Volcanic Eruptions

Learning Outcomes

In this chapter you will learn about:

- the processes that produce volcanic eruptions
- the effects of a volcanic eruption on the natural environment
- effects of a volcanic eruption on economic and social activities
- how people can prepare for and respond to the effects of a volcanic eruption.

6 Processes that Produce Volcanic Eruptions

Learning Outcome

In this unit you will learn about:

- the processes that produce volcanic eruptions.

Volcanic processes

Volcano: Opening in the Earth's crust, where molten rock and gases from the Earth's interior reach the surface.

Core: The central part of the Earth.

Mantle: That part of the Earth's interior between the crust and the core.

Crust: The cool, fragile outer shell of the Earth that floats on top of the mantle.

A **volcano** is an opening in the Earth's crust, where molten rock and gases from the Earth's interior reach the surface. Volcanoes have played an important role in forming New Zealand's landscape. In fact, much of the landscape of the central North Island of New Zealand owes it shape to thousands of years of volcanism.

Every volcanic eruption is different. Some eruptions last only a few hours but others can continue to erupt over many months. Even eruptions from the same volcano can be different. However, when a volcano erupts a typical natural sequence tends to happen.

Although there are numerous volcanoes on the solar system's rocky planets and moons, on the Earth at least, volcanoes tend to occur near the boundaries of the continental plates. However, there are exceptions. The reason for this requires an understanding of the Earth's structure.

Stage 1 – Processes within the Earth

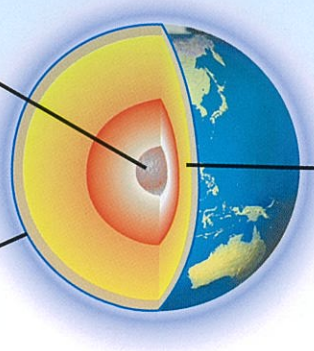
To understand why earthquakes occur requires an examination of the internal structure of the Earth.

The Earth is made up of several layers that have very different physical and chemical properties. The outer layer, or **crust**, consists of about 12 to 14 large, irregularly shaped **tectonic plates**. These plates slide over, under and past each other, on top of the partly molten inner layer known as the **mantle**.

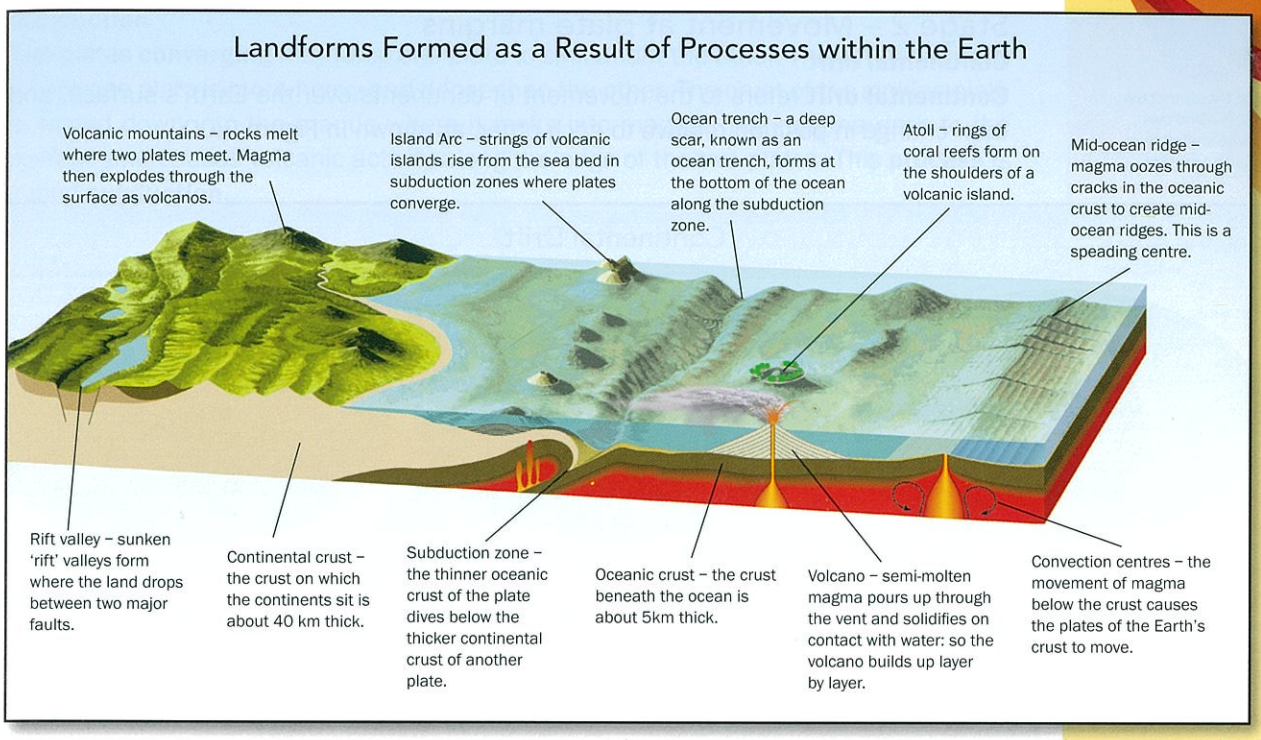
The **core** is at the centre of the Earth. The inner core is solid and tremendously hot. The outer core is liquid and very hot also.

The surface of the Earth is called the **crust** and relatively speaking, it is thought to be as thin as the skin of an apple to its flesh.

- Oceanic crust underlies most oceans and averages 6 – 10 km in thickness.
- Continental crust can be up to 70 km thick.



The mantle surrounds the core. Extreme heat from the core causes the **mantle** rocks to melt and form magma. The core heat also causes **convection currents** – molten rock moving away from the heated core to the Earth's surface, then cooling and moving back to the core as fluid magma.

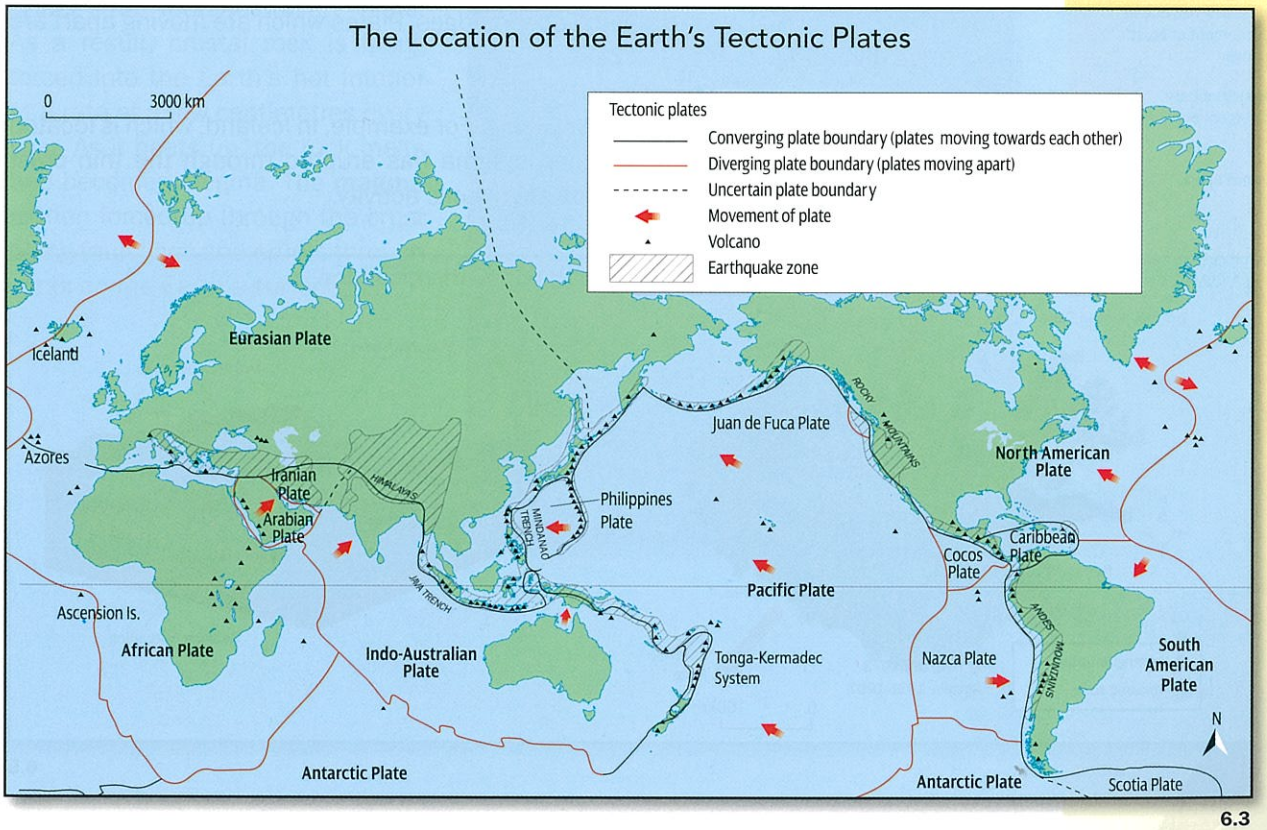


6.2

Plate tectonic theory

Plate tectonic theory is relatively new and has changed the way geographers think about the Earth. According to the theory, the surface of the Earth is broken into large plates. The size and position of these plates change over time. The edges of these plates, where they move against each other, are sites of intense geological activity, such as earthquakes, volcanoes and mountain building. Plate tectonic theory is a combination of two earlier ideas, continental drift and seafloor spreading.

Plate tectonic theory: Theory that the Earth's crust comprises a series of tectonic plates, and the movement of these plates explains the distribution of volcanic activity, earthquakes and their associated landforms.



