

Magma eruption rates, eruption styles, and preeruptive magma viscosity

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Magma eruption rate is one of the most fundamental parameters for a volcanic eruption (e.g., Pyle, 2000). It is obtained mainly by geophysical or geological observations. We interpret this important parameter from a petrological point of view and also from a fluid dynamic point of view.

We have collected a hundred of data on magma eruption rates, bulk rock chemical compositions, and phenocryst contents for various styles of eruptions (Plinian, sub-Plinian, basaltic Plinian, lava flow, and lava dome). We are compiling these data on the basis of their 'preeruptive magma viscosities', which are important measures of magma eruptibility (Takeuchi, 2011). Preeruptive magma viscosity is the viscosity of magma (melt + crystals) in the magma chamber at the preeruptive conditions. This value can be obtained by the bulk rock chemical composition and phenocryst content, using an empirical formula (Takeuchi, 2010). We have found that eruption styles are closely correlated to preeruptive magma viscosities but poorly correlated to bulk rock compositions.

We have also examined the difference in magma eruption rates between the explosive phase(s) (e.g., Plinian) and the effusive phase (e.g., dome) in a series of eruptions, in order to understand the transition between these two eruption styles (e.g., Kozono and Koyaguchi, 2009a,b). We have found that the difference is positively correlated to preeruptive magma viscosity.

The above results indicate that preeruptive magma viscosities largely control eruption styles and eruption rates. Our results also show that the eruptive magmas are divided into two types, low-viscosity type (basalt to low-phenocryst-content andesite) and high-viscosity type (high-phenocryst-content andesite to rhyolite). The boundary is at about 10^4 Pa s. These two types may be closely linked to the magma generation processes (e.g., fractional crystallization and melt segregation from crystal mush).

Keywords: magma eruption rates, eruption styles, preeruptive magma viscosity, transition between explosive and effusive eruption, phenocryst content, bulk rock chemical composition