Development of a fast geothermal simulation tool designed to the Lower Carboniferous reservoir of Hainaut in the framework of the BRAIN-Be 2.0 DESIGNATE project

Nicolas DUPONT 1*, Olivier KAUFMANN 1

1 Geology & Applied Geology Department, Faculty of Engineering, University of Mons, Belgium

The DESIGNATE project (Decision Support under Uncertainty for Geothermal Applications) investigates geothermal applications for direct heat use from deep geological reservoirs and abandoned mines. The core of the project is the development of a geothermal techno-economic simulator. This simulator is designed to serve as a decision-making-tool for the implementation of new geothermal projects in Belgium, taking into account the existing uncertainties both on the technical-economic parameters and on the considered geothermal reservoirs.

In Wallonia, the main deep geothermal reservoir is in the Lower Carboniferous rocks. In Hainaut, it has been recognized mainly by a few boreholes and by seismic surveys. In the area targeted for geothermal projects, the carbonate reservoir is more than 2 km thick, dipping southwards, and containing at least one high-transmissivity level linked to interstratal karstification of anhydrite. Where the anhydrite has been entirely dissolved, brecciated layers are observed.

To model the reservoir, a synthetic hydrogeologic model was built. Some features of the reservoir are set as parameters that may vary depending on the simulations to mimic geological uncertainties concerning the depth of the top of the reservoir, its thickness and permeability as well as the local geothermal gradient. The range of these parameters is based on the current knowledge of the reservoir.

While analytic modelling can be a fast way to simulate geothermal scenarios, this type of method is only suitable for very simple reservoir geometries. For more complex settings, numerical flow and heat modelling is necessary but requires a much longer resolution time.

Since the simulator relies on the exploration of a large number of cases to simulate, computing time was a critical issue. To allow for reasonable runtimes of the simulator, our strategy was (1) to precompute a set of hydrogeological simulations exploring the range of parameters describing the reservoir and a range of pumping rates kept constant over the simulation and store the results in a look-up table, (2) to build an interpolator function based on the look-up table, and (3) to combine the results of interpolations to approximate the evolutions when pumping rates vary over time.

Reservoir modelling and simulations have been carried out in ModFlow6 using the FloPy python package. Due to the range of parameters to be explored (including the required geothermal flowrate), more than 50,000 simulations have been performed. While the simulations have been conducted at constant flowrates, the techno-economic simulator needs to test scenarios with varying flowrates. To obtain an approximate response when flowrates are susceptible to change from one year to another, we divide the simulation timespan into periods of constant flowrates. For each period, we use the interpolator to identify how many years would have be needed to extract the total energy produced until the beginning of this period given the production history but considering a geothermal production with the flowrate of the

current period. The subsequent evolution during this period is then approximated by time series returned by the interpolation function but shifted in time by the number of years determined before.