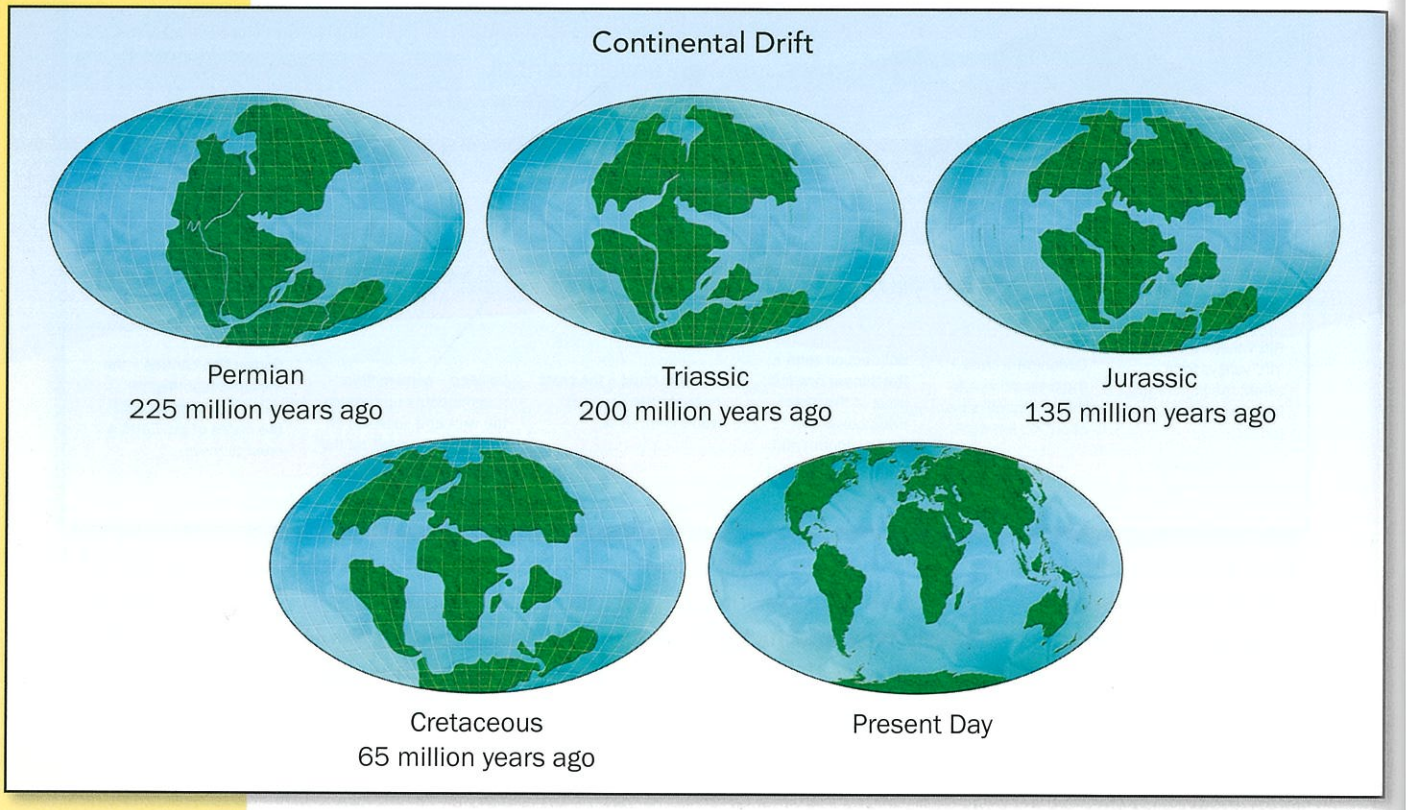
6.3

Stage 2 – Movement at plate margins

Continental drift

Continental drift: Theory that the continents are mobile and over geological time have shifted their position on the Earth's surface.

Continental drift refers to the movement of continents over the Earth's surface, and their change in position relative to each other, as shown in Figure 2.00.



6.4

Seafloor spreading

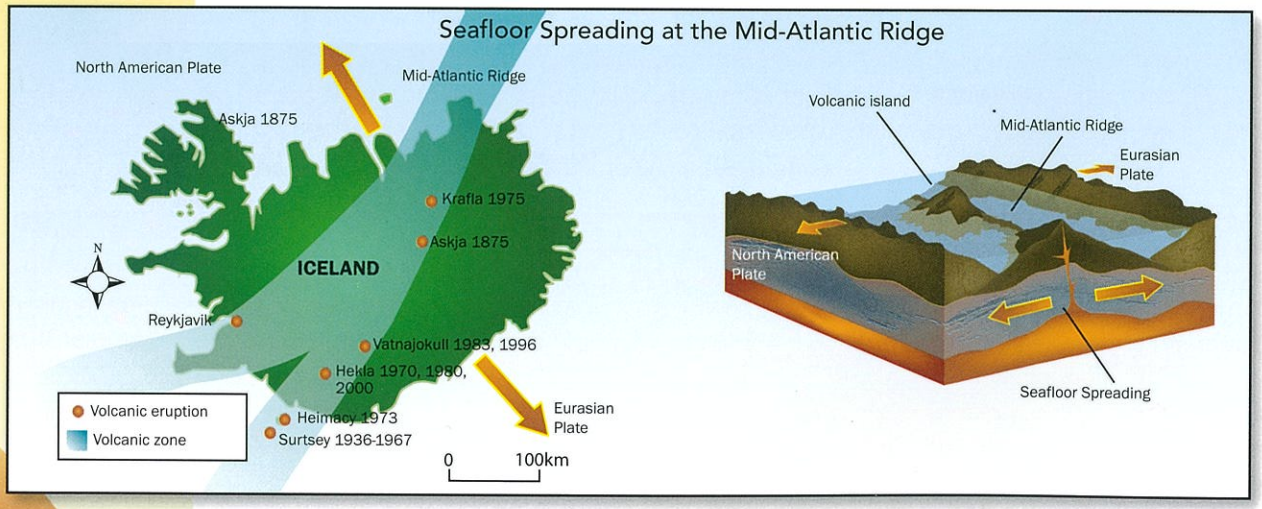
Seafloor spreading: Formation of new oceanic crust at a mid-ocean ridge and the movement of crust away from the ridge.

Mid-ocean ridge: Boundary between two divergent oceanic plates.

Diverging: To move apart.

Seafloor spreading is the creation of new oceanic crust at **mid-ocean ridges** and movement of the crust away from mid-ocean ridges. Plates which are moving apart are said to be **diverging**.

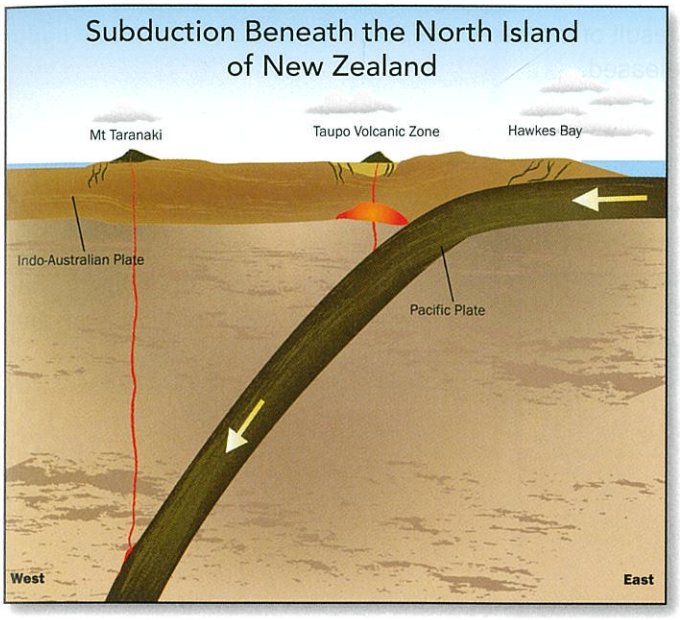
In the Atlantic Ocean, two plates are diverging. For example, in Iceland, which is located on top of the Mid-Atlantic Ridge, rising magma has erupted through the thin crust between the two plates to form a ridge of volcanic activity.



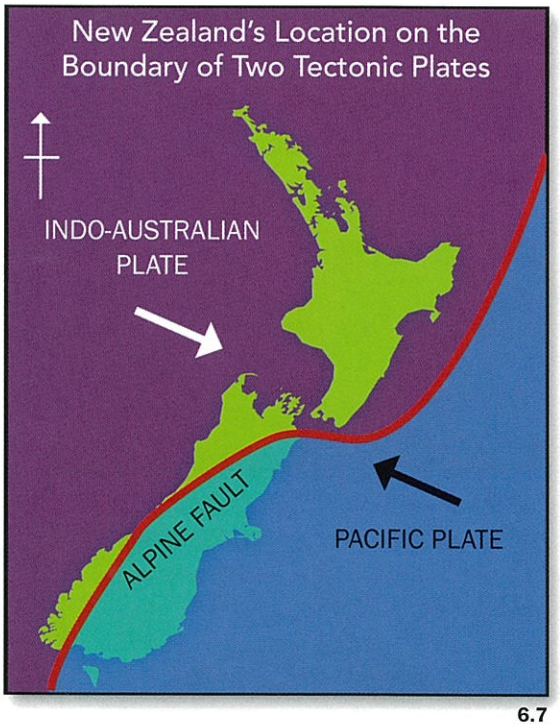
6.5

Subduction

Two plates **converging** may force one plate to sink under the other. This often happens where one plate is more heavy and dense than the other. The crust of the sinking plate is forced down into the mantle where it melts into magma. The magma rises to the surface and causes volcanic activity along the edge of the two plates. This **process** is called **subduction**.



New Zealand is located on the boundary of the Pacific and Indo-Australian plates. Beneath the North Island the Pacific plate is sinking under the Indo-Australian plate. As a result, crustal rock is being forced into the Earth's hot interior at a rate of a few centimetres every year. As it heats up, the rock melts and becomes magma. The **magma** is then forced up through the crust along fault lines and erupts through vents on the Earth's surface.



6.7

Converging: Moving towards each other.

Process: A series of related events.

Subduction: The process by which an oceanic plate (for example, Pacific Plate) slowly sinks into the mantle where it melts into magma. Subduction only occurs at destructive plate boundaries.

Magma: Hot liquid rock beneath the Earth's surface.

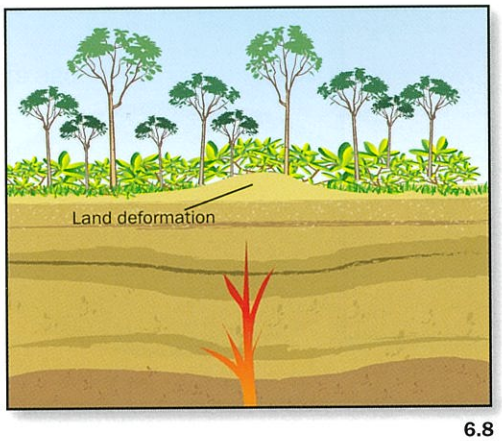
Stage 3 – Processes on the Earth

When a volcano is about to erupt, magma rises, usually from depths of around 100km, to the surface of the mantle. The magma spreads into weaknesses or **fissures** in the crust caused by plate movement.

Fissure: An opening or weakness in the Earth's crust where volcanic material can reach the Earth's surface.

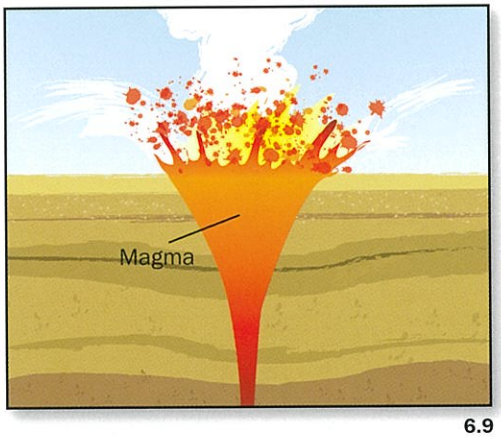
As the magma rises, pressure builds up below the surface and small earthquakes often happen. Ground temperatures rise, heating mud pools and geysers. If a crater lake is present, temperatures within the lake will rise, causing the water level of the crater lake to decrease as a result of increased evaporation. Carbon dioxide and sulfur dioxide gases may also be released.

The Sequence of Events of a Volcanic Eruption



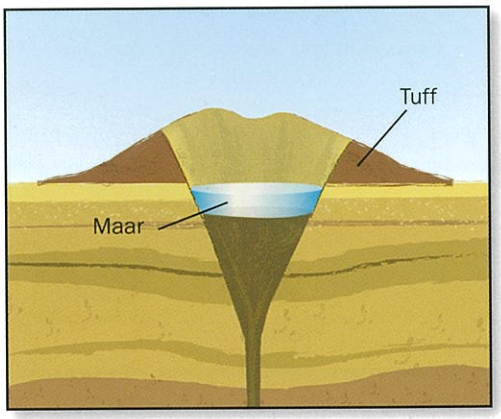
6.8

Land deformation or bulging can happen and small amounts of ash, gas or steam may escape.



