Magma

Why don't all volcanoes look and act the same?

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Discuss

What shapes can volcanoes be? (revisit photos if necessary)

- Cone shaped -Ruapehu, Taranaki, Rangitoto, White Island, Ngauruhoe
- Crater (caldera) shaped-Taupo & Rotorua
- Fissures- Tarawera, ocean spreading ridges (including Iceland)
- Domes-Tarawera and many others in Taupo Volcanic Zone
- Other shapes- Dunedin &Banks Peninsula- eroded and flooded shield volcanoes, Rangitoto-shield with a summit cone

What are possible reasons to explain the different shapes and sizes?

- Different ages meaning different amounts of erosion
- Different numbers of eruptions, more eruptions build higher, more complex,cones.
- Different types of eruption leave different things behind
- Volcanoes with vegetation don't erode so fast.
- Different sizes of eruptions, some more violent than others

How are Auckland's cone volcanoes different to those in the TVZ?

- Smaller, less volume erupted, more of them, also some craters (eg Pukaki) caused by explosions

Explain

Different types of magma cause different types of eruptions and create different sorts of volcanoes.
Magma contains molten or partly molten rock and dissolved gases such as water.

Activity

To find out how gases behave discuss and observe:

What is in the bottle of fizz?
Water, sugar, flavouring, gas/something that makes the bubbles, air (at the top of the bottle)

Can you see any gas in the liquid?
Probably not apart from the air at the top.

What happens when you shake the bottle?
Small bubbles appear.

What will happen if you begin unscrewing the top?

• (Do not fully release the cap yet, once frothing begins tighten the cap again so bubbles disappear)
The bubbles increase and rise to the top.

Where did these bubbles come from, why couldn't we see them before, what is in the bubbles?
The bubbles are gas (carbon dioxide) that was dissolved in the liquid while the liquid was under pressure inside the bottle. As soon as the pressure is released the gas can expand. When it expands it takes up more room and pushes outwards.

What will happen if the pressure is released quickly?

• Shake the bottle vigorously (outside!), point the bottle away from people and release the cap.
The expanding gas rushes out of the bottle carrying the liquid with it. This mixture of gas and liquid looks frothy but rapidly returns to normal as the gas escapes into the air.
The gases in magma behave in the same way. As the magma rises up towards the vent of the volcano, pressure decreases, the gas bubbles within the molten rock expand and may explode violently carrying their molten rock covering with them and creating pumice.

Learning Intentions

• To see that different types (shapes) of volcano are created by different types of magma leading to different types of eruption.

• Observe the flow of different liquids and compare their viscosity.

• Observe what happens to gases in a liquid under different pressure conditions

Success Criteria

Students can

• Complete the worksheet accurately.

• Describe the properties of magma, using appropriate words such as viscosity and pressure, and concepts such as the expansion of gases.

Resources

• Plastic bottle of any sort of fizzy drink.

• Milkshake, custard, honey

• flat trays

• straws and small containers for the liquids

• Magma activity sheet

Vocabulary

explosive, viscosity, viscous, pressure, gases, expand, dissolve, release, sticky, flow, expansion, fissure

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- Complete the bubble diagrams on the activity sheet.

To explore viscosity (stickyness) observe and discuss the 3 liquids.

- Pour a small amount of each onto a flat tray. Tilt the tray gently to see how the liquids flow.
- Complete the viscosity section of the activity sheet.

How does viscosity affect the gases in liquids?

- Put a straw into each of the liquids and try blowing bubbles.
  - This can get very messy as the liquids may spatter over a wide area. Best done outside with the 'blowers' wearing protective clothing. If it is impossible to blow bubbles through the honey see if students can suggest a way to make it possible. (heating the honey will lower it's viscosity and make it easier)
- Complete the activity sheet and discuss how the viscosity of a liquid has an effect on how easy it is for gases to escape.

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Magmas vary in their composition and in the conditions they meet as they rise through a vent during an eruption. Magma can be erupted passively (as lava flows or domes), or explosively as an eruption plume.
Three main factors decide how the magma behaves – the chemistry of the magma, the amount of gas (including water) dissolved in the magma and whether or not the magma interacts with water as it reaches the surface.
Basalt lava (that makes up Auckland's volcanoes) is runny; rhyolite lava (from Taupo volcano) is sticky. If magma is runny, low in dissolved gases and does not interact with water near the vent it will flow out of the vent as lava. If the magma is viscous and has more gas, or interacts with water near the surface of the Earth it may explode violently.

All the volcanoes of the Taupo Volcanic Zone and Taranaki can be very explosive and they are all caused by subduction. As the Pacific Plate descends below the Australian Plate water and sediments are included in the mix. This combination of materials lowers the melting point of the rock and creates a molten fluid full of dissolved gases. This magma mixture will take any opportunity to release the pressure by finding its way up to a cooler and less cramped environment. The Taupo Volcanic Zone shows how successful this magma has been at reaching the surface. All the TVZ's volcanoes have erupted repeatedly and Taupo is considered one of the world's most dangerous volcanoes.

