Geophysical Research Abstracts
Vol. 18, EGU2016-12700, 2016
EGU General Assembly 2016

Evaluation of the eruptive potential and probability in open conduit volcano (Mt Etna) based on soil CO_2 flux measurements

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The evaluation of the amount of magma that might be potentially erupted, i.e. the eruptive potential (EP), and the probability of eruptive event occurrence, i.e. eruptive probability (EPR) of active volcano is one of the most compelling and challenging topic addressed by the volcanology community in the last years. The evaluation of the EP in open conduit volcano is generally based on constant magma supply rate deduced by long-term series of eruptive rate. This EP computation gives good results on long-term (centuries) evaluations, but resulted less effective when short-term (years or months) estimations are needed. Actually the rate of magma supply can undergo changes both on long-term and short-term. At steady condition it can be supposed that the regular supply of magma determines an almost constant level of magma in the feeding system (FS) whereas episodic surplus of magma inputs, with respect the regular supply, can cause large variations in the magma level. Follow that the surplus of magma occasionally entered in the FS represents a supply of material that sooner or later will be disposed, i.e. it will be emitted. Afterwards the amount of surplus of magma inward the FS nearly corresponds to the amount of magma that must be erupted in order to restore the equilibrium. Further, larger is the amount of surplus of magma stored in the system higher is the energetic level of the system and its propensity to erupt or in other words its EPR.
On the light of the above consideration herein, we present an innovative methodology to evaluate the EP based on the quantification of surplus of magma with respect the regular supply, progressively intruded in the FS. To estimate the surplus of magma supply we used soil CO_2 emission data measured monthly at 130 sites in two peripheral areas of Mt Etna Volcano. Indeed as reported by many authors soil CO_2 emissions in the areas are linked to magma supply dynamics and more, anomalous discharges of CO_2 are ascribable to surplus of magma intruded in the feeding system. We analyzed ten years of data and according to Henry's law we associate anomalous periods of degassing (i.e. peaks) to a partial volume of magma (PVM) intruded in the FS. In spite of the fact that we have only a partial view of the volume of magma involved, it should be noted that the view is always the same and hence the magnitude of the recorded anomalies is proportional the total amount of the surplus of magma entered the FS. Thus, we found a conversion factor able to convert the PVM to total amount of surplus of magma. This factor was deduced by comparing, over specific periods, the cumulative value of PVM with the cumulative of the volume of eruptive products (VEP). At this point the EP, over a determinate period of time, is computed by the difference of surplus of volume of magma intruded and the VEP progressively emitted. Simple statistical treatment can be applied to the time series of the EP to define a threshold value and to identify periods of high level of EP and hence periods with a high EPR. The result over ten years of monitoring showed as the 80% of time the eruptive events started when the values of EPR were high.