An experimental basis for estimating particle properties following volcanic ash emissions

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In recent years, mitigating the impact of volcanic ash emissions has risen up political and research agendas. Despite intense research efforts, challenges remain as to the detection and forecasting of emissions, and subsequent interactions in the earth system. Monitoring instruments and ash dispersal models usually require the input of volcanic ash properties in order to operate effectively, however forensic methods are poorly suited to volcanic eruptions where near-real-time data is required, and default values are commonly used. Here, we take an experimental approach to demonstrate that the surface composition and the initial size and shape distribution of volcanic ash particles depends upon (i) the initial rock texture, chemistry and mineralogy and (ii) the fragmentation processes that produced the particles.

We compare natural pyroclasts produced during recent eruptive activity at Volcán de Colima, Mt Etna, Santiaguito, Mt Agung and Tungurahua, with particles produced in fragmentation experiments using fresh rock samples from Volcán de Colima and Mt Etna. Sets of experiments were conducted under varying conditions in shock tube, tumbling and fault friction apparatuses to simulate natural eruption processes. Using QEMSCAN, an SEM-based automated mineralogy technique, we produce micron-scale maps showing the size, shape and phase distribution of thousands of ash particles in each sample. We measure particle size-, shape- and phase distribution in each sample and show that particle sizes and shapes show characteristic variation between different experimental methods and eruptive activity. Some phases, particularly groundmass glass (or tachylite), feldspars and pyroxenes are found to vary significantly at particles boundaries compared to the bulk. The pattern of enrichment and depletion of phases is shown to relate to the fragmentation mechanism and the rock texture at the macro- and micro-scale, and correlations between experimental and natural samples indicate a robust signal.

Volcanic ash presents unique hazards to aviation, health and the environment and better constraints on ash particle properties immediately following activity may improve estimations of the intensity and spatial extent of ash-related hazards. Our results may benefit local hazard management, monitoring and forecasting efforts at the case study volcanoes.

Keywords: Volcanic ash, Fragmentation processes, Experimental volcanology, Hazards, Ash dispersal and monitoring, QEMSCAN