Three volcanic fields occur in Northland and Auckland. They are not caused by subduction. These volcanoes have formed well away from plate boundaries and are called 'intra-plate' or hot spot volcanoes.
There is scientific debate about what causes these hot spots. Theories range from magma plumes upwelling from areas as deep as the core-mantle boundary, to strain caused by variations in movement of different parts of large tectonic plates.
Hot spot volcanoes in the Auckland Volcanic Field are small by comparison with NZ's other volcanoes. Each eruption builds a single small volcano which does not erupt again (Rangitoto may be an exception). Auckland City is built amongst approximately 50 small volcanoes that have all been formed over the last 250,000 years. Although they are smaller, hot spot eruptions in an area such as Auckland could still be devastating and the next location cannot be predicted until the eruption is imminent.
Many South Island cities; Christchurch, Dunedin, Timaru and Oamaru, are built on or near the remains of large extinct hot spot volcanoes.
There are a number of active hotspots under the Pacific Plate creating island chains as the plate moves over the hot spot. These include the Hawaiian Islands and closer to home the Louisville seamount chain to the north east of NZ.

The shape of a volcano is determined by the violence with which it erupts and this in turn is decided by what is in the magma it contains.
Students need to have a basic understanding of viscosity (stickiness) in order to see that low viscosity (runny) liquids can flow easily and gas can escape from them readily.
The amount of silica and dissolved gases such as water in magma determine its viscosity. Low silica magmas have a low viscosity, they can flow easily and gas can escape from the fluid gently. This type of magma, called basalt, creates the Auckland volcanoes.
This magma can form lava flows and is represented by the milkshake.
A larger proportion of silica creates the andesite or dacite magma found in Ruapehu and Taranaki. This magma is more viscous (less runny) and gases find it harder to escape from the liquid.
This magma can form lava flows and ash falls and is represented by the custard.
The most viscous (stickiest) and silica rich magmas are rhyolites. These magmas make it difficult for gases to escape leading to very explosive eruptions such as Taupo and Rotorua.
This magma is so full of trapped gas it fragments to ash and is represented by the honey.
When magma is under pressure deep underground the gases it contains are dissolved in the liquid. As the magma rises closer to the Earth's surface the pressure decreases allowing the gases to expand and eventually burst out of the liquid.
Students will see that the thicker the liquid the more explosive this process is.

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

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What is silica?

In the Earth's crust the two most common elements are silicon and oxygen. Silicon atoms combine with oxygen atoms to form silicon dioxide (silica). In its pure form this is the mineral quartz and it is the Earth's most abundant mineral. When other elements are added to the silica different types of silicate minerals are formed creating different rock types. The more silica that magmas have, the more viscous (sticky and rigid) they become, and the more explosively they erupt. Viscous, high silica magmas can erupt so explosively that the surrounding rock collapses inward into the hole left behind. In NZ these huge depressions (calderas) have filled with water forming Lakes Taupo and Rotorua.

Can volcanoes only produce one type of magma?

No, the same volcano can produce different magmas at different times and sometimes even in the same eruption. It depends on what has melted to form the magma in the magma chamber and what this magma has mixed with on its way to the surface.

Does all magma come to the Earth's surface?

No, fortunately most magma remains underground and hardens into rock. Rocks formed from magma are called igneous rocks. There are two types of igneous rock, volcanic and plutonic. Volcanic rock has reached the surface and plutonic rock has cooled and hardened underground. Volcanic rocks have plutonic equivalents, for example the volcanic rock rhyolite has the same general chemistry as the plutonic rock granite although they look very different. Granite has large crystals because it has cooled slowly underground while rhyolite is fine grained due to rapid cooling after an eruption.

What makes the magma erupt?

Molten rock is lighter and more buoyant than surrounding rock so it moves upwards through cracks in the overlying rock. It may pool in magma chambers where, over time, it may be added to by new molten material. When the magma is forced higher the pressure decreases because there is not so much overlying rock. This allows the gases in the magma to expand and create bubbles. The pressure caused by this expansion can break the rocks above and trigger eruptions.

What happens to the magma chamber in an eruption?

Over time the magma in large chambers may separate into layers of different density because pressure and temperature are lower near the top of the chamber and denser crystals sink. Higher up the chamber where there is less pressure gases can expand. For this reason some volcanoes produce different types of material as the eruption progresses. The gassy froth may be erupted explosively first (pumice) and followed by a less violent lava flow.

If a large enough amount of magma is erupted, the surrounding rock may collapse into the chamber creating a depression at the surface called a caldera.

In subduction volcanoes the magma chamber will refill from continuing melting of the descending plate. As this new melt rises it increases the pressure on the magma already in the chamber until it is released by another eruption.

Where do hot spot volcanoes get their magma from?

Hot spot volcanoes are not caused by subduction so they do not usually occur near plate boundaries.

