Geophysical Research Abstracts
Vol. 19, EGU2017-4649, 2017
EGU General Assembly 2017

Large-scale thermal convection of viscous fluids in a faulted system: 3D test case for numerical codes

Fabien Magri (1,2), Mauro Cacace (3), Thomas Fischer (1), Olaf Kolditz (1), Wenqing Wang (1), and Norihiro Watanabe (1)

(1) Helmholtz Centre for Environmental Research - UFZ, ENVIF, Department of Environmental Informatics, Leipzig, Germany (fabien.magri@ufz.de), (2) Freie Universität Berlin, Hydrogeology, Malteserstr 74-100, 12249 Berlin, Germany, (3) GFZ – German Research Centre for Geosciences, Section 6.1 Basin Modelling, Telegrafenberg 14473 Postdam, Germany

In contrast to simple homogeneous 1D and 2D systems, no appropriate analytical solutions exist to test onset of thermal convection against numerical models of complex 3D systems that account for variable fluid density and viscosity as well as permeability heterogeneity (e.g. presence of faults).
Owing to the importance of thermal convection for the transport of energy and minerals, the development of a benchmark test for density/viscosity driven flow is crucial to ensure that the applied numerical models accurately simulate the physical processes at hands. The presented study proposes a 3D test case for the simulation of thermal convection in a faulted system that accounts for temperature dependent fluid density and viscosity. The linear stability analysis recently developed by Malkovsky and Magri (2016) is used to estimate the critical Rayleigh number above which thermal convection of viscous fluids is triggered.
The numerical simulations are carried out using the finite element technique. OpenGeoSys (Kolditz et al., 2012) and Moose (Gaston et al., 2009) results are compared to those obtained using the commercial software FEFLOW (Diersch, 2014) to test the ability of widely applied codes in matching both the critical Rayleigh number and the dynamical features of convective processes. The methodology and Rayleigh expressions given in this study can be applied to any numerical model that deals with 3D geothermal processes in faulted basins as by example the Tiberas Basin (Magri et al., 2016).

References

Kolditz, O., Bauer, S., Bilke, L., Böttcher, N., Delfs, J. O., Fischer, T., U. J. Görke, T. Kalbacher, G. Kosakowski, McDermott, C. I., Park, C. H., Radu, F., Rink, K., Shao, H., Shao, H.B., Sun, F., Sun, Y., Sun, A., Singh, K., Taron, J., Walther, M., Wang,W., Watanabe, N., Wu, Y., Xie, M., Xu, W., Zehner, B., 2012. OpenGeoSys: an open-source initiative for numerical simulation of thermo-hydro-mechanical/chemical (THM/C) processes in porous media. Environmental Earth Sciences, 67(2), 589-599.

Diersch, H. J, 2014. FEFLOW Finite Element Modeling of Flow, Mass and Heat Transport in Porous and Fractured Media, Springer-Verlag Berlin Heidelberg, ISBN 978-3-642-38738-8.
Gaston D., Newman C., Hansen G., Lebrun-Grandie D, 2009. MOOSE: A parallel solution framework for coupled systems of nonlinear equations. Nucl. Engrg. Design, 239, 1,768-1778

Magri, F., Möller, S., Inbar, N., Möller, P., Raggad, M., Rödiger, T., Rosenthal, E., Siebert, C., 2016. 2D and 3D coexisting modes of thermal convection in fractured hydrothermal systems - Implications for transboundary flow in the Lower Yarmouk Gorge. Marine and Petroleum Geology 78, 750-758, DOI: /10.1016/j.marpetgeo.2016.10.002

Malkovsky, V. I., Magri, F., 2016. Thermal convection of temperature-dependent viscous fluids within three-dimensional faulted geothermal systems: estimation from linear and numerical analyses, Water Resour. Res., 52, 2855–2867, DOI:10.1002/2015WR018001.