Investigating the Effect of Viscosity and Pulsating Effusion Rates on Lava Dome Morphology Through Physical Models

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Lava dome collapses can often be fatal, emitting highly destructive pyroclastic flows of rock debris. Predicting dome collapse behavior requires a comprehensive knowledge of factors that contribute to dome stability. Previous analog and mathematical models of dome growth have explored factors contributing to dome structure. However, for the most part these assumed constant rates of effusion. Lyman et al. (2004) considered pulsating effusion rates as a factor of dome formation on sloped surfaces. We focused on dome formation on a flat surface, studying the effects of viscosity and pulsating effusion rates on dome morphology. We conducted a series of analog laboratory experiments using a slurry of kaolin clay and PEG 600 wax, which has a dynamic viscosity high enough to guarantee laminar flow. The slurry was extruded into water at a temperature of 5±1˚C. Three ratios of PEG: kaolin was used – with kaolin weight percentages of 47.4, 46.5, and 45.6, to simulate lavas with different crystallinity. The ratio of 1.15:1, or 46.5% kaolin, is equal to that used by Lyman et al. (2004), to allow comparison of the results. Prior to each experiment, the rheology of the slurry was measured in a Brookfield viscometer. Several constant effusion rates for each viscosity were run, followed by sequences of 2 patterns of "sawtooth" pulsating effusion rates. Top and side view recordings were used to analyze dome growth patterns using Matlab image processing. The analysis examined observables such as dome area and height over time, and final dome shape, including assessment of dome growth style ('exogenic' versus 'endogenic'). Experiments evaluate the impact of these varied viscosity levels in addition to flux rate. We find that fluctuating effusion leads to greater fracturing in final dome morphology, therefore suggesting a less stable dome. Aspect ratios of height to diameter were generally lower for higher viscosities, implying greater dome stability.