A statistical method to determine total H_2O and CO_2 budgets in magmas

P. Papale (1), M. Barsanti (2), D. Barbato (1) and R. Moretti (1)

(1) Istituto Nazionale di Geofisica e Vulcanologia, Italy, (2) Università di Pisa, Dip.to Matematica Applicata, Italy

A recently developed method based on the TVLine concept (Papale, 2005) allows to determine total H_2O and CO_2 budgets in magmas from melt inclusion data. This method, however, can not be easily applied when multiple groups of inclusions are present in the dataset. This is unfortunately a frequent occurrence in many relevant cases, including recent eruptions of Etna, Stromboli, Campi Flegrei, Vesuvius, and Kilauea volcanoes. We have developed a statistical method which allows to treat analytical uncertainties and group the data according to a probabilistic criterion. The method includes the following steps: i) hypothesize a number of pairs of total H_2O and CO_2 necessary to explain the observed data; ii) minimize a χ^2-like quantity for each datum by varying the possible H_2O-CO_2 pairs, and using a model for compositional-dependent multicomponent $H_2O + CO_2$ saturation in silicate melts (Papale et al., 2006). This step allows the assignment of each datum to a given total H_2O-CO_2 pair; iii) perform a Monte Carlo simulation to determine the probability of exceeding the obtained χ^2, therefore the likelihood of the assumed number of total H_2O-CO_2 pairs to explain the database. This sequence is repeated for many possible numbers of H_2O-CO_2 pairs and many assumed values of analytical uncertainty characterizing the dataset. Application of the method to about 30 melt inclusion data from a recent Kilauea eruption spanning CO_2 contents in the range 10-300 ppm shows that a minimum of two total H_2O-CO_2 pairs is required. These pairs show that the melt inclusions formed under two different conditions, the first one characterized by a few wt%, and the second one by less than 1 wt% CO_2 abundance.