Eruption Products

What can volcanoes produce?

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Discuss

What can come out of a volcano?
Lava, ash, rocks, gases, steam, explosions, sound, pressure waves

Why do different volcanoes produce different eruptive material?
Different magma mixtures have different properties. Some are very viscous and gases can't escape easily leading to frothy magma and violent explosions. Some are runnier and don't froth up as much so they are not as explosive.
Other factors are involved as well, such as how fast the eruptive material cools, where and how it was forced out of the volcano and whether or not water was involved.

• Discuss the eruptive materials listed on the worksheet and show the students images of these using the relevant video clips from the following websites.

http://dsc.discovery.com/convergence/pompeii/videogallery/videogallery.html
http://www.teara.govt.nz/en/volcanoes/7/2

Activity

• Using the information on the volcano fact sheets complete the worksheet to show the eruptive material usually associated with Ruapehu and Taupo.

• Make obsidian (toffee) and pumice (hokey pokey)
- Recipes and instructions can be found in Building Science Concepts 12-Volcanoes.

Obsidian and pumice are both rocks formed from rhyolite magma.

This type of magma is responsible for the creation of NZ's caldera volcanoes. Rhyolite magma is very thick and viscous, the lava it produces does not flow easily. If gases have time to escape from rhyolite magma, obsidian (also called volcanic glass) can be formed.
If the gases remain in the magma a hot froth of gas and melted rock will form. When this frothy mixture is thrown out and quickly cooled in an eruption, a very light rock full of holes will be formed. This is pumice.

Explain the connections between the rocks and the sweets by asking students to describe features such as

- ability to flow (viscosity)-hot toffee with less gas flows better
- gas content (bubbles, froth) –hokey pokey expands and froths like pumice
- time taken to cool-hokey pokey cools much faster
- eight -pumice and hokey pokey are much lighter because they are full of holes left by the gas bubbles.
- colour- pumice and hokey pokey are lighter in colour.
- texture- sharp and smooth (toffee & obsidian) or rough and abrasive (pumice and hokey pokey)

Note-Obsidian is not a black rock, it looks black because of the way it refracts light. All rock types formed from rhyolite magma are light in colour because of their high silica content.

• Eat the rocks!

Learning Intentions

• See the eruptive materials a volcano can produce

• Show the eruptive materials of 2 NZ volcanoes

• Make sweets that demonstrate the properties of magma and show how different eruptive materials can be produced from the same magma under different conditions.

Success Criteria

Students can

• Name and describe different types of eruptive material

• Complete the worksheet accurately.

• Relate the gas content of volcanic rocks (pumice and obsidian) to properties of toffee and hokey pokey.

Resources

• Samples of obsidian and pumice if possible

• Worksheet

• Eruption clips

• Volcano fact sheets for Taupo, and Ruapehu

• Building Science Concepts 12 - Volcanoes -Ministry of Education

• Ingredients for toffee and hokey pokey

Vocabulary

obsidian, pumice, eruptive material, froth, lahar, ash fall, tephra, pyroclastic flow, debris avalanche

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Volcanoes can quietly trickle out lava or violently explode molten mixtures of gases, liquids and solids high in the sky. Anything between those extremes is possible and the damage caused to people and the environment will depend on how far the products of the eruption reach or how close people are.

In simple terms the amount of gas in the magma determines how violent the eruption will be. If the gas can escape the liquid easily, the magma will be able to flow out as lava. If the gas has not separated from the molten rock, the rising magma will froth as the pressure decreases and the gas expands. This frothy mixture full of gas will be ejected violently rather than flowing over the ground gently.
If surface water is added to either sort of magma it will flash to steam and increase the violence of the eruption. Water can become involved through crater or caldera lakes, streams, groundwater or the sea.
Students can probably recall seeing images of flowing lava and clouds of fiery 'ash' from volcanoes but may not realise that the 'smoke' can include pyroclastic flows, lahars and ash fall.

