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Modeling magma flow in volcanic conduit with non-equilibrium crystallization

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Modeling magma flow in volcanic conduit including with non -equilibrium crystallization There is a set of models of magma flow in volcanic conduits which predicts oscillations in magma discharge during extrusion of lava domes. These models neglect heating of surrounding rocks and use 1D approximation of the flow in the conduit.
Here magma flow is investigated with an account of heat exchange between surrounding rocks and magma and different dependences viscosity on temperature and crystal concentration. Stick-slip conditions were applied at the wall. The flow is assumed to be quasi-static and quasi 1D. Only vertical component of velocity vector is present, thus, we do not consider horizontal momentum balance. At the top of the conduit the pressure is assumed to be fixed, chamber pressure changes according with magma influx and outflux.
First set of simulation was made for the viscosity that depends on cross-section average crystal concentration and parabolic velocity profile. In earlier models that account for crystal growth kinetics the temperature was allowed to change only due to the release of latent heat of crystallization. Heat transfer leads to cooling of the outer parts of the conduit leading to high crystal contents and high magma viscosities. Changes in viscosity result in changes in discharge rate. For the non-isothermal case there is no motion during most part of the cycle and a portion of magma solidifies at the top of the conduit forming a plug. During repose period chamber pressure is growing due to influx of fresh magma, and magma discharge rate starts to increase. Influx of hot magma into the conduit leads to decrease in friction resulting in a jump in discharge rate that lead to depressurization of magma chamber. Discharge rate decreases and magma solidifies again. For isothermal model with the same parameters discharge rate monotonically tends to the value of Qin.
Simulation reveal that crystal content changes significantly across the conduit, and thus viscosity variations across the conduit are large. A more comprehensive model was developed to account for cross-conduit parameter distributions. It shows that velocity profile significantly differ from parabolic especially near the top of the conduit where slip condition s occurs.

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