4.6.7 Tracer Methods for Characterizing Fracture Stimulation in Enhanced Geothermal Systems (EGS)

Presentation Number: 034
Investigator: Pruess, Karsten (Lawrence Berkeley National Laboratory)
Objectives: To design and analyze laboratory and field experiments that would (a) identify tracers with sorption properties favorable for EGS applications, (b) apply reversibly sorbing tracers to determine the fracture-matrix interface area available for heat transfer, and (c) explore the feasibility of obtaining fracture-matrix interface area from non-isothermal, single-well injection-withdrawal (SWIW) tests.
Average Overall Score: 3.8/4.0

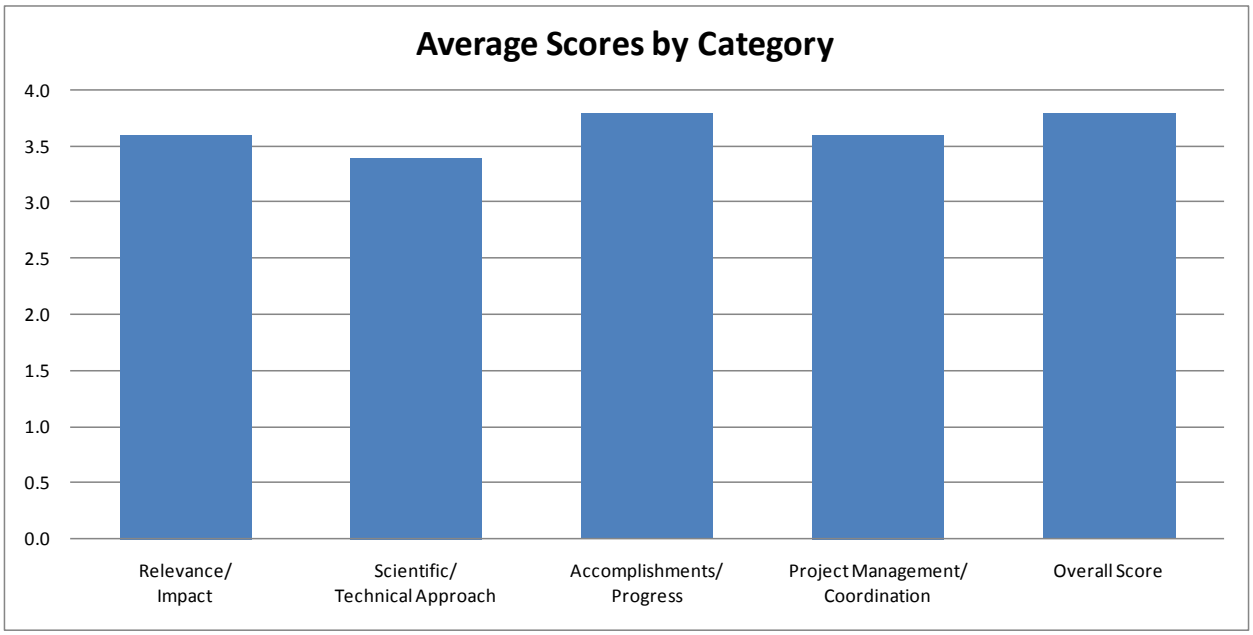

Figure 43: Tracer Methods for Characterizing Fracture Stimulation in Enhanced Geothermal Systems (EGS)

4.6.7.1 Relevance/Impact of the Research

Ratings of Five-member Peer Review Panel: Outstanding (4), Good (3), Outstanding (4), Outstanding (4), Good (3)

Supporting comments:

- The project (with a very small amount of funding) has excellent potential for site characterization using thermal and tracer response to single-well injection-withdrawal tests. The aim is to measure the surface area for heat exchange in a reservoir. Such characterization is fundamental to the success of EGS technologies.

- The project provides a low cost, simple but elegant approach to reservoir characterization using water as a tracer in single well injection-withdrawal test. One may argue with the claim that

heat conduction depends "only on thermal parameters of rocks and fluids", and is not affected by tortuosity effects. This may not be true when the crack opening is large enough. Also, the characterization of the heat transfer coefficient at the interfaces may not be very accurate.

- Characterizing the surface area of a fracture that is available to heat transfer by fluids is critical to the performance of EGS. Surface area is extremely difficult to measure by any number of tested techniques. This research suggests that surface area characterization procedures can be done using temperature with the additional benefit that heat exchange mimics the essential heat exchange process required in EGS systems. While the project is currently in the developmental stages, it has significant potential if the conceptual model can move onto a more real world scenario.