The Discovery Channel video clips are an excellent resource. They show different eruptive materials and a range of other information (including some about NZ volcanoes) in dramatic fashion. Most students will demand repeat screenings!

http://dsc.discovery.com/convergence/pompeii/videogallery/videogallery.html

For a more detailed explanation of eruptive material see

http://www.gns.cri.nz/what/earthact/volcanoes/hazards/index.html

By using the volcano fact sheets about Ruapehu and Taupo, and the information on the worksheet, students will be able to draw and label the eruptive material most commonly associated with these volcanoes.
They should see the difference between fall and flow deposits.
Fall deposits (called tephra) 'rain' down from a high, stable eruption plume and carpet the ground like snow.
Flow deposits like pyroclastic flow are too heavy to form a stable eruption plume and instead fountain out of the vent and collapse back onto the land surface where they flow outwards.
Fall and flow deposits can be produced in different stages of the same eruption.
Students should also begin to develop an understanding of the size difference between Ruapehu's eruptions and the two largest eruptions of Taupo.
The eruption of Taupo 1800 years ago (called the Taupo eruption) was the most violent eruption anywhere in the world in the last 5000 years. The eruption plume reached over 50 kilometres into the stratosphere and the pyroclastic flow travelled up to 90 kilometres from the vent. It flowed up and over the top of nearby mountains such as Tongariro. Mt Ruapehu was the only mountain tall enough to divert the flow. The flow left a thick layer of pumice and ash often welded into rock by the heat. This is called ignimbrite and the Taupo ignimbrite covered more than 20,000 km^2. Most vegetation was destroyed and carbonised logs from the original forest cover can still be seen today preserved in the ignimbrite. Areas further away were also affected, ashfall buried the sites where Napier, Hastings and Wanganui would eventually be built.

The eruption of Taupo 26,000 years ago (called the Oruanui eruption) was even bigger. It produced fall deposits and pyroclastic flows that buried much of the central North Island to depths of up to 200 metres. The volume of material ejected in this eruption would be enough to build three Ruapehu sized cones. So much material was ejected that the magma chamber under the volcano was emptied and a huge area around the vent collapsed to form the caldera which is now partially filled by Lake Taupo.
Between these two catastrophic eruptions there were at least 26 smaller eruptions which spread pumice and ash over nearby areas and formed small lava domes in and around the lake.
Making the toffee and hokey pokey is designed to reinforce the difference between magma with gas and magma without. Perhaps students should only be allowed to 'eat the rocks' if they can explain this!

Curriculum Links

Planet Earth and Beyond

Physical World

Science Concept	NOS
PE-Earth Systems L3/4 –develop an understanding of what makes up our planet **PW-Physics Concepts L1/2**-explore physical phenomena such as movement, forces and heat.	**Understanding about Science** **Investigating in Science**

Univeristy of Auckland - Colin Wilson

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How hot is lava?

Lava varies in temperature depending on what is in the molten rock mix, how fast it erupts and how deep in the Earth it came from. An average temperature would be around 1000ºC. This explains why crater lakes explode when magma reaches the water and instantly vaporizes it. A person would be killed instantly by lava but this is rare because lava is slow moving and people have time to move away.

What does pyroclastic mean?

Pyroclastic literally means fiery fragments.

Magma exploding out of a volcano is fragmented by the expanding gas/steam, this fragmental is called pyroclastic material.

Pyroclastic material is exploded into the air creating an eruption plume.

Clouds of small pyroclastic particles can rise to great heights in the eruption plume and be blown in different directions by the wind. When this light material falls back to Earth it forms fall deposits.

Fall deposits are called tephra. Tephra can range in size from dust to large blocks or bombs as big as cars.

What is pyroclastic flow?

When the eruption plume is heavier than air it will collapse back on itself and surge outwards at the base (a bit like pointing a garden hose straight up into the air). This creates a special type of volcanic landslide/avalanche called pyroclastic flow- a ground hugging flow of ash and pumice carried along by hot gases.

Pyroclastic flows and surges move across the ground like hot avalanches. You could not outrun one and they are probably the most frightening and deadly events associated with large eruptions.

What are volcanic earthquakes?

Volcanoes produce many types of earthquake, the most common are ‘volcanic-tectonic earthquakes’ and ‘volcanic tremor’. Each type creates a different signal on a seismograph. When rocks are broken by magma moving through them small earthquakes occur, these are ‘volcanic-tectonic earthquakes’. When volcanoes erupt they also create seismic signals, volcanic and explosion earthquakes. As hot volcanic gases or magma pass through cracks on the way to the surface they cause a small ground vibration, this is called volcanic tremor. These tremors can be an almost continuous seismic signal indicating movement of volcanic gases or the magma itself.

Can volcanoes cause tsunamis?