6.9

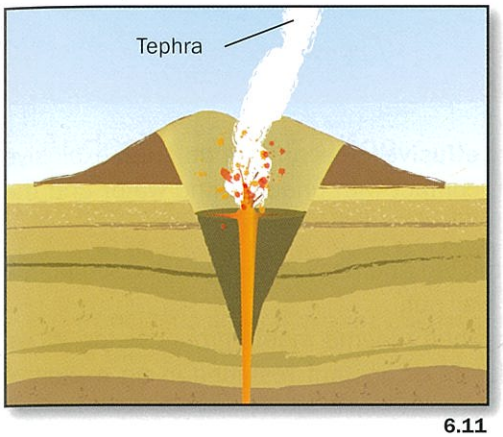
The pressure is released when the magma breaks through the surface and erupts. There are many ways erupted material can move.



6.10

If there is no more magma after the first violent eruptions then a wide crater called a **maar** forms. The crater has a low rim around the edge.

Maar: A volcanic crater with a low rim but no cone usually formed by an eruption of gas or gas and ash, but without significant flows of lava.

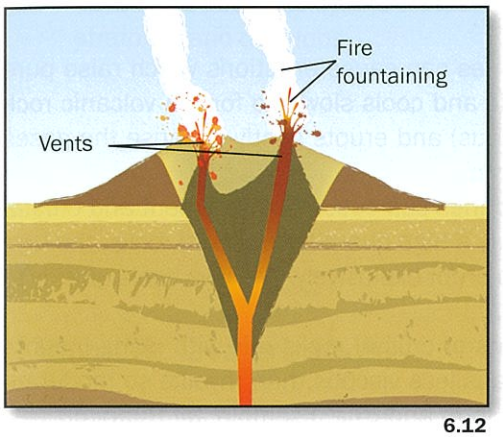


6.11

It is likely that further eruptions will occur resulting in further ground flows and **tephra** eruptions. Explosions of ash and shattered rock often land to form a **tuff** ring or rim around the vent. If magma keeps rising, a lava lake may form in the crater.

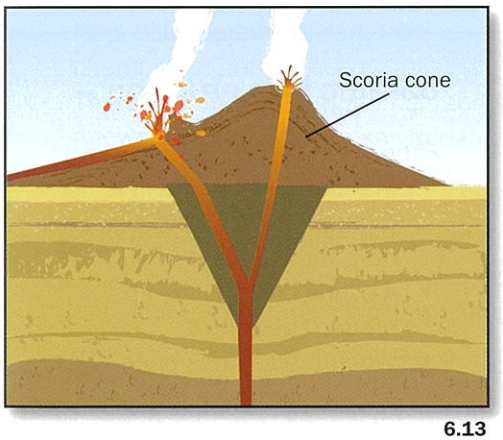
Tephra: Any material erupted directly into the atmosphere during a volcanic eruption For example, volcanic ash.

Tuff: Type of rock made of hardened volcanic ash and rock fragments.



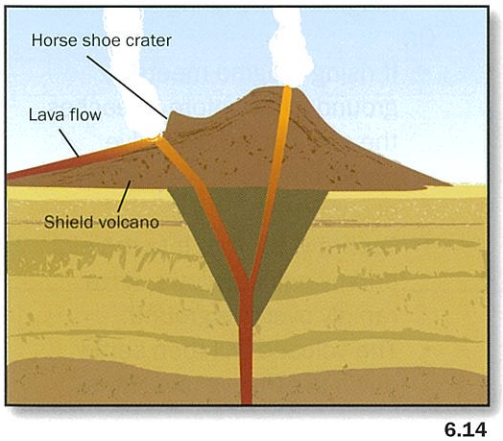
6.12

Rising magma can also lead to lava bursting from one or more vents (fire fountaining) to form scoria cones. The Auckland Domain and Mangere Mountain in Auckland are examples of where this has occurred.



6.13

As an eruption continues, scoria cones grow larger and may eventually bury the tuff ring. Often the lava will burst out of the volcano at a lower level and flow into surrounding valleys.



6.14

The stream of lava can sometimes be so great that the cone weakens and collapses into the flow and a horseshoe-shaped crater is left behind. For example, Mt Victoria, Mt Hobson, and One Tree Hill in Auckland. Sometimes a large sheet of lava may cover the nearby area forming a 'shield' volcano. For example: Rangitoto Island.

After a period of time, the main eruption period eventually stops and the volcano becomes dormant.

Types of eruption

Explosive: An explosive eruption is a volcanic term to describe a violent, explosive type of eruption.

Effusive: An effusive eruption is a volcanic term to describe eruptions which comprise mainly of lava and very little ash. Rangitoto Island formed as a result of an effusive eruption.

Viscous: Not fluid.

Phreatomagmatic: A style of volcanic eruption that takes place when the rising magma comes into contact with shallow groundwater, or erupts under shallow ocean water or lakes.

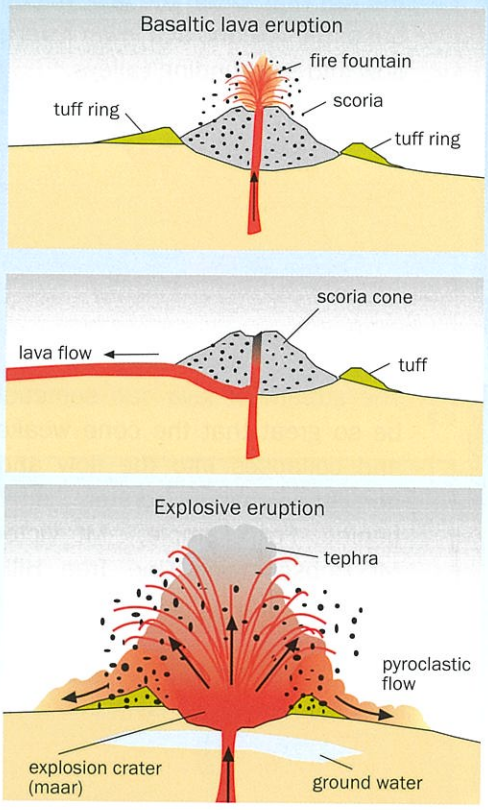
Basalt: A common grey to black volcanic rock formed when lava cools.

Some eruptions are **explosive** and others are **effusive** (quiet and gentle). How explosive an eruption is depends on the gas content, contact with underground water and the lava type.

- ***Gas*** **–** Gases are released as magma is heated and rises. If the lava is **viscous**, the gas will be trapped and may explode its way out.
- ***Water*** **–** Super-heated steam is formed when magma meets groundwater. When this happens, ground water can vaporise in an instant resulting in an explosive **phreatomagmatic** eruption.

Types of lava

- ***Basaltic lava*** **–** Diverging plate boundaries can cause eruptions which raise pure magma to the surface. The lava is basic and cools slowly to form a volcanic rock called **basalt**. The lava is fluid (not viscous) and erupts gently because the gases are free to escape. For example: Rangitoto.
- ***Rhyolitic lava*** **–** Converging plate boundaries can cause sea sediment and crustal rocks to mix with rising magma. If there is a high quantity of crustal rocks, the lava will be acidic, highly viscous and likely to erupt explosively. The lava cools quickly to form rhyolite. For example: Mt Tarawera.
- ***Andesitic lava*** **–** When average amounts of crustal rocks mix with rising magma at converging plate boundaries, the lava is less viscous than rhyolite so moderate explosions occur. It cools less quickly to form andesite. Example: Mt Ruapehu.



Basaltic lava eruption

Either:

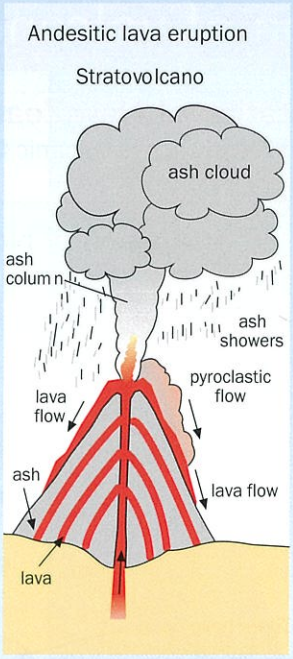
- May start with some fire fountaining as gases escape from the fluid lava.
- A scoria cone builds up around the vent.
- When the gas has been released effusive lava flows begin. The flows end when the magma stops rising

Or:

- If rising magma meets groundwater before it reaches the surface, an explosive phreatomagmatic eruption occurs.
- Tephra is blasted into the air, and pyroclastic flows move rapidly over the ground.
- The volcano will then settle down to effusive lava flows.

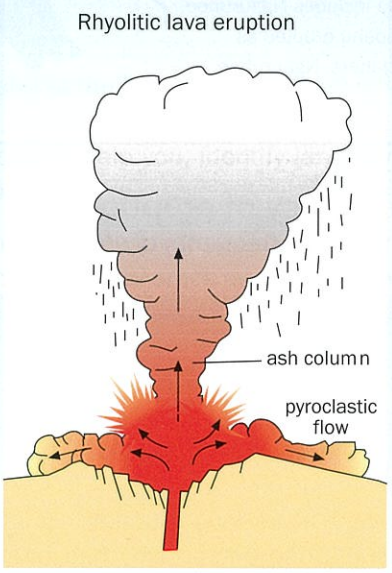
Andesitic lava eruption

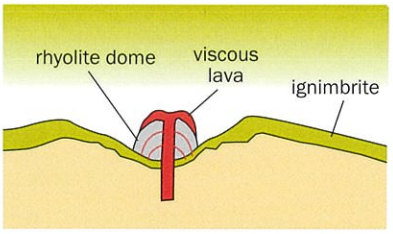
- Begins with a fairly explosive eruption of tephra and gas owing to the viscous nature of the lava.
- A tall ash column rises above the vent, and pyroclastic flows move rapidly down the slopes of the volcano.
- Eruptions of tephra and lava continue until the magma stops rising.
- Lava flows cool quickly and a steep-sided stratovolcano develops.



Rhyolitic lava eruption

- Begins with a huge eruption as gas explodes out of highly viscous lava. (Like popping a cork from a champagne bottle!)
- There is a massive eruption of tephra. A towering ash column rises into the sky. Surface pyroclastic flows race away from the shattered vent, and cool to form ignimbrite.
- The lava is too viscous to flow far and a steep-sided rhyolitic dome may develop.
- If an eruption finally empties its magma chamber source, the volcano may collapse forming a caldera.





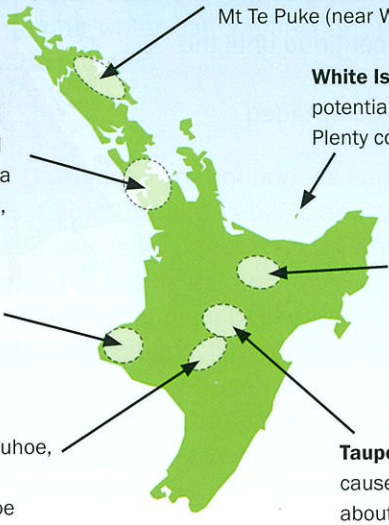
6.15

Distribution of volcanoes in New Zealand

Location of New Zealand's volcanoes

All currently active volcanic fields are in the North Island.

The Location of North Island Volcanic Fields



Northland (dormant) – The most recent eruption was Mt Te Puke (near Waitangi) about 1,500 years ago.

White Island (active) – A major eruption could potentially cause a tsunami threat to the Bay of Plenty coast.

Auckland (dormant) – There are about 50 volcanoes or craters in the central Auckland area. The last eruption was Rangitoto Island about 750 years ago. An eruption in the area today would be harmful for Auckland's large, expansive population.

Okataina (dormant) – In the last 250,000 years there have been around five major eruptions. One of the most devastating was Tarawera in 1886.

Taranaki (dormant) – There have been at least nine eruptions in the last 500 years. The main hazard is ash.

