

## SUPPLEMENTARY MATERIAL

*Experimental Generation of Volcanic Lightning*

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**Table DR1.**

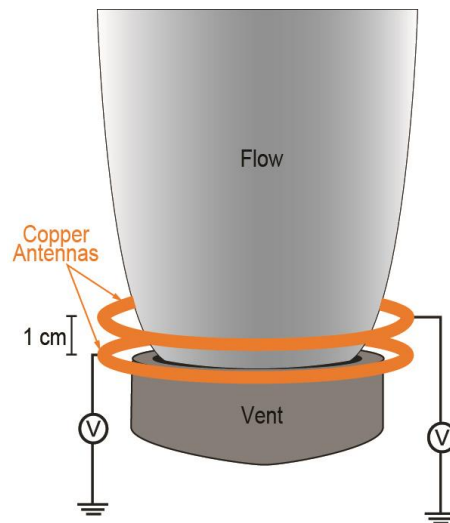
Experimental conditions and antennas recording of natural ash decompression runs. Bulk composition of natural ash samples is dacitic for Popocatepetl, trachytic for Eyjafjallajökull and andesitic for Montserrat. In the table are reported the name of the sample, the average grain size of the ash, the mass of the sample, the fraction of ash smaller than 63  $\mu\text{m}$  in weight % (created during the decompression experiment), the overpressure in the autoclave, the total number of discharges with amplitudes  $>0.2$  V recorded by the two antennas. The fraction of positive discharges recorded by both antennas is also reported.

Sample	Grain size ( $\mu\text{m}$ )	Mass (g)	Particles $<63 \mu\text{m}$ (wt.%)	Pressure (MPa)	Total discharges upper antenna (N)	Positive discharges upper antenna (%)	Total discharges lower antenna (N)	Positive discharges lower antenna (%)
Popocatepetl	125-180 <sup>n</sup>	74	0.4	9	1031	93	358	100
Popocatepetl	180-250 <sup>n</sup>	118	0.4	9	1727	60	912	76
Popocatepetl	250-355 <sup>n</sup>	74	0.2	11	1187	75	406	98
Eyjafjallajökull	125-180 <sup>w</sup>	60	1.0	11	59	93	36	92
Eyjafjallajökull	125-180 <sup>n</sup>	66	-	9	2003	63	432	80
Eyjafjallajökull	180-250 <sup>w</sup>	64	0.6	10	279	70	119	93
Eyjafjallajökull	250-355 <sup>n</sup>	67	1.0	11	442	63	149	82
Montserrat	90-125 <sup>n</sup>	57	22.8	9	$>1842^s$	$41^s$	423	43
Montserrat	125-180 <sup>w</sup>	41	1.3	9	260	74	98	94
Montserrat	250-500 <sup>w</sup>	30	0.3	11	94	91	61	98

<sup>w</sup>= samples have been washed after sieving and before the experiment<sup>n</sup>= unwashed samples.<sup>s</sup>= the antenna signal was partially saturated and not all the discharges were counted.

**Figure DR1.**

Schematics of the antennas and associated electronics. Each antenna is made of a copper ring of 7 cm diameter and are separated 1 cm to each other. Each antenna is connected to an independent, high-impedance channel of a data acquisition system acting as voltmeter. The antenna is designed to not disturb the particle-laden flow.

**Figures DR2 to DR5**

Examples of lightning flashes recorded by the high-speed camera. The brightness and the complexity of the flashes recorded in a single frame depend on the chosen exposure time (EXP) of the camera and the frame rate (FR) of recording. Single panels do not represent consecutive frames in the original videos, frame interval (FI) is reported instead. Scale bar in the figures is 1 cm.

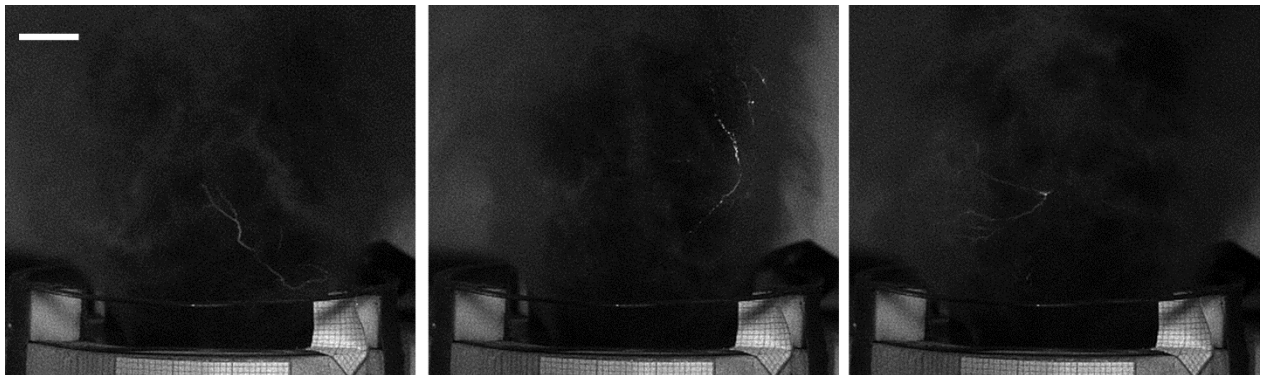


Fig. DR2

Eyjafjallajökull ash. Size:  $180 < \phi < 250 \text{ mm}$ ; EXP: 1ms; FR: 50000 fps; FI: 20 ms.

