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Numerical study of the effects of fault zone structural properties on hydraulic behavior in the frame of EGS technology

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A significant increase in geothermal energy production is expected to meet the ambitious greenhouse gas (GHG) reduction targets and for a diversification in the energy mix according to the Energy Transition Law for Green Growth (LTCEV). In the French geological context, widespread exploitation of high temperatures of the basement is required through EGS (« Engineered Geothermal System ») technology. EGS technology has a great potential in rift basins with a generally higher geothermal gradient that reduces the cost and the risk to reach the target temperature. Within rifting context, the fault fracture systems (fault zone) can provide the permeability necessary for natural migration paths for ascending hot fluids from deep geological formations. Under these circumstances, fault zones play a major role and have a high potential for geothermal energy extraction (so called fault zone geothermal reservoir). But their usability is highly conditioned by their productivity potential (directly linked to the permeability and specifically to the density, aperture, infills of fractures and their connectivity) which must be estimated prior to drilling of any exploitation well. When preexisting wells are available either from previous projects or exploration campaigns, productivity can be measured directly from well testing. Unfortunately, preexisting wells in targeted fault zone are absent in most cases. In this case, productivity and hydraulic behavior of the reservoir can be investigated through numerical simulations based on conceptual models of fault zone. Numerical simulations require to integrate hydraulic properties which, in most cases, are set following expertise on similar contexts, or tested through sensitivity analyses. Since fault zones architecture and related permeability structures form primary controls on fluid flow, the hydraulic properties depend on numerous geological factors such as, e.g., structure, lithology, and tectonics [1, 2].

In this context and in the framework of the REFLET project (ANR Géodénergies), we are working on an approach to build conceptual model of fault zone reservoir (generic models) prior to drilling to:

- To focus field data acquisition on relevant data
- Build conceptual and associated numerical models for each considered site in view of the field development
- Build numerical models in view of potential improvement
- Optimize the open hole well trajectory

In the study presented here, the primary focus is to quantify the role of the fault zone architecture (fracture networks) on geothermal reservoirs operations. Based on the elements of the methodology to conceptualize fault zones, we propose a numerical investigation on different fault zone architectures in order to assess the impact of some major geological factors such as, e.g., formation context (normal, strike-slip) or fault zone offset magnitude (fracture density, damage zone width) on the hydraulic behavior of the fault zone reservoir. In the first step of the numerical simulations, the fault zone geometry creation must be guided by the geological features governing the preferential direction of the fractures, and hence the preferential fluid circulations. The obtained geometry is a Discrete Fracture Network depicting the internal fault zone architecture. Flow simulations are then carried out through the DFN, and include well-nodes to simulate production tests. In the last step of the study, the extent of the production impact zone within the fault zone can be analyzed in terms of radius and shape-factor. Results from different architectures are compared to estimate the impact of the fault zone architecture on the production test.

References

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