# Effects of magma and conduit conditions on transitions between effusive and explosive activity: A numerical modeling approach to illuminate the 2006-2010 activity at Merapi Volcano, Indonesia

Brett B. Carr[1], Amanda B. Clarke[1], Mattia De' Michieli Vitturi[2], Barry Voight[3]

[1]SESE, Arizona State University, Tempe, AZ, United States of America, [2]Sezione di Pisa, Instituto Nazionale di Geofisica e Vulcanologia, Italy, [3]Department of Geosciences, Pennsylvania State University, University Park, PA, United States of America

E-mail: bbcarr@asu.edu

Transitions between effusive and explosive eruptions, common at silicic volcanoes, can occur between distinct eruptive episodes or can occur with switches between effusive and explosive phases in a single episode. The precise causes of these transitions are difficult to determine due to the multitude of mechanisms and variables that can influence fragmentation thresholds. Numerical modeling of magma ascent within a volcanic conduit allows the influence of key variables to be extensively tested. We use a conservative, 1-D, two-phase, steady-state model that allows for lateral gas loss at shallow depths to study the effect of different variables on the mass eruption rate at the vent. We use a fragmentation criteria based on gas volume fraction. We are able to generate a number of regime diagrams for a variety of magma and conduit conditions that constrain transitions from effusive to explosive episodes. For constant conduit geometry, initial magma crystal content and chamber overpressure have the greatest effect on the mass eruption rate. We apply our model to the recent activity at Merapi Volcano in Indonesia. We constrain model input and output parameters using current petrologic, seismic, and geodetic studies of the Merapi system, and vary critical parameters over reasonable ranges as documented in the literature. Our model is able to reproduce eruption rates observed during both the 2006 effusive and 2010 explosive/effusive eruptions. Our modeling suggests a combination of overpressure, increased volatile content, and decreased crystal content due to the voluminous injection of new magma into the shallow Merapi system is the plausible cause of explosivity in the 2010 eruption, the most violent at Merapi since 1872. Transitions in eruptive activity were also observed during the 2010 eruptive sequence, where explosive episodes lasting on a scale of hours alternated with longer periods of rapid effusive dome growth. Our modeling suggests these transitions can be plausibly controlled by (1) the degassing behavior of the shallow conduit system without needing to change the magma supply rate into the conduit from the chamber, or (2) alternating conduit magma batches with different H2O content that reflect converging extraction patterns in a volatile-heterogeneous chamber. The latter condition reflects the inevitability for a large eruption to sample, nearly simultaneously, from a wide vertical and horizontal range of locations in a zoned chamber.