Supplementary Information

Methods

Collection of natural ash samples: Samples from Mt. Redoubt utilized in this study were collected from a 2.2 m^2 area ~420 km from the vent immediately after ash deposition on 23 March 2009 in the town of Healy, Alaska. This andesite tephra was derived from Event 5 (Schaefer 2012) of the 2009 eruption, which resulted in trace tephra deposition up to 550 km from source (Wallace et al., 2013). Ash fall samples of benmoreite composition, derived from the Eyjafjallajökull, Iceland explosive events beginning in April of 2010 (Gudmundsson et al., 2012), were sampled from a location ~400 m from the vent on 13 June 2012, but the exact day of deposition is unknown.

Preparation of pseudo-ash samples: Unweathered Stoddart olivine basalt (from Halswell Quarry, Lyttelton volcano, New Zealand; Guard, 1999) was chosen as the non-soluble volcanic component for the pseudo-ash. Electrical resistivity values of pseudo-ash in Wardman et al. (2012b) show that a 0.15 Mole NaCl salt solution added to a 3:1 ratio of ash to brine will create an ash with electrical properties which are within the bounds of those observed for freshly fallen ash (resistivity values ≤ 1,000 Ωm for uncompacted deposits). Thus, this concentration was used as an appropriate dosing agent for the pseudo-ash. Two different pseudo-ashes of basaltic composition were created: (1) A predominantly fine-grained fraction (<0.1 mm); and (2) an ash with a coarse-grained component (<1 mm).

HV flashover experimental procedure: Clean-fog rapid flashover tests (IEC 60507, 1991; IEEE Std 4, 2013) were performed in the HV laboratory at the University of Canterbury, New Zealand using an adapted version of the variable voltage application after Lambeth (1988). Voltage was supplied from 2 phases of a 3-phase 400 V supply to a 50 Hz, 400 V/300 kV, 100 kVA test transformer via a 400 V/0–440 V regulator (Fig. DR2A) to an insulator (Fig. DR2B) contaminated with pseudo ash. Pseudo-ash samples were taken from the periphery of discharge tracks (Fig. DR2C), and in areas where high partial discharge and arcing activity was observed following a round of 15 tests with flashover voltages between 50 and 60 kV. The following procedure was then applied: (1) A clean insulator was installed into position for testing (Fig. 1B); (2) top and bottom surfaces of the insulator were contaminated with 6 mm and 1 mm thicknesses of pseudo-ash, respectively; (3) light rain (~6 mm/hr with a volume conductivity ~130 μS/cm) was applied for 5 minutes before energization to facilitate the transfer of electrical current through/across the pseudo-ash deposit; (4) insulator was energized and a voltage maintained for 2 minutes or until flashover occurred; (5) if no flashover occurred, the voltage was raised in 5% steps every 2 minutes until flashover; (6) when flashover occurred, the insulator was re-energized at ~2.5 steps below the flashover voltage. This sequence was repeated for each scenario, with a round of tests ending once flashover voltage values decreased to a minimum.

Grain size distributions (GSDs): GSDs for both pseudo-ashes were determined using a HORIBA, Ltd. Partica LA-950 laser diffraction particle-size analyzer. GSDs of both the Eyjafjallajökull deposit and pseudo-ash samples can be found in Figure DR2). Because the Mount Redoubt sample was a trace amount, we did not perform GSD analyses, but Wallace et al. (2013) present GSD data for all 2009 samples, and reported a dominance of fine ash in the

deposits.

References Cited

Guard, F.J., 1999, *Geology and Magma Emplacement at Halswell Quarry and Castle Rock, Lyttelton Volcano, Banks Peninsula*. PhD Thesis, University of Canterbury, Canterbury, New Zealand.

International Electrotechnical Commission (IEC) IEC-TS 60507, 1991, Artificial pollution tests on high-voltage insulators to be used on a.c. systems: IEC 60507 ed3.0, Geneva, Switzerland.

Institute of Electrical and Electronics Engineers (IEEE) Std 4, 2013, IEEE Standard Techniques for High-Voltage Testing: New York, Institute of Electrical and Electronics Engineers, ocn848941860.

Lambeth, P.J., 1988, Variable-Voltage Application for Insulator Pollution Tests: Institute of Electrical and Electronics Engineers Transactions on Power Delivery, v. 3, no. 4, p. 2103–2111, doi:10.1109/61.194022.

