MAGMA VOLUMES INVOLVED IN MT. ETNA MARCH 2015 - MAY 2016 VOLCANIC ACTIVITY

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Introduction. Investigation of volcanic gas geochemistry is paramount for understanding and forecasting eruptive phenomena. Indeed, eruptive dynamics strongly depend on the concentration of volatile species in the magma and in the process how gases exsolve and separate from magma prior to and during eruptions. Insight into eruption mechanism and forecasting can be obtained by monitoring gas chemical composition and flux with particular reference to CO_2 and SO_2. In this regard, temporal changes of these components has displayed to mirror ascent of new rich-volatile magma inputs from depth towards more shallow reservoirs (e.g., Oppenheimer, 2003; Shinohara *et al*., 2005; Giammanco *et al*., 2013). Monitoring of SO_2 flux at Mt. Etna is performed by the UV scanner network (FLAME - FLux Automatic MEasurement; Salerno *et al*., 2009), which measure automatically and continuously during daylight the bulk

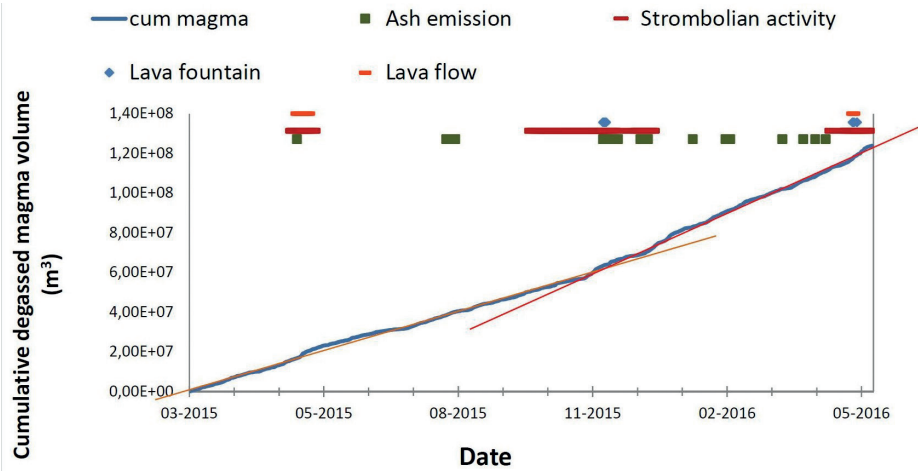

Fig. 1 Volume of the cumulative degassed magma through time and eruptive activity.

SO_2 emission in the plume issued by the summit craters. In this study, we present the daily SO_2 flux observed at Mt. Etna throughout the period March 2015 - May 2016. Over the investigated period, Mt. Etna volcano was characterized by three eruptive events, which ranged from weak Strombolian to extremely vigorous lava fountaining. Here, we explore the temporal correlation between the SO_2 flux and the eruptive activity, along the balance between the volumes of degassed vs. erupted magma.

Volcanic activity at Mt. Etna during the March 2015 - May 2016. The eruptive activity at Mt. Etna during the considered period was characterized by three major eruptive episodes. The first occurred between 11 and 20 May 2015 at the New South East Crater (NSEC), producing Strombolian activity and lava flow effusion. The second episode started on 19 October 2015 with weak ash emission and intra-crateric Strombolian activity at the Voragine crater (VOR). This weak explosive activity continued until the 3 December 2015, when an astonishing paroxysmal episode took place at VOR. Other paroxysmal episodes occurred on 4 and 5 December (Cannata *et al*., 2018). During the VOR activity, even the NSEC and the North East Crater (NEC) have been the place of Strombolian explosions with ash emission and a lava overflow from the NSEC. This activity ended on 7 December 2015. After more than 5 months, eruptive activity resumed at VOR on 16 May 2016 with Strombolian activity at the NSEC and, soon later, also at the VOR and NEC. Even this eruptive activity culminated with energetic lava fountaining at VOR on 18, 19 and 21 May (Cannata *et al*., 2018). During the following days, only lava flow effusion and weak Strombolian activity took place at the summit of Mt. Etna until 25 May 2016.

Results and discussion. SO_2 fluxes showed rather low values, generally below 5000 tons/day (t/d), for most of the period during March 2015 - May 2016. Steady increase with values up to 9500 t/d marked especially the onset of eruptive activity. The total volume of degassed magma was calculated assuming an initial sulfur content dissolved in the magma of 3000 ppm and a mean crystal fraction of 30% (e.g., Allard, 1997; Spilliart *et al*., 2006). This yielded a volume of degassed magma of 1.4×10^5 m^3 and 2.6×10^5 m^3 for 1 March 2015 and 31 May 2016, respectively. The uncertainty on the estimated volume ranges from 22% to 36% since it derives from the SO2 flux measurement. The cumulative degassed volume shows marked temporal changes of the slope in correspondence of onset of eruptive activities, a feature attributed to the release of part of the magma from the plumbing system (Fig. 1). The volume of the erupted magma as lava emission during the three eruptive events for the first eruption at the NSEC on May 2015 are estimated at minimum 2.9×10^6 m^3 and maximum 3.9×10^6 m^3. The volumes of the December 2015 eruptions consider both lavas and pyroclastics for the VOR activity and instead lava flows for NSEC. Corsaro *et al*. (2017), reports that the erupted

