



Viscous flow of magmas from Unzen volcano, Japan – implications for magma mixing and ascent

F. Vetere (1), H. Behrens (1), F. Holtz (1) and D. Neuville (2)

(1) Institut für Mineralogie, Uni Hannover, Germany, (2) Institut de Physique du Globe de Paris, France (f.vetere@mineralogie.uni-hannover.de)

Viscosity of magmas is crucial for understanding und modelling igneous processes such as magma generation, ascent of magma, differentiation of magma and volcanic eruptions. The main parameters which govern the viscosity of magmas are bulk composition of the melt (in particular the water content of the melt) and temperature, but pressure dispersed crystals and bubbles may have also an important influence.

The viscosity of hydrous andesitic melts and magmas was investigated over a large range (10^1 to 10^{13} Pa·s) using the falling sphere method and creep experiments [1] [2]. Based on the new viscosity data obtained for an Fe-free andesite analog composition (containing up to 5.6wt% H₂O) and data from literature for similar melt composition, we derived the following expression to describe the viscosity η (in Pa·s) as a function of temperature T (in K) and water content w (in wt%)

$$\log \eta = -4.85 + \frac{8154.4}{(T - 529.9)} - \frac{5863.7}{(T - 576.9)} \cdot \frac{w}{(w^{1.15484} - 2.4455 + 0.0052 \cdot T)} \quad (1)$$

This expression reproduces the experimental data (191 in total) in the viscosity range from 10^1 to 10^{13} Pa·s with a standard error of 0.15 log units.

To test the applicability of this equation for natural melts, viscosity experiments were performed with a natural Fe-bearing andesite from Unzen volcano using the falling sphere method. The position of Pd and Pt spheres in the quenched sample was monitored before and after the experiments using X-ray images. At oxidizing conditions (NNO + 3; high abundance of Fe³⁺), the viscosities of melts containing between 0.7 and 6.3 wt% H₂O are close to those predicted by Eqn.(1). However, at more reducing conditions (geologically more relevant conditions) the viscosity is expected to be

lower because Fe^{2+} , which acts as network modifier, predominates over Fe^{3+} . [2] Experiments to test this hypothesis are in progress.

First experiments were performed in the high viscosity range (creep apparatus) to study the rheological behavior of partially crystallized water-bearing andesite containing small and homogeneously distributed crystals. Samples with less than 40 vol% of crystals were synthesized at liquidus conditions (1-3 wt% H_2O ; 500 MPa; 1000 – 1150°C). As already observed for crystal-free melts [2], the effective viscosity continuously increases with time during the creep experiment. No additional crystallization was observed in the sample after the experiment, suggesting that at least one viscosity datum representative for the original andesite can be extracted from each creep experiment.

The results of viscosity determinations in andesitic systems are combined with previous data for rhyolitic systems to model viscosity changes during mixing and degassing of Unzen magmas.

[1] P. Richet et al., 1996, *Chem Geol*, 128, 185-197

[2] C. Liebske et al., 2003, *Geochim Cosmochim Acta*, 67, 473-485