

Friction properties controlling deposit shape of pyroclastic flows: insights from eruptions of Soufriere Hills volcano

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Dense pyroclastic flows generated by the collapsing of lava domes are often encountered in effusive volcanic eruptions. Capturing the major characteristics of such flows is important to assess volcanic activities and hazards, but is a significant challenge because the mechanics of the grains and their interactions are incompletely understood. One approach has been to exploit the thinness of the flows relative to their length by employing a depth-averaged description in which the flow is assumed to have a constant bulk density. A key issue is the granular friction law that is introduced into depth-averaged models. Recent laboratory studies on dense granular flows suggest that rheology can be described by a friction coefficient. Variation of this coefficient with shear rate and pressure is captured through a dimensionless inertial number. Under the shallow water assumption how well this friction model works remains unclear when applied to pyroclastic flows.

Recent dome collapse events in Soufriere Hills volcano, Montserrat, provide good examples to study the dynamics of dense pyroclastic flows and to examine granular flow models, because of abundant geological and geophysical data. In this study, the July 2003 and May 2006 dome collapse events and resultant pyroclastic flow deposits are investigated. The most intense phase of the 2003 event produced the deposit 170 M m^3 in 2.6 hours, and the shape of proximal submarine deposit offshore Montserrat is characterized by semicylindrical, steep-sided lobes. The 2006 event produced 97.8 M m^3 in 35 min and the deposit is characterized by a more elongated shape in flow direction than the 2003 deposit and by channel and levee-like facies (Trofimovs et al., 2012, BV). Geophysical observation such as seismic and strain records also constrain the variation of discharge rates of pyroclastic flows during the events.

To investigate the factors controlling the shape of pyroclastic flow deposit, we used a 2D shallow water model with two types of Coulomb-type friction models. One had a constant friction coefficient, and another had a friction coefficient that depends upon the dimensionless inertial number of the motion. The models are applied to a simple system or the terrain of Soufriere Hills volcano. When the latter friction model was examined, the variation of deposit shape such as channel and levee-like facies was reproduced, depending on initial mass, discharge rate or slope angle. Also our numerical results suggest that the inertial number dependent friction model works better after the flow passing a slope break point where slope angle is equal to the friction angle at zero shear rate. Coupling effects of discharge rates, slope and granular friction properties may explain the different shapes of the pyroclastic flow deposits produced by dome collapse events in Soufriere Hills volcano.

Keywords: pyroclastic flows, deposit shape, friction, lava dome collapse, Soufriere Hills Volcano