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Repeated episodes of magmatic fluid injections into the hydrothermal system of Campi Flegrei. Geochemical evidences and thermo-fluid-dynamic simulations

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Campi Flegrei caldera subsided for the twenty years following the last large crisis of 1982-1984. The subsidence was interrupted by 3 minor uplift episodes each accompanied by swarms of low energy earthquakes and by a peak of the concentration of magmatic fluids discharged by the fumaroles. Since 2000 the behavior of the system changed: the magmatic component of fumaroles started to increase almost continuously, swarms of earthquakes became more frequent and, after a decrease in the subsidence rate, the ground started a general uplifting trend. Contemporaneously the temperature of one of the biggest fumaroles increased, new vents formed and the deeply derived CO_2 released by the soils changed degassing pattern and locally increased. In order to investigate these phenomena, long time series of fluid pressure and temperature, estimated on the base of CO_2–H_2O–H2–CO gas equilibria, were considered. The fumarole external to Solfatara crater (Pisciarelli) shows an annual cycle of CO contents indicating the occurrence of shallow secondary processes which mask the deep signals. On the contrary the fumaroles located inside the crater (BG and BN) do not show evidences of secondary processes and the compositional variations are linked to T-P changes within the hydrothermal system, indicating a pressurization of the upper part of the hydrothermal system. Furthermore, the CO_2/CH4 ratio of the fumaroles, a good tracer of the input of magmatic fluids into the hydrothermal system, displayed a general increase with numerous peaks well correlated in the time with pulsed episodes of ground uplifts and seismic swarm suggesting the occurrence of repeated episodes of injections of deep magmatic gases with high CO_2 contents. The process was modeled by means of a geothermal simulator which was able to reproduce the H2S/CO_2 fumarolic ratios and the PCO_2 independently estimated for the fumaroles. Total injected fluid in the simulated events are in the range of fluids emitted during small-medium size volcanic eruption. The cumulative mass curve of magmatic injections shows a flex in 2000 which divides a first period of decrease in the flux of magmatic fluids from the present phase of increasing activity which is accompanied by a concurrent acceleration in the ground uplift.