2016 Working Group 12 Report – Deep Roots of Volcanic Systems

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1. Introduction

The transfer of heat from the deep roots of volcanic geothermal systems to shallow depths is complicated. It involves the flow of magma, flow of single-phase, two-phase or supercritical fluids, heat transfer, chemical (water-rock) reactions with gases and brines, and so on. Such processes cannot be simulated with conventional geothermal modelling tools. Developing a strategy for energy utilisation from deep roots therefore requires improved modelling methods, innovation of measurement tools, and better understanding of high temperature water-rock-gas interaction. Advances will be accelerated by collaborative research, close cooperation, and coordination of international research groups. Many of these activities are represented by IEA Geothermal participants.

Working Group 12 strategies to address these challenges are as follows:

Task A: Compilation of conceptual models of the roots of volcanic geothermal systems and associated research methods, using open-source information from participating countries to provide background material for deep-roots research, including information on exploration and modelling methods and tools.

Task B: Advancement of methods for deep geothermal exploration to disseminate information on advances in exploration methods, facilitate cooperation amongst research-groups, and enhance the depth resolution of available methods by using the power of joint interpretation of data-sets.

Task C: Methods for modelling conditions and processes in deep geothermal resources, by advancement of methods applied in the modelling of physical processes, revealing the overall process of upwards heat transfer, improving geothermal reservoir modelling, and enhancing synergy by avoiding duplication of effort and improved sharing of open-source software.

2. Progress in 2016

Although specific task leaders have not been assigned to each of these objectives, all activities to date have been jointly coordinated by the Working Group leader, Gudni Axelsson (Iceland), and the deputy leader Chris Bromley (New Zealand). Participation from other country representatives (especially Japan, USA, Switzerland and Italy) has also been enthusiastic.

Significant progress was made during 2016 by WG12 participants who organised and contributed to four sessions and workshop events held in Iceland, Mexico, Japan and Germany (see section 6.1, General presentations). Participants described and discussed their newly-established deep-roots and super-critical-fluid research programmes. In addition, researchers from participating countries attended, published and presented their preliminary results at the following international geothermal conferences and workshops: European Geothermal Congress (September 2016, Strasbourg, France), New Zealand Geothermal Workshop (November, 2016, Auckland, New Zealand), and Geothermal Resources Council Meeting (October, 2016, Sacramento, USA).

3. Outputs

Presentations on Deep Roots research work were made at workshops organised by IEA Geothermal in Cuernavaca, Mexico, and Munich, Germany. They are available through the www.IEA-GIA.org website and are listed in section 6.1 (General presentations). Another presentation on a similar 'Deep Roots' theme was made at a collaborative event held in Tokyo, Japan.

The topics addressed by researchers in papers published and presented at major international conferences include: high temperature (450 °C) tool development, super-critical reservoir simulators, super-critical fluid-rock interaction from laboratory experiments, and the effects of cold water injection into super-heated reservoirs. These references are listed in section 6 under sub-headings labelled: 6.2 Deep Roots and Deep EGS projects, 6.3 Supercritical tools/modelling, and 6.4 Supercritical water-rock interaction.

Conference publications can be accessed through searching the conference paper database at: https://www.geothermal-energy.org/publications_and_services/conference_paper_database.html

4. Highlights

Key highlights for WG12 in 2016 are listed below:

- Cooperation has been strengthened between WG12 participants and a working group from the IPGT who are developing modelling software capable of simulating super-critical reservoir conditions, and also with the GEORG (Iceland) supported DRG (Deep Roots of Geothermal resources) project, the EU supported IMAGE and DeepEGS projects, the Swiss supported COTHERM project, the EU/Italian supported DESCRAMBLE project, a Japanese supported project on super-critical resources and the New Zealand supported 'Supermodels' and 'supercritical water-rock interaction' projects.
- Presentations at four sessions and workshop events were held during the year in Iceland, Mexico, Japan and Germany. Participants discussed their newly-established deep-roots and super-critical-fluid research programmes.
- Nine publications on novel technologies to deal with supercritical fluid resources, including reservoir simulators and fluid-rock-chemical reactions, were published and presented at three major geothermal conferences.

5. Future Activities

Future plans are to build further on the achievements to date, by communicating and sharing research results amongst participating countries and organisations, thereby reducing duplication of effort and eventually accelerating deployment opportunities for supercritical (deep roots) geothermal resource utilisation. Future plans also include plans to organize an IEA Geothermal workshop on supercritical (deep roots) research and development.

