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Preliminary insights into a model for mafic magma fragmentation

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Fragmentation of mafic magmas remains a poorly understood process despite the common occurrence of low viscosity explosive eruptions. In fact, it has been commonly overlooked based on the assumption that low viscosity magmas have very limited explosivity and low potential to undergo brittle fragmentation. However, it is now known that highly explosive, ash forming eruptions can be relatively frequent at several mafic volcanoes. Three questions arise due to this - What is the specific fragmentation mechanism occuring in these eruptions? What are the primary factors controlling fragmentation efficiency? Can a link between eruption style and fragmentation efficiency be quantified?

We addressed these questions by coupling theoretical observations and field analysis of the recent May 2016 eruption at Mount Etna volcano. Within this complex 10-day event three paroxysmal episodes of pulsating basaltic lava jets alternating with small lava flows were recorded from a vent within the Voragine crater. The associated plumes which were produced deposited tephra along narrow axes to the east and south east. Sampling was done on the deposits associated with the first two plumes and the third one.

We briefly characterise the May 2016 eruption by assessing plume height, eruption phases, total erupted masses and fallout boundaries and comparing them to previous eruptions. We also analyse the total grainsize distribution (TGSD) of the scoria particles formed in the jets. Conventional methods for obtaining grainsize and total distributions of an eruption are based on mass and provide limited information on fragmentation though. For this reason, the TGSD was assessed by coupling particle analyser data and conventional sieving data to assess both particle size and number of particle distributions with better precision. This allowed for more accurate testing of several existing models describing the shape of the TGSD. Coupled further with observations on eruption dynamics and eruption phase durations obtained from the network of fixed INGV cameras, early insight into possible links between fragmentation and eruption conditions are identified. A link between fragmentation and magma properties is also examined.

We discuss the relationship between the conventional and new analytical methods and their potential in unraveling key information on the fragmentation process and analyse how the dataset on the May eruption can be modelled with the current fragmentation theories. Finally, we suggest the systematic use of a comprehensive TGSD dataset to develop a fragmentation model for mafic eruptions.