Eruptions on the fast track, part b): The variability of strombolian explosions from high speed thermal and optical videos

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Strombolian activity style is characterised by discrete explosions at variable frequency, lasting a few to tens of seconds, and ejecting pyroclasts at heights of tens to hundreds of meters. New imaging techniques, including high speed camera observations, have already shown that these explosions are complex phenomena that include pyroclast ejection pulses, typically lasting tenths of seconds, characterized by a non-linear decay on the ejection velocity over time and related to individual pressure release events. Here, we show the results of a new computing techniques (described in a companion abstract, Eruptions on Fast Track, part a), based on joint application of Particle Image Velocimetry (PIV, providing information on the ash and gas clouds) and Particle Tracking Velocimetry (PTV, providing information on the cm-to m-sized pyroclasts) to high-speed visible and thermal videos of Strombolian explosions at Stromboli (Italy) and Yasur (Vanuatu) volcanoes. In comparison to previous studies, which manually analysed the videos, the techniques we use increase by ten-fold the number of identified and measured particles, allowing a significant advancement in the study of Strombolian dynamics.

A variable number (a few to several tens) of well-defined ejection pulses are present in all analyzed explosions. Pulses sometimes are organised in larger ejection events, or super-pulses, lasting up to a few seconds, characterised by a velocity decay following the same non-linear trend shown by pulses. The mean source depth of the pulses, modeled from the velocity decay trends, are mostly in the tens of meters range and remains constant on the whole explosion, while super-pulses seems to originate deeper (up to hundred of meters) in the conduit.

Within each pulse, we observe a strong correlation of ejection parameters: the spread of the ejection angle and the size of particles increases while the number of particles and their velocity decreases. This correlation is tentatively linked to the explosion dynamics of gas pockets at the surface, where maximum pressure differential is initially released through a small, ventral opening that gets wider with time, with possible effects of inter-particle collisions also playing a role.

At the time scale of the whole explosion, ejection angle is a reflection of the overall vent orientation. The temperature of the bombs and ash decrease over time and height above the vent, more slowly for the bombs, to be compared with theoretical predictions. The total mass of the pyroclasts ejected during a single pulse ranges from tens of kg to several tons, while the comulative one for an explosion can reach hundreds of tons. The ejection mass rate tends to decrease during one explosion, suggesting that, despite the presence of ejection pulses, each explosion still represent one well-identified and impulsive energy release event.