Geophysical Research Abstracts
Vol. 20, EGU2018-12793, 2018
EGU General Assembly 2018

What controls the occurrence of lightning in volcanic ash plumes? A quantitative lab analysis

Damien Gaudin, Corrado Cimarelli, Veronica Becker, and Marco Knüver
Ludwig-Maximilians-Universität, München, Germany (damgaudin@gmail.com)

Explosive eruptions such as Augustine (2006), Redoubt (2009), Eyjafjallajökull (2010), and more recently Bogoslof (2017) have highlighted the ubiquitousness of electrical activity in volcanic plumes, and its potential for the detection of ash-rich explosive eruptions. Indeed, such eruptions can be recorded by local –and, for the most intense explosions, global– networks of radio-frequency antennas. However, the applicability of this method as an operational monitoring system is limited by the lack of quantitative relationships between the eruption parameters –in particular, the amount of ash erupted– and the occurrence and intensity of flashes.

In a lab experiment, we modeled the electrical activity within the jet phase of an ash-rich explosive eruption. We used three autoclaves of different diameters (20, 26 and 33 mm) to pressurize a variable mass (m, from 21 to 61 g) of ash, with a variable proportion (f, from 0 to 15%) of fine particles (i.e. particles with Stokes number <1) to a variable initial pressure (p, from 2 to 20 MPa). The sudden rupture of a diaphragm produces a fast decompression of the sample and the ejection of the gas-particle mixture into a collection tank at room pressure. The electrical activity generated during the experiments is monitored by a large Faraday cage inside the tank, from which we derive the number and the cumulative intensity of the discharges from the jet to the ground.

Discharges are observed to occur during the jet phase. Their number and intensity are linearly correlated with the mass of ejected fine particles (f*m). The effect of initial pressure (p) is more complex: higher-pressure experiments produce larger discharges, but in a smaller number, and during a shorter time than at lower pressures.

Overall, the total charge neutralized to the ground is directly proportional to the product p*f*m. This simple relationship is in good agreement with field observations, in particular at Sakurajima volcano (Japan), where the number of flashes have been observed to be proportional to the pressure at burst (Cimarelli, et al. 2016) and suggest that a simple, general law could be derived to predict the number of observable flashes for a given explosion.

The next steps of our experimental work will investigate the effects of atmospheric conditions (air temperature and humidity) and ash characteristics (chemical composition and crystallinity).