4.2.1 GRED Drilling Award – GRED III Phase II

Presentation Number: 011
Investigator: Karl, Bernie (Chena Hot Springs Resort)
Objectives: To gain a better understanding of the geothermal reservoir at Chena Hot Springs Resort in Alaska; to test and document the reliability of previous predictions as to the nature of the reservoir; and to find a hotter resource to scale up power production at Chena Hot Springs for use at Eielson Air Force Base.
Average Overall Score: 2.5/4.0

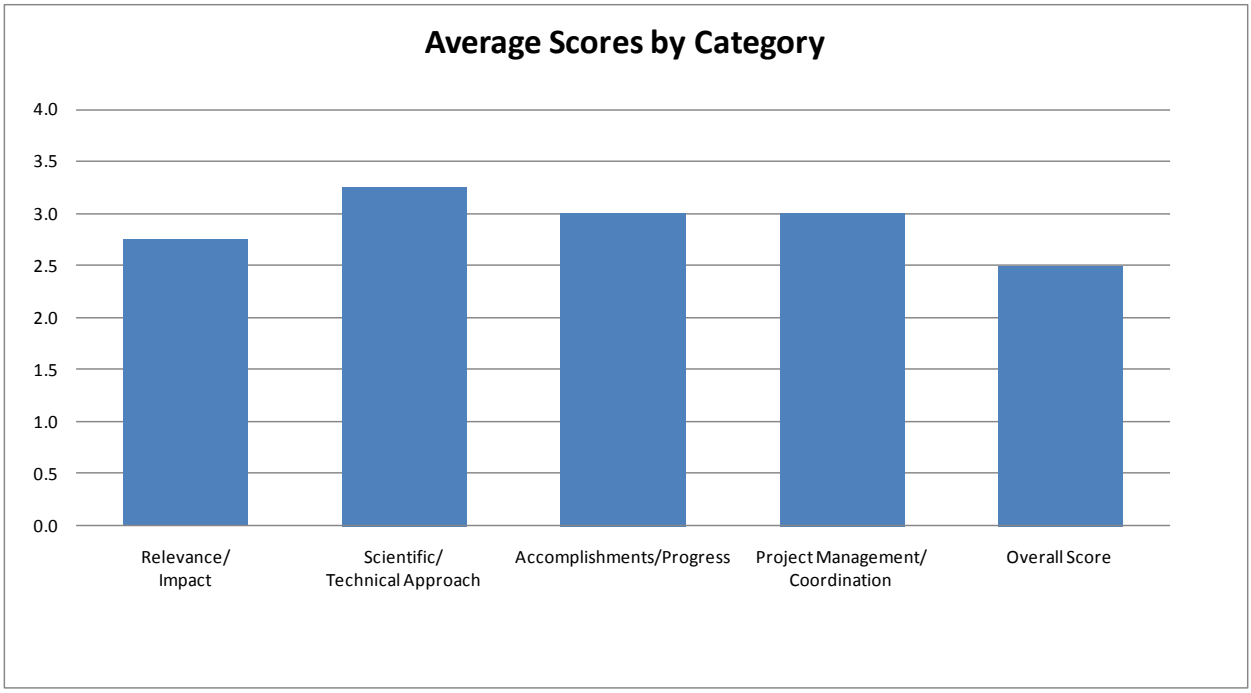

Figure 11: GRED Drilling Award – GRED III Phase ll

4.2.1.1 Relevance/Impact of the Research

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

Supporting comments:

- Good information was obtained that could be valuable for other resources.
- The primary objective of this project was to develop a greater depth of knowledge about the Chena Hot Springs (CHS) reservoir. The importance of achieving the project's objectives is significant to the economic sustainability of the Chena Hot Springs Resort (CHSR) and future expansion plans to provide electricity to Eielson Air Force Base.

  Currently, CHSR has three organic Rankine cycle (ORC) geothermal power plants to meet the electrical needs. CHSR has been operating the 400 kW power plant from two production wells,

Well Nos. 7 and Well TG-8, with 159 °F water. CHSR averages approximately 500 kW of electrical load. It is hoped that by drilling a deeper exploration well the CHSR will be able to find hotter temperatures and more water flow to provide all the electrical supply to the CHSR. Well water temperature data collected over the last three years from Wells Nos. 7 and TG-8 indicate a temperature loss of about 6 °F, from 165 to 159 °F, which has reduced the electrical production of the geothermal power plant.

