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The driving mechanism of lava fountains: insight from FTIR remote sensing of the gas phase composition

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Lava fountains are paroxysmal eruptive manifestations of low-viscosity magmas, during which gas and lava fragments are continuously jetted to great height (up to one kilometre) for variable durations (hours to days). Two models have been proposed for their source mechanism: i) the homogenous flow and effervescent disruption of fast-rising bubbly melt [1,2] or ii) the separate ascent of a bubble foam layer previously accumulated on top of a reservoir [3,4]. However, robust discrimination between these two mechanisms still suffers from the lack of contemporaneous and systematic field measurements. A key insight into the source mechanism of a lava fountain may be gained by measuring the chemical composition of its driving gas phase. Indeed, this composition should differ markedly depending on the possible extent and depth of gas-magma separation before eruption. In 2000-2002 we performed the very first remote sensing measurements of the composition of magmatic gas during a series of powerful (300-700 m high) lava fountains on Mount Etna, using Fourier transform infrared spectroscopy [5-7]. The chemical proportions of both major and minor volcanic gas species were determined from FTIR absorption spectra of the lava radiation, collected at high temporal frequency ($\sim$4-7 sec) and at distances of 0.5-1 km from the erupting vents. Spectral analysis also allowed determination of the physical temperatures of both volcanic gas and solid particles in the targeted fountain area. The results reveal very interesting chemical differences between different types of lava fountain and allow to constrain their respective driving mechanism. We show that periodic lava fountains at Southeast summit crater of Etna in 2000-2001 were mainly controlled by separate gas accumulation at depths of $\sim$1.5-2 km below the crater, whereas fire fountains at flank vents powered by dyke intrusion mainly resulted from the syn-eruptive bulk degassing of fast-rising magma. This distinction is supported by analysis of the

residual volatile content of the co-erupted lavas. We thus argue that since both of the two proposed models for the origin of lava fountains have been observed in action on Etna, the source mechanism for each individual fountain event must be assessed on a case by case basis. We highlight that remote sensing analysis of the gas phase driving lava fountains is a reliable tool for distinguishing which model is most applicable.

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