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Reconstructing fragmentation processes at Santiaguito volcano by combining ash analysis with geophysical measurements

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Santiaguito volcano exhibits cyclic deformation and regular Vulcanian gas-and-ash explosions, ongoing for almost 100 years. Airfall ash samples collected 500 m from the active Caliente vent constitute a snapshot of the ash-forming mechanisms between and during eruptive events. Samples collected following ashfall from Vulcanian explosion plumes and following a major dome collapse with associated pyroclastic density currents on 28 November 2012, appear blocky and poorly vesicular under scanning electron microscope, indicating fragmentation of dense, low porosity magma. Particle size distributions show a single dominant fragmentation mechanism during co-pyroclastic flow airfall ash, at least three significant sources of erupted ash can be identified for vulcanian plume-derived ash. We employ QEMSCAN analysis, which provides a micron-scale dataset of ash particle morphology and phase distribution, to explore the textural fingerprint of these fragmentation processes. Ash generated during dome collapse shows a greater abundance of interstitial glass at particle boundaries over most of the particle size range, showing that the segregation of glass-enriched fines into airfall deposits during pyroclastic flow cannot fully account for this trend. Conversely, the relative depletion of glass in vulcanian explosion deposits may be due to viscous stress accommodation within interstitial glass, which concentrates stress within crystalline phases during fragmentation. By comparing ash analyses with observations of dome inflation and faulting, lava effusion and seismic and infrasound measurements, including recent measurements recorded during Workshops on Volcanoes 2016, we describe a stable sequence of ash-generating processes occurring during normal vulcanian activity:
1) Fracture and faulting and abrasion of plug material,
2) Failure and fragmentation of magma below the plug,
3) Expulsion of clastic material residing above the fragmentation depth,
4) Expansion and flow of the pyroclastic mixture.
We propose that fault-induced thermal vesiculation of magma may act as a trigger for explosive eruptions at Santiaguito, providing a mechanism to account for ash production from low gas-fraction magma during lava dome eruptions.