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Influence of geometry on eruptive behaviour of magma reservoirs

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All active polygenetic volcanoes erupt magma sourced from a shallow crustal reservoir. Those chambers are complex entities that act as a collector of magma originating from deeper crustal sources. The geometry of those active storage systems depends on the rheology of the magma and on the rock properties of the host. Studying how the geometry influences the eruptive behaviour of a magma chamber has implications for our understanding of volcanic hazard.
We introduced a simple model where a magma reservoir is cooled by an overlying geothermal system and recharged by a deeper magma source. The geometry of the chamber is defined by its volume and aspect ratio. The model tracked changes in pressure, mixture enthalpy and composition, and implemented parameterisations of eruption, hydrothermal cooling, viscoelastic relaxation, and volatile leakage. The thermodynamic properties of the melt, crystals and water were computed using rhyolite-MELTS.
A large number of simulations sweeping our parameter space gave us insight into how the different magmatic processes trade off with respect to the geometry of the inclusion. An example of the complex control of geometry on the eruptive behaviour can be made regarding cooling and the effective compressibility of an ellipsoidal inclusion. On the one hand, a larger aspect ratio will favor eruptibility by offering a larger area for cooling therefore increasing the exsolution of water and pressure build up. On the other hand, a larger aspect ratio will work against eruptibility by decreasing the compressibility making it harder to build overpressures within the chamber. We found that a specific geometry is required in order for a chamber to erupt without any external stimuli (such as a large recharge event).
A limiting factor of our model is the assumption of a perfect mixing. Whereas, in reality, we would expect recharge, cooling and leakage to occur within specific regions of the chamber. In a model where mixing is not considered perfect, those processes would be a source of heterogeneity. We could conjecture that under the right conditions, eruptible regions would appear within the chamber. A model focusing more on the flows within the chamber might be able to give additional insights on the eruptive behaviour of magma chambers.