



Exploration Best Practices and Success Rates

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PI: Katherine Young

Presented by: Tom Williams
National Renewable Energy Laboratory

Analysis, Data System, and Education

This presentation does not contain any proprietary
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Objective

The purpose of this project is to provide an overview of current geothermal exploration best practices and a baseline values for exploration (both non-drilling and drilling) success rates in the U.S.

Total Budget

- \$240k in FY10
 - \$125k for best practices
 - \$115k for success rate

General Timeline

- Start Date: January 2010
- End Dates:
 - Exploration Best Practices, August 2010
 - » May 2010 = 30% complete
 - Exploration Success Rate, February 2010
 - » May 2010 = 10% complete

Barriers/Issues Addressed

- High exploration risks and upfront costs associated with site selection
 - Inadequate measuring techniques and knowledge preclude low-risk/cost exploration to effectively select sites and characterize physical parameters of the host rock; therefore, new and improved remote geologic, geochemical, and geophysical techniques are needed to find geothermal resources.
- Exploration success rates
 - Defined as:
 - » Locating a potential geothermal resource (this may include some drilling)
 - » Drilling of the resource until a successful production well is achieved
 - In general, the values used in cost modeling and risk analysis for success rates of exploration for geothermal resources are poorly constrained.

Collaborators

- Mack Kennedy (LBNL)

- This project seeks to address two concerns:
 - 1.) The high risk of geothermal exploration and up front cost
 - 2.) The less than optimal success rate of geothermal exploration
- The geothermal best practices study will aid in the reduction of geothermal exploration (i.e., upfront) costs by determining techniques and defining strategies that work best for various geologic settings (e.g., extensional, magmatic, etc.) associated with geothermal resources.
- By determining exploration success rate baseline values, DOE-GTP will be able to conduct an exploration risk analysis that will, in turn, be used in cost-benefit and market penetration analyses.

Additionally, this project will provide a needed update on the current state of geothermal exploration practices and success rates, which will aid in the future decision-making processes regarding geothermal exploration R&D funding allocations.

- Exploration Best Practices Data/Information Gathering
 - Data/Information to be gathered include:
 - Cataloging current geologic, geochemical, and geophysical exploration practices used by the geothermal industry
 - Information about geologic settings (e.g., extensional, magmatic, etc.) associated with various established geothermal/hydrothermal resources
 - Costs associated with each technique and/or aggregate cost of exploration
 - Data/Information sources include:
 - Comprehensive literature review (sources: OSTI, GRC, GEA, DOE-GTP, etc.)
 - Interviews with:
 - Industry (e.g., Ormat, ThermaSource, etc.)
 - Trade Associations (e.g., GEA, GRC, etc.)
 - Academia (e.g., GBCGE, OIT, etc.)
 - What we are not looking at:
 - Recent ARRA funded exploration techniques studies

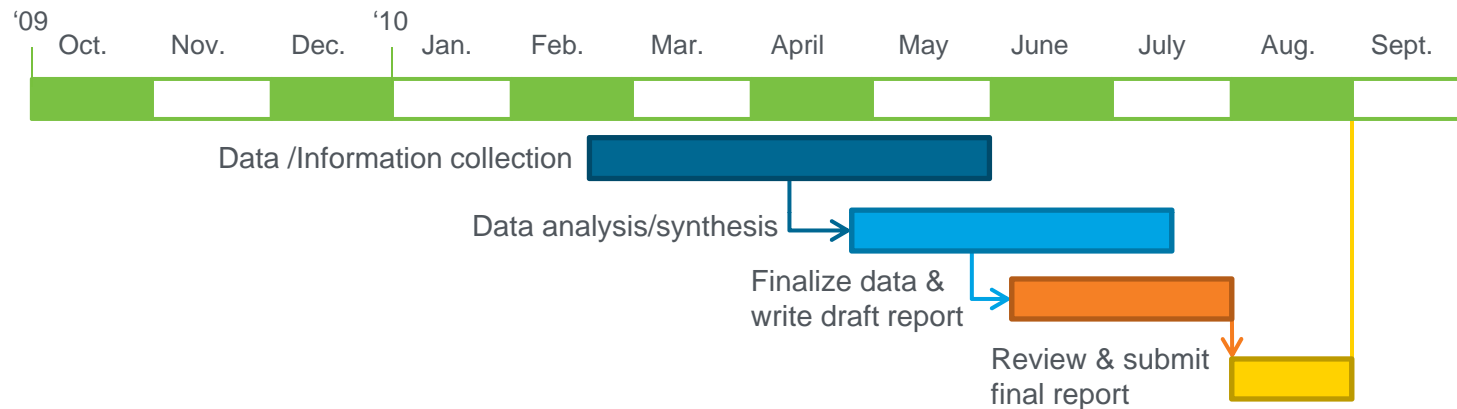
- Exploration Success Rates Data/Information Gathering
 - Data/information to be gathered, in addition to that gathered for the exploration best practices, include:
 - Number of boreholes drilled for a given project (exploratory and production wells)
 - General cost information associated with the exploratory drilling phase (which includes the first successful production well)
 - Industry perspective on what is success, with regard to both exploration and drilling
 - Data/Information sources for this task are the same as for exploration best practices, but with more emphasis on industry and trade association interviews.
 - What we are not looking at:
 - Drilling methodology and specific drilling cost information (e.g., dollar amounts per well or per foot)

