Europlanet TA Scientific Report

PROJECT LEADER

Project number: 20-EPN-053
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TA Facility visited: Planetary Environment Facility of Aarhus University (TA2 Facility 4)

Project Title: Investigation of the electrical properties of volcanic ash

Scientific Report Summary.
(plain text, no figures, maximum 250 words, to be included in database and published)

The set of experiments within the 20-EPN-053 project represents a preliminary step towards the characterization of the electrical properties of volcanic ash in a collaboration between the University of Geneva and the Aarhus University. This topic is fundamental to better understand aggregates formation in a volcanic eruption and improve model forecasting.
The main setup consists of a horizontal wind tunnel where a recirculating flow allows volcanic ash of different sizes (e.g. from 1 μm to 500 μm, sieved in intervals of half-phi on the Krumbein scale) and compositions (e.g. from basaltic to andesitic) to be resuspended and collide together. Single particles and aggregates are filmed during their motion in the wind tunnel by means of a High Speed Camera (HSC) placed crosswise to the main flow direction. In addition to this, a set of four Optical Particle Counters (OPCs) are located at different heights downwind to the flow (i.e. 5 cm, 10 cm, 25 cm, 50 cm) with the goal of capturing differences in particle population for very fine ash (i.e. <40μm) due to electrostatic phenomena.
The primary goal is to detected particle trajectories that will be later used to quantify the bulk charge carried by single particles by means of an inversion of the equation of motion. The secondary goal is to understand if OPCs can be used combined with the wind tunnel facility to reveal a change in particle population on the recorded histograms that can be associated with aggregation processes due to the electrostatic force.

Full Scientific Report on the outcome of your TNA visit

The collaboration within the Europlanet visit aimed to investigate the capability of successfully applying the High Speed Camera (HSC) and Optical Particle Counters (OPCs) of the University of Geneva to the study of volcanic ash electrification within the recirculating horizontal wind tunnel of the Planetary Environment Facility of Aarhus University (TA2 Facility 4). This represents the short-term goal of the collaboration that has been accomplished with our visit. On the other hand, the long-term goal is to produce a robust database of experiments using HSC, OPCs, High Voltage devices and the Aarhus wind tunnel to measure the influence of electric charge on the collision kernels behind ash aggregation processes.

The setup of the experiments consists of:

1. A test-bed of ash samples located inside the wind tunnel that is resuspended by the flow at ambient pressure and temperature. Samples from four different eruptions were chosen according to their composition: rhyolite from Askja (Iceland) and Cordon Caulle (Chile); basalt from La Palma (Canary Islands); Andesite from Sabancaya (Peru). All the samples were sieved in half-phi on the Krumbein scale from 500 μm down to 31 μm. Particles smaller than 31 μm are combined in one single sample due to the lack of sieves with grids smaller than this size.
2. A Phantom Miro HSC placed inside the wind tunnel that can access the main section by means of the lateral porthole. The HSC was capable to record high-speed movies of the ash particles crosswise to the flow (fig.1a, 1b). The 60 mm macro lens mounted on the HSC guarantees a proper magnification for coarse ash (>63mm) and aggregates. The area of the test bed filmed by the HSC was illuminated by a red laser sheet in order to enhance the contrast of the pixels and allow for a short focus depth of the lens (i.e. a brighter image).
3. Four Alphasense OPCs located downwind to the test-bed at heights of respectively 5 cm, 10 cm, 25 cm and 55 cm (fig. 1c). These devices, which use a laser detection technique and a constant pump rate of 280 mL/min, are capable to detect single particles from 0.35 μm to 40 μm using a 24 binning. The sampling interval is 1 s.

Two are the main ideas behind the experiment:

1. To verify if the HSC could detect particle collisions from the test bed area and therefore a proper reconstruction of their trajectory (Fig.2) in the current setup (which will be used in the long-term). As a matter of fact, the future investigation of the charge carried by single particles will be obtained by inverting the trajectory of ash passing between two High Voltage Copper Plates.
2. To use the Alphasense OPCs to detect a change in size with height and time of the very fine fraction (i.e.< 40 μm). The reason for this is that a footprint of the occurrence of aggregation processes downwind to the stream is the shift of the detected ash samples toward larger sizes in time. This shift, if present, is recorded in the histograms of the OPCs for each given height. In addition, having more than one sensor, each of them located at different heights, helps in understanding the contribute of resuspension processes to the recorded data.