Yes. Tsunamis are seismic sea waves (like earthquakes through water instead of land). The eruption of an underwater volcano or the earthquakes associated with the eruption can trigger a tsunami. The eruption of Krakatoa in the Pacific in 1883 triggered 30 metre high waves which drowned 36000 people, due to displacements of the sea by cone collapse and pyroclastic flows entering the sea.

Volcanic tsunami may also be produced by landslides or debris avalanches flowing into the sea around a submarine or island volcano.

Large earthquakes before or during a volcanic eruption from a vent in a lake such as Taupo or Rotorua, may generate seiches (waves) on the lake. Low-lying land on the edge of a lake would be flooded by a seiche. Seiches can also travel down rivers that flow from the lake. Small seiches are common in the Taupo and Rotorua Lakes and in the South Island’s Lake Wakatipu.

Why can lahars happen when there is no eruption?

Lahars are volcanic debris carried down the mountain by water. They look like lumpy mudflows and can crush anything in their path. They can happen when an eruption is in progress or later. In 2007 the blocked outlet of the crater lake at Ruapehu collapsed and the contents of the lake plus parts of the outlet dam flowed down the mountainside and into the Whangaehu River. There was no eruption at the time but the outlet was blocked during the 1995/96 eruption by tephra.

For footage of this event see
http://www.gns.cri.nz/news/release/20070327_lahar_words.html
http://www.youtube.com/watch?v=lMNlijm6xk4

Do some volcanoes erupt more often than others?

Yes Fortunately our most dangerous caldera volcanoes, Taupo and Okataina typically have the longest interval between eruptions. They are rhyolite volcanoes and erupt on average every 1000 years. Unfortunately neither of these volcanoes shows any relationship between the size of the eruption and the time between eruptions. A big eruption, such as the Taupo eruption 1800 years ago, does not mean a long gap until the next eruption.

Andesite cones such as Ruapehu, Tongariro and White Island erupt every few decades on average.

Basalt volcanoes such as the Auckland Volcanic Field usually only erupt once but this means it is harder to tell when and where the next new volcano will pop up. All of Auckland’s volcanoes have been created in the last 250,000 years. That gives an average of just under one every 5000years. These figures are the subject of current research and it should be noted that more eruptions have occurred in the last 100,000 years than in the previous 150,000 years.

To show the different volcanoes produced by different combinations of viscosity and gas try the interactive activity at:
http://www.nationalgeographic.com/features/04/forcesofnature/interactive/index.html?section=v

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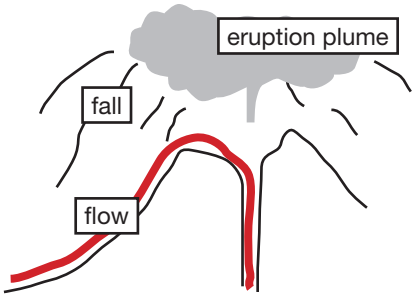
Use the information below and the volcano fact sheets for Ruapehu and Taupo to draw and label common eruptive materials and other volcanic hazards from each volcano.



Fall Deposits

Magma and rock around the vent are exploded upwards into an eruption plume.
This fragmented rock is moved by the wind and 'rains' down from the plume as fall deposits. These deposits are usually called **tephra**.
Tephra is divided into 3 size ranges- ash (less than 2mm wide), lapilli (2-64mm wide), and blocks or bombs (more than 64mm wide).

Flow Deposits

Fast moving flows of ash and pumice that 'fountain' out of the vent and are carried along the ground by hot gases are called **pyroclastic flows**. This flow tends to travel along valleys but can be explosive enough to flow over mountains! (eg the Taupo eruption flowed over Tongariro)

Lava

Magma (molten rock) that flows out onto the surface of the Earth where it cools and hardens.

Lahars

Fast flowing streams or rivers that carry volcanic debris (rock and ash) from a crater lake down the sides of a volcano. They can also be caused by heavy rainfall remobilising ashfall deposits.

Volcanic gases

Mainly steam and carbon dioxide with smaller amounts of sulphur and chlorine compounds, gases are only hazardous within a kilometre or two of the crater.

Atmospheric effects

Electrical storms caused by ash clouds, darkness during the day, rain and acid rain due to volcanic dust seeding clouds

Volcanic earthquakes

Seismic waves due to the movement of rock, magma or gases in or under the volcano.

Landslides (debris avalanches)

Rock slides triggered by earthquakes or magma movement changing the slope angle so loose material runs off the steep sides of volcanoes.

Ruapehu

Taupo