6. References

6.1 General presentations

GEORG 18-19 February 2016 'Deep Roots' meeting held in Reykjavik, Iceland, with presentations on the following topics from Icelandic presenters: DEEPEGS, IMAGE, GEOWELL, FUTUREVOLC,

IDDP, KMDP, Krafla Magma, supercritical modelling iTOUGH2, corrosion, casing design, geophysics, seismicity, fluid-rock interaction, deformation; from Switzerland (COTHERM); from New Zealand (geophysics, modelling); and from Italy (DESCRAMBLE). Presentations can be downloaded from www.georg.hi.is/node/255, http://georg.hi.is/frettir/deep_roots_geothermal_conference_2016_summary

Axelsson, G. and Bromley C.J. (2016) 'Deep Roots of Geothermal Systems- Understanding and Utilizing' presentation at Central and South American Workshop on Geothermal Energy Cuernavaca, Mexico, 21st April 2016 , in session titled 'New and Innovative Projects' (iea-gia.org website).

Bromley, C.J., and Kissling, W. (2016) 'Deep geothermal system exploration in Taupo Volcanic Zone, New Zealand – A new technical approach for assessing supercritical geothermal resource potential' invited presentation at JOGMEC-GNS International Geothermal Collaboration Workshop in Tokyo, 2nd June 2016, https://www.youtube.com/watch?v=Gq8CfVDwTAk&list=PLBIv78_IaSREjx-85p-_qMOpTk-iv6O2H&index=8

Bromley, C.J., (2016), 'Exploration of Deep Roots of Geothermal Systems in New Zealand-Assessing the Super-Critical Resource Potential', presentation on deep roots research at IEA-Geothermal Munich Molasse Meeting, 15 September, 2016, Munich, Germany. (www.iea-gia.org)

Bromley, C.J. and Axelsson, G., (2016) Opportunities For Innovation & Collaboration in Working Group (Annex) 12: Deep Roots, Presentation of Working Group 12 activities, at IEA-Geothermal ExCo meeting, Munich, 13 September, 2016.

6.2 Deep Roots and Deep EGS projects

Ingólfsson, H P; Árnason, K; Axelsson, G; Franzson, H; Hreinsdóttir, S; Jónsson, M T; Sævarsdóttir, G A; Gunnarsson, G; Júlíusson, E; Podgorney, R P; Sigmundsson, F; Gardarsson, S M, (2016) Deep Roots of Geothermal Systems - a GEORG Collaborative Project, Proc. European Geothermal Congress 2016, S-O-93.

Fridleifsson, G O; Bogason, S G; Stoklosa, A W; Ingolfsson, H P; Vergnes, P; Thorbjörnsson, I Ö; Peter-Borie, M; Kohl, T; Edelmann, T; Bertani, R; Sæther, S; Palsson, B., (2016) Deployment of Deep Enhanced Geothermal Systems for Sustainable Energy Business, Proc. European Geothermal Congress 2016, T-PO-87.

6.3 Supercritical tools/modelling

Stamnes, Ø; Røed, M H; Hjelstuen, M; Kolberg, S; Knudsen, S; Vedum, J; Halladay, N., (2016) Development of a Novel Logging Tool for 450°C Geothermal Wells, Proc. European Geothermal Congress 2016, T-O-295.

O' Sullivan, John, (2016), Improvements to the AUTOUGH2 Supercritical Simulator with Extension to the Air-Water Equation of State, Geothermal Resources Council Transactions, (2016), v.40, Geothermal Resources Council, Davis, California. GRC ID #1032412.

Croucher, M.J. O`Sullivan, J. O`Sullivan1, J. Pogacnik, A. Yeh, J. Burnell, W. Kissling (2016) Geothermal Supermodels Project: an Update on Flow Simulator Development, Proc. 38th New Zealand Geothermal Workshop, University of Auckland, Paper 103.

6.4 Supercritical water-rock interaction

Mountain, B.W., I. Chambefort, L. Sajkowski (2016) Progressive Devolitization of Greywacke from Sub-Critical to Supercritical Conditions, Proc. 38th New Zealand Geothermal Workshop, University of Auckland, Paper 64.

Passarella, M., B.W. Mountain, T.M. Seward (2016) Basalt-Fluid Interaction at Supercritical Conditions (400˚C, 500 bar): an Experimental Approach, Proc. 38th New Zealand Geothermal Workshop, University of Auckland, Paper 151.

Okabe, T., M. Kato, T. Sato, Y. Abe, H. Asanuma (2016) Current Status of the EGS Project for Water Injection in the Superheated Region at Okuaizu Geothermal Field in Japan, Proc. 38th New Zealand Geothermal Workshop, University of Auckland, Paper 67.

Tsuchiya, Noriyoshi, Ryoichi Yamada, Masaoki Uno (2016) Supercritical geothermal reservoir revealed by a granite–porphyry system, Geothermics, Volume 63, September 2016, Pages 182-194, ISSN 0375-6505, http://doi.org/10.1016/j.geothermics.2015.12.011.

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