EGU2020-14698
https://doi.org/10.5194/egusphere-egu2020-14698
EGU General Assembly 2020

Integrated monitoring of soil gases, plume SO2 and volcanic tremor to detect impulsive magma transfer at Mt. Etna volcano (Italy)

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Magma transfer in an open-conduit volcano is a complex process that is still open to debate and not entirely understood. For this reason, a multidisciplinary monitoring of active volcanoes is not only welcome, but also necessary for a correct comprehension of how volcanoes work. Mt. Etna is probably one of the best test sites for doing this, because of the large multidisciplinary monitoring network setup by the Osservatorio Etneo of Istituto Nazionale di Geofisica e Vulcanologia (INGV-OE), the high frequency of eruptions and the relatively easy access to most of its surface.
We present new data on integrated monitoring of volcanic tremor, plume sulphur dioxide (SO_2) flux and soil hydrogen (H_2) and carbon dioxide (CO_2) concentration from Mt. Etna. The RMS amplitude of volcanic tremor was measured by seismic stations at various distances from the summit craters, plume SO_2 flux was measured from nine stations around the volcano and soil gases were measured in a station located in a low-temperature (T □ 85 °C) fumarole field on the upper north side of the volcano.
During our monitoring period, we observed clear and marked anomalous changes in all parameters, with a nice temporal sequence that started with a soil CO_2 and SO_2 flux increase, followed a few days later by a soil H_2 spike-like increase and finally with sharp spike-like increases in RMS amplitude (about 24 h after the onset of the anomaly in H_2) at all seismic stations.
After the initial spikes, all parameters returned more or less slowly to their background levels. Geochemical data, however, showed persistence of slight anomalous degassing for some more weeks, even in the apparent absence of RMS amplitude triggers. This suggests that the conditions of slight instability in the degassing magma column inside the volcano conduits lasted for a long period, probably until return to some sort of balance with the “normal” pressure conditions.
The RMS amplitude increase accompanied the onset of strong Strombolian activity at the Northeast Crater, one of the four summit craters of Mt. Etna, which continued during the following period of moderate geochemical anomalies. This suggests a cause-effect relationship between the anomalies observed in all parameters and magma migration inside the central conduits of the volcano. Volcanic tremor is a well-established key parameter in the assessment of the probability of eruptive activity at Etna and it is actually used as a basis for a multistation system for detection of volcanic anomalies that has been developed by INGV-OE at Etna. Adding the information provided by our geochemical parameters gave us more solid support to this system, helping us

understand better the mechanisms of magma migration inside of an active, open-conduit basaltic volcano.