Bradys EGS Project

DOE: DE-FG36-08GO18200

Project Officer: Bill Vandermeer
Total Project Funding: $6.6M
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Overview

- Timeline
  - Project start date: September 2008, contract singed on June 2009
  - Project end date: December 2013
  - percent complete: ~50%
- Budget
  - Total project funding: $6,407,947
  - DOE share: $4,482,796
  - Awardee share:$1,925,151
  - Spent as of Jan-2012: $1,674,130

<u>For EGS activities and development of Bradys Well 15-12 ST-1:</u>

- Phase 1: Feasibility Evaluation
  - Sub-tasks completed; currently evaluating Go/No-go Decision
- Phase 2: Well Stimulation & Analysis of Stimulation Results
  - Planned for Q2/Q3 2013
- Phase 3: Long-term Testing & Commercial Validation
  - Pending results of stimulation

Relevance/Impact of Research

Project Goals:

- Improve Productivity or Injectivity of well 15-12 ST-1 to commercial levels
- Improve hydraulic connection to rest of the producing field
  - Common EGS/Geothermal development goal
- Incorporate techniques used and lessons learned at Desert Peak EGS Project
- Deploy cost-effective techniques that are transferrable to other projects

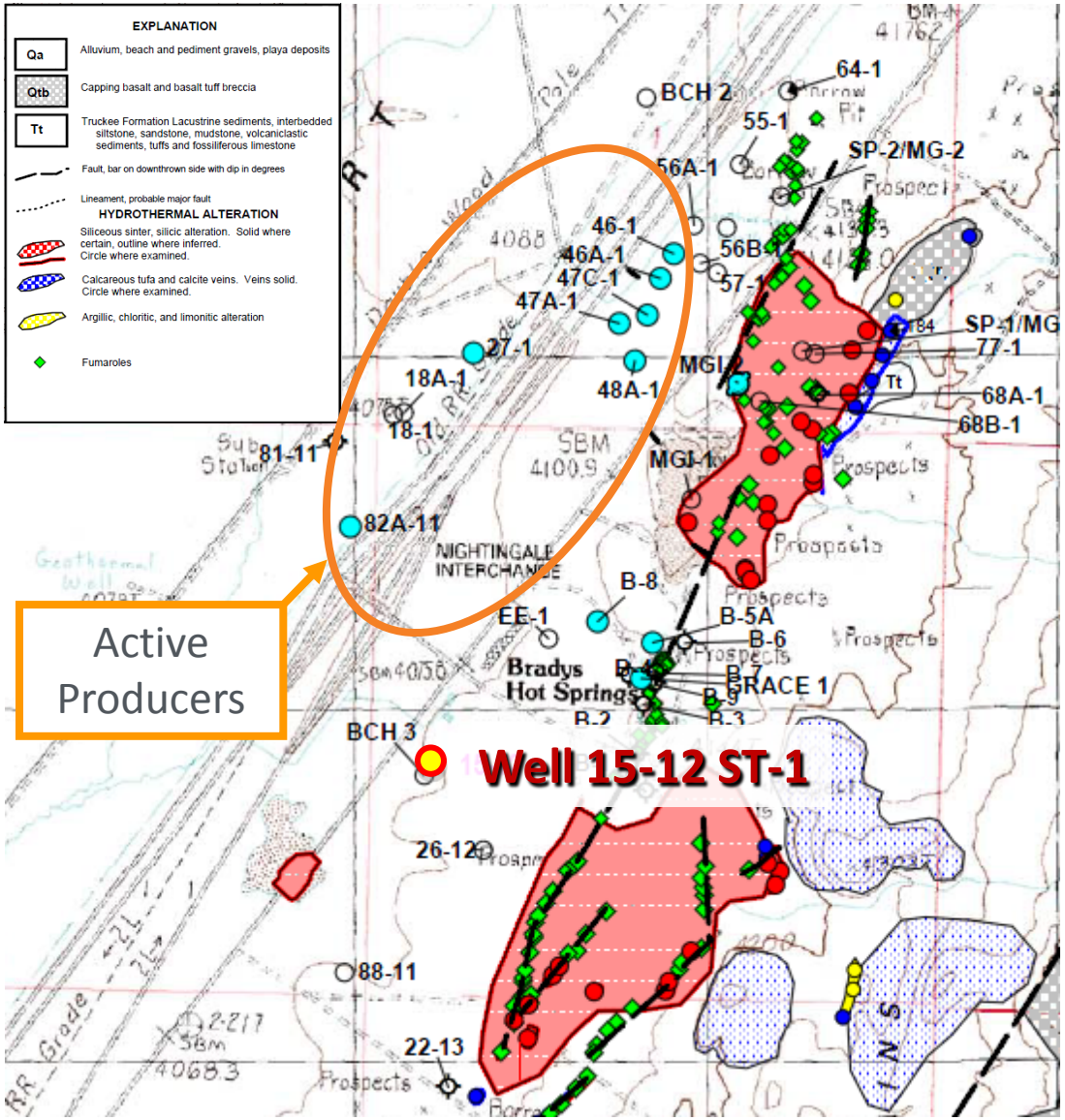
Project Challenges:

