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Insights into explosion dynamics at Stromboli in 2009 from ash samples collected in real-time

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Rapid characterization of tephra during explosive eruptions can provide valuable insights into eruptive mechanisms, also integrating other monitoring systems. Here we reveal a perspective on Stromboli's conduit processes by linking ash textures to geophysical estimates of eruption parameters of observed explosions. A three day campaign at Stromboli was undertaken by Italy's Istituto Nazionale di Geofisica e Vulcanologia (INGV) in October 2009. At this time activity was moderately intense, with an average 4 to 5, both ash-rich and ash-poor, explosions per hour at each the SW and NE vents. A total of fifteen ash samples were collected in real time. We used binocular and scanning electron microscopes to analyze the components, grain size and morphology distributions, and surface chemistry of ash particles within eight selected samples. In addition, the INGV monitoring network provided visual, thermal, and seismic information on the explosions that generated the sampled ash. In each sample, the proportion of fluidal, glassy sideromelane (as opposed to blocky, microcrystalline tachylite plus lithics), the degree of "chemical freshness" (as opposed to chemical alteration), and the average size of particles appear to correlate directly with the maximum height and the seismic amplitude of the corresponding explosion, and inversely correlate with the amount of ash erupted, as estimated by monitoring videos. These observations suggest that more violent explosions (i.e. those driven by the release of larger and more pressurized gas volumes) produce ash via the fragmentation of hotter, more fluid magma, while weaker ones mostly erupt ash-sized particles derived by the fragmentation of colder magma and incorporation of conduit wall debris. The formation of fluidal ash particles (up to Pele's hairs) requires aerodynamic deformation of a relatively low-viscosity magma, in agreement with the strong acceleration imposed upon fragmented magma clots by the rapid expansion of pressurized gas, as directly observed in high-speed videos of the sampled explosions. Our findings show that ash monitoring of mafic explosions permits characterization of the eruptive style, and can provide indirect information on the intensity of the eruption.