4.6.5 The Role of Geochemistry and Stress on Fracture Development and Proppant Behavior in EGS Reservoirs

Presentation Number: 032
Investigator: Moore, Joseph (University of Utah)
Objectives: To develop improved methods for maintaining permeable fracture volumes in EGS reservoirs.
Average Overall Score: 2.8/4.0

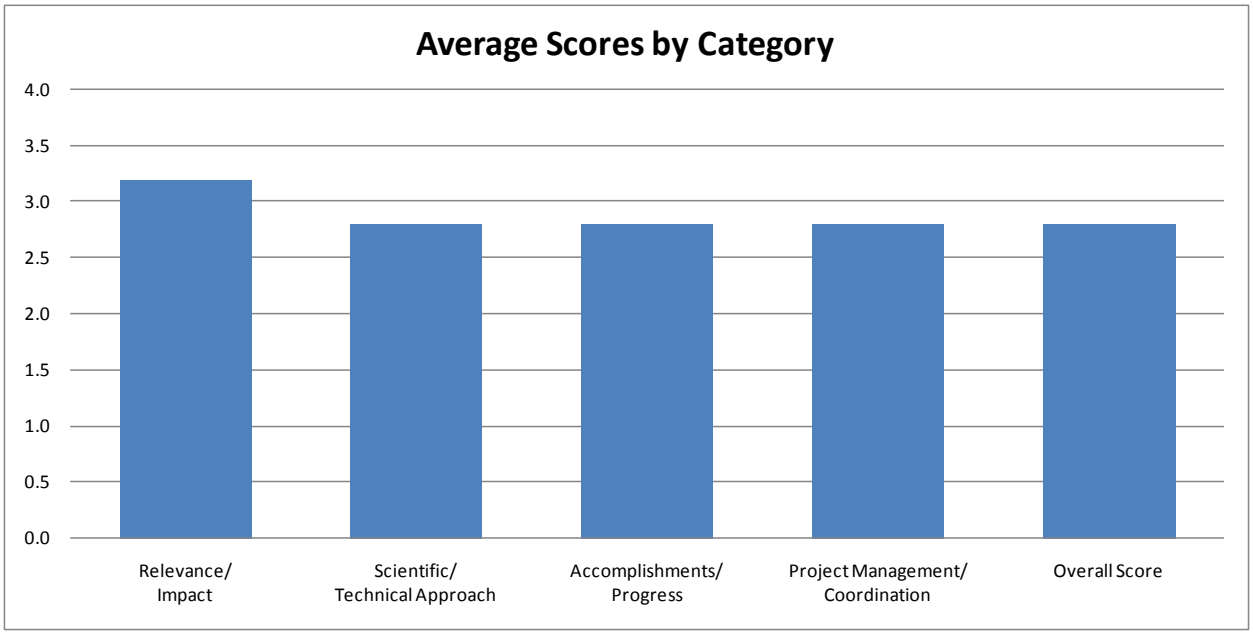

Figure 41: The Role of Geochemistry and Stress on Fracture Development and Proppant Behavior in EGS Reservoirs

4.6.5.1 Relevance/Impact of the Research

Ratings of Five-member Peer Review Panel: Fair (2), Outstanding (4), Good (3), Outstanding (4), Good (3)

Supporting comments:

- Although the goals of the research address significant problems related to EGS development, the progress made for approximately 1.5 years of project duration seemed trivial. From what was presented, vague evidence of surface corrosion of a bauxite proppant (as expected for contact with deionized water) and a few short duration permeability tests were the main results. I would have expected more significant quantitative results. The construction of a high-temperature apparatus could be counted as some progress. Proppants could have great potential for geothermal systems following induced hydrofracture to keep fractures open, but bauxite seems like a poor choice for high-temperature applications, and significant testing with

premium ceramic proppants should have already been conducted. I have some doubt that zonal isolation would work well via proppant injection, but tests still need to be done.

- The project directly contributes to several critical needs of EGS reservoir development: fracture characterization, zonal isolation, controlling fracture propagation and predictive modeling. If proppants are to be used in order to maintain flow path in EGS, understanding their long term behavior is essential. This project also has applications beyond EGS.

- This study focuses on maintaining fracture openings, once created, by the use of proppants. Determining the proppant's thermal-chemical-mechanical stability is essential to understanding their applicability for fracture maintenance (or inhibition) and sustainability in EGS systems. Thus it addresses a significant technical barrier. Dissolution and/or precipitation of proppants and other minerals in the rock can dramatically alter fracture conductivity and connectivity. In addition, mineral dissolution/precipitation near fluid-injection points moves the system far from chemical equilibrium and may promote fluid-mineral interactions that alter the effectiveness of EGS techniques. This study is designed to quantitatively understand these processes. To date, the proposed research is highly relevant but as yet results are unconfirmed. There is potential to contribute to the overall knowledge base of EGS systems.

- Project investigates the effectiveness of proppants in EGS. Because proppants have been widely (and apparently successfully) used in oil production, they may also be necessary to maintain open fractures in EGS (although this seems unclear at this point). Since environmental conditions are more severe in EGS, it is important to determine whether those proppants that have been used in petroleum recovery can also be effective under geothermal conditions and, if not, determine proppants that are.

- Investigators making good progress.

4.6.5.2 Scientific/Technical Approach

Ratings of Five-member Peer Review Panel: Fair (2), Outstanding (4), Fair (2), Good (3), Good (3)

Supporting comments:

- It appeared that only deionized water (DI) was used in tests done to date, but DI plus crushed granite may have also been used. DI spiked with silica was described to be used in ongoing experiments. If brines are a relevant fluid, more experiments should have also been done with such fluids. It is true that DI could be like condensate, but long-term exposure between fluids and rock would be expected to have solutes in nearer to equilibrium with the rock than DI in significant portions of a geothermal system. Expected solute loads should be used in experiments.

