Magma Viscosity – Tutorial Script

Viscosity is a measurement of a fluid's resistance to flow. Taffy is more viscous than syrup. Syrup is more viscous than water. How can we make syrup less viscous (more runny)? Heat it up, remove sugar from it, or add water. To make it thicker or more viscous, we do the opposite: cool it, add more sugar, or remove water.

How does viscosity relate to magmas? Magmas formed at depth are hot and low in SiO_2. These make them low in viscosity. As they rise upward through the crust they cool, which makes them more viscous. In addition, as they cool, crystals start to form. As these crystals are removed from the magma, the SiO_2 content of the magma increases, which also makes viscosity increase. Why? The higher the SiO_2 content in a magma, the more silicon-oxygen tetrahedra, which as we know from the Inside Minerals video tutorial, when found in high abundance, will attract each other and start bonding together in chains. This bonding will happen even in the liquid phase and linked tetrahedra will make a magma more resistant to flow.

So what? Magma viscosity impacts igneous rocks in a few ways.

At the surface, when magma viscosity is high, magmas have a hard time migrating out of vents. They can get stuck in these vents. In addition, gases have a hard time escaping from viscous magmas. Together: magmas rich in gas plugging up vents can allow pressure to build behind them heightening the risk of explosive eruptions. In contrast, when viscosity is low, magmas erupt more easily, and gases are released more easily. Hazard level is lower.

Erupted lavas that are high in viscosity will generally have smaller crystals because the lavas cool faster than ions can travel through the magma to nucleation sites. In extremely viscous lavas, there can be no time for any crystals to grow, and we end up with glass, or obsidian.

Magmas that stay underground and have unusually low viscosities will do the opposite: the ions can migrate rapidly through the low-viscosity magma to nucleation sites, and instead of many small minerals forming, we see fewer crystals, but each much larger. The texture we get with these unusually large crystals forming in low-viscosity magmas is called a **pegmatite**. Pegmatites form when highly evolved magmas, rich in SiO_2, mix with a water phase that had separated and sat at the top of the magma chamber absorbing incompatible elements from the magma (elements that have no place in the main crystals forming from the magma). I like to call this phase the "spit phase" as it's filled with all the unwanted "garbage" elements (such as gold, silver, and platinum) much like the spit that's left behind in a soda can after you take a swig. As we know the more sips you take of the soda, the more of your spit is left behind until finally the last sip is mostly spit, or so they say. This now-mixed magma + water or "spit" phase has unusually low viscosity but also higher pressures, which can crack the rock and inject the magma into veins around the magma chamber. In these pegmatite intrusions, because of the high concentration of incompatible elements in the "spit", we also see rare minerals forming like tourmalines, beryls, and emeralds.

What happens to the "spit phase" if the magma chamber is opened up and the pressure released to the surface? An explosive volcanic eruption, in which the liquid is carried upward by the force of the escaping gas. The liquid flash freezes to form ash, and it's thrown up high into the atmosphere where winds will carry it potentially thousands of miles away. This process is similar to what happens when soda is shaken up and then opened. Everything in that spit phase will migrate upwards with the gas and be distributed along with the ash.

<u>Igneous Rocks Series:</u>
Part I: Igneous Rocks
Part II: Plutons
Part III: Magma Viscosity

[end credits]

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