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Non-Newtonian rheology of bubble-bearing magmas: effects on conduit dynamics.

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Non-Newtonian rheology typically arises in magmas from the presence of a dispersed phase. In particular bubbles can reduce or increase the relative viscosity, depending on size and strain regime (i.e. capillary number), for example large bubbles, as well as low strain, reduce the apparent viscosity. In a Non-Newtonian regime it is not possible to define a strain-rate-independent viscosity and the velocity profile is complex.
In this work we extended the 1D, steady, isothermal, multiphase non-homogeneous magma ascent model of Papale (2001) to 1.5D to include the Non-Newtonian effect of a bubble-bearing magma.
The model has been tested with a basaltic test case. In this way we were able to calculate depth-dependent Non-newtonian velocity profiles across the conduit radius along with shear strain-rate and viscosity distributions. Moreover, the model could quantify the effects of the Non-Newtonian rheology on conduit flow dynamics, in terms of flow variables (e.g. velocity, pressure).

P. Papale (2001). Dynamics of magma flow in volcanic conduits with variable fragmentation efficiency and nonequilibrium pumice degassing. JGR, 106, 11043-11065.