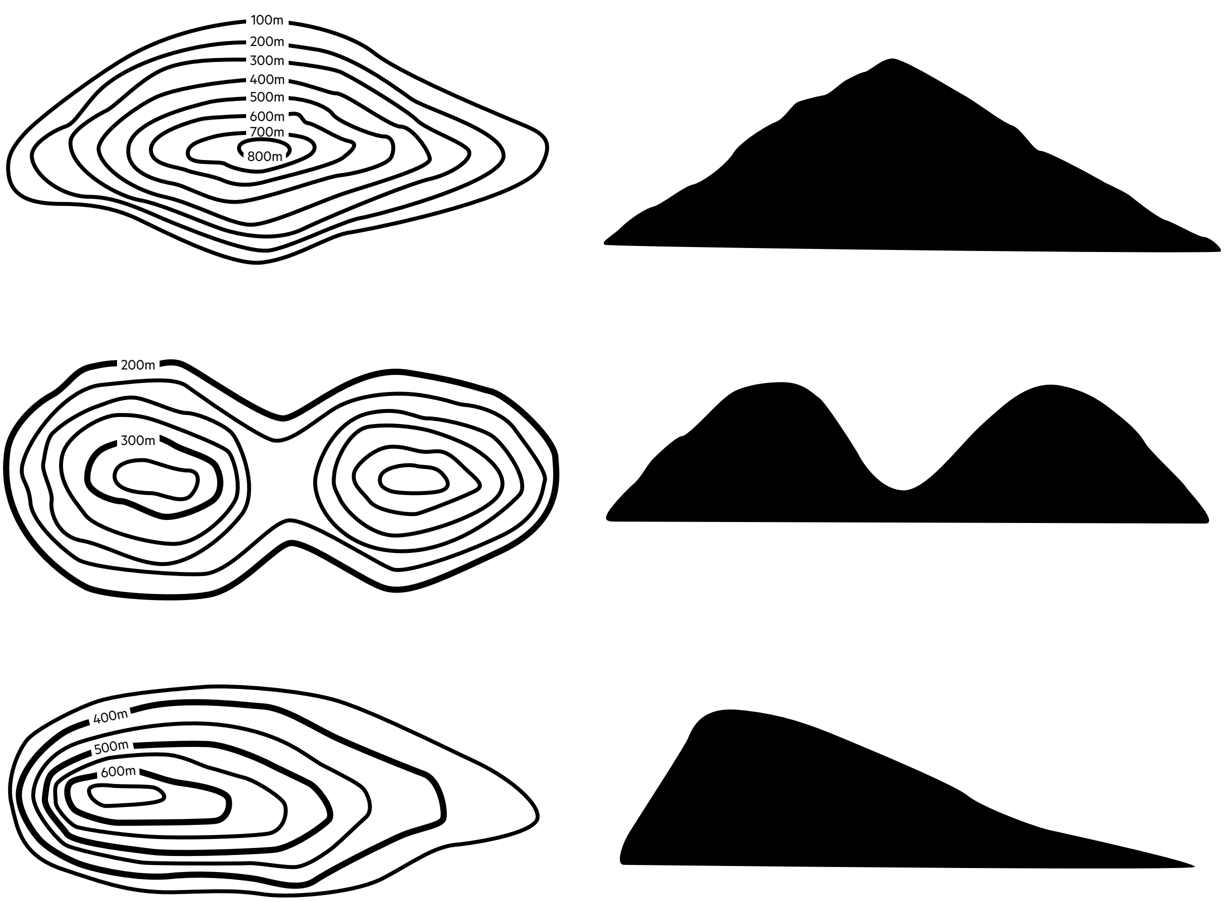
1 km

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:

[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.