Schaefer, J.R., ed., 2012, The 2009 Eruption of Redoubt Volcano, Alaska: Alaska Division of Geological and Geophysical Surveys Report, 2011–5, p. 45.

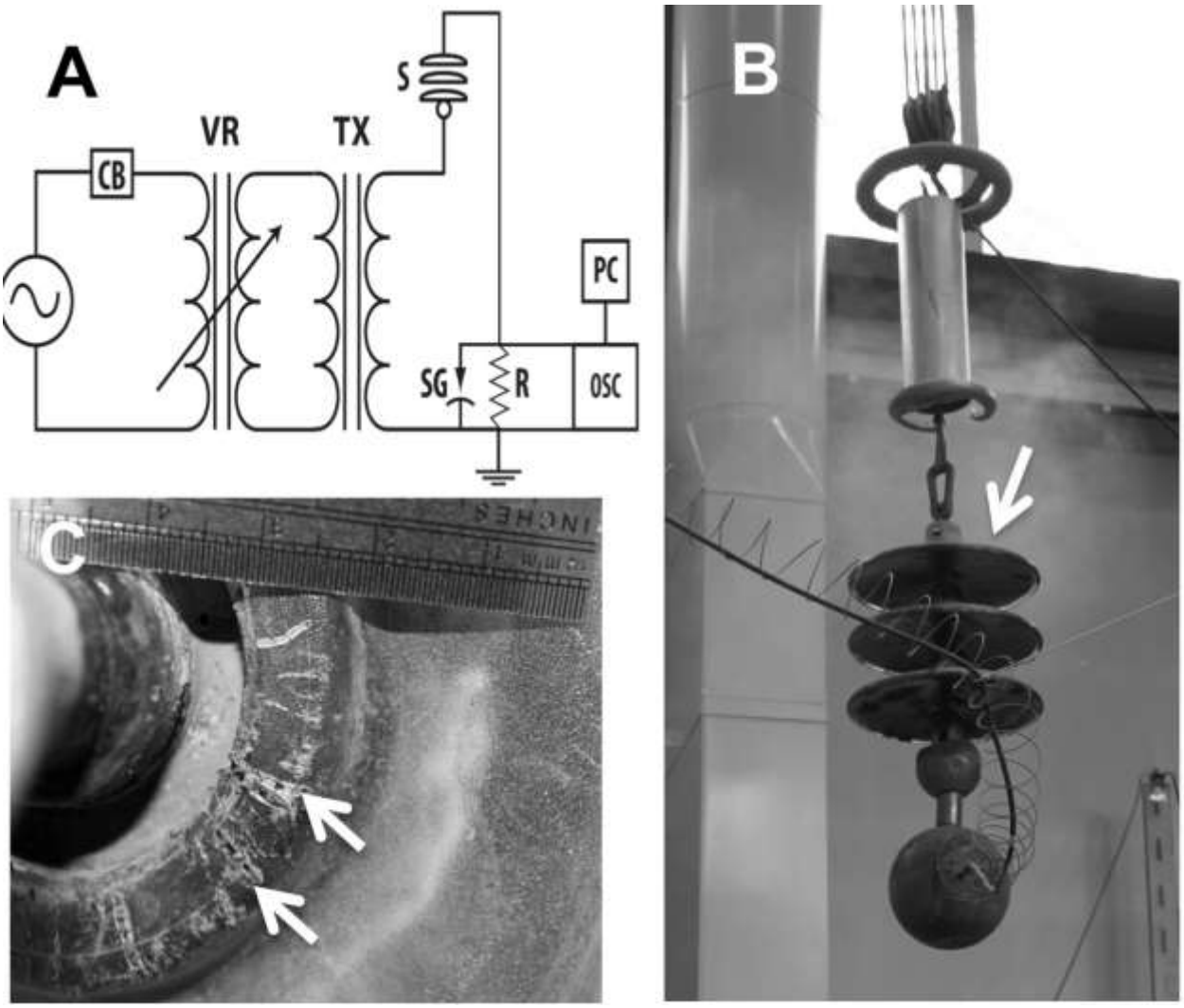

Figure DR1. (A) Electrical test circuit: CB is the circuit breaker (600 A), VR is the voltage regulator (400 V/0–400 V), TX is the test transformer (400 V/300 kV, 100 kVA), S is the insulator specimen, SG is the spark gap, R is the shunt resistor (R = 0.2 Ohms), OSC is the oscilloscope, and PC is the computer used for data collection; (B) suspended insulator; and (C) tracks of electrical discharge on insulator surfaces from where pseudo-ash samples were removed for scanning electron microscopic examination.

