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Numerical model of the Amiata Volcano geothermal fields, Italy

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The Amiata geothermal fields form an annulus all around the Northeastern (Poggio Zoccolino field), Southeastern (Piancastagnaio field), Southern (Poggio al Nibbio field) and Southwestern (Bagnore field) base of the volcano. The fields, first exploited between the 1950s and the 1960s, produced an incondensable-gas rich fluid, which later evolved to become vapour-dominated. During the first years of geothermal exploitation, the pressure of the fields dropped from 40-50 bars (at Piancastagnaio) and 20-25 bars (at Bagnore) to about 20 bars and 5 bars, respectively. Depressurization of these fields induced the drainage of the freshwater aquifer contained in the volcanic rocks, a substantial drop of its water-table and a decrease in springs flow rates.

Our work aims at modelling the hydrothermal system of the Amiata Volcano and the development of the geothermal fields. We use the TOUGH2 poly-phase , multi-component thermal porous-media flow code developed at LBNL, as implemented by the GUI Petrasim^{TM}, with the ESWAG equation of state. Our model is based on geological, geophysical and geochemical data made public during the past 50 years in addition to work published in scientific journals. It represent an area of 32 x 36 km2 with cells of 1*1 km; the model extends 6.65 km in depth and is divided in 58 layers that increase from 50 m thick at the surface to 400 m at depth for a total of about 48.000 cells. Although the geology of the model is necessarily simplified, it retains the characteristic topology and structure found in the field.

Our results show that the hot fluids rising below the volcano become diverted outward by the fresh water of the volcanic aquifer that recharges the hydrothermal system at its centre. This topology of the hydrothermal system correctly reproduces the location of the geothermal fields and results in a superficial temperature gradient that is comparable to the measured one. At the base of the volcano, the incondensable gases (mainly CO_2) accumulate in geologic traps formed by clayey chaotic complexes (caprock) that overlay doming anhydrite rocks (reservoir). Depressurization of the gas traps during geothermal field exploitation induces traps flooding by the adjacent and overlying aquifers. In turn, the water table of superficial acquifers decreases its elevation in order to equilibrate at the lower pressure of the geothermal fields.