Postdoctoral position on advanced thermal well modelling for high performance simulation of geothermal systems

in collaboration between
Université Cote d'Azur, CNRS, LJAD, Inria,
Storengy
BRGM

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Geothermal energy is a carbon-free steady energy source with low environmental impact. In countries with a favorable geological context, high temperature geothermal energy can make a significant contribution to power production. On the French territory, it is already an attractive option in volcanic islands context compared to importing fossil fuel. Today, about 5 percents of yearly electricity consumption of Guadeloupe already comes from geothermal energy and it is essential for achieving energetic and environmental targets, according to which the overseas territories should produce 50 percents of their electricity consumption from renewable resources by 2020 and achieve their energy autonomy in 2030. As for other parts of the world, the geothermal development potential of the Caribbean islands is high and several industrial projects are in preparation or already underway, in French overseas territories (Guadeloupe, Martinique) as well as in nearby islands (Dominica, Montserrat).

Numerical modeling has become essential in all phases of geothermal operations. It is used in the exploration phases to assess the geothermal potential, validate conceptual hypothesis and help well siting. Field development and resource management need quantitative estimation to prevent resource exhaustion and achieve its sustainable exploitation (production/injection scenarios). Finally numerical modeling is also helpful in studying exploitation related industrial risks such as the interaction with shallow water levels (drinking water resources, hydrothermal vents or eruption).

The code ComPASS `http://www.anr-charms.org/page/compass-code` is an open source parallel code initiated by LJAD-Inria and BRGM (Bureau de Recherches Géologiques et Minières

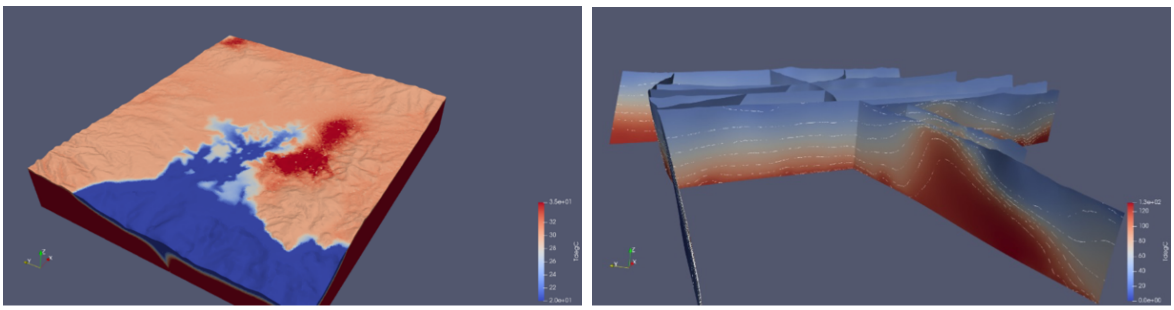

Figure 1: Simulation of the Baie du Lamentin hydrothermal system using ComPASS (Y. Labeau, Ph.D Thesis, 2018).

- French Geological Survey) in 2015 [1, 2, 3]. It is devoted to the simulation of multiphase non-isothermal Darcy flows and includes complex network of fractures/faults represented as interfaces of co-dimension one coupled to the surrounding matrix. The discretization is based on vertex and cell unknowns and is adapted to polyhedral meshes and heterogeneous media. The ComPASS code is co-developed since 2017 by the partners of the ANR CHARMS project including BGRM, LJAD-Inria, Storengy, la Maison de la Simulation and the Jacques Louis Lions laboratory. The main objective of the CHARMS project is to develop a new generation flow simulation tool for geothermal systems focusing on fluids and accounting for complex fault networks and wells.

The objective of this postdoctoral project is to focus on advanced well modelling which plays a key role in geothermal studies both to monitor the hot fluid production and cold water injection, and to assimilate available well data measurements. At the reservoir kilometer scale, the mesh cannot resolve the well boundary with a radius of say 10 cm. It results that the well will be modelled as a 1D trajectory. Considering our nodal spatial discretization, it will be convenient and efficient to represent the 1D well trajectory as a subset of edges of the mesh, allowing to account easily for slanted or multibranch wells (see Figure 2).

The thermal well model is typically based either on a Drift Flux Model (DFM) [4] or on a No Pressure Wave (NPW) model [5] both accounting for the mass, momentum and energy conservations along the well. This type of models must take into account the liquid and gas phases, the thermodynamical equilibrium between phases, phase compressibility, buoyancy forces, wall friction, and slip between phases. Compared with the DFM model, the NPW model considers a simplified version of the momemtum equation by ignoring the pressure waves and will be prefered in this project. Its discretization in space will be based on a staggered finite volume scheme discretizing typically the pressure, temperature, volume fractions and molar fractions unknowns at the nodes of the well while the liquid and gas velocities are discretized at the edges of the well. The well model will be considered stationary at the reservoir time scale. It will be coupled to the reservoir model using a fully implicit time integration combined with two point Fourier and Darcy fluxes taking into account the radial flow geometry. One of the major numerical difficulties to be addressed is the need for efficient and robust nonlinear and linear solvers in order to be able to use time steps that are consistent with the reservoir evolution time scale.

