First measurement of magma degassing processes and co-varying seismic tremor during an eruption of Piton de la Fournaise hot spot basaltic volcano, Reunion island

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Piton de la Fournaise (PdF), in the western Indian Ocean, is a very active hot spot basaltic volcano whose eruptions (1 to 2 per year on average) are well anticipated by the local geophysical monitoring network but whose magmatic gases had never been measured. Here we report on the first data for magmatic gas composition (OPFTIR absorption spectroscopy, in situ MultiGas analysis plus filterpack sampling) and budget (DOAS), coupled with recording of seismic tremor and the lava extrusion rate (space-borne MODIS sensing), during a fissure eruption of PDF in October 2010. Dyke ascent from about 2 km beneath the summit crater was tracked by a few hours of precursory seismic signals and volcano deformation. After a strong initial burst coinciding with eruptive fissure opening, both the tremor amplitude, lava extrusion rate and SO2 flux coherently decreased during the first week of eruption. The emitted magmatic gases, whose composition varied slightly over time, were found to be water-rich and to display high S/Cl but low C/S, Cl/F and Cl/Br ratios. These features are consistent with a hydrous hot spot mantle source and previous volatile fractionation during shallow magma storage. Volatile fluxes referred to the magma extrusion rate and available melt inclusion data point to essentially syn-eruptive (closed system) degassing of sulfur, chlorine and fluorine during the first half of the eruption. In contrast, additional inputs of CO2 and H2O are required to explain the gas composition. Differential CO2 bubbling is supported by high-frequency correlations between the FTIR-sensed CO2/HCl ratio and seismic tremor, while entrainment of hydrothermal steam might have enhanced the H2O gas content. The second week of the eruption was marked by a spectacular decoupling between declining lava extrusion and reincreasing seismic tremor amplitude (especially in the low-frequency band), indicating a key control of tremor and degassing activity by differential (open system) gas bubbling across the feeder dyke. Finally, the end of the eruption was preceded by a new sharp tremor increase, with remarkable anti-correlated variations of the 1-3 Hz and 3-5 Hz spectral signals, which we attribute to abrupt geometrical changes prior to dyke closure. Combined geochemical and geophysical survey of Piton de la Fournaise volcano in the future should permit a better understanding and forecasting of its eruptive behavior.