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New wells architectures to access deep geothermal reservoirs and increase well productivity

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The “WELLCOME” (WELL COMpletion Evaluation on productivity and injectivity) project is part of an effort to promote the development of deep geothermal resources not or little exploited today because of poor and/or uncertain permeability. The main objective of this project is to evaluate the impact of geothermal wells (injector and producer) architecture on the initial productivity and injectivity of the reservoir. This project has emerged in order to give operators quantitative elements to assess the economic feasibility of the geothermal exploitation of deeper and less permeable or less continuous aquifers than the famous Dogger aquifer of the Paris basin (e.g.: Trias) with alternative well architectures compared to the classical slightly deviated wells of the geothermal doublets. The main idea of all these innovative architectures is to increase the reservoir-to-well exposure surface in order to maximize and optimize the wells productivity and injectivity. Consequently, the main challenge is to ensure economic profitability of the project with the higher costs of well drilling and completion.

Our first step in tackling the problem, was to consider detailed thermo-hydrodynamic modelling cases in the vicinity of the wells using homogeneous blocks or heterogeneous blocks for simulating the distribution of initial permeability in the reservoir (e.g. disconnected fluvial channels, layered reservoirs with vertical discontinuous bodies). The wells were simulated by 1D elements fully coupled to the 3D block. Different well designs already used in oil or gas production practises were considered (e.g. horizontal wells, multilateral wells). The objective of this first step is to exclude solutions with poor hydraulic performances.

We have developed an integrated wellbore-reservoir flow model using COMSOL Multiphysics software. The Darcian flow in the reservoir is coupled with the wellbore flow which is modelled by a 1D momentum equation describing the conservation of the fluid displacement. We also developed a 1D energy conservation equation describing the temperature evolution in the wellbore fluid coupled to the heat transfer in the reservoir. We apply this coupled wellbore and reservoir models to different well architectures (vertical wells, slightly deviated wells, highly deviated to horizontal wells) and we calculate the corresponding productivity and injectivity of each well (injector and producer) and the doublet lifetime due to the emergence of the cold front arrival at the production well. Those simulations are applied to different reservoir permeability distribution (horizontally or vertically continuous or discontinuous) which can be found in deep geothermal reservoirs in the Paris basin (e.g. Dogger, Trias). For each modelling case we compare the results (doublet performance, doublet lifetime) to a conventional geothermal doublet design in the Dogger aquifer.

Evaluation of the economic aspects of the well drilling and design are primordial for accessing the economic profitability of a geothermal operation. Consequently, our second step will be dedicated to the economic assessment of solutions with the best benefits in terms of reservoir productivity and thermal lifetime of the operation.

Our hope is that this work will be a contribution to promote the use of new well architectures for geothermal exploitation of deep sedimentary resources and will provide operators with incentive quantitative elements to evaluate and minimize the risk of targeting and developing the exploitation of unexploited or poorly known reservoirs such as the Trias formation of the Paris basin.