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3D Groundwater flow model at the Upper Rhine Graben scale to delineate preferential target areas for geothermal projects

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Any deep unconventional geothermal project remains risky because of the uncertainty regarding the presence of the geothermal resource at depth and the drilling costs increasing accordingly. That's why this resource must be located as precisely as possible to increase the chances of successful projects and their economic viability. To minimize the risk, as much information as possible should be gathered prior to any drilling. Usually, the position of the exploration wells of geothermal energy systems is chosen based on structural geology observations, geophysics measurements and geochemical analyses. Confronting these observations to results from additional disciplines should bring more objectivity in locating the region to explore and where to implant the geothermal system.

The Upper Rhine Graben (URG) is a tectonically active rift system that corresponds to one branch of the European Cenozoic Rift System where the basin hosts a significant potential for geothermal energy. The large fault network inherited from a complex tectonic history and settled under the sedimentary deposits hosts fluid circulation patterns. Geothermal anomalies are strongly influenced by fluid circulations within permeable structures such as fault zones. In order to better predict the location of the geothermal resource, it is necessary to understand how it is influenced by heat transport mechanisms such as groundwater flow. The understanding of fluid circulation in hot fractured media at large scale can help in the identification of preferential zones at a finer scale where additional exploration can be carried out. Numerical simulations is a useful tool to deal with the issue of fluid circulations through large fault networks that enable the uplift of deep and hot fluids.

Therefore, we build a numerical model to study groundwater flow at the URG scale (150 x 130km), which aims to delineate preferential zones. The numerical model is based on a hybrid method using a Discrete Fracture Network (DFN) and 3D elements to simulate groundwater flow in the 3D regional fault network and in sedimentary deposits, respectively. Firstly, the geometry of the 3D fracture network and its hydraulic connections with 3D elements (sedimentary cover) is built in accordance with the tectonic history and based on geological and geophysical evidences. Secondly, data from previous studies and site-specific geological knowledge provide information on the fault zones family sets and on respective hydraulic properties. Then, from the simulated 3D groundwater flow model and based on a particle tracking methodology, groundwater flow paths are constructed. The regional groundwater flow paths results are extracted and analysed to delineate preferential zones to explore at finer scale and so to define the potential positions of the exploration wells.

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