U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Desert Peak Numerical Modeling

Project Officer: Lauren Boyd
Total Project Funding: $100,000.
May 12 2015

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Principal Investigator: Sharad Kelkar (always include)
Presenter Name (if not the PI)
Organization

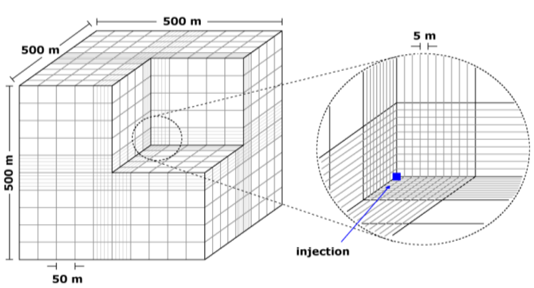
Track 4: EGS2

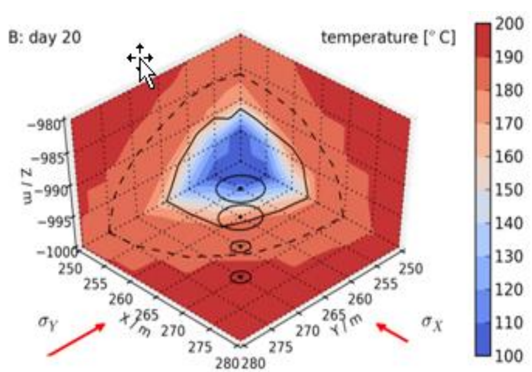
Relevance/Impact of Research

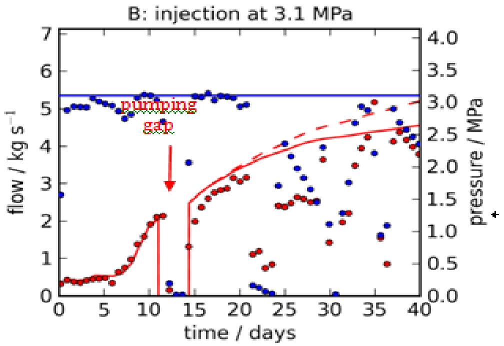
Background

Well stimulation funded by DOE-GTO at the Desert Peak 2 EGS project (Ormat Technologies, Nevada, USA) has increased power output of its nearby operating geothermal field by nearly 38%—providing an additional 1.7 megawatts of power to the grid.

Precursor to this project included successful modeling of shear stimulation of the well DP 27-15 (Dempsey et al. 2013, ARMA).







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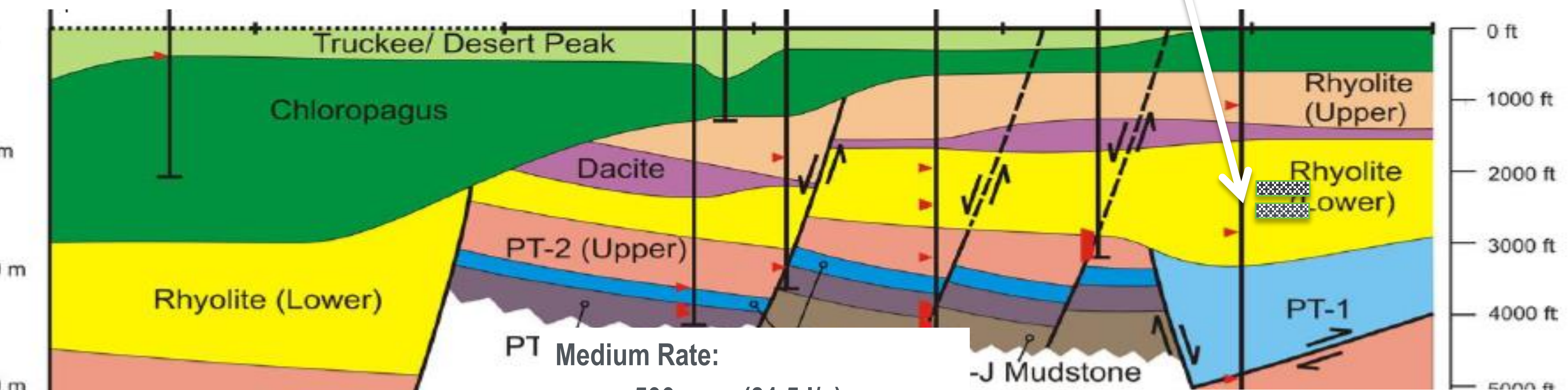
Project Objectives and Purpose