Tongariro (active) – This area includes Ngauruhoe, Ruapehu and Tongariro. Ruapehu erupted as recently as 2007, producing lahars. Ngauruhoe last erupted in 1975.

Taupo (dormant) – The lake is a giant caldera caused by a series of huge eruptions ending about 1850 years ago when everything around the vent for 20,000 sq km was destroyed.

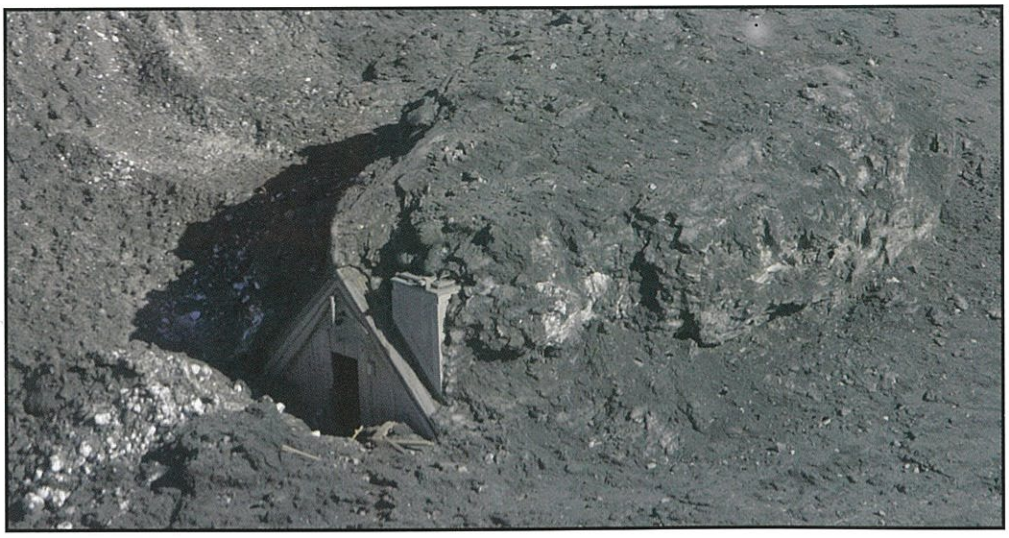
6.16

Frequency of eruptions

Although the frequency of eruptions in New Zealand varies greatly, scientists have been able to date when some volcanoes erupted in the past. From this they can calculate an average eruption frequency, which is around five eruptions over 10,000 years.

Tongariro and Tarawera both erupted in the nineteenth century and White Island, Ruapehu and Ngauruhoe erupted in the twentieth century. Today, White Island erupts continuously. There have been no eruptions in the South Island for millions of years.

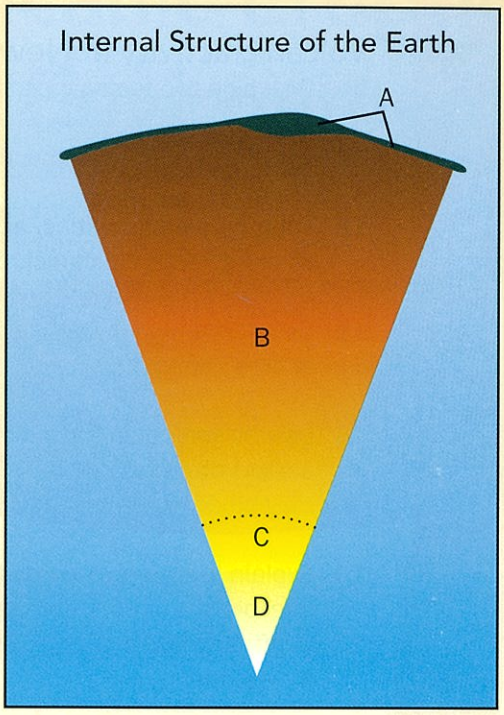
A recent hazardous eruption occurred in New Zealand in September 2007. In this eruption, one person who had been staying in the Dome Hut at the summit of Mt Ruapehu was seriously injured when the volcano exploded without warning.



An aerial view of the summit of Mt Ruapehu showing the effects of the eruption in 2007. An almost submerged Dome Hut, a hut near the crater lake, was bombarded with mud and boulders.

Learning Activities

Processes that produce volcanoes



6.17

1 Study Resource 6.17 and identify the features of the internal structure of the Earth by naming A, B, C and D.

2 What is a tectonic plate?

3 What drives the movement of crustal plates across the Earth's surface?

4 How fast do plates travel across the Earth's surface?

5 What type of movement (diverging or converging) is taking place between the following plates:

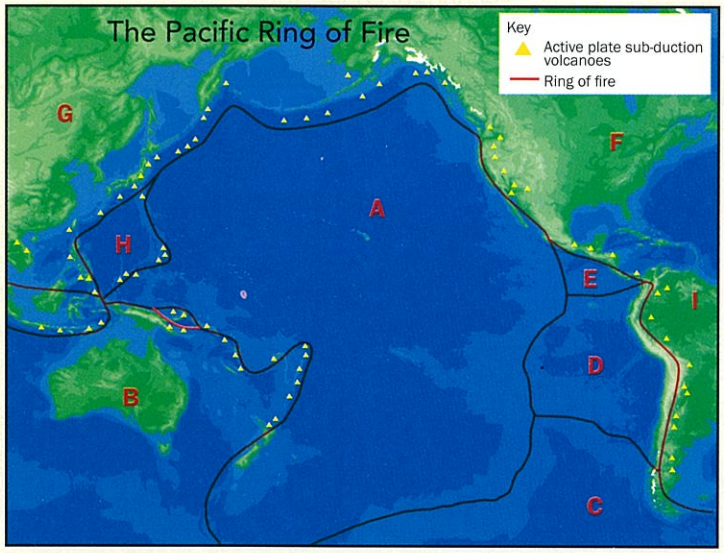
- **a** Pacific and Nazca?
- **b** Pacific and Indo-Australian?
- **c** Indo-Australian and Eurasian?
- **d** North American and Eurasian?
- **e** Nazca and South America?

6 What type of plate margin is found at the Mid-Atlantic Ridge?

7 Using a map of the physical world to help you, identify landforms that have resulted from the movements in Question 5.

The Pacific Ring of Fire

8 The Pacific Ring of Fire is a zone of frequent earthquakes and volcanic eruptions encircling the Pacific Ocean. An estimated 90% of the world's earthquakes and 81% of the world's largest earthquakes occur along the Ring of Fire.



6.18

- **a** Suggest reasons for the name of the 'Ring of Fire'.
- **b** Match the plate names given below with the plates A – I in the map above. Antarctic; Cocos; Eurasian; Nazca; Indo-Australian; North American, Pacific; Philippines; South American.
- **c** What do the location of earthquakes and volcanoes have in common?
- **d** What relationship exists between the location of volcanoes and the type of movement at plate boundaries? Are there any exceptions?

Learning Activities

Volcanic activity in New Zealand

9 On which two tectonic plates does New Zealand lie?

10 With the aid of diagrams, describe the process of subduction in New Zealand.

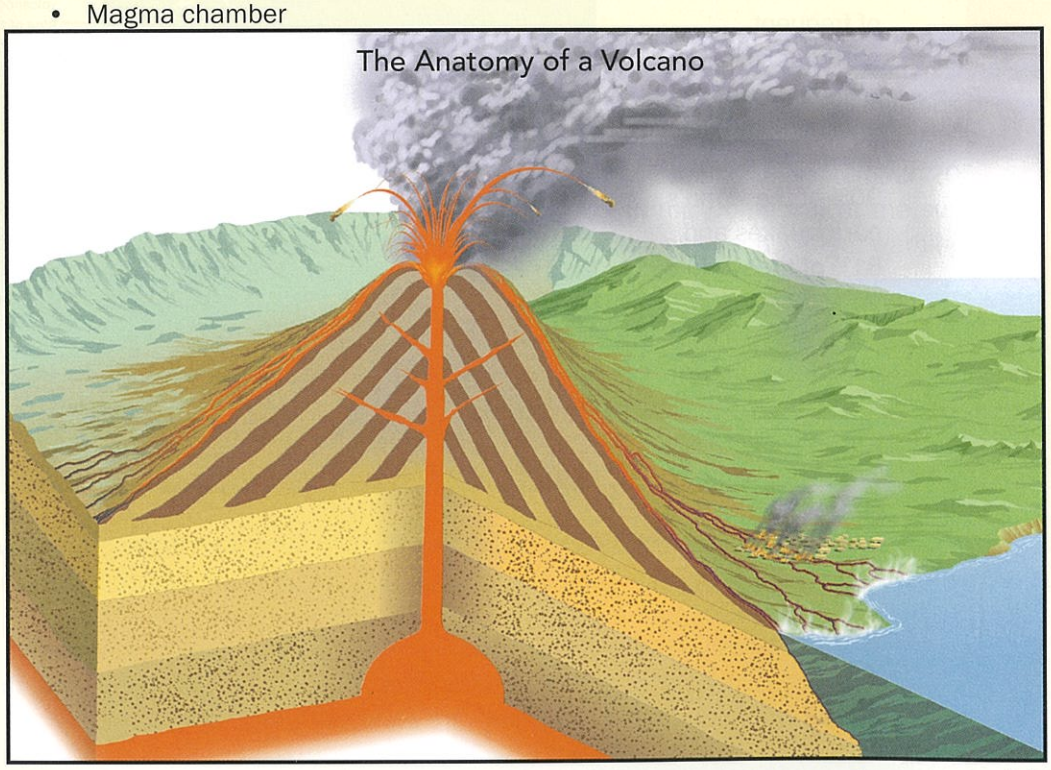
11 With the aid of an atlas, examine a geological map of New Zealand, to identify areas where igneous (volcanic) rocks are found.

12 Using Resource 6.16, give reasons for the distribution of volcanoes in the North Island of New Zealand.

13 Use the internet to find out more about one of the volcanic zones on Resource 6.16. Write a short project about it. Try to include a map to show its location, a description of the magnitude of the volcano, the impact of the volcano on people and their property.

14 Explain in your own words the meaning of:
- **a** explosive or phreatomagmatic eruption
- **b** effusive eruption
- **c** viscous.

15 Redraw the anatomy of a volcano diagram below. Include the missing labels from the list below.
- Crater
- Lava flow
- Layers of ash and lava
- Steam, gas and dust
- Volcanic bombs
- Falling ash
- Secondary cones
- Main vent
- Magma chamber



6.19

7 Effects of a Volcanic Eruption on the Natural Environment

Learning Outcome

In this unit you will learn about:

- the effect of a volcanic eruption on the natural environment.

Effects on the natural environment

Impact of volcanic eruptions on the natural landscape

The degree of **change** caused by volcanic eruptions depends on the type and size of eruptions. Possible changes include:

Change: Change in one part of the environment may lead to change in another.