In response to the diminishing temperature at the CHSR, the awardees proposed to locate hotter temperature fractures and to get a better understanding of the geothermal field by drilling a new well - Well TG-12, located approx 300ft from Wells Nos. 7 and TG-8 with shallow depths of 600 and 1,020 ft, respectively.

This project did provide important project advances and adds to the knowledge base. The TG-12 well was logged to identify any permeable intervals and characterize productivity and injectivity of the well. Short-term interference testing was conducted between TG-12 and T-7 and TG-8. This project field will require further reservoir exploration and tracer testing is needed to confirm long-term well temperature and the reservoir behavior.

The project proposed to drill an exploration hole (TG-12) to a depth of 2,500-3,500 ft but due to a reversal of water temperatures around 2,700 ft, the drilling was rightly terminated. TG-12 achieved an average temperature of around 176 °F. A lot of interesting field dynamics was learned from this project regarding the resource. For example, during drilling operations it was observed that as water was pumped into TG-12, the temperature of Well TG-8 increased from 168 to 172 °F, and has been logged at a temperature as high as 176 °F.

The project also proposes to maximize field resource potential by eliminating the need for diesel and potentially supply electricity to Eielson Air Force Base, which is located 40 miles away. Which is not the best idea. It may be cheaper and better, strategically speaking, to conduct a resource assessment under the Air Base and develop the geothermal resource under the Air Base. Why develop a 40-mile transmission line? Who is going to pay for it? What about the environmental impacts it will have?

- The development at Chena is a world first and it is important that we learn a lot more about the power potential of these fracture dominated systems. Even though such systems may only be capable of providing limited power generation, they are still very relevant for remote sites. I rate this as good

- The goal is to increase the understanding of a particular hydrothermal system and to increase the utilization of that system. The PI did not indicate how this information might be useful to other applications of geothermal energy. The earlier parts of this project, successfully demonstrating an application of low-temperature resources, were very relevant to the current DOE goals.

4.2.1.2 Scientific/Technical Approach

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

Supporting comments:

- Bernie Karl brought in experts such as David Blackwell and Dick Benoit to give the best opportunity for success.

- The CHSR personnel utilized the appropriate scientific/technical methods and procedures to achieve project objectives with the available funding and personnel. The technical approach is based on sound engineering principles and are incorporated into the deployment of the drilling plan. The retainer of Southern Methodist University (David Blackwell, Ph.D.), University of Alaska Fairbanks (UA) (Joanna Mongrain, Ph.D.) and Arctic Drilling to participate in this project is a positive feature.

  The initial project concept was logically planned, well grounded and focused on completion of the specified goals and objectives. The CHSR made the right decisions at the right times. For example, they stopped drilling when water temperatures were getting colder at TG-12.

  The well and reservoir analysis were properly and accurately performed. The UK's GRED III report provided the following conclusion and made specific recommendations as to the sustainability of the CHSR reservoir:

  1. The CHSR reservoir is a shallow predominately conductive zone with a deeper productive zone exhibiting convective behavior. The two zones are separated by a lateral barrier to flow, distinguished by distinct temperature and pressure profiles. The deeper zone seems to be unaffected by cooler water in the shallower zone above. The deeper resource characterized by the isothermal section in TG-9 has not experienced any temperature and pressure declines.

  2. It is uncertain if temperature and pressure declines in Well 7 can be verified. Observations suggest that the field is being managed properly and will be sustainable with the current injection volumes.

  3. The reason for temperature declines at the power plant is illustrated by the influx of cooler water down the wellbore in TG-9. The effect of this can be seen in the dramatic temperature decline in TG-3 and is also affecting the producing temperature of TG-8. Cementing the influx zone in TG-9 was recommended.

  4. Increasing injection volume to TG-7 from Well 1, and deepening Well 1 would reverse the cooling trend seen in Well 7.

  5. Installation of inline flow meters would improve field operations, and help calibrate reservoir models.

  6. To assess the connectivity of TG-12 with the reservoir and determine optimum operating conditions, the TG-12 well should be retested.

- I was not sure if this ranking should be 2 or 3 because there was very little technical detail in the presentation. The deep resource temperature should have been assessed from geochemistry but none of this was presented. The cross sections of the field that were included had no information on the technical data on which they were based. Also they had not been updated to take account of most recent well data. I thought the more recent well testing and pressure

monitoring was sound. My decision to score this at 3 was in part based on the recent well testing and that, given the caliber of the supporting technical team, I believe there may be a lot of technical data that were not presented. I rate this as good.

