The bolsena-torre alfina geothermal field (Italy): a case of caldera-related blind geothermal resource

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The Torre Alfina geothermal field is located about 10 km north of the Quaternary Bolsena caldera. The reservoir is a buried structural high made of Mesozoic-Cenozoic carbonatic sequences characterised by discontinuous secondary permeability and sealed by clay-rich alloctonous syn-orogenic flysch successions and Pliocene neo-authoctonous marine clays. The reservoir is locally highly productive, water-dominated and CO2-rich, with T at its top of 120 degrees C. The origin of the heat source was not investigated in detail but generally attributed to some unidentified deep magmatic body. Our field structural data document fracturing and faulting that affect both the reservoir and the seal units with dominant NE-SW and a subordinate E-W as maximum extension directions. The surface pattern and kinematics indicate that fault systems are part of the Pliocene-Quaternary tectonic episode in Central Italy, where strike-slip kinematics transfers deformation between main extensional shear zones. The fault network controls intense hydrothermal manifestations and travertine deposition north of the Torre Alfina area. 230Th/234U dating allows distinguishing three different stages of hydrothermal pulses bracketed between 200 and 90 ka. To improve the current understanding of the geometry and density of subsurface fracture system we applied the Shear Wave Splitting (SWS) technique studying the waveforms from local microearthquakes recorded in the area from 2008 to 2011. The analysis of SWS provides parameters directly related to the strike of the subsurface fluid-filled fractures and their density. According to the extensive-dilatancy anisotropy hypothesis (Crampin, 1984) SWS is generated by propagation through distributions of fluid-filled cracks, microcracks, and preferentially oriented pore space aligned according to the active stress field in the area.

The analysis was made using the software ANISOMAT and gives a major direction NW-SE. The results agree both with structural data and with the focal mechanism of the earthquakes collected in the area between years 1977 and 1992. From the analysis on the crack density our data gives as result a good index of fracture for the reservoir's rocks. Based on the updated conceptual model we performed numerical simulations in TOUGH2 code. Results indicate that deep circulation is forced by the geometry of the reservoir and by T and P gradients. We interpret the Torre Alfina field as a "blind" system, formed dominantly by lateral advection of heat and mass from the Bolsena caldera deep system driven both by high T and by the greater depth at which reservoir rocks are downthrown by the volcano-tectonic collapse. Preferential fracture fabric in the deep carbonates allows the lateral heat transfer. The cap-rocks have excellent sealing characteristics allowing the preservation of heat in correspondence with positive structural traps.