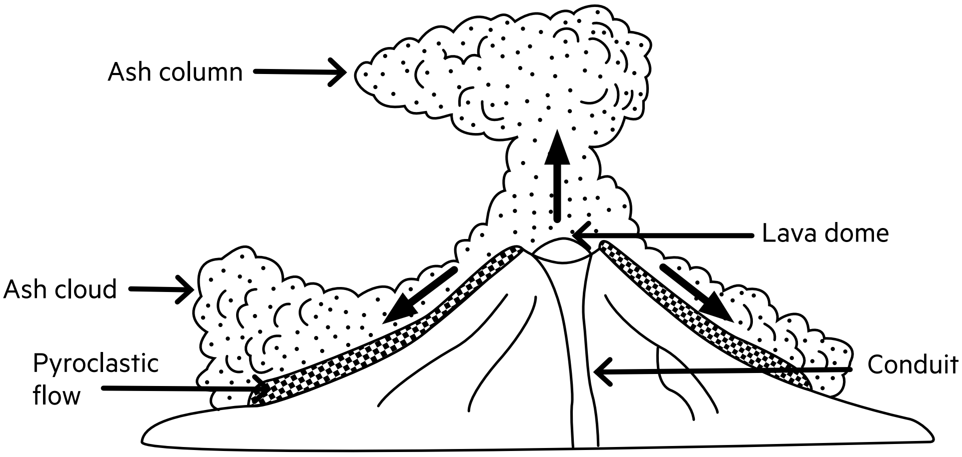
This natural event can flatten and incinerate everything in its path. Pyroclastic flows can therefore be one of the most destructive effects of volcanic activity.

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

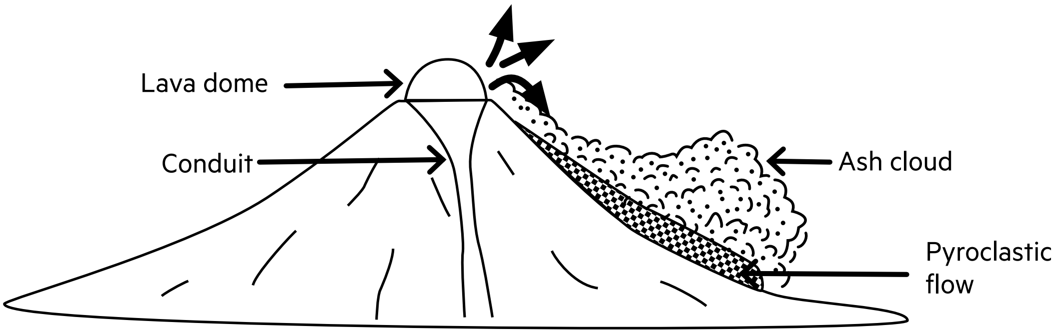
Pyroclastic flows differ to lava flows in a number of ways. Lava flows are characterised by the flow of extremely hot molten rock. Most lava flows can easily be avoided by people on foot as they do not move much faster than walking speed. In contrast, pyroclastic flows do not contain molten rock, but 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 arning can be almost impossible to escape.

Pyroclastic flows can form in three ways:

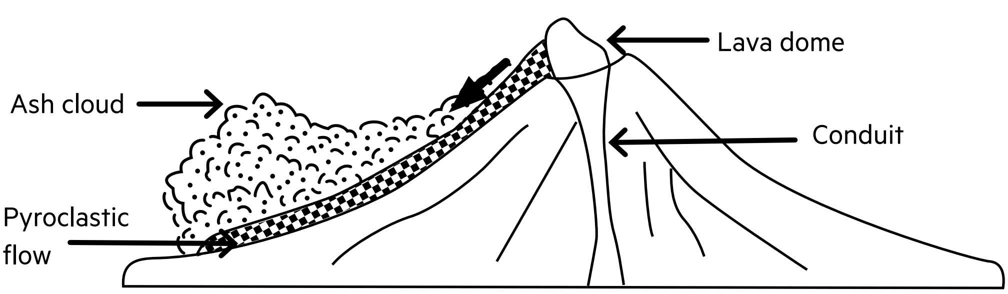
Ash column collapse:
An ash column emerging from the volcano suddenly becomes denser than the surrounding air and collapses. The ash cloud falls back to Earth and rushes down the sides of the volcano.



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.	