The in-flight grain size distribution of lapilli and bombs from Strombolian explosions

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Grain size distribution is one of the fundamental physical parameters of pyroclastic deposits, key to understanding both magma fragmentation and tephra emplacement processes during an explosive eruption. Most commonly, the grain size distribution of pyroclasts from one eruption is obtained from field sampling and analysis of the resulting tephra deposit; integration of multiple analyses gives a total grain size distribution. In this process it is often assumed that the grain size distribution of the deposit reflects that of the assemblage of pyroclasts that left the eruptive vent. However, observations suggest that multiple processes may act to change the size of erupted pyroclasts during their emplacement, so that the grain size distribution of a deposit may differ, to a variable degree, from that at the vent. Here, we use high-speed imaging to measure the in-flight grain size distribution of pyroclasts for the first tens of meters above an eruptive vent.

We focus on lapilli and bombs from Strombolian- explosions at Stromboli volcano (Italy) in September 2018. At that time, multiple, well-collimated jets with incandescent pyroclasts and no visible ash erupted from a vent about one meter in diameter and in plain view. The activity was recorded by using a high-speed camera filming with a temporal and spatial resolution of 500 frames per second and 0.012 m/pixel, respectively. The high-speed videos were pre-processed for background subtraction, then thresholded for gray level intensity, and finally the individual particles measured for their 2-D size and shape by using image processing. Particle velocity and size was also measured using particle tracking algorithms.

In a parametric study, the effect of different thresholding levels and frame sampling has been investigated. The results define the best parameters and the most effective truncation limits of the measured grain size distributions. Modal values of the grain size are broadly centered around the phi -4 to -5 size classes (16-32 mm) by particle number and the phi -5 to -6 size classes (32 to 64) by particle mass, respectively. The grain size distribution of erupted pyroclasts shifts considerably over time, with smaller clasts being ejected at the beginning of an explosion, and larger median diameters recorded at instants of higher pyroclast volume fluxes.

These results highlight the complexity and variability of the erupted size distributions at the vent, but also the need for a careful assessment of analytical error and methodological limitations.

Keywords: strombolian, explosion, grain size distribution

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