Geophysical Research Abstracts
Vol. 16, EGU2014-10533-1, 2014
EGU General Assembly 2014

The effect of crystal shape, size and bimodality on the maximum packing and the rheology of crystal bearing magma

Pranabendu Moitra and Helge Gonnermann
Rice University, Houston, Texas, United States (pm10@rice.edu)

Magma often contains crystals of various shapes and sizes. We present experimental results on the effect of the shape- and size-distribution of solid particles on the rheological properties of solid-liquid suspensions, which are hydrodynamically analogous to crystal-bearing magmas. The suspensions were comprised of either a single particle shape and size (unimodal) or a mixture of two different particle shapes and sizes (bimodal). For each type of suspension we characterized the dry maximum packing fraction of the particle mixture using the tap density method. We then systematically varied the total volume fraction of particles in the suspension, as well as the relative proportion of the two different particle types in the bimodal suspensions. For each of the resultant mixtures (suspensions) we performed controlled shear stress experiments using a rotational rheometer in parallel-plate geometry spanning 4 orders of magnitude in shear stress. The resultant data curves of shear stress as a function of shear rate were fitted using a Herschel-Bulkley rheological model. We find that the dry maximum packing decreases with increasing particle aspect ratio (a_r) and decreasing particle size ratio (λ). The highest dry maximum packing was obtained at 60-75% volume of larger particles for bimodal spherical particle mixture. Normalized consistency, K_r, defined as the ratio of the consistency of the suspension and the viscosity of the suspending liquid, was fitted using a Krieger-Dougherty model as a function of the total solid volume fraction (ϕ). The maximum packing fractions (ϕ_m) obtained from the shear experimental data fitting of the unimodal suspensions were similar in magnitude with the dry maximum packing fractions of the unimodal particles. Subsequently, we used the dry maximum packing fractions of the bimodal particle mixtures to fit K_r as a function of ϕ for the bimodal suspensions. We find that K_r increases rapidly for suspensions with larger a_r and smaller λ. We also find that both the apparent yield stress and the shear thinning behavior of the suspensions increase with increasing a_r and become significant at $\phi/\phi_m \geq 0.4$.