Shear localization during magma ascent: results from quasi-2D numerical simulations

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At large crystal contents magma exhibits non-Newtonian behavior, typically shear thinning due to crystal orientation along streamlines. 1D models widely used for extrusive eruption simulations cannot capture efficiently the complexity of cross-conduit variations of the properties of magmas as they assume parabolic velocity profile and averaged properties of magma. Large aspect ratios of volcanic conduits (length/diameter) makes use of fully 2D numerical models computationally expensive and not reliable because of extremely large cross-conduit variation of parameters.

Here we present results of numerical simulations of a quasi-2D model that accounts for magma crystallization with the release of the latent heat, shear thinning rheology, heat transfer and viscous dissipation. Simulated velocity profile is far from parabolic. Shear layers form initially near the wall of the conduit and migrate towards the interior as magma ascends. Shear heating results in significant increases in temperature of the magma in narrow shear bands. There is a drastic difference between the predictions of 1D and quasi-2D models in terms of pressure-discharge rate relations. Lava dome morphology can be strongly affected by the formation of shear zones inside volcanic conduits during magma ascent.