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The rheology of bimodal crystal size distribution magmas - analogue experiments

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The fluid mechanical behavior of magma in a volcanic conduit controls not only the intensity of a volcanic eruption but also the eruption style. The fluid mechanical behavior of magma in the conduit is influenced by the rheological change in magmas that result from processes including vesiculation, degassing, and microlite crystallization induced by decompression. During magma ascent, microlites originate from supercooling, or an increase in the liquidus temperature due to water exsolution, or vesiculation induced by pressure changes. It is not uncommon in volcanic rock textures to find microlites in association with pre-existing phenocrysts. Bimodal crystal size distributions like these suggest that microlite formation is a shallow-level process typical of the last stages of magma evolution prior to the eruption. Progressive increase of microlite volume percentage can thus dramatically affect the rheology of rising magma within the conduit consequentially affecting its eruptive style.

The experiments presented here were designed in order to investigate the role of increasing microlite content on the rheology of a magma with different starting amounts of phenocrysts. In order to reduce the total variable parameters and better understand the role of different crystal content, shape and size distribution we neglected the rheological effects of bubbles.

Rheology of the samples has been measured performing controlled shear stress tests in a rotational rheometer using a parallel plate geometry. Rheology measurements were performed on suspensions of particles with different geometries in a Newtonian silicone oil. The suspensions have been blended adding different proportions of smaller particles to a fixed amount of larger particles. In this way the increasing total volume fraction of particles is dependent on the progressive relative abundance of smaller particles respect to the fixed percentage of larger ones. Suspended particles were chosen in order to i) resemble the shapes and the dimensions of natural microlites and phenocrystals, ii) display uniform particle size distributions among the respective type of particles and iii) have moderate density contrast respect to the silicon oil in order to avoid rapid settling during the experiments. Glass beads and carbon fibres were employed in the experiments representing natural phenocrysts and microlite respectively. Moreover, being natural crystals characterized by angular surfaces, suspensions of SiC grit and wollastonite particles have been blended in order to investigate the effect of particle roughness on flow properties. Bidispersed suspensions of bimodal glass beads have also been measured for comparison.