- The technical barrier is uncertainty about the characteristics of the hydrothermal system at this site. The approach was to drill a deeper well into an area where higher temperatures were expected, and to conduct well tests on several wells in the field. These efforts were successfully carried out, despite the practical issues that impede work in an operating field. The technical plan did not define how the temperature data in this well would be used to increase understanding of the field. Had they found higher temperatures, that would not have been a problem. However, given the result that they drilled through an outflow plume that may have come from any direction, it is not clear what they learned about the system. The result has encouraged the operator to drill in another location, so that is a positive outcome.

4.2.1.3 Accomplishments, Expected Outcomes and Progress

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

Supporting comments:

- Interesting to see an 8 °F increase in the temperature from Well TG-8. This could provide valuable information for future exploration and drilling.

- This project is well thought out as evidenced by CHSR's deployment strategy through temperature surveys, pressure gradient measurements, and well inference testing.

  Temperature Surveys

  A comprehensive set of temperature logs was taken between May 21st and May 25th on TG3, TG9, TG12, Well1, Well 7 and Well 4. Additional logs were taken of TG12 as the well was drilled. The temperature logs allowed for assessment of any resource degradation. The surveys also provided evidence of changes in the shape of the temperature profiles since the start of the power plant in 2006.

  Pressure Gradient Measurements

  Static pressure gradients are useful in determining the stabilized reservoir pressure for a well. Reductions in reservoir pressure inferred that there is insufficient reinjection. Build ups in pressure adjacent to injection wells can indicate low injectivity.

  Well Interference Testing

  An interference test was deployed from June 1-3, 2009. The aim of the inference test was to characterize the reservoir dynamics at Well 7 and simultaneously assess how the production at Well 7 affects the whole field. In a traditional interference test, a well will be shut in and nearby wells monitored for the effect of the shut-in on the bottom hole pressures in the well. Key attributes are how fast the effect of the shut-in well is "felt" at another well. This is an indicator of reservoir connectivity and permeability. The magnitude of the effect can also be analyzed to

assess the connected volume of fluid to both wells.

The level of work productivity was timely and on schedule with respect to the budget. The accomplishments against the planned goals and objectives, technical targets, awards, were on schedule and responsive to the original timelines, goals and objectives.

The project team is well qualified to conduct this research. The CHSR, through the project management of Mr. Karl and subcontractors, has been awarded numerous awards, and has received national and international recognition.

- A good team. I rate this as good.

- The team is good. The drilling was successful. The well testing did as much as could be expected given the fact that the field was operating during the tests. Since there was nothing presented about what the updated model of the system might be, I cannot assess the quality of the team in this area.

4.2.1.4 Project Management/Coordination

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

Supporting comments:

- Bernie's perseverance is admirable.

- The project has been successfully completed and achieved its objectives. The milestones accomplished were compatible with the goals and objectives and budget. It appears that the technical, policy and spending plans for the project were carried out successfully. The work presented was clear and the project was executed in a logical manner.

  The project accomplished the following goals:
  1. Located source of hotter resource under Well TG-8
  2. Gained a better understanding of the geothermal resource
  3. Based on information gathered, developed a plan for geothermal resource optimization
  4. Refined information gathered in Phase I

  The CHSR future plans consist of the following:
  1. Further drilling and exploration
  2. Deepen wells, production Well TG-8 and injection Well 1
  3. Plug non-producing wells with chipped bentonite
  4. Update reservoir model

  Weaknesses:
  Phase I:
  DOE Share - $848,000
  Awardees Share - $296,714

  Phase II:

DOE Share - $846,409
Awardees Share - $547,910

Total DOE Award Phase I and II - $1,694,409

What was CHSR's actual project match share for Phase I and II?

A summary of the budget was provided, but a detailed break-down of expenses was not included.

No economic analysis or data were presented to substantiate a favorable return on investment. A clear schedule or Gantt chart describing project trajectory and critical decision points, and beginning and ending dates for each project task, were not provided. Information on due dates and deliverables would have been useful. There was no indication of go/no-go reviews or when they should have taken place.

- I rate this as good.

- The management is not well structured, but the energy and dedication of the PI keeps this project moving on effectively.

4.2.1.5 Overall

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

Supporting comments:

- Most of the benefit goes to the local Chena area, but still a good project with potentially valuable information for other resources.

- Overall the project met all technical and operational expectations given its unique location and excellent qualifications of the CHSR, Southern Methodist University, University of Alaska Fairbanks, and Arctic Drilling.

- The presentation could have been strengthened by more technical data. I rated this as good.

- The concern about this project is the specificity of the results which appear to be of use only to this site, and the lack of information to be used to judge how the system model was changed by this work.

4.2.1.6 PI Response

No response.