

4.5.1 Microearthquake Technology for EGS Fracture Characterization

Presentation Number: 021

Investigator: Foulger, Gillian (Foulger Consulting)

Objectives: To understand how EGS fracture networks develop; to develop technology to determine accurate absolute three-dimensional positions of EGS fracture networks; to understand the physical source processes of earthquake moment tensors; to develop new technology for determining three-dimensional seismic wave-speed structures of reservoirs; to transfer state-of the art microearthquake EGS technology to industry.

Average Overall Score: 3.3/4.0

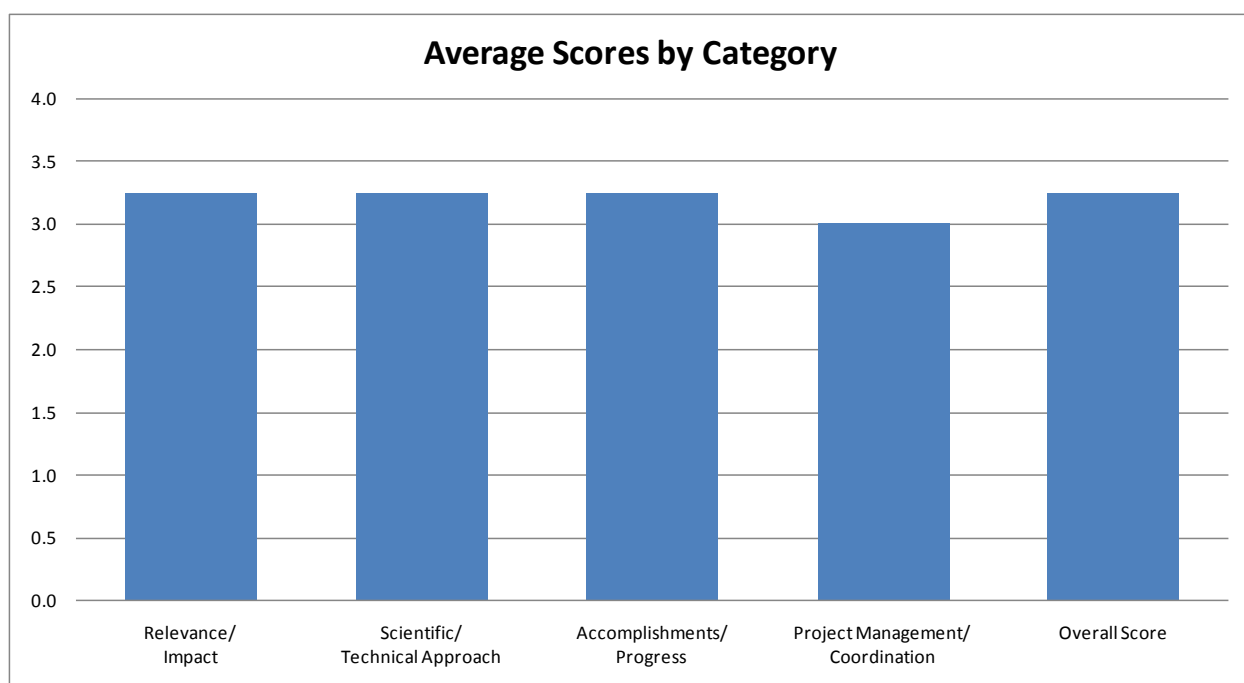


Figure 29: Microearthquake Technology for EGS Fracture Characterization

4.5.1.1 Relevance/Impact of the Research

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

Supporting comments:

- This project develops tools and methodology for characterizing reservoir dynamics using microseismicity. The main approaches are improved earthquake locations (including both relative and absolute locations) and source characteristics such as full moment tensor solutions. The latter may in principle provide valuable information about the type of failure (slip on a fault versus volume change) and bear on fluid transport within the geothermal reservoir.

