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Can bromine/sulphur ratios be used to forcast volcanic eruptions? An example study at Mt Etna.

Nicole Bobrowski (1) and Giovanni Bruno Giuffrida (2)

(1) University of Heidelberg, Germany (nicole.bobrowski@iup.uni-heidelberg.de), (2) Istituto Nazionale di Geofisica e Vulcanologia, Palermo, Italy

During three years, 2006-2009, scattered sky light DOAS measurements have frequently taken place at Mt. Etna about six kilometres downwind from the summit craters. At the same time frame volcanic observation were carried out by visiting various parts of Mt Etna regularly.

Results from theses measurements are presented and discussed. The investigations are focussed on the bromine monoxide/sulphur dioxide (BrO/SO_2) ratios which varied an order of magnitude over the investigated time frame.

That halogen/sulphur ratio can serve as precursor or indicator for the development of eruptive activity was supposed already by earlier investigations (e.g. Noguchi and Kamiya 1963, Menyailov 1975, Pennisi and Cloarec, 1998, Aiuppa 2002). Nevertheless still today there is only a limited understanding because of the complexity with which halogen gases are released under various magma compositions and degassing conditions, e.g. the rate and mechanisms of bubble nucleation, growth and ascent in silicate melts (Carroll and Holloway, 1994), the halogen vapour-melt partitioning and the volatile diffusivity in the melt (Aiuppa et al., 2009).

With this study we aim to add one more piece to the puzzle what halogen/sulphur ratios might tell about volcanic activities. The BrO/SO_2 ratios in our data set show an increase several weeks' prior eruptions (up to $3.9 \cdot 10^{-4}$) followed by a decreasing trend before and in the beginning of eruptive activities (down to $0.4 \cdot 10^{-4}$) BrO/SO_2 increases to medium values (about 1-2 $\cdot 10^{-4}$) with an ending phase of activity and stays with medium values during generally quite phases. A first empirical model to explain the observed changes in the BrO/SO_2 ratio is proposed and suggests that bromine is, in contrast to chlorine and fluorine, less soluble in the magmatic melt than sulphur. This approach is motivated by general consideration about solubility's in melt and in the context with visible observations.

We are aware that by using the DOAS method we measure the main part of the emitted sulphur at Mt Etna by determining SO_2, but might measure only a smaller or even a variable part of the bromine by measuring the radical bromine monoxide (BrO). We will show first investigations that cause the assumption that despite of the above mentioned disadvantages BrO could serve nevertheless as a new parameter giving indication of the state of a volcano simply by taking the measurements under certain, but still relatively broad conditions.