ground water

Readers' Forum/

Challenges for Numerical Modeling of Enhanced Geothermal Systems

by J.P. Fairley[1], S.E. Ingebritsen[2], and R.K. Podgorney[3]

[1]Corresponding author: Department of Geological Sciences, University of Idaho, Moscow, ID 83844-3022; (208) 885-9259; fax: (208) 885-5724; jfairley@ uidaho.edu
[2]United States Geological Survey, MS 439, 345 Middlefield Road, Menlo Park, CA 94025.
[3]Idaho National Laboratory, P.O. Box 1625, Idaho Falls, ID 83415.

A recent guest editorial by Wood (2009) pointed out the potential of enhanced geothermal systems (EGS) as a future source of "green" energy and suggested that EGS offers research opportunities for hydrogeologists seeking to become involved in the world's energy future. Although EGS may have a bright future as a sustainable, low-carbon emission energy source, significant technical challenges must be overcome before this promising energy resource can be commercially viable. Because pilot EGS projects in the United States face very different economic constraints than current European projects, there is a real need to make technological advances to improve the return on capital investment. In this article, we amplify on Wood's excellent editorial by describing some of the challenges that exist for the simulation of EGS.

On March 18, 2010, the U.S. Modeling Working Group of the International Partnership for Geothermal Technology (IPGT) held an online meeting of researchers and end-users of geothermal system simulations. The IPGT is an international collaboration between Australia, Iceland, Switzerland, and the United States that is designed to promote and accelerate the development of advanced geothermal power systems, with particular emphasis on EGS. The purpose of the meeting was to discuss the critical needs of the geothermal industry with regard to numerical simulation and to identify key challenges that will need to be addressed to support the development of economically viable EGS. The 18 participants, drawn from industry, academia, the National Laboratories, and the United States Geological Survey (USGS), discussed the needs of energy producers and a wide range of technical issues surrounding simulation of EGS. Of the numerous topics discussed, five are presented below. These topics are not necessarily the greatest or most immediate challenges identified by the group; rather, they are chosen to illustrate the breadth of problems that need to be addressed and to demonstrate that research is required within a wide range of disciplines and across disciplines, including rock and fluid mechanics, chemistry/geochemistry, applied mathematics, and computer science. Five major challenges are the development of:

1. Realistic, fully coupled thermal-hydro-mechanical (THM) models that can reasonably reproduce the results of borehole stimulation and make reliable predictions of short-term to medium-term reservoir performance. This includes the difficult problem of simulating rock failure and the growth of discrete fractures.
2. Realistic, fully coupled thermal-hydro-chemical (THC) models that can provide insight into dissolution and precipitation processes and their effect on medium-term to long-term reservoir performance. Especially critical in this area is the ability to accurately represent water-rock interaction with realistic (i.e., impure) hydrothermal fluids and "exotic" (e.g., supercritical CO_2) working fluids.
3. Thermal-hydro-mechanical-chemical (THMC) models that can reliably represent the permeability changes and complex precipitation and dissolution processes accompanying rapid variations in stress state and temperature during borehole stimulation and heat recovery.
4. Codes and computational methods that are adapted to the simulation of large, high-resolution domains—particularly with respect to discrete fractures and fracture networks—and the simultaneous simulation of processes operating on very different timescales (e.g., chemical and mechanical processes).
5. Next-generation thermodynamic data for geochemical reactions at high temperatures and pressures in the presence of complex mixtures of fluids, and constitutive relation submodels for fractures and fracture networks (e.g., fracture permeability as a function of stress/strain and dissolution/precipitation, fracture relative permeability, viscosity and interfacial tension relationships for multiphase systems, etc.).

Copyright © 2010 The Author(s)
Journal compilation © 2010 National Ground Water Association.
doi: 10.1111/j.1745-6584.2010.00716.x

The last bullet, in particular, includes scope for laboratory-based empirical research to expand existing thermodynamic databases and test multiphase fracture submodels. The group discussion additionally illuminated the need for improved history matching to support EGS field management, better integration and use of geophysical and geochemical data for model conditioning and production management, and better archiving and availability of field data to the community. There was also some sentiment to partner with computer scientists in an open-source, community approach to common issues such as gridding, numerical methods, and graphical display. Perhaps most importantly, there was strong agreement on the need for a set of standardized test cases and trial problems for model testing and evaluation.

Although the challenges and needs described here are aimed specifically at supporting EGS development as an economically viable technology, past experience has shown that the tools and methods constructed for one goal almost always find unexpected applications in broader venues. The issues presented here, therefore, offer the opportunity for the hydrogeological community to build the tools needed for future research while contributing to development of clean, renewable energy systems today.

Reference

Wood, W.W. 2009. Enhanced geothermal systems: An opportunity for hydrogeology. Guest editorial. *Ground Water* 47, no. 6: 751.

Readers' Forum/

Editor's Correction to: "Citation and Acceptance of the 2009 Ross L. Oliver Award", Vol. 48, no. 3, May–June 2010, p. 333–334.

The citation for the 2009 Oliver Award contained two errors. We should have stated that Professor Irwin Remson, the 2009 recipient of the Oliver Award, is the fourth member of the SED (Scientists and Engineers Division, formerly AGWSE) to receive the award. The award, typically given annually, was first presented in 1964. Previous winners from the SED (formerly AGWSE) are: Morris Deutsch (1971), James C. Warman (1974), and Jay Lehr, PhD (1986). The complete list of awardees may be found at http://ngwa.org/programs/awards/excellence/oliver.aspx.

Secondly, Professor Remson retired from Stanford University in 1996. [Correction added after online publication 24 May, 2010]