ACTIVITY 2: WHAT MAKES A VOLCANO EXPLOSIVE?

The type of plate boundary affects the chemistry of the magma. The longer magma is stored in a particular location with no replenishment of new melt, the more it cools and crystallises (like when you freeze water and form ice crystals). Crystals that grow early in the magma's history do not have much silica (SiO_2) in them (the crystals predominantly grow using elements such as Mg, Fe, Ca); this causes the remaining magma to become progressively enriched in silica as the crystals grow and settle out due to gravity.

The chemistry of the magma affects its physical properties (the way it moves). This includes viscosity (see glossary and figure 1). More viscous substances (like golden syrup) are stickier than less viscous substances (like water). The more silica magma has in it, the higher the viscosity (this is because silica forms long molecular chains within the magma – like polymer chains in plastics). However, even a lower viscosity magma is **A LOT** stickier than things we use in the kitchen, such as golden syrup!

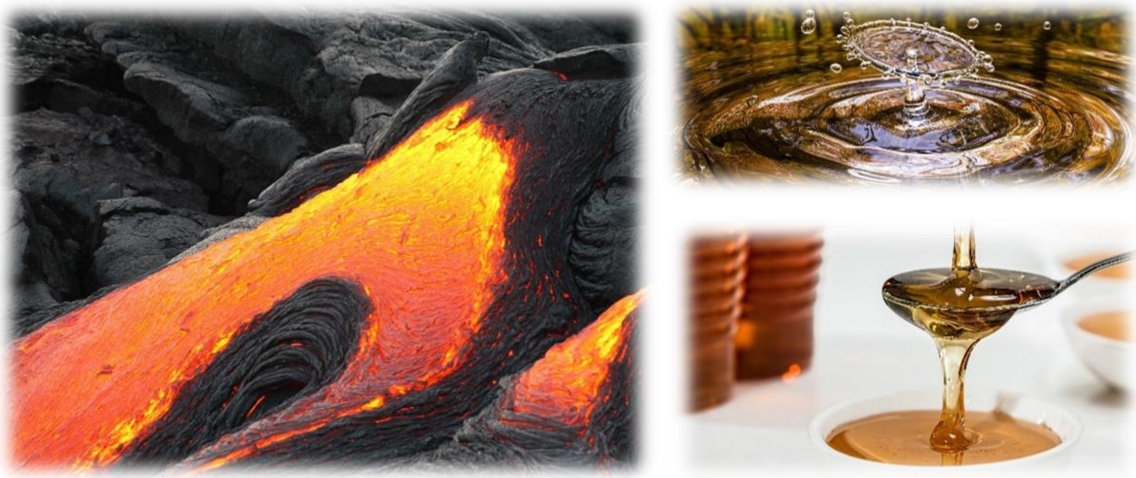

Figure 1. On the left is a low silica magma (basaltic). On the upper right is water, which has a low viscosity, while on the lower right is golden syrup, which has a high viscosity. Golden syrup is stickier than water.

So, silica-rich magmas flow very slowly and are cooler than their low silica counterparts: silica-rich magmas are generally ~900°C when erupted, as opposed to silica-poor magmas that are ~1200°C. Remember your average household oven goes to 250°C max, so these are really hot molten rocks! Silica-rich magmas are generally lighter in colour when they solidify, while less silica-rich magmas are darker in colour; this is because low silica rocks tend to have more elements that are metallic in their composition e.g. Fe, Mg, and Ti.

Silica-rich magmas erupted from volcanoes are called 'rhyolitic', while at the other end of the spectrum, lower-silica magmas are 'basaltic'.

Whether a volcano is explosive or effusive depends on how much gas is in the magma and how easy it is for that gas to escape from the magma. At depth in the Earth's crust, magma is stored at a higher pressure than at the Earth's surface. At high pressure it is possible for gas to be dissolved in a magma. This is similar to gas in fizzy water: if you have a bottle of fizzy water, you cannot see the gas bubbles until you undo the lid. The gas is there, but the water is under pressure and the gas is dissolved in the liquid. Undoing the lid releases the pressure in the bottle and causes the gas to separate out ("exsolve") from the water. The same thing happens when the pressure of the magma is changed: gas can exsolve (separate-out) from the magma and form bubbles! What happens next depends on the viscosity of the magma, i.e. how sticky it is. The stickier the magma, the lower the chances of the gas getting out, and the more gas trapped in the magma, the more explosive the volcano will be.

For further information on why volcanoes erupt, have a look at this interesting article: https://theconversation.com/curious-kids-why-do-volcanoes-erupt-98251

The gas in magmas is generally comprised of a number of compounds that you will already have heard of, chiefly: water (H_2O), carbon dioxide (CO_2), and sulfur dioxide (SO_2). What is interesting is that these gases have implications for regulating the Earth's climate. However, unlike the human contribution to climate change, volcanic inputs have been moderated over geological time by the Earth's feedback systems. For more information on climate change, have a look at the HE+ activity 1 from the Climate Change topic (http://www.myheplus.com/post-16/subjects/geography/climate-change).

1. **Given the physical properties of the two types of magma we've discussed (basaltic and rhyolitic), think about which is more likely to be associated with more explosive or effusive eruptions.**

We describe hand specimens of rocks by looking at their:

Overall colour	The proportion of light and dark minerals
Density of the rock	Any bubbles (or vesicles)
Any textures i.e. banding/layering/orientations	The sizes of the different grains in the rock

From these observations, volcanologists can broadly classify whether an igneous rock (i.e. one that has crystallised/solidified from lava) is more basaltic or more rhyolitic. Remember, this directly links to how much silica it has in its composition. Basaltic magma is hotter, with a lower viscosity. Gas bubbles can easily escape from the lower viscosity magma and so basaltic magmas are generally associated with effusive eruptions. In contrast, rhyolitic magmas are cooler, with a high viscosity. It is much more difficult for gas to escape and so rhyolitic magmas are generally associated with explosive eruptions. As a result of this classification, it is possible to deduce whether the volcano the rock came from was likely to be more explosive or effusive.

2. **Look at the four photos of different rock types below. Describe each of them based on the hand specimen observations in the table above.**
3. **Then, using what you've learnt about the chemistry and physical properties of two types of magma, suggest what type of magma the rocks could have solidified from and why. Do you think the rocks were from explosive or effusive eruptions?**

(It may be the case that you would rather have more information (or rock samples) to better quantify the problem. That would be very reasonable(!); volcanologists often find themselves in positions where they have a limited amount of data and then have to make scientific <u>interpretations</u> from the limited information or observations that they have available to them.)

Rock 1.

Rock 2.

Rock 3.

Rock 4.