Numerical Evidence of Unrest-Related Electromagnetic Effects in the Campi Flegrei Caldera, Italy

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Abstract

Electric, magnetic and electromagnetic (em) methods are widely used to monitor active volcanoes. A review of such applications is presented in Johnston (cit). Em signals were recorded in correspondence of numerous volcanic eruptions, for example in the case of the Mt. Unzen in Giapppone, of Merapi in Indonesia, Etna in Italy and during rapid deformation in Long Valley in California. Observations of volcanomagnetic effects are reported also for the Mt St. Helens and for Piton de la Fournaise. During volcanic activity, different physical processes giving rise to perturbations of electric field and magnetic field as the physical conditions (stress, temperature, flow, etc.) and the geometry of the magmatic bodies changes.

Large-scale variations in electromagnetic fields were also recorded before the eruptions, related to the mechanical stress accumulation and consistent with the ground deformation. These eruptions related changes, occurring mainly near the active vents,result strong and localized and related to huge mass displacement, rocks magnetization / demagnetization and stress variation effects. Thermal contributions result instead related to the transport of large and high temperatures fluid volumes. Generally, the experimental observations indicate that both the magma upwelling and the hydrothermal systems reactivation phenomena significantly affect the values of the em fields and several volcanological observatories in the world have made observation networks. Different studies have explained this relationship linking it to the effects of circulation of charges induced by the endogenous dynamics of volcanic structures, ending that the recording of em fields provide information for the determination of risk comparable to those contained in the gravimetric and deformation signals, already currently monitored regularly.

A numerical study performed using the COMSOL Multiphysics® software is presented, carried out to evaluate the effects on the main physically observable fields of an ideal unrest episode of the Campi Flegrei Caldera (Italy), one of the most dangerous volcanic zone in the world. Four distinct phases have been modeled, each one characterized by a fixed injection of a multiphase mixture of water and CO2 in the bottom of the caldera. The thermodynamical evolution of the whole hydrothermal system has been evaluated in terms of temperature and pressure changes. In the following, these changes in the caldera state are considered as sources of the ground displacement, of the gravity anomaly, of the electric potential anomaly and of the magnetic

anomaly generated during the ideal unrest, using the AC/DC Module and the Structural Mechanics Module.

Figures used in the abstract

Figure 1

Figure 2

Figure 3

Figure 4