Geophysical Research Abstracts
Vol. 19, EGU2017-18390, 2017
EGU General Assembly 2017

A geochemical and geophysical reappraisal to the significance of the recent unrest at Campi Flegrei caldera (Southern Italy)

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Volcanic unrest at calderas involve complex interaction between magma, hydrothermal fluids and crustal stress and strain. Campi Flegrei caldera (CFc), located in the Naples (Italy) area and characterised by the highest volcanic risk on Earth for the extreme urbanisation, undergoes unrest phenomena involving several meters of uplift and intense shallow micro-seismicity since several decades. Despite unrest episodes display in the last decade only moderate ground deformation and seismicity, current interpretations of geochemical data point to a highly pressurized hydrothermal system. We show that at CFc, the usual assumption of vapour-liquid coexistence in the fumarole plumes leads to largely overestimated hydrothermal pressures and, accordingly, interpretations of elevated unrest. By relaxing unconstrained geochemical assumptions, we infer an alternative model yielding better agreement between geophysical and geochemical observations. The model reconciles discrepancies between what observed 1) for two decades since the 1982-84 large unrest, when shallow magma was supplying heat and fluids to the hydrothermal system, and 2) in the last decade. Compared to the 1980's unrest, the post-2005 phenomena are characterized by much lower aquifers overpressure and magmatic involvement, as indicated by geophysical data and despite large changes in geochemical indicators. Our interpretation points out a model in which shallow sills, intruded during 1969-1984, have completely cooled, so that fumarole emissions are affected now by deeper, CO_2-richer, magmatic gases producing a relatively modest heating and overpressure of the hydrothermal system. Our results do have important implications on the short-term eruption hazard assessment and on the best strategies for monitoring and interpreting geochemical data.