- Well-calibrated tracers will be important for characterizing subsurface fracture systems in selecting possible sites and inferring their changes during production. In addition to looking at sorbing tracers, the project is investigating the novel possibility that using temperature itself as an indicator appears to be advantageous.

- Investigators making good progress.

4.6.7.2 Scientific/Technical Approach

Ratings of Five-member Peer Review Panel: Good (3), Outstanding (4), Good (3), Outstanding (4), Good (3)

Supporting comments:

- I particularly liked the section on equivalence between the reversibly-sorbing solutes and heat. As noted, this provides an additional method (heat) in addition to tracers to assess surface areas accessible for heat exchange in geothermal reservoirs. There was particular weakness in the description of boundary conditions and geometry for the model and results to extract the surface area. The relevance of a dispersion-free particle tracking method was poorly explained, and of doubtful importance. There are some ambiguities when moving from the simple fracture model to real field examples of complex fracture arrays that should have been discussed.

- The idea of using temperature as a tracer in reservoir characterization is both simple and elegant. The preliminary numerical and analytical results are very encouraging. At this stage, the project has only focused on analytical and numerical work. Field or lab tests are necessary to validate the approach. My only worry is that it reinforces even further the reliance of the GTP on a single numerical tool, a cost-efficient but potentially fragile approach.

- The approach relies on mathematical modeling using well-calibrated models. Verification and validation of the modeling approach will be provided by field tests. Assumptions are largely

known and stated. Effects of differing fluid and rock compositions (H_2O, CO_2, NaCl, cation/anion composition; amount of ferromagnesian phases) on heat exchange have not yet been addressed nor shown to be insignificant, as assumed, but may have important impacts. Conceptual model is limited to single fracture such that intersecting fractures have yet to be modeled.

- Thus far project has focused on numerical simulation of ideal situations in order to gain an understanding of behavior. Undoubtedly field and even laboratory systems will be more complex but intelligent interpretation of these requires a thorough understanding of less complex systems.

- Overall good progress. Strongly recommend looking at heterogeneous earth, not just homogeneous medium.

4.6.7.3 Accomplishments, Expected Outcomes and Progress

Ratings of Five-member Peer Review Panel: Outstanding (4), Outstanding (4), Outstanding (4), Outstanding (4), Good (3)

Supporting comments:

- Although there were some geometric ambiguities of some of the modeling results (mentioned above), this project had a lot of "bang for the buck", given the nice exposition of the equivalence of tracer and thermal methods under some assumptions.

- The project is at a very early stage and has a fairly small budget, compared to others in this session. However, it has already lead to significant scientific accomplishments, and one conference proceedings paper.

- Productivity of the research is excellent, especially with respect to the low cost of the project. Results from a simplistic conceptual model had excellent agreement with the analytical solution supporting the approach as did the equivalence of solute and heat transfer. First order calculations support the hypothesis that temperature recovery is related to fracture-matrix surface area as measured by tracers. This paves the way for further, more refined, calculations. With additional parameters, this method has potential. Quality of the team and facilities is outstanding. A proceeding publication resulted from this work.

- This project has been very productive for its small scope and resources. The project undoubtedly benefits from an environment at LBNL that provides excellent resources and experience in numerical computation.

- Well qualified performers. They have some good initial results.

4.6.7.4 Project Management/Coordination

Ratings of Five-member Peer Review Panel: Good (3), Outstanding (4), Outstanding (4), Outstanding (4), Good (3)

Supporting comments:

- The project management plan was not really given. Coordination with University of Utah was clear and relevant. It seems that the project is to end in 2010, and was only of 2 year duration. It should be extended if possible to an additional year, especially as relevant to support the tracer work of Rose.
- This is a small yet well managed project. The quality of the management is demonstrated by the good scientific productivity in such a short time.
- Management is minimal due to the small size of the project. Interactions and collaborations are on-going and effective.
- Project is small and well managed.
- Limited information on this metric, but no red flags.

4.6.7.5 Overall

Ratings of Five-member Peer Review Panel: Outstanding (4), Outstanding (4), Outstanding (4), Outstanding (4), Good (3)

Supporting comments:

- This project will help advance theoretical understanding of characterization of rock surface areas usable for heat extraction in geothermal reservoirs. More complex geometries should be assessed and limitation of the comparison of solutes and thermal methods should be explored.
- This well managed project has progressed very quickly towards goals of significant importance for the GTP.
- Significant progress has been made to provide a new technique for measuring fluid-rock interface surface area, a critical parameter in the development and utilization of EGS. In light of the small budget, this is an exceptional study with far-reaching results.
- No comments.
- Important project for geothermal R&D.

4.6.7.6 PI Response

No response.