dense-rock equivalent masses during the first paroxysm were of 10^9 kg and the second 10^8 kg or 3.5 x 10^5 m^3 e 3.5 x 10^4 m^3, respectively. However, masses and volumes related to the second paroxysm could be largely underestimated. Volumes of the pyroclastic deposits of VOR have been estimated at 7.1 x 10^6 m^3 (Corsaro *et al*., 2017). Volumes of lava flows emitted by NSEC on December 2015 display a minimum at 2 x 10^6 m^3 and a maximum at 2.6 x 10^6 m^3. The total average volumes erupted during the three main eruptive episodes (May 2015, December 2015 and May 2016) are therefore the following: (1) May 2015: 3.9 x 10^6 m^3; (2) December 2015: 9.7 x 10^6 m^3; and (3) May 2016: 5.6 - 8.8 x 10^6 m^3 (Branca, personal communication). This allow estimating a total average erupted volume of magma of about 2.0 x 10^7 m^3 over the considered period. Considering the total volume of degassed magma on 31 May 2016 (1.2 x 10^8 m^3), the balance between the degassed and erupted magma yields a volumetric ratio of about 6:1, which imply a volume of intruded and not erupted magma of about 1.0 x 10^8 m^3.

Conclusions. We investigated the correlation between the daily bulk flux of SO_2 and the eruptive activity at Mt. Etna during the period March 2015 - May 2016. The SO2 emission displayed changes in connection with eruptive activity at both temporal and magnitude scale. Balance between the volumes of degassed magma and erupted magma reveals an unbalance of 6:1. This ratio implies two scenarios in (i) which intruded magma are confined at depth with the crust (Francis *et al*., 1993, Allard *et al*., 1996) or (ii) potential remobilization upward of degassed magma through a flushing processes or gas-rich magma injections from depth (Giuffrida *et al*., 2018).

References

Allard, P. (1997), *Endogenous magma degassing and storage at Mount Etna*, Geophys. Res. Lett., **24**, 2219–2222, doi:10.1029/97GL02101

Cannata A., Di Grazia G., Giuffrida M., Gresta S., Palano M., Sciotto M., Viccaro M. and Zuccarello F.; 2018: *Space-time evolution of magma storage and transfer at Mt. Etna volcano (Italy): The 2015-2016 reawakening of Voragine crater*. Geochem. Geophys. Geosyst., **19**, 471-495, doi 10.1002/2017GC007296.

Corsaro R.A., Andronico D., Behncke B., Branca S., Caltabiano T., Ciancitto S., Cristaldi A., De Beni E., La Spina A., Lodato L., Miraglia L., Neri M., Salerno G., Scollo S. and Spata G.; 2017: *Monitoring the December 2015 summit eruptions of Mt. Etna (Italy): Implications on eruptive dynamics*. J. Volcanol. Geotherm. Res., **341**, 56-69, doi 10.1016/j.jvolgeores.2017.04.018.

Francis P., Oppenheimer C., Stevenson D., 1993; *Endogenous growth of persistently active volcanoes*. Nature, **366** (6455), 554.

Giammanco S., M. Neri, G.G. Salerno, T. Caltabiano, M.R, Burton, V. Longo: 2013; *Evidence for a recent change in the shallow plumbing system of Mt. Etna (Italy): gas geochemistry and structural data during 2001-2005*. J. Volcanol. Geotherm. Res., **251**, 90-97.

Giuffrida M., Viccaro M. and Ottolini L.; 2018: *Ultrafast syn-eruptive degassing and ascent trigger high-energy basic eruptions*. Scientific Reports, **8**, 147, doi 10.1038/s41598-017-18580-8

Oppenheimer C.; 2003: *Volcanic degassing*. Treatise in Geochemistry, **3-9**, 123-166.

Salerno G.G., Burton M., Oppenheimer C., Caltabiano T., Tsanev V.I. and Bruno N.; 2009: *Novel retrieval of volcanic SO_2 abundance from ultraviolet spectra*. J. Volcanol. Geotherm. Res., **181**, 141-153, doi 10.1016/j.jvolgeores.2009.01.009.

Spilliaert, N., P. Allard, N. Métrich, and A. V. Sobolev (2006), *Melt inclusion record of the conditions of ascent, degassing, and extrusion of volatile- rich alkali basalt during the powerful 2002 flank eruption of Mount Etna (Italy)*. J. Geophys. Res., **111**, B04203, doi:10.1029/2005JB003934

Shinohara H. and Witter J.; 2005: *Volcanic gases emitted during mild Strombolian activity of Villarrica volcano, Chile*. Geophys. Res. Lett., **32**, L20308, doi 10.1029/2005GL024131.