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Open-path FTIR spectroscopy of magma degassing processes during eight lava fountains on Mount Etna

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In June–July 2001 a series of 16 discrete lava fountain paroxysms occurred at the Southeast summit crater (SEC) of Mount Etna, preceding a 28-day long violent flank eruption. Each paroxysm was preceded by lava effusion, growing seismic tremor and a crescendo of Strombolian explosive activity culminating into powerful lava fountaining up to 500m in height. During 8 of these 16 events we could measure the chemical composition of the magmatic gas phase (H_2O, CO_2, SO_2, HCl, HF and CO), using open-path Fourier transform infrared (OP-FTIR) spectrometry at $\sim$1–2km distance from SEC and absorption spectra of the radiation emitted by hot lava fragments. We show that each fountaining episode was characterized by increasingly CO_2-rich gas release, with $CO_2/SO_2$and CO_2/HCl ratios peaking in coincidence with maxima in seismic tremor and fountain height, whilst the SO_2/HCl ratio showed a weak inverse relationship with respect to eruption intensity. Moreover, peak values in both CO_2/SO_2ratio and seismic tremor amplitude for each paroxysm were found to increase linearly in proportion with the repose interval (2–6 days) between lava fountains. These observations, together with a model of volatile degassing at Etna, support the following driving process. Prior to and during the June–July 2001 lava fountain sequence, the shallow ($\sim$2km) magma reservoir feeding SEC received an increasing influx of deeply derived carbon dioxide, likely promoted by the deep ascent of volatile-rich primitive basalt that produced the subsequent flank eruption. This CO_2-rich gas supply led to gas accumulation and overpressure in SEC reservoir, generating a bubble foam layer whose periodical collapse powered the successive fountaining events. The anti-correlation between SO_2/HCl and eruption intensity is best explained by enhanced syn-eruptive degassing of chlorine from finer particles produced during more intense magma fragmentation.