- The long term behavior of proppants in EGS is still uncertain. This project will provide valuable insight for their use. The methodology is appropriate, the team has access to high quality experimental facilities, and the level of interactions between academic and industrial partners is appropriate.

- The approach is largely measurement based - selecting rocks, fluids, proppants for measurement at ambient conditions followed by laboratory experiments to determine mineral/rock alteration and its effect on fracture conductivity at elevated P-T conditions. This is to be supplemented by geochemical and geomechanical modeling. Higher T/P experimental techniques at a DOE lab have yet to be developed (but likely DOE staff at the facility would be helpful in developing such techniques).

  It is important to carefully characterize the starting materials for the experiments so that results can be extrapolated to other materials or systems. If bauxite is used, then the chemical makeup and bauxite mineralogy should be determined because the proportions of the hydroxides comprising the bauxite (or silicates composing the granodiorite) may differ.

  In addition, one should do some geochemical modeling first to assess the expected outcome of the experiments. Little information was presented on the geochemical modeling approach. Data exist for these fluid and mineral species, such that reaction paths can be modeled and the most appropriate experiments determined.

  It is unclear why the rock (granodiorite) was sawed - this is not a surface that will exist in the subsurface. This may be useful for mineral characterization and modal analyses (none completed) but not for experiments. While distilled water provides an end member to the reaction problem, it is far from what will be introduced in the subsurface. Other fluid compositions should be tested for applicability to EGS systems.

- The approach, which seems mainly based on laboratory experiments is sound, but seems to be a bit slow off the mark and not very well laid out. The presentation alluded to study of mechanical (not just chemical) properties of proppants but there seems to have been no progress on this front or any clear plan for doing so. This could be a potentially useful and important study, but thus far, it does not seem well-focused.

- Good scientific approach and organization.

4.6.5.3 Accomplishments, Expected Outcomes and Progress

Ratings of Five-member Peer Review Panel: Fair (2), Outstanding (4), Fair (2), Good (3), Good (3)

Supporting comments:

- I would have expected more significant results to date (as described above). Although the project title alludes to the role of geochemistry and stress on fracture development and proppant behavior, very little work was done on geochemistry, stress, or fracture development. I would have expected that the team and facilities were well matched for the project, but the productivity seems to have been too weak. Geochemical modeling was to have been in progress for one year at time of presentation, but no results were given. It was stated that TOUGHREACT would be used. This model would be appropriate, but after one year on the project it is surprising that no results were available.

- The project is approximately at its middle point and is essentially on track with the original timeline. It has already identified dissolution or precipitation issues with several proppants. It also provides a systematic methodology for the testing of long term properties of proppants in EGS.

- Productivity: PI estimates that the project is 40% complete. Tests materials have been selected and baseline measurements acquired. Petrologic assessment of fluid-proppant interactions via experiments and geochemical modeling are in their initial stages, although no geochemical modeling was presented. Mechanical testing and modeling do not appear to have occurred. No elevated P-T measurements have been made.

  To date, fluid interactions rely on distilled water - useful for an end member scenario but more realistic fluid compositions should be used. Fluid mixtures are important and may cause dramatically different interactions. Crushing of material, e.g. granite, causes enhanced surface energy which drives the chemical reaction (not fluid-mineral interactions) and may not be realistic for subsurface conditions. Geochemical modeling should be underway for assessment of fluid-mineral interactions. Accomplishments appear to be modest based on the information presented.

  Quality: The quality of the current experiments appears sound. More analyses are warranted. Collaborators in geochemical modeling should be included. Two presentations at the GRC resulted.

- Work is of high quality and results are interesting but output seems limited. Project seems to be lagging in reaching its objectives.

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

4.6.5.4 Project Management/Coordination

Ratings of Five-member Peer Review Panel: Fair (2), Outstanding (4), Good (3), Fair (2), Good (3)

Supporting comments:

- Although the timeline and management plan seemed appropriate, the achieved results were weak. It is difficult to assess what structural problems exist from the material presented. It was stated that the project was "on schedule", but the presentation did not reflect that.

- The project is very well lead. The degree of collaboration between the industrial and academic partner are appropriate.

- Management appears to be effective and well coordinated. The involvement of students (responsible for geochemical modeling?) may slow results, understandably, and be reflected in the absence of modeling results.

- Although the project is relatively small in terms of the number of people involved it seems to be progressing somewhat slowly. The management plan seems to be well laid out, but, thus far, not effectively executed.

- Limited information on this metric, but no red flags.

4.6.5.5 Overall

Ratings of Five-member Peer Review Panel: Poor (1), Outstanding (4), Good (3), Good (3), Good (3)

Supporting comments:

- As described above, it would be expected that significantly more results would be obtained on experiments and modeling, as well as the use of other proppants. I would think that the PIs could recover from the current lack of progress with a concerted effort. As it stands, there was more fluff than substance.

- This is a very well managed project. The balance between academic and industrial research is good. The outcome of this project are valuable to the GTP, as well as to multiple areas outside of the GTP.

- Because of the lack of modeling and characterization of materials, this project is weakened. Overall, this project rates between a good and fair although only one box could be checked. With improved experiments and integration of modeling, results could be significant.

- No comments.

- Important project for geothermal R&D.

4.6.5.6 PI Response

No response.