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Fluid injection and withdrawal in deep geothermal borehole.

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Geothermal systems represents a large resource that can provide, with a reasonable investment, a very high and cost-competitive power generating capacity. Considering also the very low environmental impact, their development represents, in the next decades, an enormous perspective. Despite this unquestionable potential, geothermal exploitation has always been perceived as limited, mainly because of the dependance of a site usefulness on several pre-existing conditions, mainly correlated to the reservoir rock's permeability and porosity, the amount of fluid saturation and, first of all, a convenient temperature-depth relationship. However, this major barrier it is not insurmountable and a notable progress in recent tests is achieved with the Enhanced Geothermal System (EGS), where massive fluid injection and withdrawal were performed to enlarge the natural fracture system of the basement rock. The permeability of the surrounding rocks results highly increased by pressurized fluids circulation and geothermal resources, in such way, become accessible in areas where deep reservoir exploitation, otherwise, could be not advantageous or even possible. Still problematic remains, however, most of the key technical requirements as, firstly, deep fluid injection, that represents a necessary field practice in EGS development. This kind of procedure have often strong and uncontrolled physical effects on the neighboring environment, involving possibly even large areas and, in particular, they represent one of the most important sources of seismicity induced by human activities. In some cases, seismicity reaches level that can not be sustained, as in the paradigmatic case of the 2006 M=3.4 earthquake induced in the Basel city (Swiss), with the consequent EGS project early termination.
We test a numerical procedure that models deep fluid injection and withdrawal, during well stimulation, and its effects on induced seismicity. We propose such a procedure as a way to estimate how the potential for failure along regions of the geothermal reservoir changes due to well stimulation. We adopt the combined use of both numerical code TOUGH2 (Pruess 1991; Pruess et al. 1999) and COMSOL Multiphysics, computing the Pressure and Temperature changes, as well as heat and fluid fluxes, originated by flows of fluid mixtures within a porous medium of assigned permeability. These reconstructed changes in Pressure and Temperature are subsequently considered as mechanical sources, heterogeneously distributed in the whole discretized volume. In that way, we use the obtained DT and DP as source term to estimate all the mechanical variation across the analyzed body. In particular, we obtain the incremental stress due to fluid injection that we sum with a background regional tectonic loading, finally obtaining an estimate of the Coulomb stress changes, identified as the key parameter to describe the induced seismicity.