Geophysical Research Abstracts
Vol. 15, EGU2013-3356, 2013
EGU General Assembly 2013

Geochemical data, geophysical signals and physical simulations of the hydrothermal system highlight the beginning of a new volcanic unrest at Campi Flegrei caldera

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The temporal variation of magmatic fluid release at Campi Flegrei caldera is investigated using numerical simulations of the hydrothermal system constrained by diffuse CO_2 emission data and by the chemical composition of fumarolic vents. The main aim is to understand the recent dynamics of Campi Flegrei, where hundreds of thousands of people live in an area subjected since the middle of the 20th century to a long term crisis characterized by several episodes of ground uplift and correspondent seismic swarms (bradyseism). In 1998, the first measurements of diffuse degassing from the Solfatara crater, the most active zone of Campi Flegrei, revealed the very intense release of hydrothermal- magmatic CO_2 ($\sim$1500 t/d) and of thermal energy ($\sim$100 MW) highlighting that the expulsion of deep fluids is the main form of energy loss from the entire caldera and suggesting an important role of magma degassing during the crisis. The hydrothermal system of Solfatara recently underwent large changes, including compositional variations of fumarolic effluents, compositional homogenization of the fluid released at different vents, changes in the pattern of diffuse degassing, increases in the pressures of the system, and increases in the temperature and in the flow rate of the fumaroles. Furthermore, after 20 yr of subsidence, an uplift period started in 2005. Comparing long-term series of geochemical signals with ground deformation and seismicity, we show that these changes are at least partially caused by repeated injections of magmatic fluid into the hydrothermal system. The frequency of these degassing episodes has increased in the last years, causing pulsed uplift episodes and swarms of low magnitude earthquakes. Modeling of these injection events allowed us to derive synthetic time series of geochemical parameters which well match those independently derived for the fumaroles. Total injected fluid masses in the simulated events are of the same order of magnitude as those emitted during small-medium size volcanic eruptions, and their cumulative curve shows an inversion in 2000 which divides a preliminary period of decrease in the flux of magmatic fluids from the present phase of increasing activity. The increased amount of magmatic fluids entering the system would have caused both fluid-pressure increases at shallow depths and the observed macroscopic changes in the fumarolic activity which include the increase of the discharge temperature, episodes of mud emission, formation of boiling pools, the opening of new vigorous vents. Independently from the simulation results, also the ground deformation data show an acceleration of the process with maximum uplift rates registered in the last year. At the moment it is not possible to exclude that these signals are precursor of a new large unrest at Campi Flegrei.