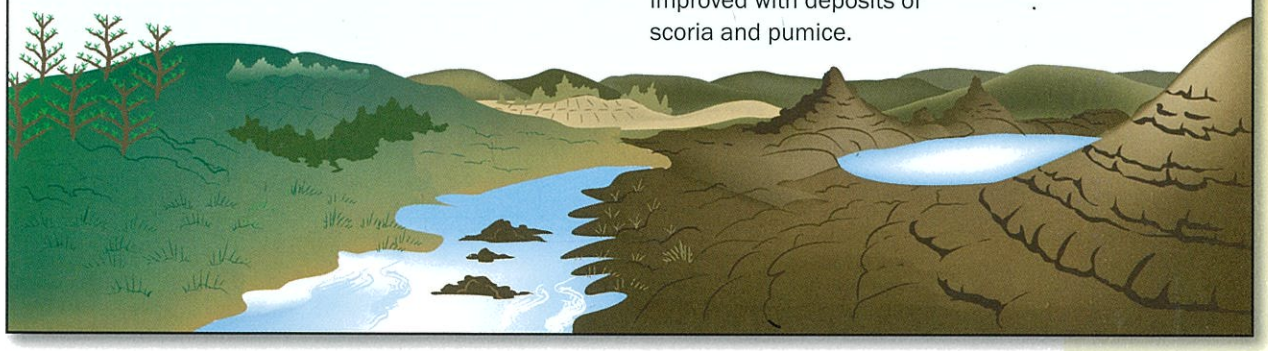
How a Volcanic Eruption can Change the Natural Landscape

Vegetation – Lava and pyroclastic flows can blow over or burn plants, trees and grasses close to the eruption.

Waterways – Lahars can flow into rivers and raise water levels, causing floods. Examples include the Ruapehu lahars of 1953 and 2007. River courses can be blocked or altered by erupted volcanic material. Changes to the topography may change drainage patterns.

Soil – Soil fertility improves with any volcanic ash deposits. Although too much volcanic material can cause soil to become deficient in cobalt. This makes the land unsuitable for farming as is the case in the North Island's Central Volcanic Plateau. Land drainage is improved with deposits of scoria and pumice.

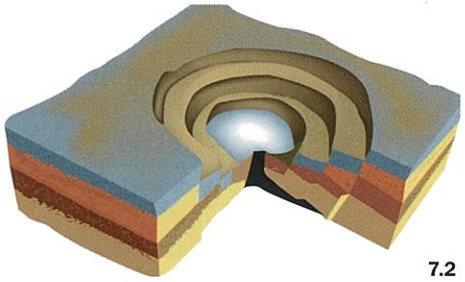
Relief – The land is built up as layers of tephra, lava, lahar and pyroclastic flows are deposited by eruptions.



7.1

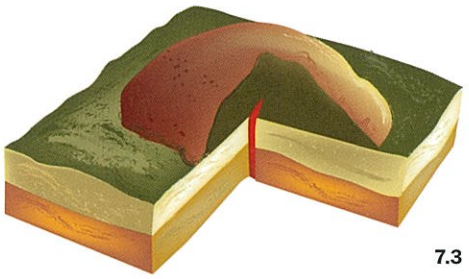
Classifying volcanoes according to their shape

Caldera volcano – A huge basin-like hollow formed by the collapse of the roof of a gas-rich rhyolite magma chamber. The chamber has been emptied by massive, explosive ignimbrite eruptions. For example, Lake Taupo and Lake Rotorua.



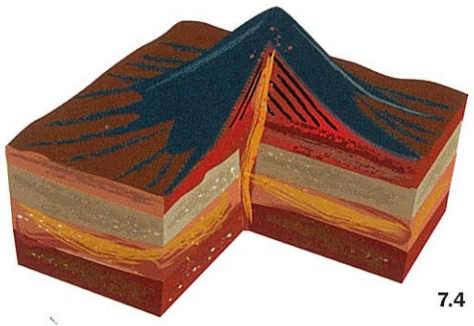
7.2

Lava dome – A steep-sided, rounded hill or mountain formed when thick, gas-deprived rhyolite lava is squeezed upward and outward around the vent. For example, Mt Ngongataha and Mt Maunganui.



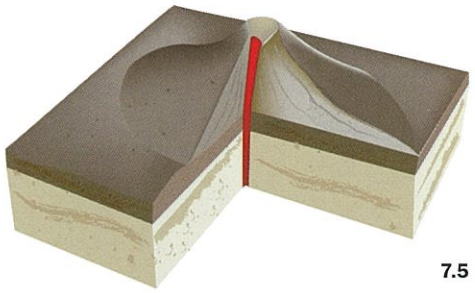
7.3

Stratovolcano – A large cone built up by andesite lava flows interlayered with ash and rough debris. It is usually surrounded by a wide, gently sloping ring plain made up of volcanic mud (lahar) deposits. For example, Mt Taranaki and Mt Ruapehu.



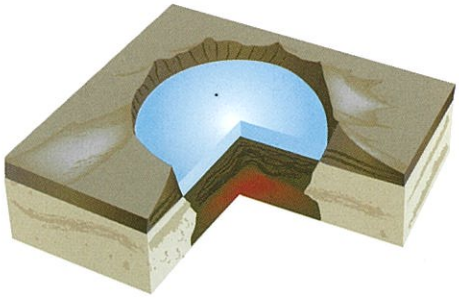
7.4

Scoria cone – A small, step-sided cone, usually with a deep central crater. It is formed by fountaining eruptions of frothy, gas-rich basalt or andesite lava. For example, Whangarei and Kaikohe lava fields.



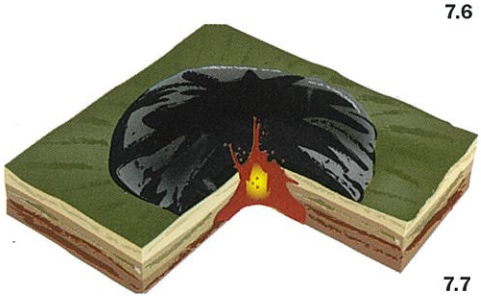
7.5

Tuff ring – A shallow crater surrounded by a low rim of debris which has been thrown out by an explosive eruption. Tuff rings are usually formed by rising, gas-rich, basalt magma which often explodes when it meets water. For example, Orakei Basin and Lake Pupuke.



7.6

Shield volcano – A wide, gently sloping volcano that is built from many basalt lava flows. The flows ooze upwards and outwards from fissures or craters during quiet eruptions. For example, Rangitoto Island and the Lyttelton and Akaroa dormant volcanoes.

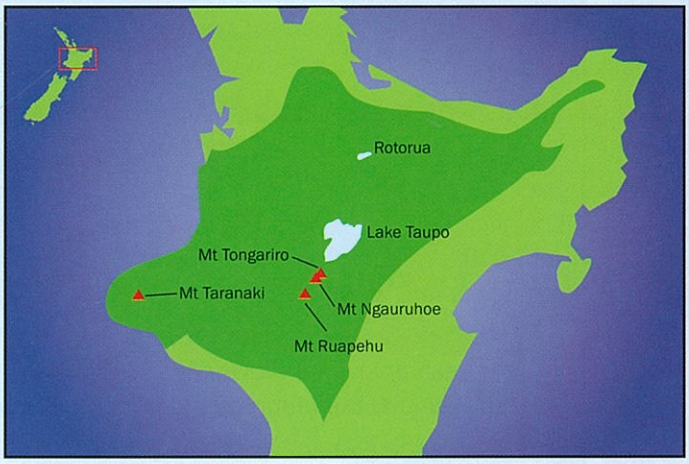


7.7

Case Study

The Central Volcanic Plateau of New Zealand

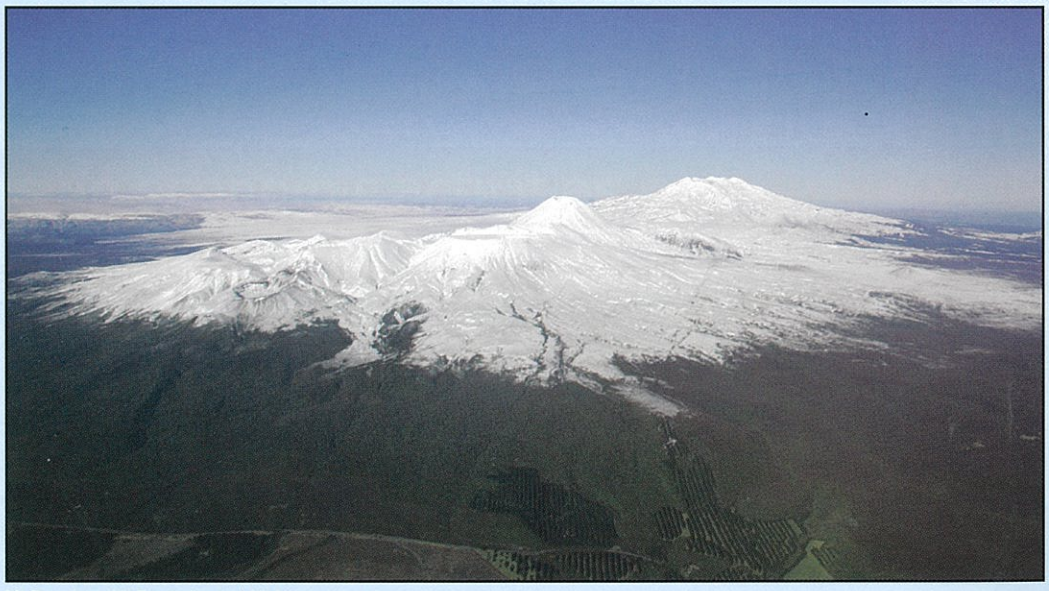
Rotorua's geysers.



Volcanic eruptions have changed the natural environment of the central North Island, also called the Volcanic Plateau. The Volcanic Plateau is made up of 20 000 cubic kilometres of volcanic rock that have been exploded from the many volcanic vents in the area. The Volcanic Plateau has huge craters, over 200 volcanic cones and 17 active geothermal areas.
Lake Taupo, a huge caldera and site of the world's most known violent eruption, is the core of the Volcanic Plateau.

Geothermal activity occurs on the plateau where groundwater is heated by volcanic activity. Geothermal landscapes have boiling mud pools, steam vents and geysers. The famous Pink and White Terraces, destroyed by the Tarawera eruption, were the result of geothermal activity.

Boiling mud pools.



Mt Ruapheu, Mt Tongariro and Mt Ngauruhoe.

Learning Activities

Skill: Paragraph writing

Using the GREED approach to paragraph writing, write a geographic paragraph to describe how volcanic eruptions affect the natural environment.

The GREED technique helps you to write well-organised paragraphs about geographic topics. GREED is an acronym so its letters have special meaning.

Example:

GR – Start with a generalisation:
The extent to which a volcanic eruption changes topography depends on the type and size of the eruption.

E – Expand your generalisation with some further information:
Eruptions can cause layers of tephra, lava, pyroclastic flows and lahars to gradually build up the land.

E – Add one or two examples to support your earlier statements:
For example, lahar flows from Mt Ruapehu carry large amounts of material to the base of the mountain, forming hammocks (or large mounds).

D – Draw a diagram or sketch map to illustrate some of the points you have made in your paragraph.