The preliminary analysis of the data confirms that both the HSC and the OPCs can be fruitful used to the study of ash electrification if combined with the Planetary Environment Facility of Aarhus University. The whole dataset is formed by more than 15 Tb of high speed movies and 32 single runs of the wind tunnel facility (e.g. 32 runs x 4 OPC = 128 histograms).

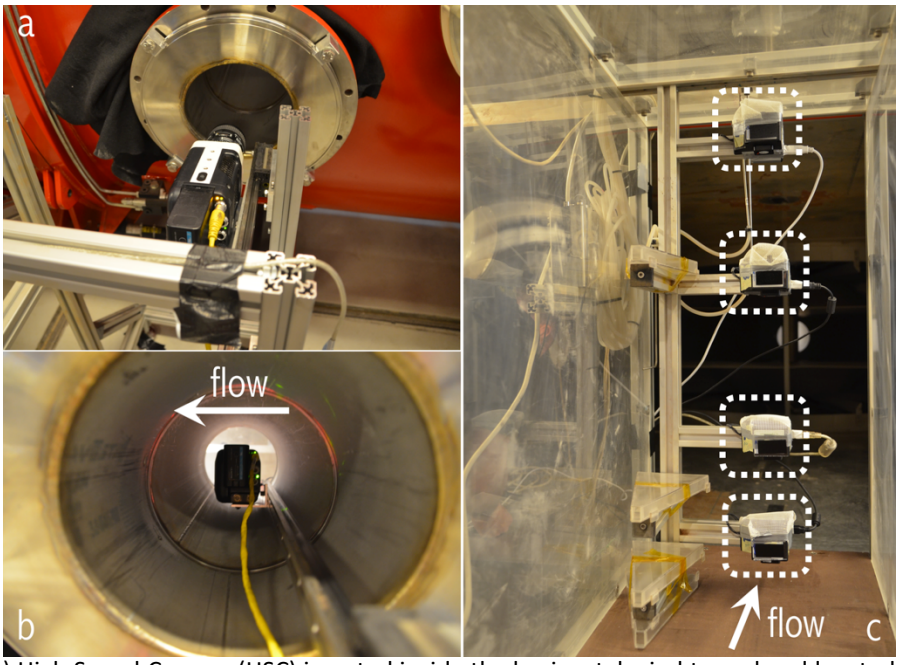

Figure 1 (a, b) High Speed Camera (HSC) inserted inside the horizontal wind tunnel and located crosswise to the main flow direction; (c) Array of four Optical Particle Counters (OPC) located inside the wind tunnel, downwind to the flow.

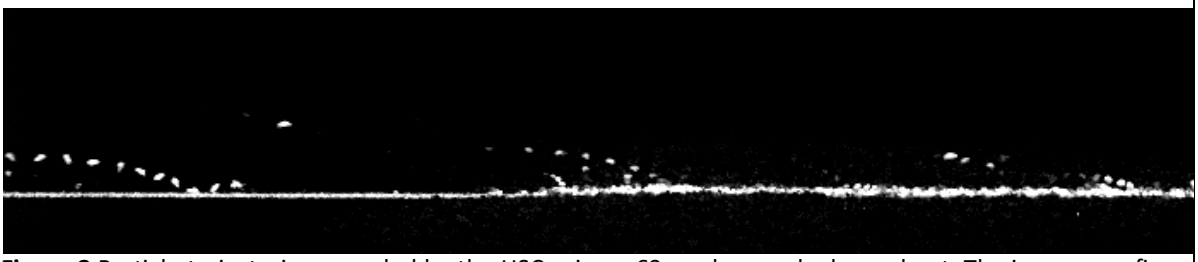

Figure 2 Particle trajectories recorded by the HSC using a 60mm lens and a laser sheet. The images confirm that coarse ash particles larger than 63 μm can be clearly detected by camera and that the wind tunnel can be used to generate particle collisions for charge generation measurements.

- Give details of any publications arising/planned (include conference abstracts etc)

- Host confirmation

Please can hosts fill in/check this table confirming the breakdown of time for this TA project:

Dates for travel to accommodation for TA visit (if physical visit by applicant)	Start Date of TA project at facility	Number of lab/field days spent on TA Visit pre-analytical preparation	Number of days in lab/field site for TA Visit	Number of days spent in lab for TA Visit data analysis	End Date of TA project at facility	Dates for travel home (if physical visit by applicant)
Departed: 6-6-2022 Arrived: 6-6-2022	11-6-2022	0	5	0	17-6-2022	Departed: 17-6-2022 Arrived: 17-6-2022

The host is required to approve the report agreeing it is an accurate account of the research performed.

Host Name	
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Project Leader Name	Eduardo Rossi
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Date	8/9/2022