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Lessons learnt from 8 years of FTIR measurements on Mt. Etna

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Solar occultation FTIR measurements of volcanic gas emitted from Mt. Etna have been carried out on average 1-2 times per week since March 2000 by geochemists from INGV Catania. These measurements provide constraints on the amounts of SO_2, HCl and HF in the path between the instrument and the Sun. Atmospheric burdens of these gases are below detection limits, and therefore we observe pure volcanic gas amounts. The final product of FTIR measurements are the ratios SO_2/HCl, HCl/HF and SO_2/HF. When combined with SO_2 flux measurements, determined independently using ultraviolet spectroscopy, these ratios allow the flux of HCl and HF from the volcano to be determined. The overarching goal of this monitoring approach is to better understand the magma dynamics controlling volcanic activity at Mt. Etna. The focus of this paper is to summarise our findings on the empirical relationships between volcanic activity and volcanic gas emissions from 2000 to 2007.

Several eruptive episodes have been observed on Mt. Etna in the last 8 years. A sequence of 60 lava fountains occurred from the south-east summit crater (SEC) in the first half of 2000. This was followed by a sequence of 13 fountains from May to July 2001 that led to the 2001 southern flank eruption from July-August 2001. After fifteen months of quiescence the 2002 flank eruption began in October 2002, and concluded in January 2003. In September 2004 a very low energy effusive eruption began near the SEC, which developed in early 2005 into a more violent strombolian activity that concluded in March 2005. In April 2006 explosive activity began again at the SEC, ceasing in late 2006. Between and during each eruption we observed large systematic variations in the volcanic plume composition, with SO2/HCl varying between 1 and 8, SO_2/HF varying between 3 and 60 and HCl/HF varying between 2 and 6. SO_2 fluxes

varied from 500 tonnes per day (t/d) to 25,000 t/d. Gas emissions are therefore highly variable, and implictly contain critical information on the state of the volcano.

Eruptions tended to be preceded by several weeks to months of elevated SO_2/HCl ratio, produced by a relative reduction in HCl flux from the volcano. In order to interpret this observation we must first have a clear model of magma and gas dynamics within Mt. Etna. Recent work on melt inclusions and gas percolation provide the framework for this model, in which buoyant, vesiculating magma rises up through a sinking flow of dense degassed magma to the surface. Gas can separate from magma and flow independently and more rapidly towards the surface once the vesiculating magma is sufficiently permeable. Calculations of vesicularity as a function of pressure suggest that this can occur at pressures up to 100 MPa. We will show that the heightened SO_2/HCl ratio observed prior to Mt. Etna's eruptions is consistent with inefficient magma circulation that partially inhibits ascent of magma to the surface and enhances the probability of eruptiions.