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A model for cyclic extrusion of a lava dome based on a stick-slip mechanism

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Lava dome eruptions are sometimes characterized by large periodic fluctuations in extrusion rate over periods of hours that may be accompanied by Vulcanian explosions and pyroclastic flows. Here we present a simple system of nonlinear equations describing a 1D flow of lava extrusion through a deep elastic dyke feeding a shallower cylindrical conduit. Stick-slip conditions depending on a critical shear stress are assumed at the wall boundary of the cylindrical conduit. By analogy with the behaviour of industrial polymers, the elastic dyke acts like a barrel and the shallower cylindrical portion of the conduit as a die for the flow of magma acting as a polymer. The model is able to reproduce some features of the observed short-period cyclicity. When we applied the model to the Soufrière Hills volcano, Montserrat, for which the key parameters have been evaluated from previous studies, cyclic extrusions with periods from 3 to 30 hours were readily simulated, matching observations. The model also explains the reduced period of cycles observed when a major unloading event occurs due to lava dome collapse.