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Distinct degassing processes during lava fountains revealed by OP-FTIR measurements: Mt. Etna's 2001 lava fountain sequence

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During the two months preceding the 2001 July-August flank eruption of Mt. Etna, 17 discrete lava fountaining events were observed at the southeast crater (SEC, 3250 m a.s.l.). Each episode was preceded by lava effusion and mild strombolian activity from a fracture on the NE flank of the SEC.
We used an open-path Fourier transform infrared spectrometer (OP-FTIR) to measure every about 5 seconds an IR absorption spectrum of the gas powering the lava fountains, lava being the source of radiation. Spectral-fitting procedures allowed retrieval of the relative amounts of H2O, CO2, SO2, HCl and HF present in the volcanic gas phase, allowing us to track variations in the gas composition both during each fountain event and over the entire sequence.
We present the chemical composition of gases emitted from the SEC during 9 of the 17 lava fountaining events. Three distinct phases in each fountain were observed in terms of seismic tremor, volcanic activity and gas composition. We observed the following: (i) The highest CO2/SO2 ratio observed during each paroxysm coincided with the peak in fountaining intensity and seismic tremor amplitude; (ii) The longer the pause between lava fountains the higher the observed peak CO2/SO2 ratio and tremor amplitude; and (iii) the SO2/HCl ratio noticeably decreased during phases of enhanced fine ash emission. We interpret the variations in gas composition and volcanic activity as due to the combined effects of two distinct processes: periodic emptying of a bubble foam layer accumulating at $\sim$2 km depth and syn-eruptive degassing during magma fragmentation. The clear correlation between the repose time between lava fountains and their intensity and CO2/SO2 peak ratio evidences a main control of the fountain series by bubble foam accumulation and emptying. The surprising decrease in SO2/HCl during the peaks in eruptive activity is attributed to enhanced HCl outgassing during more extensive magma fragmentation and entrainment of atmospheric air. Such an interpretation is consistent with recent decompression experiments on water-rich rhyolitic melts (Gardner et al., 2006) showing that the efficiency of Cl outgassing increases with the decreasing size and wall thickness of erupted pumice clasts. Therefore, our results demonstrate that both gas-melt separation (bubble foam growth) and syn-eruptive degassing can contribute to determine the dynamics of a same lava fountain.