Profile: applicants should have a PhD in scientific computing/applied mathematics and be familiar with scientific programming (Fortran and/or C++, Python, MPI), numerical methods for PDEs and collaborative development tools.

Supervision and location: the postdoctoral position will be held in the J.A. Dieudonné department of Mathematics (LJAD) at the University Nice Sophia Antipolis (UNS) in collaboration with Roland Masson, Konstantin Brenner from Inria/LJAD, Simon Lopez and Farid Smai from BRGM, and Laurent Jeannin and Marc Perreaux from Storengy. The postdoc will be member of both LJAD and of the INRIA team Coffee (Complex Flows For Environment and Energy, `http://www.inria.fr/equipes/coffee`).

Duration and starting date: the position is for two years and should start before the end of 2019.

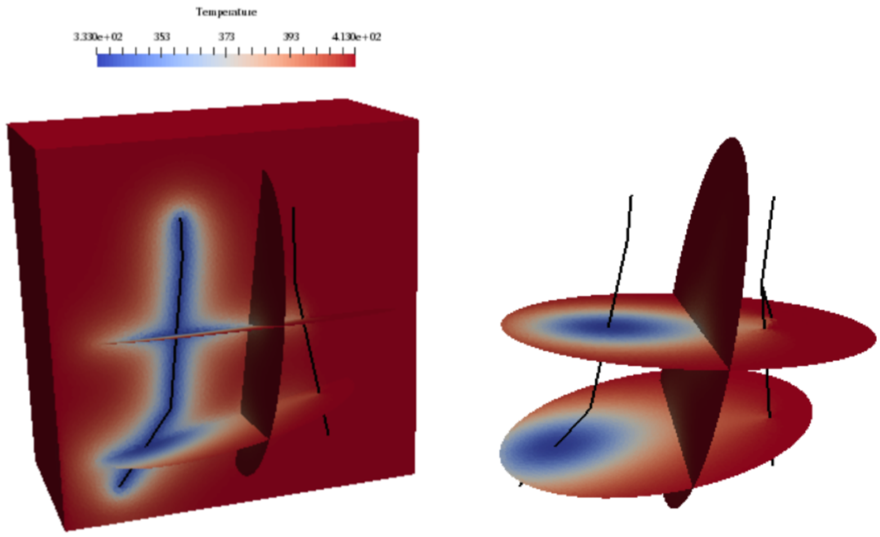

Figure 2: Example of injection and production wells and temperature field in a faulted geothermal reservoir.

Salary: About 2600 Euros net/month

How to apply: send applications with CV, letter of motivation, and references, to roland.masson@unice.fr, laurent.jeannin@storengy.com, s.lopez@brgm.fr, marc.perreaux@storengy.com

Key words: scientific computing, finite volume schemes, thermal well models, non-isothermal liquid gas Darcy flows, geothermal systems.

References

[1] F. Xing, R. Masson, S. Lopez, Parallel numerical modeling of hybrid-dimensional compositional non-isothermal Darcy flows in fractured porous media, Journal of Computational Physics, 345, pp. 637-664, 2017, `https://hal.archives-ouvertes.fr/hal-01420361`

[2] L. Beaude, T. Beltzung, K. Brenner, S. Lopez, R. Masson, F. Smai, J.F. Thebault, F. Xing, Parallel geothermal numerical model with faults and multibranch wells, ESAIM Proceedings, june 2018. `https://hal-brgm.archives-ouvertes.fr/hal-01472944`

[3] S. Lopez, R. Masson, F. Xing, L. Beaude, N. Birgle, F. Smai, K. Brenner, M. Kern, G. Courrioux, S. Caritg, Y. Labeau, Geothermal Modeling in Complex Geological Systems with the ComPASS Code. Stanford Geothermal workshop, February 12sd-14th 2018.

[4] J.M. Masella, Q.H. Tran, D. Ferre, C. Pauchon, Transient simulation of two-phase flows in pipes, International Journal of Multiphase Flow, 24, pp. 739-755, 1998.

[5] Q.H. Tran, I. Faille, C. Pauchon, F. Willien. The No Pressure Wave (NPW) model: application to oil and gas transport, Finite volumes for complex applications III : Third International Symposium on Finite Volumes for Complex Applications, June, 24 - 28, 2002 - Porquerolles, France.