Bubble-mania

The bubbling clues to magma viscosity and eruptions

Pour a viscous liquid (eg. honey, syrup) into one transparent container and a pale-coloured soft drink (eg. ginger beer) or just coloured water into another. Put both of these onto a plastic tray or table. Ask your pupils to use a drinking straw to blow bubbles into the soft drink, then ask them to 'use the same blow' to blow bubbles in the more viscous liquid. When nothing happens, ask them to blow harder until the liquid 'erupts'.

Honey and a soft drink – ready for bubble-mania.

Apparatus photo: Chris King

Ask:
- How were the 'eruptions' different?
- How were the bubbles different?
- What caused the differences?
- Some volcanoes have magmas that are 'runny' (like the soft drink) and some have much more viscous magmas (like the other liquid) – how might these volcanoes erupt differently?
- Which sort of eruption would you most like to see – one with low viscosity (runny) magma, like the soft drink, or one with high viscosity (thick) magma like the viscous liquid?

Magma fountain within the crater of Volcan Villarrica, Pucón, Chile.

viscosity

wo similar-
on style.

Time needed to complete activity: 10 mins

Pupil learning outcomes: Pupils can:
- describe the difference in viscosity between two similar-looking liquids and relate this to the difficulty of blowing bubbles in the liquids;
- describe how the differences in the viscosities of the liquids they have tested, link with the viscosities of magmas and the relationship between magma viscosity and eruption-style.

Context:
Note that pupils often confuse the terms 'magma' and lava', 'magma' is liquid or partially liquid rock underground; when it flows out of the ground in eruptions it becomes lava.

Possible answers to the questions posed are given opposite:

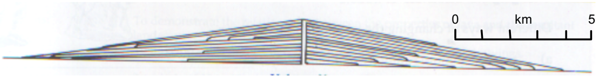
- How were the 'eruptions' different?
  It was easy to blow bubbles into the soft drink and it 'fizzed' a bit, but the bubbles soon disappeared; it was much harder to blow bubbles into the viscous liquid and they grew large and sometimes burst out of the container or splattered the blower

- How were the bubbles different?
  The soft drink bubbles were small and soon disappeared; most of the bubbles in the viscous liquid were much larger and lasted longer; some burst, overflowing the container or splattering.

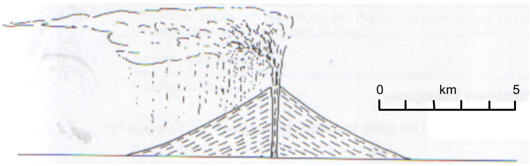
- What caused the differences?
  The soft drink was less viscous (more runny) than the thicker viscous liquid.

- Some volcanoes have magmas that are 'runny' (like the soft drink) and some have much more viscous magmas (like the other liquid) – how might these volcanoes erupt differently?
  Most eruptions are caused by the 'degassing' of magma when the dissolved gas in the magma is released, either when the pressure is reduced (eg. when the plug of solid magma in the neck of a volcano is blown out and the magma is forced out like cola from a shaken bottle, when the top is removed), or when crystallisation of the magma causes an increase in the gas content. The type of eruption that then happens depends on the gas content and the viscosity of the magma.
  - *Low viscosity (runny) magma loses its gas quickly (like the soft drink in the test above) and so flows gently, but quickly out of the volcano, as lava. This fast-flowing lava can flow a long*

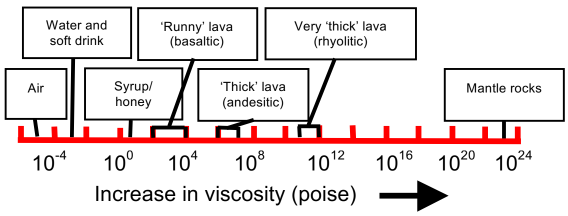
way, producing a volcanic cone with a flat shape. Sometimes gas bubbles can be trapped in the magma as it cools, as round gas holes called vesicles.



- *High viscosity (thick) magma causes much more explosive eruptions - with violent degassing throwing magma as ash often high in the air; when the ash rains down, it forms a steeper-sided volcano. When lava does flow out of the volcano, it doesn't flow far, leaves steeper slopes, and the bubbles can be trapped (as in the viscous liquid in the test above), so that it flows like a froth and when it cools down, can form low density pumice full of gas holes.*



Viscosity is measured in poise and the viscosity of lavas is usually shown on a logarithmic (log) scale, where each unit is ten times greater than the previous unit in the scale. The log scale below shows where the liquids tested above and different lavas fit onto the scale (scale from the University of British Columbia).



Basaltic, iron-rich, silica-poor lava is the lowest viscosity magma, whilst iron-poor, silica-rich rhyolitic lava is the most viscous.

- Which sort of eruption would you most like to see – one with low viscosity (runny) magma, like the soft drink, or one with high viscosity (thick) magma like the viscous liquid?
  Low viscosity magma eruptions are fairly safe and the magma spraying or flowing from the volcano can usually be viewed safely from a distance. High viscosity magmas cause the most dangerous eruptions, resulting in death and destruction – avoid these if you want to stay alive.

Note that the direct link between magma viscosity and violence of eruption is lost for:

- andesitic and rhyolitic lavas which have previously degassed – these can flow non-violently to form magma domes or sheets of obsidian (volcanic glass);
- basaltic lavas that come into contact with water – the water causes explosive activity.

Following up the activity:
Try the Earthlearningidea 'See how they run' activity, testing the effects of temperature, solid content and water content on the viscosity (flow rate) of treacle to simulate their effects on magma flows.

You could use darker liquids (eg. treacle, cola) to represent darker-coloured magmas that will become basalts, rather than the pale coloured liquids here, more similar to silica-rich lavas.

Underlying principles:

- Some liquids are less runny (more viscous) than others (eg. different magmas).
- Bubbles form more readily in low viscosity fluids, but are more easily lost.
- Low viscosity basaltic (iron-rich, silica-poor) magmas lose their gas easily, and so are relatively safe and produce shallow volcanic cones.
- Higher viscosity andesitic and rhyolitic (iron-poor, silica rich) magmas are much more explosive and dangerous, forming steep sided ash cones, and can produce frothy pumice lava.

Thinking skill development:
If pupils construct for themselves the pattern that similar-coloured liquids are likely to have similar viscosity, then they will encounter cognitive conflict when it becomes much more difficult to blow bubbles in the higher viscosity liquid. Translation of their ideas from the liquids tested to 'real world' volcanic eruptions is a bridging activity.

Resource list:
Per group:

- two transparent containers, eg. plastic cup or glass tumbler
- two drinking straws
- enough soft drink or coloured water and viscous liquid (eg. honey, corn syrup, or syrup) to two-thirds fill each container
- plastic trays or tables in which/on which to carry out the activity, which can be messy
- cloths and plenty of warm water to clean up

Safety note: When the bubbles of honey or syrup burst, they can splatter onto clothes or into the eyes of the blower; being a sugary liquid, this is not dangerous, but should be washed out immediately.

Source: Devised by Eileen van der Flier-Keller, Associate Professor at the School of Earth and Ocean Sciences at the University of Victoria, Canada. Many thanks to Steve Sparks for helpful comments on an earlier version.