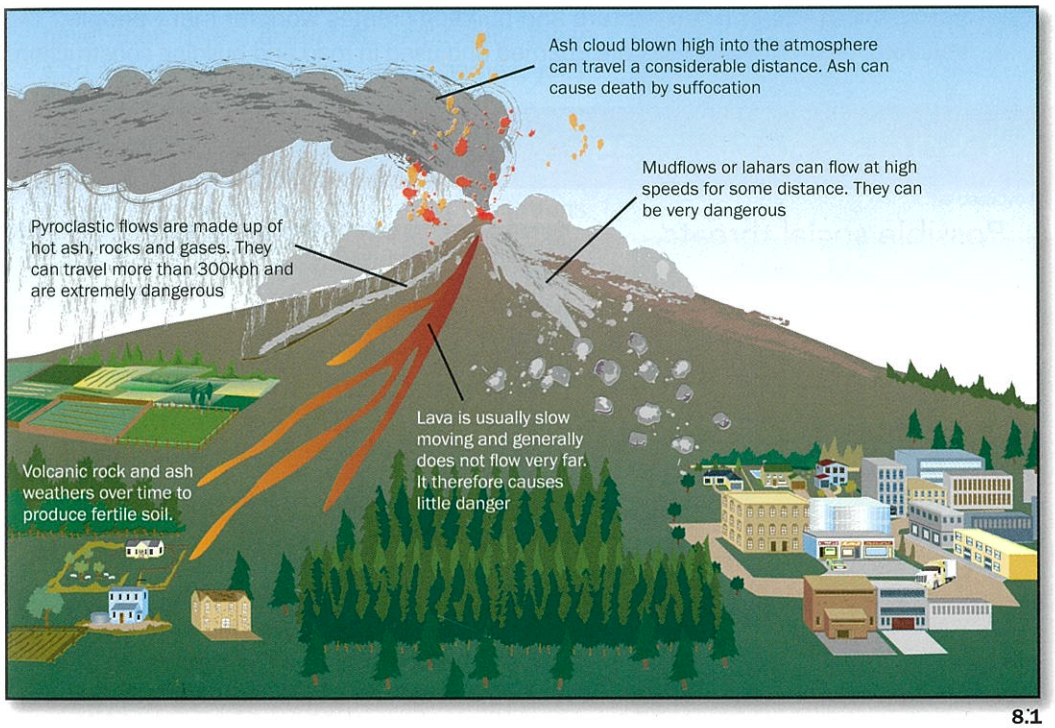
8 Effects of a Volcanic Eruption on Economic and Social Activities

Learning Outcome

In this unit you will learn about:

- effects of a volcanic eruption on economic and social activities.

Volcanic eruptions have social and economic effects on communities and countries. The extent of the effects, and whether they are threats or opportunities, depends on the type, size, location and duration of the eruption.



8.1

Effects on economic activities

Possible economic threats

An eruption in a large urban area would have greater economic effect than in a rural area.

- ***Personal property*** – If homes, furniture and vehicles are damaged by eruptions then the main concern will become health and safety.
- ***Commercial property*** – Some shops, offices and factories may be closed for months. Some will close permanently. Businesses and employees will lose income and less will be spent in shops.
- ***Farm livestock*** – Eruptions may kill or injure farm animals. Feed, water and pasture for animals may be destroyed or contaminated by lava flows and ashfalls. Farmers and other suppliers of goods and services may lose contracts with customers in other areas and countries.

- ***Forestry*** – Exotic forest near the eruption site may be flattened by lava, lahars or pyroclastic flows. Further away, heavy ash falls may cause severe damage to trees, stripping foliage and breaking branches. Damage to power supplies may also occur due to tree branches falling and shorting power lines.
- ***Transport facilities*** – Damaged or destroyed roads, railways and airports will affect the supply of goods and services for customers.
- ***Tourist attractions*** – These may be destroyed or altered by eruptions. For example, Pink and White Terraces, Mt Tarawera.
- ***Recreation facilities*** – Ski fields, trout-fishing streams, jet-boating rivers and walking tracks are likely to be affected by an erupting volcano.

Possible economic opportunities

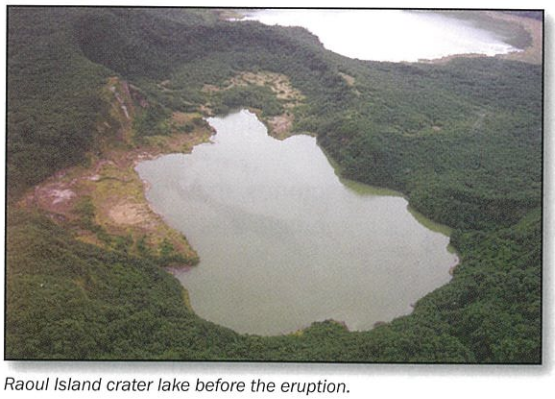
- ***Land*** – Ash and lava deposits make the soil suitable for different crops or plants. For example, pine forestry on the Volcanic Plateau. Soil becomes more fertile for farming.
- ***Geothermal*** - New steam deposits are used for generating electricity. For example, Wairakei.
- ***Tourism*** – New tourist attractions are created. For example, ski slopes on newly formed volcanic cones, new geysers, steam fields and mudpools.
- ***Infrastructure*** – New and improved roads, railways and airports are built. Better housing and business developments are planned and constructed.
- ***Employment*** – New infrastructure and building creates work for many people.
- ***Volcanic rock*** – New deposits are quarried and used in road and building construction.

Effects on social activities

Possible social threats

- ***Injury and death*** – Fast-moving pyroclastic flows are the most deadly effect of a volcanic eruption. Globally they have caused 70% of volcanic eruption deaths since 1900. Death can be caused by suffocation, burial and burning or collapsing buildings. Lahars have caused 12% of volcanic eruption deaths since 1900. Death can be caused by burial or scalding. Deaths from lava flows are rare as they are usually slow enough to escape from. A recent hazardous eruption resulting in death occurred in March 2006 on the volcanic island of Raoul, located 1000km NE of the North Island. One person, a Department of Conservation worker who had been monitoring the crater lake's temperature, was killed in the eruption.

Raoul Island



Raoul Island crater lake before the eruption.

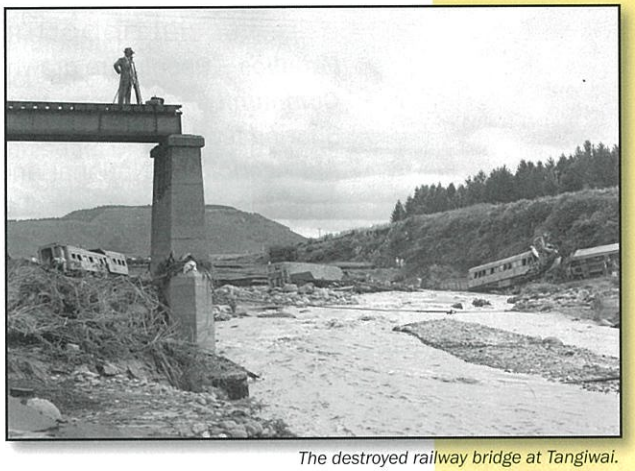
Raoul Island crater lake after the eruption.

Summary of deaths in volcanic areas of New Zealand during the past 150 years

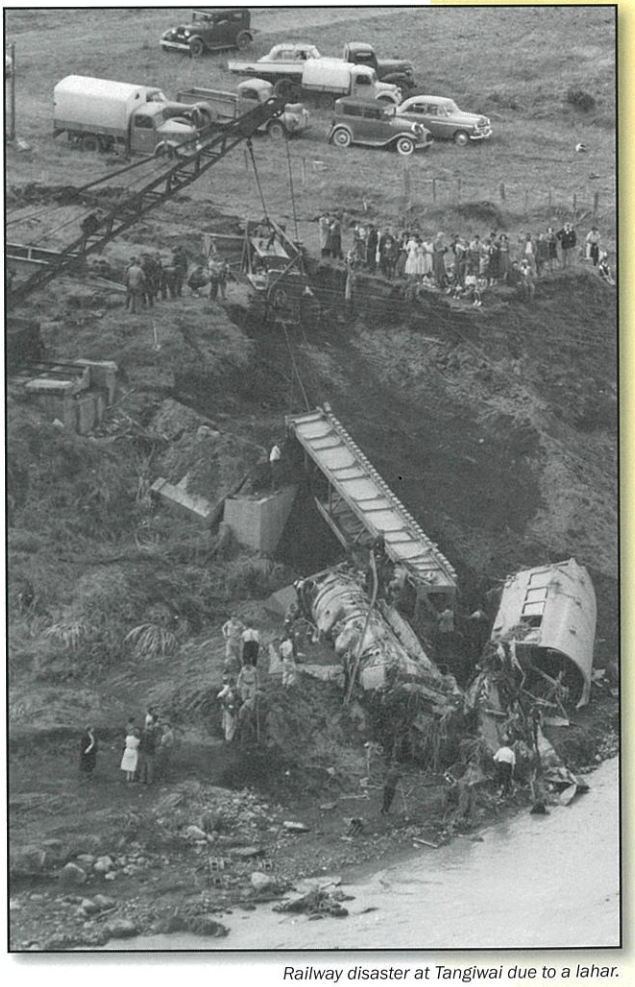
Year	Location (eruption)	Cause - hazard	Fatalities
1846	Waihi (Lake Taupo)	debris avalanche mudflow from thermal area	c.60
1886	Tarawera Rift	large volcanic eruption	>108
1903	Waimangu (Tarawera)	hydrothermal explosion	4
1910	Waihi (Lake Taupo)	debris avalanche from crater wall	1
1914	White Island	debris avalanche/mudflow from thermal area	11
1917	Waimangu (Tarawera)	hydrothermal explosion	2
1953	Tangiwai (Ruapehu)	lahar and flood from crater lake	151
2006	Raoul Island	hydrothermal explosion	1
			Total >338

8.2

- ***Trauma and disruption*** – Before, during and after an eruption some people will suffer emotional trauma, particularly if family, friends or pets have been killed. If an eruption happens during school hours, children may be separated from their families indefinitely. Counselling will usually be required to help people overcome an eruption experience. Many people will have their lives disrupted, especially those who are evacuated or lose their homes, jobs, businesses, schools or possessions.
- ***Public health*** – Ashfalls can be extremely thick, although in most cases they are light but still cause eye, skin and respiratory irritations. Providing and wearing dust masks and goggles helps reduce these symptoms.
- ***Buildings and building services*** – Ashfalls also cause damage to insides and outsides of buildings. Fine and coarse ash can foul paintwork and roofs. It can also enter buildings through doors and windows. Ash is difficult to remove and grinds down floor coverings. It also blocks air-conditioning units.
- ***Electricity*** – Eruptions can damage electrical systems. Power lines can break and ash settling on insulators can cause shorting or blackouts. Loss of electricity can shut down community water pumps and radio and communication facilities. Unless people have back-up batteries or generators then there will be losses of heating, light and refrigerated food.
- ***Water*** – Ash, lahars, lava flows and pyroclastic flows can contaminate water supplies. Chemicals in volcanic material can poison water in roof tanks, troughs, lakes and streams.
- ***Waste*** – Sewage and stormwater pipelines can become blocked with volcanic material which might result in flooding. Blocked sewage pumps may cause wastewater systems to fail and increase the threat of disease. Bacterial growth in oxidation ponds may be damaged which can alter the treatment of effluent.



The destroyed railway bridge at Tangiwai.



Railway disaster at Tangiwai due to a lahar.

- ***Transportation*** – Road, rail and air links can be disrupted by volcanic eruptions. Ash on wet roads and railways turns to mud causing traction difficulties. Lahars and lava flows can wipe out entire sections of road and rail. Fine ash can enter vehicle filter systems, causing breakdowns. Ash in aircraft engines can cause failure which could result in air crashes. As volcanic ash cannot be detected by aircraft radar, pilots won't be aware they are flying into eruption ash. Ash clouds were the main cause of flight disruptions during the Mt Ruapehu eruptions during 1995 and 1996.
- ***Communications*** – Overloading of telephone lines due to increased demand and direct damage to communication facilities causes disruption around an erupting volcano. Mobile phones may be disabled if ash clouds interfere with signals.
- ***Crops*** – Volcanic eruptions may kill or contaminate vegetables and fruit. Soil make-up can also be altered by ash deposits and lahar and lava flow damage.

