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Interaction between hydrothermal and magmatic systems: modelling of magmatic gas release and ascent at Campi Flegrei (Italy)

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We model the perturbation of a hydrothermal system caused by the gas release from sub-surface magma chambers. First, we simulate the evolution of the magmatic system composed by two magma reservoirs: a small and shallow chamber, filled with degassed phonolite, connected to a deeper reservoir of gas-rich shoshonite through a vertical dyke. The fluid-dynamics governing the replenishment of the upper chamber is computed with a 2D code solving conservation equations of mass, momentum and energy for a homogeneous multicomponent, multiphase Newtonian mixture, accounting for exsolution and dissolution of volatiles (H_2O+CO_2). We then assume that the volatiles that accumulate at the top of the upper chamber, escape from the reservoir and enter a steady state hydrothermal system.

The response of the hydrothermal circulation is simulated with two multi-phase, multi-component porous media codes (MUFITS and TOUGH2) that describe the propagation of magmatic volatiles toward the surface. We create a simple model of Campi Flegrei hydrothermal system covering both shallow and deep regions where the temperature exceeds the critical temperature for water. Simulation results suggest that the rate at which volatiles are released from the magma chamber, the permeability distribution and the conditions of the hydrothermal system when degassing takes place can determine very different evolutions: accordingly, carbon dioxide may reach the surface within a time span ranging from weeks to millennia. The simulations indicate also that a single unrest event, associated with volatiles release from the chamber, can result in a periodic behaviour of observable parameters such as gas flux and fumarole composition. Duration of the period is of the order of 10 years, which is comparable with the time span between major unrest events observed at Campi Flegrei.