Using Seismic Signals to Forecast Volcanic Processes

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Understanding seismic signals generated during volcanic unrest have the ability to allow scientists to more accurately predict and understand active volcanoes since they are intrinsically linked to rock failure at depth (Voight, 1988). In particular, low frequency long period signals (LP events) have been related to the movement of fluid and the brittle failure of magma at depth due to high strain rates (Hammer and Neuberg, 2009). This fundamentally relates to surface processes. However, there is currently no physical quantitative model for determining the likelihood of an eruption following precursory seismic signals, or the timing or type of eruption that will ensue (Benson et al., 2010).

Since the beginning of its current eruptive phase, accelerating LP swarms (< 10 events per hour) have been a common feature at Soufriere Hills volcano, Montserrat prior to surface expressions such as dome collapse or eruptions (Miller et al., 1998). The dynamical behaviour of such swarms can be related to accelerated magma ascent rates since the seismicity is thought to be a consequence of magma deformation as it rises to the surface. In particular, acceleration rates can be successfully used in collaboration with the inverse material failure law; a linear relationship against time (Voight, 1988); in the accurate prediction of volcanic eruption timings. Currently, this has only been investigated for retrospective events (Hammer and Neuberg, 2009).

The identification of LP swarms on Montserrat and analysis of their dynamical characteristics allows a better understanding of the nature of the seismic signals themselves, as well as their relationship to surface processes such as magma extrusion rates. Acceleration and deceleration rates of seismic swarms provide insights into the plumbing system of the volcano at depth. The application of the material failure law to multiple LP swarms of data allows a critical evaluation of the accuracy of the method which further refines current understanding of the relationship between seismic signals and volcanic eruptions. It is hoped that such analysis will assist the development of real time forecasting models.

Word count: 332