Possible social opportunities

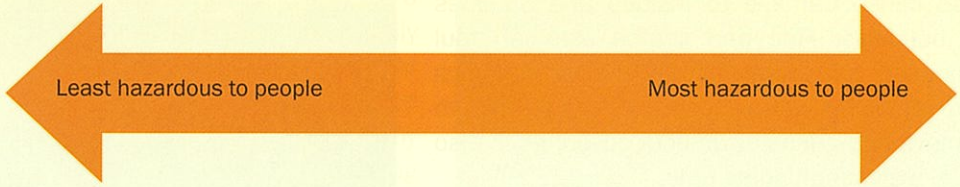
- ***Families*** – People are drawn closer together as they try to help each other.
- ***Community*** – Everyone works together to overcome the effects of an eruption. Sharing food, water, transport and shelter can improve people's lives.
- ***Aid agencies*** – National and international agencies coordinate relief – transport links, food, clothing, school aids, and health care for the eruption-affected areas.

Learning Activities

Effects on the cultural environment

1 Construct a continuum like the one below. On it rank the following volcanic threats from least hazardous to people to most hazardous to people.

- lava
- pyroclastic flows
- lahar
- ash cloud



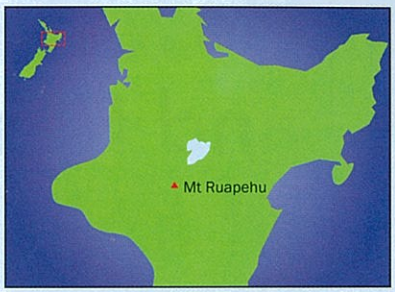
2 Justify your ranking with examples from the text.

3 **a** Using the information in Resource 8.2, construct a bar graph to show the number of deaths caused by volcanic activity in the last 150 years.

b Which hazard has caused the most deaths?

Case Study

Mt Ruapehu Eruption (September 2007)



Located on the Central Volcanic Plateau at a height of 2797m, Mt Ruapehu is New Zealand's largest volcano and its second most active volcano after White Island. Mt Ruapehu is a stratovolcano and as such, has been erupting frequently for more than 250,000 years.

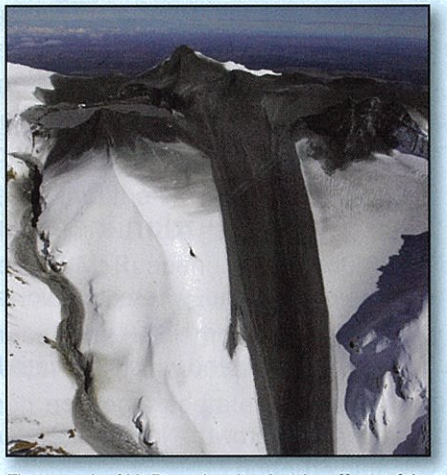
The area around the crater lake of Mt Ruapehu was covered with mud and ash from the eruption.

In recent times, minor eruptions from Mt Ruapehu have generated ash falls and lahars and caused little or no harm to social and economic activities. Major eruptions however, have from time to time, caused the outlet of Mt Ruapehu's crater lake to become blocked or dammed with volcanic debris. As volcanic debris is usually made up of rock and ash, it is generally unstable and therefore, susceptible to collapsing.

Such an event occurred when the 1945 eruption of Mt Ruapehu emptied the crater lake and caused the lake outlet to become blocked with tephra. Over time, the crater slowly refilled with water until eventually on Christmas Eve in 1953, the tephra dam collapsed causing a lahar to flow down the mountain side and into the Whangaehu River. The lahar caused the Tangiwai railway bridge which crossed the Whangaehu River to collapse only moments before the Wellington to Auckland overnight express train was about to cross it. A total of 151 lives were lost in what is now referred to as the Tangiwai disaster.

Since the Tangiwai disaster, Mt Ruapehu has been heavily monitored. However, when Mt Ruapehu erupted again on the evening of the 25th September 2007, it did so without warning. On this occasion, the eruption was accompanied by a magnitude 2.9 earthquake which lasted seven minutes. Volcanic debris was hurled more than 1.5km from the crater while two small lahars escaped the crater lake and flowed down the Whangaehu and Whakapapa glaciers. Although there was no loss of life, the effect of the eruption on social and economic activities was significant:

- A climber who was staying in the Dome Hut at the summit of Mt Ruapehu lost his leg when a rock which had been blasted from the crater crashed onto him during the eruption. A skifield worker driving a snowgroomer was also injured.
- More than 30 holidaymakers were evacuated from the Ngauruhoe ski lodge on Mt Ruapehu. Of those evacuated, some children were frightened and began crying.
  Some people suffered from anxiety while others simply remained calm.
- Public access roads on the mountain were closed.
- Turoa and Whakapapa skifields were closed resulting in a loss of $200,000 of chairlift revenue for skifield operators.
- The Department of Conservation warned people against sightseeing and trekking to the upper slopes of the mountain for the seven days following the eruption.



The summit of Mt Ruapehu showing the effects of the lahar after the 2007 eruption.

9 How People can Prepare for and Respond to the Effects of a Volcanic Eruption

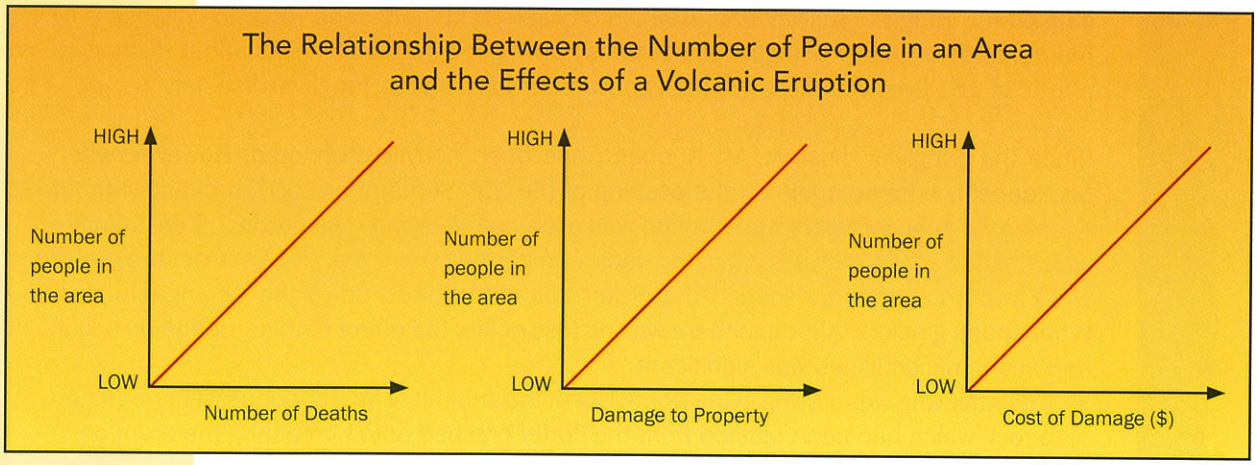
Learning Outcome

In this unit you will learn about:

- how people can prepare for and respond to the effects of a volcanic eruption.

Although people are unable to influence the natural processes that cause volcanic eruptions, they can by their actions, increase or decrease the likelihood of a volcanic eruption becoming hazardous.

The likelihood of volcanic eruptions being hazardous is increased if people are close to regions known for volcanic activity.



9.1

In New Zealand, volcanoes have killed more people than any other natural event. Although organisations like the Institute of Geological and Nuclear Sciences, and Government agencies such as the Ministry of Civil Defence and Emergency Management and the Earthquake Commission, have helped people become better prepared for volcanic eruptions, the threat of volcanoes continues to grow.

Why is the threat of a major volcanic eruption increasing?

- The population close to volcanic areas is growing.
- Population growth is largest in the North Island where the volcanic threat is greater.
- The greatest population growth has been in Auckland which is located on a volcanic field with more than 48 volcanoes.
- Population growth usually results in economic growth. New houses, factories, shops and roads will be affected by a volcanic eruption.
- Tourist support for attractions on or surrounding features of volcanic areas.
- Agriculture/forestry on volcanic soils means a growth of services and population.

Preparation

The likelihood of a volcanic eruption being hazardous is decreased if people are not located close by and if satisfactory warning systems are in place.

In New Zealand, people will continue to live and work in active volcanic areas where there are fertile soils suitable for farming, job opportunities at volcanic tourist spots and potential geothermal energy resources. This means that any future eruption activity has to be monitored so that possible threats to peoples' lives and property can be calculated and hopefully decreased.

Volcanic hazard management

Most volcanoes have dormant periods between eruptions. These can last a few years or even thousands of years. Because of this, the management of volcanic hazards can be separated into four phases – non-eruptive, pre-eruption, eruption, and post-eruption.

1 Non-eruptive phase: planning and preparation

- ***Vulnerability analysis*** – Identify equipment and facilities most likely to be affected by a hazard.
- ***Protection procedures*** – Develop methods to protect vulnerable facilities and equipment.
- ***Priority lists*** – Identify facilities that can't be shut down during a hazard.
- ***Essential plans*** – Establish plans for warning/notification of an imminent hazard and implementation of emergency procedures.
- ***Testing of procedures*** – All planning and preparation procedures for possible natural hazard to need be tested carefully.

2 Pre-eruption phase

- ***National Contingency Plan for volcanic eruptions*** – This is part of the National Civil Defence Plan. The plan outlines actions to be taken by government, councils and other agencies including Civil Defence for preparation and response to volcanic eruptions.
- ***Volcanic surveillance*** – Scientists believe movement of magma beneath a volcano will happen before an eruption. They use many methods to detect this movement.
- ***Ground deformation*** – When magma forces its way to the surface it pushes aside underground rocks. This causes ground deformation - bulging and swelling around the volcano. GPS is used to detect any ground deformation. To detect deformation, ground levelling networks are set up on the main crater floor of White Island. Levelling systems are also in use north of Taupo, south of Rotorua and around Okataina.
- ***Volcanic gases and crater lake chemistry*** – Magma contains dissolved gases. When magma rises, the gases are released through surface vents. The gases give scientists information about how close magma is to the surface. The gases are often released into the crater lake so scientists regularly test the lake water. Gas samples are collected from gas vents at White Island, Mt Tarawera, Mt Tongariro, Mt Ngauruhoe, and Mt Ruapehu. Continuous measurements of the crater lake levels, temperature and gas content are taken at Raoul Island, Okataina and Waimangu.
- ***Seismic monitoring*** – Seismometers measure ground vibration caused by moving magma, volcanic earthquakes or movement of underground gas and steam. Seismograph networks operate in Taranaki, Auckland, the Taupo Volcanic Zone and Raoul Island.

- ***The Earthquake Detection System*** – Installed after the 1995-96 Mt Ruapehu eruptions for example, is designed to minimise the risk from lahars by providing 1–10 minutes warning to nearby ski fields and 15–20 minutes warning to Whakapapa Village of a lahar travelling down the mountain from Mt Ruepehu's crater lake. The system uses a mix of sensors including measurement of seismic activity and air blast sensors that will activate an alarm if certain seismic thresholds and other conditions are met. The threshold is currently programmed to respond to an earthquake event of magnitude 3.0 or greater.
- ***Warnings*** – The volcano alert level decides what warnings are given. Usually the Director of Civil Defence Emergency Management or the CEO of the Regional Council will issue warnings to alert local civil defence organisations and the general public to a possible serious volcanic eruption. At low alert levels, some people may become concerned and leave the volcano area voluntarily. Tourist and community events may be cancelled or delayed. People may buy and stockpile emergency supplies like candles, water, tinned food and batteries. At medium and high alert levels, a Civil Defence Emergency is declared. Information and advice is broadcast over radio, television and on the internet.

Ruapehu's lahar of March 2007.

