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Modelling of Bouillante geothermal field (Guadeloupe, French West Indies)

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The French islands of West Indies are experiencing rapid population growth. There is a consequent rise in energy demand with a high dependence on oil. In this context, and given their volcanic origin, the development of geothermal high energy in these islands is economically and environmentally interesting. Since the commissioning of the second production unit of the plant of Bouillante in 2005, geothermal energy provides 6 to 8% of electricity consumption energy of the Guadeloupe island. Yet, the geothermal fluid withdrawal was tripled which induced an increase in the quantity of separated brines which are cooled and mixed with sea water before disposal to the sea. It also caused a change in the Bouillante reservoir behavior and well head pressures evolution with a quick and steady pressure drop. Consequently, to optimize the exploitation of the geothermal resource, there was need to better characterize the reservoir, predict pressures evolution and plan reinjection of the separated brines. With this aim in view, available data were gathered to build a geological model integrating both regional and reservoir scale data. In parallel, a 3D hydrodynamic model using the computer code TOUGH 2 is developed to study and predict the behavior of pressure and temperature of Bouillante geothermal field during its exploitation and evaluate the contribution of reinjection to exploitation strategy. Both models should ultimately be linked.

The hydrodynamic model is centered on neighboring wells BO-4, BO-5 and BO-6 which are the three producing wells at the moment. The old producing well BO-2 is now used to monitor pressure evolutions at the top of the reservoir. As a first step, model parameters were fitted to reproduce the pressure interference between the three wells recorded between July 2002 and April 2003 when well BO-5 was the only producing well.

The model reproduces the hydrodynamic properties of the reservoir via the MINC method (Multiple INteracting Continua). (Pruess, 1992) which generalizes the “dual porosity” model (Warren and Root, 1963). The reservoir is conceptually decomposed into a "fracture" medium and a "matrix" one, each characterized by specific properties such as porosity, permeability and pore compressibility. Both media communicate with the possibility for the flow of matter or heat between fracture and matrix and between different fractures, possibly taking also into account the flow between matrix elements (“dual permeability”).

Simulations were fitted to data both manually and automatically. Manual fit of parameters allowed the physical understanding of the influence of each parameter on the pressure curves. Yet, given the multitude of parameters and the large number of simulations to run, we also performed an automatic fit using optimization algorithms from the scipy optimization module. The resulting curves satisfactorily reproduce the measurement curves, especially the rapid pressure transients characterizing fractured media.

The next step is to couple the hydrodynamic model to the 3D geological model incorporating information on the geothermal reservoir in terms of fracturation and the correlated distribution of petrophysical parameters…