- Exploration Best Practices and Success Rates Data/Information Synthesis
 - **Database Development**
 - Basic project information (e.g., name, site location)
 - Exploration technique(s) used
 - anecdotal information about usefulness of a given technique
 - Geologic setting
 - Host rock information
 - Topography
 - Accessibility
 - Costs associated with both non-well and well exploration
 - Information regarding “success” of exploration and/or drilling (both exploratory and production wells)

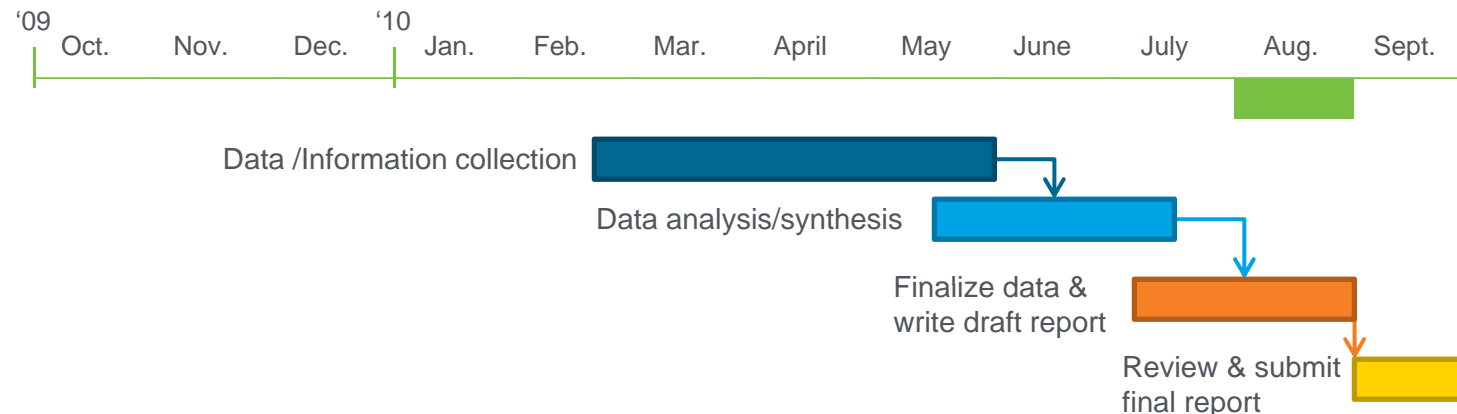
- Exploration Best Practices and Success Rates Data/Information Synthesis (cont.)
 - **Analysis**
 - Exploration best practices will use a GIS to:
 - Define geothermal resource regions based on geologic regime
 - Determine which exploration techniques worked best for a given geologic region using a simple correlation
 - Exploration success rates (at regional and U.S. scale) will use a simple statistical approach to determine:
 - Non-well exploration success rate
 - » Based on if a project was further funded for well drilling (i.e., go-no go decision)
 - Production well drilling success rate
 - » Based on total number wells drilled to get a successful production well
 - Additionally, cost of non-well exploration and exploratory drilling will be analyzed to determine if there is any significance associated with dollars spent in either phase versus “success”

- Milestones (projects phases are integrated)

Exploration Best Practices Timeline



Exploration Success Rate Analysis Timeline



- Exploration Best Practices
 - A comprehensive overview of the current state of geothermal exploration practices
 - Guidance regarding exploration strategy based on a given geologic setting
 - For example, in the Great Basin region (an extensional geologic regime) of the U.S., remote sensing for mineral alteration, due to hydrothermal activity, coupled with a survey of shallow (1-3 m) thermal probes has proven successful (e.g., Coolbaugh, 2008).
 - Highlights of areas for improvement in exploration technique(s)
- Exploration Success Rate
 - Arrive at properly vetted and defensible values for success rates of geothermal resource identification and drilling to production that can be used in risk analysis and other modeling activities.

- NREL is currently moving toward the data synthesis phase of the study, while still continuing to collect additional data for a more robust analysis.
- This work will be completed by the end of FY10.

- Information and data collected/synthesized for the exploration best practices and success rate study will be used in a planned exploration risk analysis.
- Additional future tasks
 - Conduct a comprehensive review of exploration techniques used in geothermal resource exploration.
 - Review ARRA projects related to exploration to determine impact on the geothermal market.Trade-off analysis to determine where money can be best spent to improve exploration success rates.

References

Coolbaugh, M. 2008. The important role of grass-roots exploration in expanding the use of geothermal energy in the Great Basin, USA. *GRC Transactions*: Vol. 32, pg. 139-140.