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Understanding the dynamics of volcanic jet through laboratory experiments

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Explosive volcanic eruptions pose great hazards in both the near- and far-field. Understanding the factors controlling the dynamics of pyroclast ejection is essential for better assessment of related hazards. The dynamics of volcanic explosions, which can be observed and characterized in the field only in a very incomplete manner due to their inaccessibility and hazards, can be simulated in the laboratory where experiments can be performed in their immediate proximity under controlled conditions. Using a shock-tube we ejected loose particles while controlling parameters such as temperature, applied overpressure, starting grain size distribution, conduit length and exit vent geometry. We recorded each explosion with a high-speed camera and collected the sample after deposition, thereby quantifying the velocity of individual particles, the jet spreading angle and the production of fines. The experiments were performed at 500°C and 15MPa using materials of two different densities ("Schaumlava" and "Laacher See Bims") and three grain size ranges (1-2 mm, 0.5-1 mm and 0.125-0.250 mm). Additionally, we varied the setup to allow for different sample-to-gas ratios and varying fragmentation depth at start of each experiment. We also deployed four different exit vents: a cylindrical continuation of the shock-tube, a funnel with a flaring of 30°, a funnel with a flaring of 15° and a nozzle. All vents are characterized by the same height and bottom diameter. The results of the current investigation together with comparison with other experimental campaigns showed particle velocities ranging from 130 to 290 m/s, gas spreading angles varying from 14 to 37° and particles spreading angles from 12° to 2°. Moreover we observed dynamically evolving ejection characteristics (speed and spreading angle) and strong variations in the production of fines (up to a factor of 2) during the course of individual experiments. We further qualitatively present the impact of experimental conditions on the initial shock wave, the presence or absence of lightning and the distribution of particles in the ejected gas-particle flow. Our experiments mechanistically mimic the process of pyroclast ejection and plume formation. The capability to constrain the effects of input parameters (fragmentation conditions) and conduit/vent geometry on ballistic pyroclastic plumes has been clearly established. These data obtained in the presence of well-documented conduit and vent conditions, should greatly enhance our ability to numerically model explosive ejecta in nature.