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The types of unrest occurring at Campi Flegrei caldera (Southern Italy) since 1982 and the role of magma

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The thermodynamic response of a multiphase (at least biphasic) and multicomponent system that has enough degrees of freedom to respond to variations of external constraints consists in re-equilibrating phase proportions and compositions of dissolved components. For volcanic systems in unrest, such as CampiFlegrei, this puts first-order thermal constraints that typically the procedures of geophysical inversion of geodetic and gravimetric data cannot identify.In this study, based on a thermodyamically internally consistent approach to the geochemical data recorded in the last 35 years, we show that:
1) The fumarole-feeding portions of the Solfatara geothermal field have fluid pressures below the lithostatic gradients. Shallow steam condensation occurs certainly in the surroundingsof fumarole emissions, and was attained in few circumstances during the 1982-84 unrest.
2) Inert gases help evaluating the geochemical signature of the deep upcoming gas, not compatible with a magma migrating to shallow depths in recent times. Any magma emplaced at shallow depth should have a volatile content and a size incompatible with geophysical measurements and models on shallow magma emplacement.After exhaustion of the shallow magma emplaced in1982-84, the system is fed by a deep magmatic gas.
3) Gas indicators and the observed increase in magmatic fraction (Y) after year 2000 require a raise in the temperature of the formed hydrothermal vapour and the likely involvement of a supercritical fluid phase. This determines the opening of awindow for magmatic gases at surface, which is however hardly compatible with a magma raising to shallow depths.
4) The unrest style can be related to the P-T-H conditions of the deep hydrothermal vapour. These determine if the pore-filling fluid is a biphasic liquid+vapour. like in 1982-84, when pore overpressures developed under nearly undrained conditions.
5) The nature of the 1982-84 unrest was magmatic, due to the emplacement of a shallow (3-4 km deep) magma. This interfered with the “normal” degassing dynamics of deep (8 km) and regional origin. On the contrary, the post-2005 unrest is unlikely magmatic and likely hydrothermal, following the crystallizing history of the magma emplaced in 1982-84.
6) The pictured scenarios confirm in all cases, and independently of the type of unrest, the strong role played by the CO_2-rich gas release of deep provenance. This is in line with the recent discovery of huge doming, due to gas overpressures, in the offshore portion of the CFc, i.e. the nearby Pozzuoli harbour (Passaro et al., 2016).