Constraints on magma ascent and pressurisation prior to explosive paroxysms on Stromboli

Mike Burton, Catherine Hayer, and Giuseppe La Spina
University of Manchester, Department of Earth and Environmental Science, Manchester, United Kingdom of Great Britain and Northern Ireland (mike.burton@manchester.ac.uk)

The paroxysmal eruptions of Stromboli in July and August 2019 highlighted with stark clarity the risks associated with visiting the summit of this remarkable volcano. It is an imperative for the volcanological community to recognise signals which precede such paroxysms, with the aim of maximising the warning time before an eruption. The common interpretation of the process driving paroxysms is that a volume of buoyant magma rises from depth, degassing in closed-system. The ascent is rapid, from 10 km depth to the surface in a few hours. This rapid ascent produces a kinetic limit to crystal growth, reflected in the ‘blonde’ colour of the eruption products. Closed-system degassing leads to an overpressure in the rising slug, which helps lift magma in the conduit, pressurising also the shallow system.

The gas plume produced by the 28 August 2019 eruption was observed approximately 2 hours after eruption by the orbiting TROPOMI imaging spectrometer aboard Sentinel-5P. Using the Plume Trajectory modelling approach, we have reconstructed a time series of SO₂ flux associated with the explosion. This reveals no clear precursor in SO₂ emissions, but our temporal resolution is limited to 20-30 minutes. A total SO₂ mass of 360 tonnes was quantified.

We can use this SO₂ mass together with previously measured gas compositions of explosive gas emissions to quantify the total mass of gas at explosion and an estimate of the magma mass required to produce this SO₂ mass. Together, these provide the initial conditions required to apply a magma ascent model in which we calculate the overpressure of the slug during its ascent. This provides a basis for determining the shallow deformation produced by both the increase in magma level and over-pressurised gas slug, and this may be helpful in constraining the timescales of precursory deformation.