Scientists believe they may be caused by giant plumes of heat welling up from deep in the mantle. These plumes may form as deep as the core-mantle boundary. The plumes are thought to be in fixed spots but the plates are slowly moving above them. Chains of hot spot volcanoes, such as Hawaii and the Louisville seamount chain near NZ are formed as the crust slowly moves over a mantle plume. For more on seamounts see lesson 15 from- http://www.montereyinstitute.org/noaa/

Another explanation of hot spot volcanoes is that the friction and strain of a plate under tension can create the heat needed to produce a hot spot. 'Bubbles' of magma from the hotspot 'pinch' off and rise rapidly to the surface creating small volcanoes. In the Auckland Volcanic Field this would explain why the volcanoes are small and usually only erupt once-the bubble runs out of magma. Until the next 'bubble' is almost at the surface it is impossible to predict where a new volcano will emerge.

How do volcanoes erupt under the sea?

Submarine volcanoes are caused by the same processes as those on land and have the same variety of cone and caldera forms.

Their eruptions are influenced by the seawater above them. A deepwater volcano is under huge pressure from the overlying water and this means gas in the magma cannot escape easily. The magma usually erupts as a lava flow rather than exploding because the gases in the magma cannot expand and fragment the rock. Even very large deepwater eruptions may not disturb the surface of the ocean.

If the volcano is in shallower water (100-200m) bubbles will form, the magma will froth and the eruption will be more explosive throwing pyroclastic material into the air above the ocean surface.

To see this occurring in a 2009 eruption near Tonga see:
http://www.youtube.com/watch?v=fRU22t1BhNY

It is possible (with the right sort of submersible vehicle!) to get quite close to an erupting submarine volcano because the water pressure confines the erupted material to a narrow area and cools it down.

For more information and images of the first and only submarine volcano so far observed in eruption see:
http://www.gns.cri.nz/news/release/20090511nwrota.html

For a summary of types of magma and how they relate to types of eruption see:

http://www.teara.govt.nz/en/volcanoes/1

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Name:

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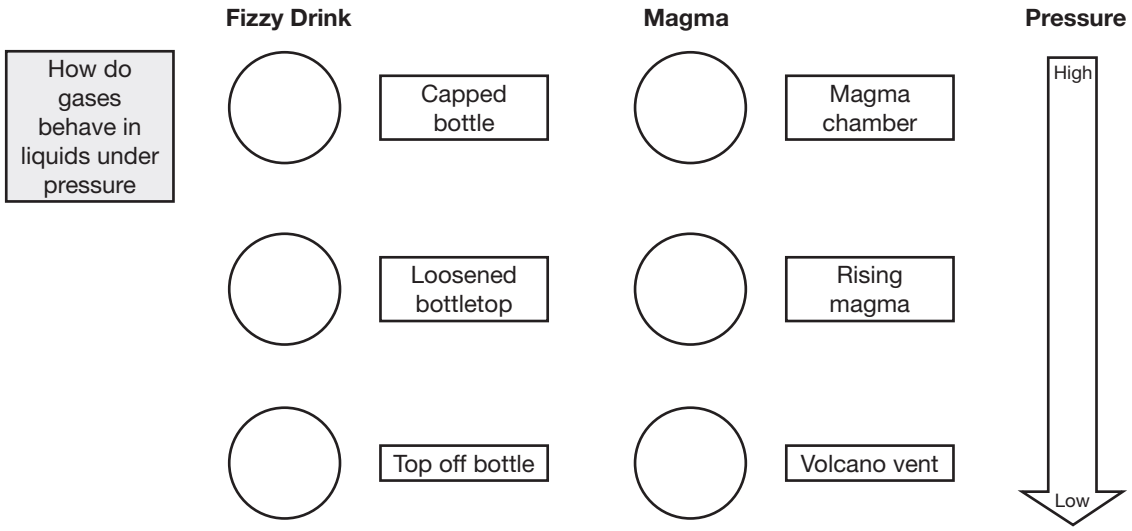
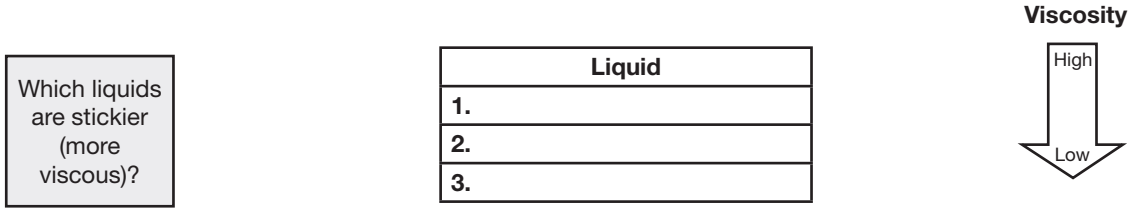
Why don't all volcanoes look and act the same?

Exploring the properties of different liquids will show that different types of magma create different types of volcano.



1. Draw the bubbles in each circle to show how the gases expand as the pressure decreases.



2. By observing how easily your liquids flow downhill, order the liquids from the highest to the lowest viscosity.

3. Name the liquid in each container, draw the straw and draw what happened when you blew in each liquid.

4. Use your observations above to help you decide what sort of magma you think will create the most explosive volcano.

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