An approach based on a groundwater flow model and a geomechanical model for estimating thermal anomalies locations

T. Guillon, BRGM
A. Armandine Les Landes, BRGM
M. Peter-Borie, BRGM
S. Gentier, BRGM
X. Rachez, BRGM
A. Blaisonneau, BRGM

Key words
Geothermal exploration, Groundwater flow, Geomechanics, Discrete Fracture Network

Abstract
Geothermal power generation is one of the technologies considered for contributing to the energy mix. To provide enough energy, geothermal production must target deep thermal anomalies that, in addition, must remain below reasonable depths to guarantee the economic viability of the geothermal project. In some geological contexts such as, e.g., faulted basements under sedimentary covers, thermal information at depth is lacking and little to no surface manifestations exist which compromises the potential to locate thermal anomalies. In this context, we propose an approach to help locating thermal anomalies based on a groundwater flow model and a geomechanical model. Groundwater flows are studied since they are mostly responsible for the thermal anomalies at depth [1]. Geomechanics has a less straightforward yet non-negligible impact on the setup of thermal anomalies, since stresses affect the groundwater flows either directly (effect on hydraulic heads) or indirectly (modification of flow network by, e.g., opening/closing fault zones or fracturing the medium). The first step of the approach is a thorough structural interpretation of the available geological data in order to build a conceptual model for the faulted context (Discrete Fracture Network). The DFN is then used for creating the geometry common to both models (see Figure 1). In the next step, the two models are run independently, and are interpreted in terms of "favorable areas" for the thermal anomalies. The delineation of "favorable areas" must be driven by criteria specific to each physics and related to features of the thermal anomalies. Finally, the areas from each models can be compared to deduce the "most favorable areas".

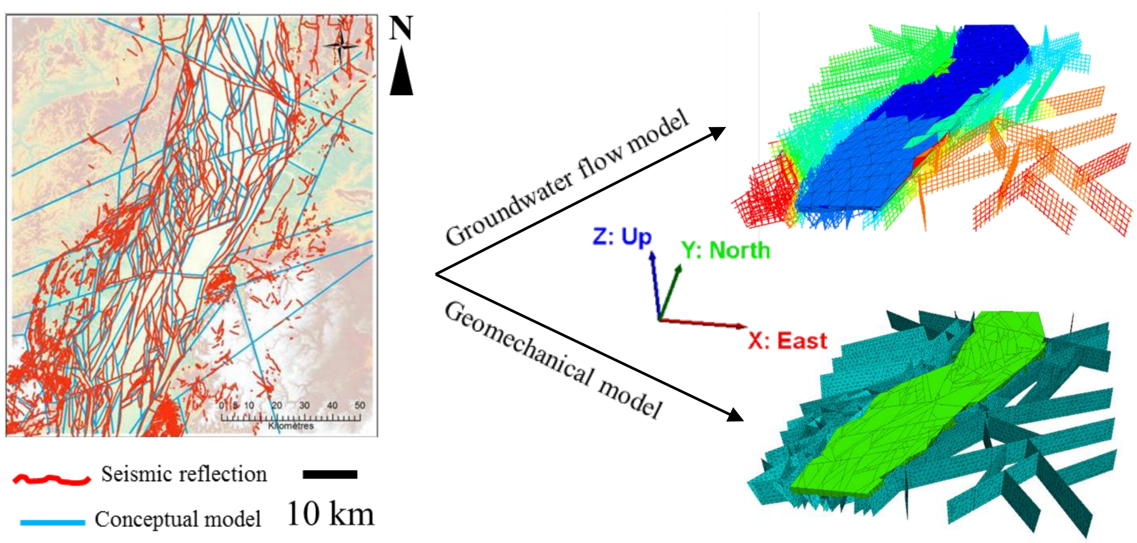

Figure 1: From a structural-based Discrete Fracture Network (left) to geometries (right). Basement is not considered in the groundwater flow model (impermeable) and not represented for the mechanical model for plotting purposes.

The approach is illustrated with a case-study located in the Upper Rhine Graben (URG). The conceptual model is built at a regional scale (i.e., 130x150 km^2) according to structural arguments [2] and interpretations of seismic lines [3]. The physical models are then presented, including how physical parameters are guided by geological information whenever possible. The selection criteria are also defined: for the groundwater flow model, “favorable areas” are depicted by major discharge areas (link with principal vertical upflows) for long-distance and deep-reaching flow paths (link with regional-size fluid circulations); for the geomechanical model, less compressed areas favor the upflows and are interpreted as the “favorable areas”. The final “most favorable areas” are given by the cross-analysis of the results from both models and correlate reasonably well with in situ information. A complementary study is proposed, where a groundwater flow and a geomechanical model are built for one of the “most favorable areas”. At this smaller scale where coupling effects are expected to play a greater role, we investigate the impact of explicitly accounting for the geomechanical results in the groundwater flow model.

Acknowledgments

The research leading to these results has received funding from the EC Seventh Framework Programme under grant agreement No. 608553 (Project IMAGE).

References

[1] J. Tóth. Geothermal phenomena in the context of gravity-driven basinal flow of groundwater. Cent. Eur. Geol., **58**, 1-27, (2015).

[2] J.B. Edel, H. Whitechurch and M. Diraison. Seismicity wedge beneath the Upper Rhine Graben due to backwards Alpine push?. *Tectonophysics*, **428**, 49-64, (2006).

[3] GeORG team: Geopotentials of the deep Upper Rhine Graben. Interreg Project GeORG scientific and technical report, online PDF (http://www.geopotenziale.eu), 1-4, (2013).