Model Controlled Hydraulic Fracturing of DP #27-15

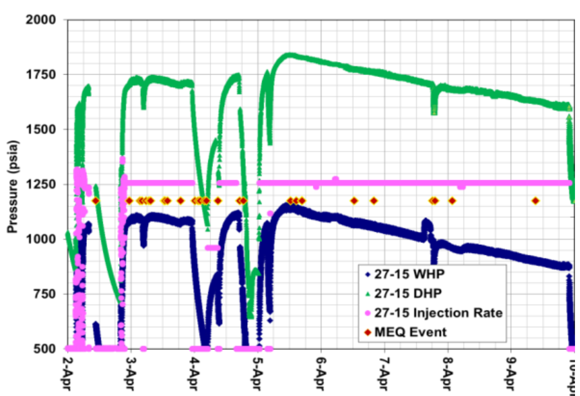


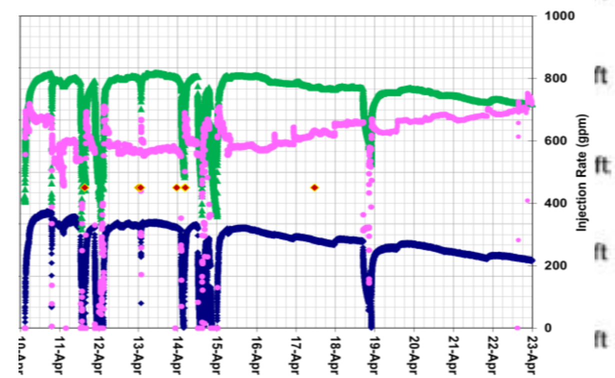
Medium Rate:

- 500 gpm (31.5 l/s)
- 850-1150 psi
- 0.32 – 0.52 gpm/psi

High Rate:

- 575-725 gpm (36.2-46.7 Mpa)
- 850-1010 psi
- 0.73 gpm/psi





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Relevance/Impact of Research

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Project Objectives and Purpose

Build reservoir models to match the data from high pressure stimulation treatments conducted in the Desert Peak Well #27-15

Relevance

The insights from this modeling will impact future development decisions at the Desert Peak and Brady's field, and the expertise will be highly relevant to other field demonstration projects.

Validated Reservoir-scale models are necessary in order to make informed decisions regarding optimal EGS reservoir development (maximizing return on investment and minimize levelized cost of electricity).

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Technical Barriers and Targets

This work addresses barrier F, and also L from MYRD&D; as well as the knowledge gap concerning reservoir simulation models.

Barrier F: Modeling – Insufficient modeling and validation capabilities to effectively couple fluid flow, geochemistry, and thermal-mechanical phenomenon for 1) stimulation prediction, and 2) reservoir simulation.

Barrier L: Well Field Design – Inability to assess and select the most efficient well-field design.

Every phase of an EGS development, from initial well stimulation to reservoir development and production optimization requires reservoir modeling. The IPGT (IPGT 2011) has identified the need for reservoir simulators with capabilities to model permeability enhancement and dynamic changes in permeability in response to changes in reservoir pressure, temperature, stresses and chemistry. Models developed for petroleum and hydrothermal applications have been inadequate for making reliable prediction of stimulation results and identification of the best options for creating the EGS system.

