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Experimental constrains on crystal fragmentation in deformed concentrated magmatic suspensions.

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Fragmentation of crystals and rocks typically occurs in fault rocks, in which it is recognized to originate from brittle deformation processes. Cracked fragments of crystals are also common in magmatic rocks. In such case, they are generally interpreted as flow-related textures developed in shear-localized zones such as basal zones of lava flow or conduit walls. We have investigated the grain size and shape distributions in experimentally deformed magmas in order to constrain the control of the temperature T, the strain γ and the strain rate γ_r on the crystal fragmentation process.

The starting magmatic suspension is composed of a haplogranitic melt with 2.5 wt% H_2O and 54 vol% of a sieved fraction (45μm$< \phi <90\mu$m) of crushed alumina. Torsion experiments were performed in a gas medium Paterson apparatus at 300 MPa confining pressure and temperatures ranging from 500˚C to 650˚C. Varying shear strain rates from 3.1x10^{-3} to 8.5x10^{-5} s^{-1} allowed us to determine that the rheologic behavior of the suspension is shear thinning with a stress exponent n varying from 1.96±0.01 at 650˚C to 1.52±0.09 at 500˚C.

Two-dimensional Crystal Size Distribution (CSD) and Shape preferred Orientation (SPO) of alumina grains were obtained from polished sections normal to the shear direction, i.e. from the centre (γ = 0) to the rim (γ_{max} ranging from 3.9 to 21.3) of the deformed cylinders. A first phase of crystals fragmentation is observed in all experiments, irrespective of the achieved strains. This fragmentation produces a spectrum of

angular fragments by breakage of touching grains. We attribute this breakage, which first affects grain contacts, to the localisation of the stress that propagates over the connected solid framework of grains when the sample is put under pressure. A second fragmentation process is observed for T $\leq$ 550˚C and γ_r > 6.2x10^{-4} s^{-1}. Determination of the specific glass transition and elastic domain of the melt in the T/γ_r explored field shows that this second fragmentation appears in experiments whose deformation conditions are in the vicinity of the elastic domain. This suggests that this second stage of fragmentation can be attributed to the (partial?) stress propagation over both the melt and partially isolated crystals. Finally, average aspect ratios and corresponding standard deviations of the crystal population decrease with strain in all experiments. This phenomenon that produce rounded particles possibly originate from an abrasive process developed at large strains.

We conclude our discussion on the likely causes of shear-induced abrasion and both crystal fragmentation processes described in our experiments by investigating their possible implications in the context of magma ascent.