DRG Final Meeting

December 14, 2017

Numerical Modelling of Volcanic Geothermal Systems

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Scope of DRG Part 2

To aid in the advancement of the methods that can be applied in the modelling of the physical processes occurring in the roots of volcanic geothermal systems, with the purpose of

- illuminating the overall process controlling the upwards heat transfer from the heat sources
- as well as improve and advance the methods that are applied in conventional geothermal reservoir modelling; consequently used for geothermal resource management

The heat transfer from the roots up to shallower levels is a complicated process involving flow of magma, flow of fluids (two-phase, superheated steam and/or supercritical water), heat transfer as well as thermo-elastic rock mechanics and chemical processes

Schematic figure of a high-temperature geothermal system with ”deep roots”

Part 2.1 of DRG

- Mainly assigned to two geothermal reservoir modelling specialists at Iceland GeoSurvey (ÍSOR) and Vatnaskil Consulting Engineers
- Devoted to training and application of the Hydrotherm and CSMP++ reservoir modelling software, both academic software applicable to volcanic geothermal systems
- Cooperation with the COTHERM project, guided by Dr. Thomas Driesner at ETH in Zurich, Switzerland
- Later application of iTOUGH2 (industry-standard software) with improvements developed under part 2.2
- Modelling of both theoretical examples and case studies based on Krafla and IDDP-1

Part 2.2 of DRG

- Assigned to a postdoctoral scholar based in the USA, Dr. Lilja Magnúsdóttir
- Devoted to the upgrading of industry standard reservoir modelling software intended for detailed well-by-well analysis, which Hydrotherm and CSMP++ are not, for the modelling of the extreme physical conditions deep in volcano-geothermal systems
- After initial screening of available software the TOUGH2/iTOUGH2 package was chosen for further development
- Included most significantly the development of a new supercritical equation-of-state module EOS1sc for TOUGH2/iTOUGH2
- Done in cooperation with LBL in Berkeley, California

Main achievements

- Comprehensive training in the use of Hydrotherm and CSMP++
- These software applied to various hypothetical models (case studies), relevant for increased understanding of geothermal activity around intrusions, including IDDP-1 case study
- Neither Hydrotherm nor CSMP++ appear suitable for industry-style modelling, but are valuable for more academic modelling
- New EOS for TOUGH2/iTOUGH2 (EOS1sc) developed within the project; extremely valuable, extends applicability of software to much higher p+T and greater depth
- Temperature dependent rock permeability (brittle-ductile transition) has been incorporated in TOUGH2/iTOUGH2, yet outside the GEORG project; makes the software even more versatile and makes it resemble Hydrotherm and CSMP++ in deep-root applicability
- TOUGH2/iTOUGH2 with new capabilities applied to further theoretical case-studies (intrusions of various shapes and sizes)
- TOUGH2/iTOUGH2 with new capabilities applied Krafla related case studies, including studies of IDDP-1
- TOUGH2/iTOUGH2 with new capabilities applied to random dike-injection (heat sources) model
- Modification of existing Hengill numerical model performed in preparation of applying new capabilities of TOUGH2/iTOUGH2
- Industry will greatly benefit from both increased understanding and improved modelling tools

Publications

Magnúsdóttir, L., and S. Finsterle, 2015: An iTOUGH2 equation-of-state module for modeling supercritical conditions in geothermal reservoirs, Geothermics, 57, 8–17.

Magnúsdóttir, L., and S. Finsterle, 2015: Simulating Supercritical Water in Magmatic Geothermal Reservoirs, PROCEEDINGS, TOUGH Symposium 2015, Lawrence Berkeley National Laboratory, Berkeley, California.

Magnúsdóttir, L., 2014: Modeling the Deep Roots of Geothermal Systems, PROCEEDINGS, Thirty-Ninth Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, California, 11 pp.

Magnúsdóttir, L., and S. Finsterle, 2015: Extending the Applicability of the iTOUGH2 Simulator to Supercritical Conditions, PROCEEDINGS, World Geothermal Congress 2015, Melbourne, Australia, 8 pp.

Gunnarsson, G. and E.S.P. Aradóttir, 2015: The Deep roots of geothermal systems in volcanic areas: Boundary conditions and heat sources in reservoir modelling. Transport in Porous Media, 108:43–59.

Planned at Stanford 2018:

Magnúsdóttir, L., and M.Th. Jonsson, 2018: Increased reliability of supercritical EOS1sc module in iTOUGH2.

Thorgilsson, G., Axelsson, G., Berthet, J.C.C., Magnusdottir, L., Árnason, K., Gunnarsson, G., and Júlíusson, E., 2018: Modelling of the Deep Roots of Volcanic Geothermal Systems.

In addition Part 2 of the DRG project has been introduced/presented at different functions worldwide as well as in Iceland