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Ash fragmentation at Mount Etna and implications of different particle shape on ash dispersal in the atmosphere, ETNASH

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- **Introduction and motivation**
- Ash is a common manifestation of explosive basaltic volcanism. At Mount Etna ash emissions accompany different eruptive styles, from mild to moderate Strombolian explosions to high energy fire-fountain activity. Based on visual observations of the eruptive activity and textural and compositional features of ash samples, it was found that the characteristics of coarse ash particles at Mount Etna vary systematically with the eruptive style. For example, ash emitted at the peak of high energy activity is more vesicular, less crystallised and less compositionally evolved than that erupted during lower energy explosive activity or at the end of a long-lasting explosive eruption, and it contains fewer or no lithic material (Taddeucci et al. 2004JVGR, 137, Andronico et al. 2008JVGR, 173). Abundant ash venting has characterised activity at Etna since 1998 (Andronico et al. 2013JGR, 118, 2014BV, 76), deeply affecting people's everyday life and the overall economy in Eastern Sicily. Previous research on ash characteristics and the link between ash and eruption behaviour has improved our general knowledge on the dynamics of ash emissions at Mount Etna. However, no systematic description on mechanisms of ash fragmentation at Mount Etna has ever been provided. In addition, different ash characteristics translate into different transport patterns when the particles are released in the atmosphere, with implications for the environment and ground/air transportation that go far beyond the local economy and climate. The present proposal addresses this topic head-on.
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- **Scientific objectives**
- The scientific objectives of this study are manifolds: i) review the characteristics of ash and ash-dominated eruptions at Mount Etna, ii) investigate different episodes of ash emissions with ash samples coming either from the past, each associated with a different eruptive style and marked by a different duration, intensity and sedimentation rate of the ash fallout, or on-going Etna activity, iii) link such ash emissions to a different mechanism of ash fragmentation, and iv) investigate ash dispersal in the atmosphere via numerical modelling. The results of this study will produce a paradigm shift on knowledge of mechanisms through which ash fragments are dispersed in the atmosphere not only at Mount Etna but also at other basaltic volcanoes.
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- **Methodology and experimental set-up**
- Textural and morphological features of ash particles will be carried out by CAMSIZER® (Retsch) and Stereoscopic Zoom Microscope (Nikon SMZ1500). The former measures particle sizes in the range 30 µm-30 mm, and will enable measuring the grain-size of the different ash samples and the main shape parameters for each size-class of investigated ash particles. More detailed information of the instrument is given at http://www.retsch-technology.com/rt/products/digital-image-processing. The latter instrument is linked to a Nikon DS-Fi1 camera for capturing low-chromatic aberration, undistorted images of the observed samples, which are visualised in real time by the monitor of a connected computer. The microscope allows us to see and photograph any specimen (in particular volcanic ash),

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from macro views to high-magnification micro visualization with zoom ratio of 15X covering a range from 0.75x to 11.25x. Observations under the binocular microscope will provide additional information on the ash particles, like external morphology, surface texture and vesicle and crystal content, size, shape and orientation.

- The role of some parameters and properties (shape, density) characterising ash particles on ash transport under the action of realistic atmospheric conditions will be investigated through numerical simulations with Lagrangian models and formal uncertainty quantification and global sensitivity analysis, following the approach of Pardini et al. (2016JGR).
- In particular, the LPAC model (de' Michieli Vitturi et al., 2010JGR, 115) will allow us to solve for the particle motion equations derived by expressing the particle acceleration as the sum of forces acting along its trajectory, with the drag force calculated as a function of particle diameter, density, shape, and Reynolds number. Application of formalised uncertainty quantification and sensitivity analysis techniques through polynomial chaos expansion will enable statistical exploration of the model, providing information on the extent to which uncertainty in particles parameters propagates to dispersal uncertainty. The simulations will be performed coupling the LPAC code with the open-source toolkit DAKOTA (Adams et al. 2010, SAND2010-2183).

- **Preliminary results and conclusions**

  The participants of this proposal, nominally Polacci, Andronico, de' Michieli Vitturi and Cristaldi, had a 3 day meeting in Catania between 18-21 June 2017 where they addressed points i), ii) and iii) described under Scientific objectives.

- **Multidisciplinary approach**
- This researche has fostered a collaboration between 3 institutions: the University of Manchester, Osservatorio Etneo in Catania and INGV in Pisa.

- **Outcome and future studies**

  During the 2017 June visit the participants of this project generated the framework for, and initiated to write, a scientific publication on mechanisms of ash fragmentation at Mount Etna. They also discussed about setting up a potential PhD project involving the School of Earth and Environmental Sciences in Manchester, Osservatorio Etneo (ETNA-INGV) in Catania, and the INGV office in Pisa.

- **References**
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