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Evidence for magma convection to shallow depths during quiescent degassing of Mt. Etna

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Mt. Etna, Italy, is one of the most intensely studied persistently active volcanoes in the world, and represents an important resource for volcanologists to better understand volcanic processes through quantitative empirical observations. Here we present the integrated results of open-path Fourier transform infrared (OP-FTIR) measurements of relative amounts of SO_2, HCl and HF within the volcanic plume produced during quiescent degassing, and SO_2 fluxes measured with an automatic network of scanning ultraviolet spectrometers in the period 2007-2009. The objective of this investigation is to better understand the magma dynamics which control gas release at this volcano, allowing a deeper insight into the interpretation of gas composition data in general for volcanology. During 2007-2009, SO_2/HCl and SO_2/HF molar ratios measured with solar OP-FTIR showed a progressive increase during an eruptive events which began on May 13th 2008, and some peaks related to 2007 activity at the Southeast crater (SEC). The cumulative amounts of SO_2 and HCl emitted by Mt. Etna indicate that between eruptions over brief periods of time these two gases may be uncoupled, over longer periods they behave in a close-to-bulk degassing manner, such that the totality of gas released is that which would be expected based on original and final volatile contents measured using petrological analyses of eruptive products. Conversely, during the low-intensity but long-lived effusive eruption from May 2008 to July 2009 a dramatic departure from bulk degassing behaviour was observed, with halogen fluxes dropping significantly relative to SO_2 flux. These measurements therefore provide compelling evidence that it is the shallow storage of magma at Etna ($\sim$10-20 MPa) which produces the majority of the observed halogen flux between eruptions. These observations allow us to propose a qualitative interpretative model for variations in SO_2, HCl, HF amounts.

We propose that a decreasing in the observed SO_2 degassing relative to HCl indicates a process of deep intrusion, in which magma rather than ascending to the shallow ($\sim$3 km depth) conduit is stored at depth where it may later erupt. On the contrary, reduced HCl degassing indicates a reduction in magma supply to the uppermost 500m of the magmatic system, which may occur during a shallow intrusion. Over the investigated period we observed both these processes, but overall the system remained very close to bulk degassing, suggesting that such intrusions are temporary deviations from a system which can efficiently degas essentially all the magma that enters the uppermost 4-5km of the feeding system.