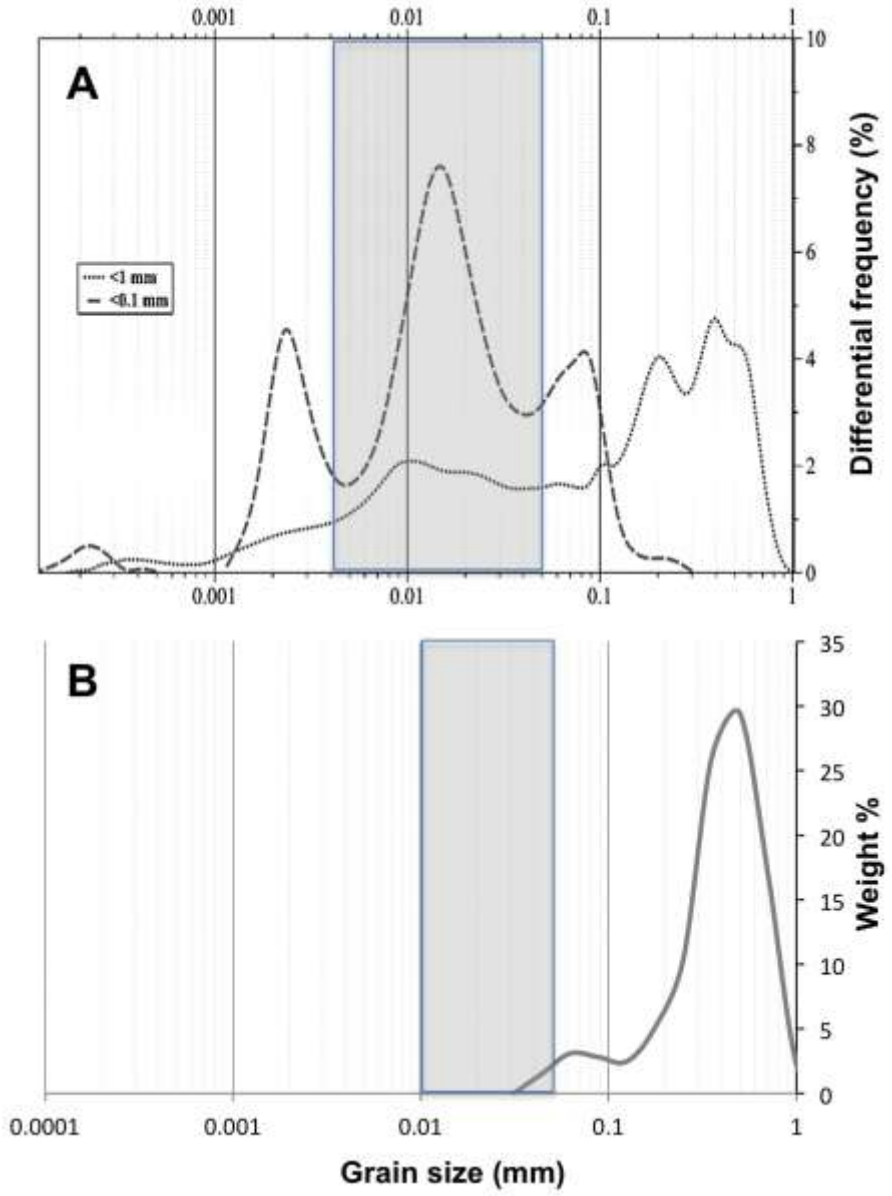

Figure DR2. Grain size distributions of (A) two pseudo-ash samples used in HV flashover experiments, with one containing all particles <1 mm (dotted curve) and one with all particles <0.1 mm (dashed curve); and (B) fall tephra from the 2010 eruption of Eyjafjallajökull that were used in the study presented here. Measurements were conducted at two separate institutions using two different methods, and are thus, useful primarily for qualitative purposes. The shaded area marks the approximate size range of proposed lightning-induced volcanic spherules found within both samples.