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Dissection of crystal bearing melts rheology

Benoit Cordonnier (1,2), Michael Manga (1), and Boris Kauss (2)

(1) Department of Earth and Planetary Science, University of California, Berkeley, (2) Geological Institute, Eidgenoessische Technische Hochschule, Zuerich

The major drawback to scale back experimental results to volcanic systems is a good comprehension of the physical processes involved. The rheology of magmatic suspensions is a complex flow of bubbles, crystals and melt. The crystal is the phase, which after temperature, affects the most the viscosity of magmas ($>$ 7 orders of magnitude). The dynamics of crystal bearing melts is a complex combination of a liquid flowing around a solid network of particles, themselves displaced and aligned by the fluid but constrained by their own network. Many parameters affects a fluid suspension, the most effective being the crystal fraction, the bulk stress and the temperature.

Our results constrain experimentally, theoretically and numerically the different flow regimes of crystal bearing melts namely Newtonian, hydrodynamic, friction, lubrication, turbulent and brittle regimes.

Two major effects explain the increase of apparent viscosity of magmatic suspensions: the stress localisation within the melt phase and the effects due to the crystal network. As stated above the stress within the fluid phase will align the crystals but the crystal arrangement will define the stress within the fluid. For a given stress, the suspension will find an equilibrium between these two competitive effects. It comes that for quantification reasons, one this two parameter has to be fixed in order to evaluate the other. Here we present two-phase flow numerical simulations performed to constrain the effect of stress localisation within the fluid. Our numerical results obtained on the melt phase demonstrates how the stress localizes for different crystals pattern (i.e. random, clusters or aligned).