- More examples of locations and inversions of real data would have been useful to see. Progress has been made on the coding aspects but the applications have not shown significant improvement over earlier studies.
- Two of the major impediments to understanding the role of microearthquakes (MEQ) in EGS have been the incomplete understanding of their mechanisms, and inaccurate/imprecise MEQ locations. This project aims to develop technology that will aid in both situations. Progress toward this goal is appropriate for project length.
- This microseismic software development project, if successfully completed, will make an important contribution to the Geothermal Program mission. The project activities will illuminate, not necessarily solve, known technical barriers, such as how fractures migrate when fracturing the rock. If this project is successfully completed, this reviewer is confident that the EGS program will benefit and that the results will surely add to the knowledge base.

4.5.1.2 Scientific/Technical Approach

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

Supporting comments:

- Techniques developed by the PIs will be helpful for monitoring geothermal production. Some questions raised by the panel include (1) likely trade-offs between absolute earthquake locations and the 3-D velocity model and (2) the minimum earthquake magnitude for which a full moment tensor solution can be obtained. If the magnitude is sufficiently large (given surface or shallow borehole observations), the amount of earthquakes available for such analysis will be relatively small, limiting its overall usefulness. These issues need to be carefully addressed.
- Technical approach is good, methodology is clear and researchers are competent. Most of the techniques presented are established and well known. I would have liked to see more advanced (creative) methodologies developed - what about anisotropy?
- The project discards inefficient and incomplete prior attempts at software solutions, while building on them for their new techniques. It is remarkably well-focused. They have narrowed their work to include only P and S wave amplitudes, rather than matching waveforms, and this makes the work easier, although less precise, while allowing smaller earthquakes (and therefore larger numbers of earthquakes) to be studied.
- The overall technical approach is good. Microseismic tools like this are very important if microseismic locations as a function of time are considered important. However, it is not clear from the presentation that the authors are aware of the literature which means that this work might have already been done or can be done better with other techniques, i.e., not state-of-the-art R&D. This reviewer is familiar with other location codes and techniques that were not

mentioned by the authors. It looks like there are adequate resources and more than sufficient rigor of the work elements, as well as procedures and methods that, if followed, will achieve the project objectives. The design of the project is straightforward and deemed reasonable and the technical approach is adequately described and clearly laid-out in the tasks provided and project timeline.

4.5.1.3 Accomplishments, Expected Outcomes and Progress

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

Supporting comments:

- During the first year of the project the main advance was the development and testing of the computer codes. This part of the project seems to be on track.
- Research team is excellent. Bruce Julian is a leader in the field and will bring significant insight into the management and progress of this effort. At this point in the research it is still too early to tell if major advances will be made through this work.
- The team is highly qualified for this project, and they are deploying appropriate effort to it.
- The overall quality of the research team, equipment and facilities is very good given the list of partners. That being said, relevant experience and the balance of appropriate skills of the research team are unknown because individual contributors were not listed. There are several accomplishments to date and the results look promising, but the project is, according to my rough calculations, behind schedule (report says 30% scope done in 1.4 years out of 3.1 years total or 45% schedule = behind schedule by 15%). I was not able to ascertain the accomplishments as compared to costs to date since current costing was not given.

4.5.1.4 Project Management/Coordination

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

Supporting comments:

- The work accomplished so far indicates a fairly effective management.
- I would have liked to see more actual application at this point in time. Assessment of absolute locations and the errors involved should have been done.
- It appears that the project is well-managed.
- The technical, policy, business, and spend plans for the project are well thought-out, make sense and are, at least logistically on track and project decisions points are appropriately placed.

4.5.1.5 Overall

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

Supporting comments:

- The project is in the initial phase and it is hard to evaluate the overall outcome at this point. The initial presented results using limited sets of data look encouraging. It will be important to demonstrate the utility and applicability of the full moment tensor inversions for microearthquakes.
- Overall I rate this effort significant. The researchers have a lot of experience working in the geothermal area and are computation experts. I have high confidence that they will make a significant contribution.
- If this project is successful, and it appears that it will be, the products (software) will be useful in other fields. It will assist other investigators in studying any EGS field.
- Overall, this reviewer recommends that the project proceed. However, it might be prudent to ask the research team to put a white paper together surveying and discussing the entire field of microseismic location algorithms and software available and why they have decided to build their own. It is recommended that the PI accelerate the tasks to catch-up on schedule variance.

4.5.1.6 PI Response

No response.