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Particles in motion: coupling high-resolution videos and geophysical techniques in the lab to decipher pyroclast ejection dynamics

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During subaerial explosive volcanic eruptions, pyroclasts are ejected from the volcanic conduit and into the atmosphere. Their velocity and trajectory show significant dynamical variations, strongly controlled by eruption source conditions, e.g. gas overpressure, conduit length, and vent geometry. To better understand pyroclast ejection dynamics and their related control parameters, we have performed a series of experiments using a 3-meters long, 4 cm diameter Plexiglas shock-tube apparatus.

In the experiments, natural pyroclasts from 0.5 to 4 mm in size and initially resting on a mesh (< 0.5 mm pore diameter) are accelerated by air streaming upwards following the rapid decompression of a pressurised reservoir located just below the pyroclast. The reservoir pressure is 2 bar. The transparent setup allows the high-speed recording of the pyroclast acceleration and flow inside the entire tube as well as their ejection. Along the outside of the tube, evenly spaced at 50 cm distance, we place seven piezoelectric sensors and synchronize these elasto-acoustic signals with the videos.

Manual and automated image analysis of the recordings reveals pyroclast acceleration to be completed within 40 to 100 cm from the starting location with peak velocities ranging between 80 to 60 m/s depending on pyroclast size. At the exit, strong deceleration following the formation of a head vortex and air entrainment is observed. Moreover, the correlation of images of pyroclasts in motion and their associated time series offers unique insights in the identification of flow dynamics and their corresponding elasto-acoustic fingerprints.

This experimental combination of visual and geophysical signals opens the opportunity to study gas flow and pyroclast ejection dynamics providing tools to increase the interpretability of field-based observations.