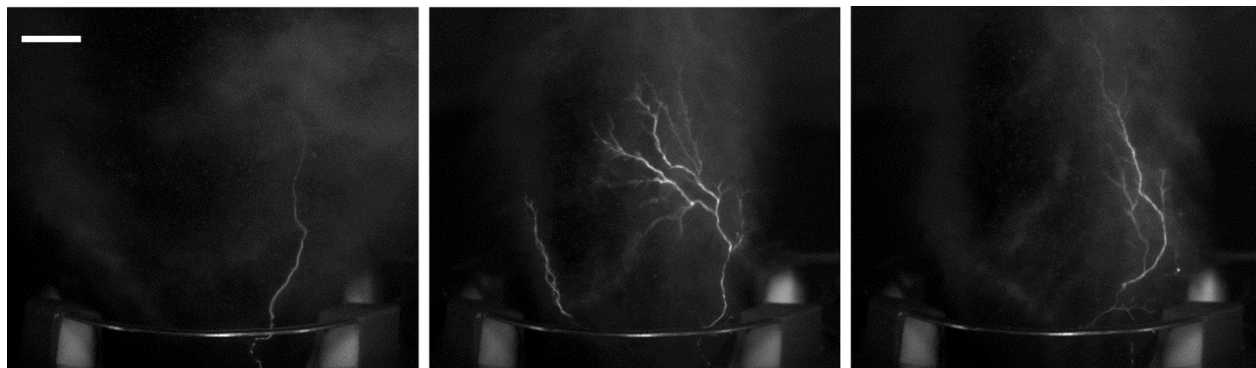


Fig. DR3

Popocatepetl ash. Size:  $125 < \phi < 180 \mu\text{m}$ ; EXP: 1ms; FR: 50000 fps; FI: 20ms.

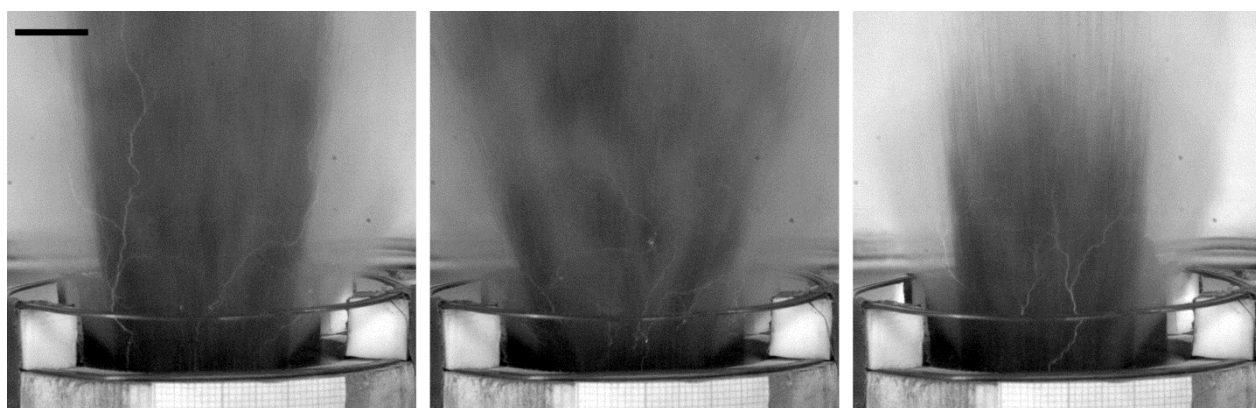


Fig. DR4

Popocatepetl ash. Size:  $180 < \phi < 250 \mu\text{m}$ ; EXP: 39ms; FR: 25000 fps; FI: 40ms.

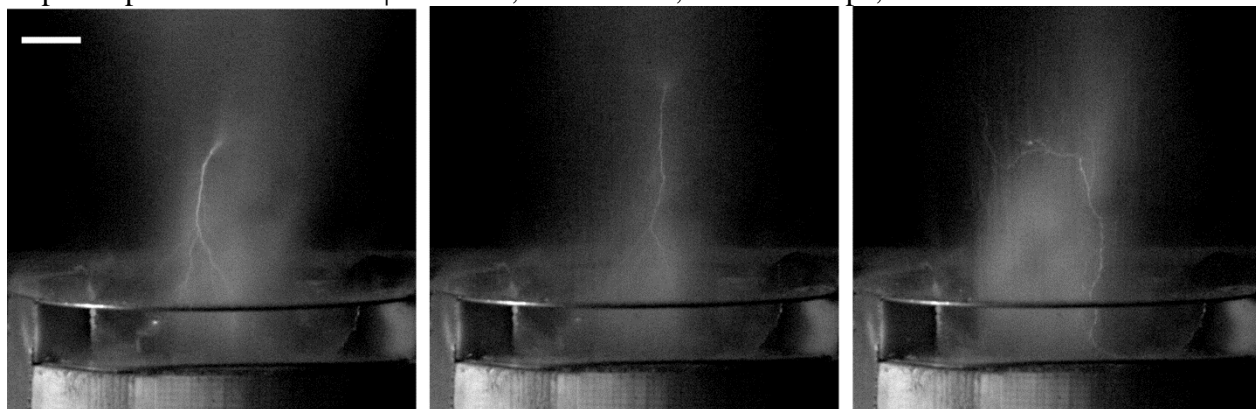


Fig. DR5.

Bimodal glass beads. Size: 50 $\mu\text{m}$  (95 wt%) and 500 $\mu\text{m}$  (5 wt%); EXP: 49ms; FR: 20000 fps; FI: 20 ms.