Both the lahar warning system on Ruapehu and the flood gauge on the Whangaehu River were put to the test in March of 2007, when a 4m high lahar broke free from Crater Lake sending more than a million cubic meters of water, rocks and ash down the mountain before entering the Whangaehu River. The emergency warning systems worked as intended, automatically sending alerts to emergency services including police, road and rail authorities and the local district council.

New Zealand Volcano Alert Levels

White Island, Tongariro-Ngauruhoe, Ruapehu		VOLCANO ALERT LEVEL	Kermadecs, Northland, Auckland, Mayor Island, Rotorua, Okataina, Taupo, Egmont/Taranaki	
Volcano Status	Indicative Phenomena		Indicative Phenomena	Volcano Status
Usual dormant, or quiescent state	Typical background surface activity; seismicity deformation and heat flow at low levels.	0	Typical background surface activity; seismicity deformation and heat flow at low levels.	Usual dormant, or quiescent state.
Signs of volcano unrest	Departure from typical background surface activity.	1	Apparent seismic, geodetic, thermal or other unrest indicators.	Signs of volcano unrest.
Minor eruptive activity	Onset of eruptive activity, accompanied by changes to monitored indicators.	2	Increase in number or intensity of unrest indicators (seismicity, deformation, heat flow etc).	Minor eruptive activity.
Significant local eruption in progress	Increased vigour of ongoing activity and monitored indicators. Significant effects on volcano, possible effects beyond.	3	Minor steam eruptions. High increasing trends of unrest indicators, significant effects on volcano, possible beyond.	Significant local eruption in progress.
Hazardous local eruption in progress	Significant change to ongoing activity and monitoring indicators. Effects beyond volcano.	4	Eruption of new magma. Sustained high levels of unrest indicators, significant effects beyond volcano.	Hazardous local eruption in progress.
Large hazardous eruption in progress	Destruction with major damage beyond volcano. Significant risk over wider areas.	5	Destruction with major damage beyond volcano. Significant risk over wider areas.	Large hazardous eruption in progress.

Mt Ruapehu has a lahar warning system. If the instruments detect an approaching lahar, people on the mountain will have 5-10 minutes to get out of valleys and onto ridges. There is also a flood gauge on the Whangaehu River, upstream from the Tangiwai rail bridge. If a lahar were to flow from Mt Ruapehu into the river, the rise in water level will trigger a gauge to warn approaching trains.

3 Eruption phase

The Civil Defence organisation was set up by the government in the 1950s to protect New Zealanders from natural and other disasters. It is now part of the Ministry for Emergency Management.

Civil Defence has authority to declare an emergency and to take full control during the emergency including:

- evacuating buildings and places
- restricting entry into buildings
- removing vehicles obstructing their work
- making use of private property that may help them during the emergency, such as, family car, home or buildings.

Evacuation of people, animals and property begins once a Civil Defence emergency is declared. The alert level determines the size of the evacuation area.

The Ministry for Civil Defence and Emergency Management are responsible for making sure that people are prepared for volcanic eruptions and other natural hazards.

4 Post eruption

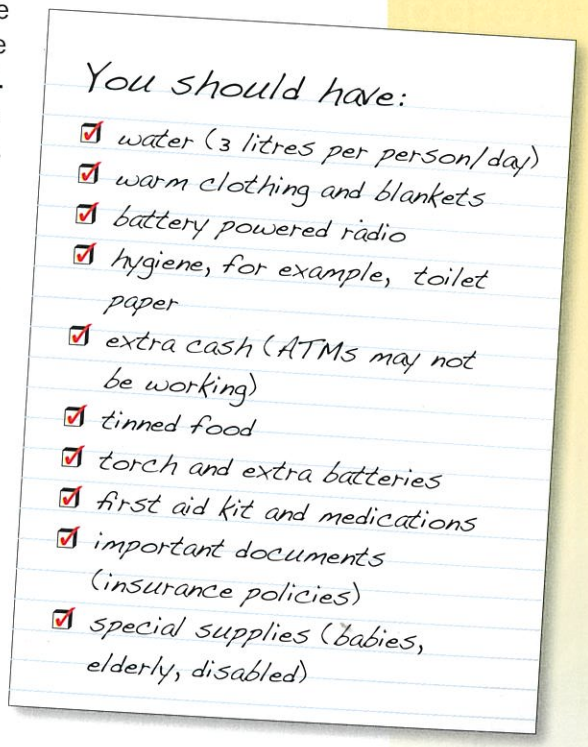
As an eruption quietens or ceases, Civil Defence coordinates the treatment of injuries, the search for survivors, the transporting of people to evacuation centres or hospitals and the extinguishing of fires.

In the following weeks, relief teams assess damage to property and supplies to determine how much government assistance is needed. Badly damaged buildings are condemned, ash deposits are cleaned up and infrastructure (electricity, sewage, water) is restored to reduce health problems.

In the months and years that follow an eruption, some evacuees may return to their homes while others will move to safer areas. Insurance claims are lodged and assessed. Damaged property is repaired or rebuilt. Reconstruction of major infrastructure like roads, railways, airports, waterways also begins.

5 Be ready to survive

You can gather together items that you will need to help yourself and your family survive a disaster before a disaster happens.



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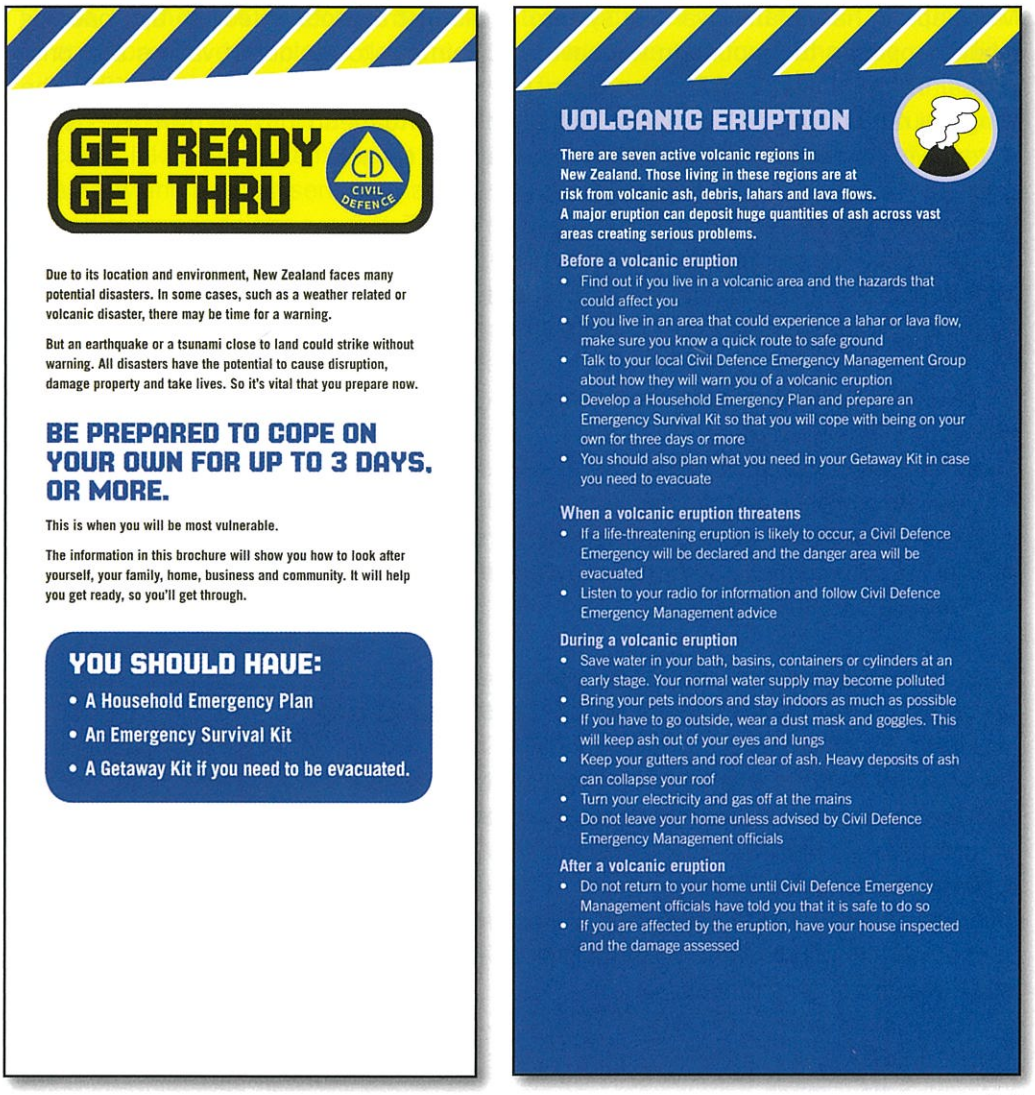

GET READY GET THRU

CIVIL DEFENCE

Due to its location and environment, New Zealand faces many potential disasters. In some cases, such as a weather related or volcanic disaster, there may be time for a warning.

But an earthquake or a tsunami close to land could strike without warning. All disasters have the potential to cause disruption, damage property and take lives. So it's vital that you prepare now.

BE PREPARED TO COPE ON YOUR OWN FOR UP TO 3 DAYS, OR MORE.

This is when you will be most vulnerable.

The information in this brochure will show you how to look after yourself, your family, home, business and community. It will help you get ready, so you'll get through.

YOU SHOULD HAVE:

- A Household Emergency Plan
- An Emergency Survival Kit
- A Getaway Kit if you need to be evacuated.

VOLCANIC ERUPTION

There are seven active volcanic regions in New Zealand. Those living in these regions are at risk from volcanic ash, debris, lahars and lava flows. A major eruption can deposit huge quantities of ash across vast areas creating serious problems.

Before a volcanic eruption

- Find out if you live in a volcanic area and the hazards that could affect you
- If you live in an area that could experience a lahar or lava flow, make sure you know a quick route to safe ground
- Talk to your local Civil Defence Emergency Management Group about how they will warn you of a volcanic eruption
- Develop a Household Emergency Plan and prepare an Emergency Survival Kit so that you will cope with being on your own for three days or more
- You should also plan what you need in your Getaway Kit in case you need to evacuate

When a volcanic eruption threatens

- If a life-threatening eruption is likely to occur, a Civil Defence Emergency will be declared and the danger area will be evacuated
- Listen to your radio for information and follow Civil Defence Emergency Management advice

During a volcanic eruption

- Save water in your bath, basins, containers or cylinders at an early stage. Your normal water supply may become polluted
- Bring your pets indoors and stay indoors as much as possible
- If you have to go outside, wear a dust mask and goggles. This will keep ash out of your eyes and lungs
- Keep your gutters and roof clear of ash. Heavy deposits of ash can collapse your roof
- Turn your electricity and gas off at the mains
- Do not leave your home unless advised by Civil Defence Emergency Management officials

After a volcanic eruption

- Do not return to your home until Civil Defence Emergency Management officials have told you that it is safe to do so
- If you are affected by the eruption, have your house inspected and the damage assessed

9.4

Response

The Earthquake Commission (EQC) was set up in 1945 to provide insurance cover for homes damaged by volcanic eruptions and other natural disasters. But the insurance fund has limited ability to decrease the effects of a volcanic eruption. It does not pay out on damage to a standing forest, bridge or viaduct, tunnel or cutting, retaining wall or dam, drain or channel, reservoir or swimming pool, water tank or septic tank and livestock or growing crops.

The Resource Management Act (1991) requires all Regional Councils to identify areas that are at risk to hazards connected to volcanic eruptions.

The Civil Defence Emergency Management Act (2002) sets out a vision for communities to understand and manage their hazards. Everyone in an active volcanic area needs to know the sequence of events associated with the natural hazard and the social, economic and cultural impacts of an eruption.