

## Rheological law and viscous-brittle transition of 3 phase magma; a case study for the 1946 andesitic lava from Sakurajima volcano, Japan

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Uniaxial compression deformation experiments were done for the 1946 andesitic lava from Sakurajima volcano, Japan, under conditions of temperatures from 1300 to 1130 K, strain rates from  $10^{-2.5}$  to  $10^{-5.5} \text{ s}^{-1}$ , and ambient pressure. The starting lava sample has ca. 20 vol. % of bubbles and the solid part consists of ca. 47 vol.% of rhyolitic glass, ca. 23 vol.% of microlites and ca. 30 vol.% of phenocrysts of plagioclase, pyroxenes, and Fe-Ti oxides. The experiments were done by using the uniaxial deformation apparatus at ERI, University of Tokyo. Deformation experiments were done after ca. 2h pre-heating at the experimental temperatures and the samples were quenched to 873 K with 15 min after the deformation was finished. During the experiments, stress and sample high were monitored under constant temperature. Deformation rate was changed stepwise due to examine non-Newtonian behaviors. Viscosity was calculated by the equation of Gent (1960) from the monitored stress-sample high dataset.

The lava behaves as a power law shear-thinning fluid at temperatures from 1300 to 1160 K under the experimental strain rate conditions. Viscosity increases from ca.  $10^{7.3}$  to ca.  $10^{11.3} \text{ Pa s}$  with decreasing temperature and strain rate. An equation describing its dependence on temperature and strain rate was proposed. Relative viscosity, defined as the ratio of magma viscosity/melt viscosity, is almost constant around 100 (with assumption that melt water content is 0.2 wt. %) regardless of experimental temperature. At 1130K, fracturing occurs at strain rate of  $10^{-3.5} \text{ s}^{-1}$  whereas the lava behaves as viscous under strain rate of  $10^{-4} \text{ s}^{-1}$ . Crystallinity is almost constant around 0.53 regardless of temperature.

Deborah numbers are calculated to be lower than  $10^{-2.65}$  for non-fractured samples and ca.  $10^{-2.65}$  for the fractured sample. The relation between crystallinity and critical Deborah number for viscous-brittle transition is consistent with the criteria for crystal-bearing magmas proposed by Cordonnier et al. (2012). Present results indicate that the critical stress for viscous-brittle transition is ca.  $10^{7.4} \text{ Pa}$ . The present rheological law was used to calculate flow velocity of the 1946 andesitic lava flow; the result calculated at 1273 K well explains the field observation of Hagiwara et al. (1946). The temperature is consistent with petrological constraints. The calculated maximum shear stress in the lava flow is lower than  $10^{6.5} \text{ Pa}$ , indicating that any process concentrating stress on the lava surface is required to form the blocky structure.

Keywords: Rheological law, Lava flow, brittle-viscous transition, magma, Sakurajima volcano