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Numerical simulations of highly buoyant flows in the Castel Giorgio - Torre Alfina deep geothermal reservoir

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Geothermal heat is a viable source of energy and its environmental impact in terms of CO_2 emissions is significantly lower than conventional fossil fuels. However, nowadays its utilization is inconsistent with the enormous amount of energy available underneath the surface of the earth. This is mainly due to the uncertainties associated with it, as for example the lack of appropriate computational tools, necessary to perform effective analyses.
The aim of the present study is to build an accurate 3D numerical model, to simulate the exploitation process of the deep geothermal reservoir of Castel Giorgio - Torre Alfina (central Italy), and to compare results and performances of parallel simulations performed with TOUGH2 (Pruess et al. 1999), FEFLOW (Diersch 2014) and the open source software OpenGeoSys (Kolditz et al. 2012). Detailed geological, structural and hydrogeological data, available for the selected area since early 70s, show that Castel Giorgio - Torre Alfina is a potential geothermal reservoir with high thermal characteristics (120 ° C - 150 ° C) and fluids such as pressurized water and gas, mainly CO_2, hosted in a carbonate formation.
Our two steps simulations firstly recreate the undisturbed natural state of the considered system and then perform the predictive analysis of the industrial exploitation process. The three adopted software showed a strong numerical simulations accuracy, which has been verified by comparing the simulated and measured temperature and pressure values of the geothermal wells in the area. The results of our simulations have demonstrated the sustainability of the investigated geothermal field for the development of a 5 MW pilot plant with total fluids reinjection in the same original formation. From the thermal point of view, a very efficient buoyant circulation inside the geothermal system has been observed, thus allowing the reservoir to support the hypothesis of a 50 years production time with a flow rate of 1050 t/h. Furthermore, with the modeled distances our simulations showed no interference effects between the production and re-injection wells.
Besides providing valuable guidelines for future exploitation of the Castel Giorgio – Torre Alfina deep geothermal reservoir, this example also highlights the large applicability and the high performance of the OpenGeoSys open-source code in handling coupled hydro-thermal simulations.

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