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Modelling extrusion cycles of dome-forming eruptions

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We investigated the transient dynamics of magma ascent along a dome-forming conduit coupled with the extrusion of a solid plug. The numerical model DOMEFLOW, developed by the authors for this work, has been extended in order to simulate stick-slip extrusion cycles. DOMEFLOW is a transient 1.5D isothermal two-phase flow model of magma ascent through an axisymmetric conduit of variable radius, which accounts for gas exsolution, bubble growth, crystallization induced by degassing, permeable gas loss through overlying magma and through conduit walls, as well as viscosity changes due to crystallization and degassing. During ascent, magma pressure decreases and water vapor degasses from the melt as the melt simultaneously crystallizes, causing changes in mixture density and viscosity, and eventually the formation of a solid plug sealing the conduit. The modified model describes the displacement of the vent plug by considering frictional forces between the walls and the plug, producing as a result stick-slip extrusion cycles. In particular, when the magma pressure at the base of the plug exceeds the sum of the magmastatic pressure and the static friction, the plug begins to slip along the conduit walls and the pressure drops, eventually leading to a new stick-phase and a new cycle. Results are compared to well-documented cyclic phases of the ongoing eruption of the Soufrière Hills volcano, Montserrat, in order to demonstrate the appropriateness of the formulation. The model is then used to understand basic controls on cycle period and its sensitivity to magma ascent rate for a given set of magma characteristics and imposed friction coefficients.