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A reservoir-scale computer model is being developed to match the pressure-flow rate data from the stimulation of DP 27-15

In the DP27-15 high pressure stimulation lasted for about 20 days, pressure changes were on the order of 7 - 9 Mpa, flow rates around 500-750 gpm, and temperature changes were on the order of 50-100^{0}C. Overall injectivity gain from the treatment was by a factor of about 4, but near the wellbore permeability changes could be by several orders of magnitude.

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Large changes in fluid pressures, temperatures, and stresses; large time and distance scales; and highly nonlinear material properties are involved during the process of hydraulic stimulation.

A computer model is being developed using the code FEHM (Finite Element Heat and Mass transfer) to solve the coupled, nonlinear fluid flow-heat transfer-solid deformation equations.

Permeability change as a function of tensile stress is being incorporated by modifying this model, important for analyzing high pressure hydraulic fracturing treatments.

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Scientific/Technical Approach

Permeability will be permitted to increase when tensile failure threshold is exceeded. A parametric relationship between permeability and stress changes caused by changes in pressure and temperature is being implemented for the purpose.

We may also conduct using the commercial simulator Abaqus to model fracture aperture changes during hydraulic fracturing stimulations.

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FEHM is a continuum code based on control volume – finite element approach. It is designed to address spatial scales on the order of 0.1 – 1000 m and temporal scales of minutes to decades. Fully coupled heat-mass equations are coupled sequentially with the equations of non-linear elasticity. FEHM has been developed for and applied extensively to a variety of subsurface projects such as EGS, CO2-sequestration, Fossil Energy, Environmental Management, Nuclear Waste and Arctic Permafrost (Kelkar et al. 2013 IJRMMS; Zyvoloski 2007).

Most recently, the code was validated against field data from the Desert Peak shear stimulation treatment (Kelkar et al. 2012 SGW; Dempsey et al 2013 ARMA).

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An article titled “Numerical modeling of injection, stress and permeability enhancement during controlled hydraulic fracturing at the Desert Peak Enhanced Geothermal System demonstration, Nevada” is being submitted to *2015 GRC Annual Meeting*.

A presentation titled “Modeling coupled Thermo-Hydro-Mechanical processes including plastic deformation in geological porous media ” was made at the 5th International Conference on Coupled Thermo-Hydro- Mechanical-Chemical (THMC) Processes in Geosystems, February 27, 2015, Salt Lake City, Utah, USA.

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Accomplishments, Results and Progress

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Original Planned Milestone/ Technical Accomplishment	Actual Milestone	Date Completed (expected)
Modify Model to include rock deformation		05/31/2015
Develop High Pressure Stimulation Model for Well 27-15		08/31/2015

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Future Directions

There are no Go/No-Go Decisions on this project because of Small Budget

The project will be concluded at the end of FY15

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References

Chabora E, Zemach E, Spielman P, et al. Hydraulic Stimulation of Well 27-15, Desert Peak Geothermal Field, Nevada, USA. 37th Workshop on Geothermal Reservoir Engineering. Stanford, CA, 2012.

Dempsey D., Kelkar S., Lewis K., Hickman S., Davatzes N., Moos D., and Zymach E. Modeling shear stimulation of the EGS well Desert Peak 27-15 using a coupled Thermal-hydrological-Mechanical simulator. 47th US Rock Mechanics / Geomechanics Symposium held in San Francisco, CA, USA, 23-26 June 2013.

Kelkar, S., K. Lewis, S. Karra, G. Zyvoloski, S. Rapaka, H. Viswanathan, P. K. Mishra, S. Chu, D. Coblentz, and R. Pawar. "A simulator for modeling coupled thermo-hydro-mechanical processes in subsurface geological media." *International Journal of Rock Mechanics and Mining Sciences* 70 (2014): 569-580.

Zyvoloski G. FEHM: A control volume finite element code for simulating subsurface multi-phase multi-fluid heat and mass transfer. Los Alamos: Los Alamos National Laboratory, 2007.

Optional slide- keep to one slide