- Creating a sustainable man-made reservoir by applying commercially available stimulation technologies
- BLM permit approval process
- Achieving “self-propping” shear stimulation – Preconditioning stage

Successful Demonstration of Technology:

- Yields more production and enables more power generation
- Bradys methodologies can apply to other EGS projects – “EGS Toolbox”

Bradys Hot Springs Geothermal Field



- Bradys Hot Springs located ~7km from Desert Peak Field
- 15-12 ST-1 encountered low perm. but high temp. (~ 400°F)
- Geology potentially amenable to EGS stimulation
- Adjacent core hole BCH-3 found higher perm.; good core recovery

Project Management/Coordination

- Managing a multi-disciplinary, multi-partner investigation
- “Decision-tree” workflows for rapid operational decision process
- Regular evaluation of cost-effective approaches
- Executing stimulation plan and gathering data
- Information flow & exchange:
  - Conducting technical workshops and quarterly meetings
  - Disseminating daily stimulation reports to stakeholders
- Capturing critical data and experience from Desert Peak project
- Currently engaged in Go/No-go discussion for Phase 2 Stimulation
  - Operational plans and logistics for stimulation in place
  - Detailed stimulation plan documented and milestones defined

Collaborations

- **Ormat**– oversight, organization and scheduling,
- **GeothermEx, Schlumberger** – technical management, hydraulic testing, modeling
- **UNR** – geologic mapping, structural model, 3D geologic model, surface stress indicators
- **USGS & Temple University** – stress field analysis and structural modeling
- **UoU EGI** – tracer testing, geologic modeling
- **Schlumberger TerraTek** – petrology, stratigraphy, core testing
- **GMI**– image log & failure analysis, stimulation planning
- **LBNL** – seismic monitoring and analysis
- **Hi-Q Geophysics** – surface seismic acquisition and interpretation
- **LANL, NETL** – imaging, characterizing, and modeling of fracture networks in EGS
- **Sandia Nat. Lab.** – borehole televiewer acquisition and support

Scientific/Technical Approach

Phase 1 Feasibility Evaluation → Stimulation Plan

- Geologic structural & 3D modeling → define permeability controls and extent of geothermal reservoir
- Petrology & Mineralogy → characterize stimulation target
- Geomechanics/Stress Analysis → failure mode prediction
- Robust seismic monitoring array → real-time stimulation monitoring
- Desert Peak Stimulation Review → Best practices & lessons learned
- Geomechanical Modeling Numerical → Fracture prediction and Stim. management tool
- Downhole Multi-String Geophone detection system → Higher MEQ detection/location

Phase 1 Objective → Phase 2 Stimulation Plan

- Shear Stimulation, Injection at pressures below Shmin for 10 days (Based on LANL modeling)
- Mixed-mode Hydro-shear stimulation, Injection at increasing rates and pressures above Shmin for 7 – 10 days
- High-rate Pulse Stimulation, rapid increase in injection rate 4 days

Bradys Project Time line

- Phase 2 Stimulation Plan estimated for Q2 2013
  - Phase I Studies and Engineering Summary report (March 2012)
  - Protocol For Induced Seismicity (March 2012)
  - Go/No-Go agreement with DOE independent reviewers (May 2012)
  - **BLM Downhole EA (Jan 2012 - Jan 2013)**
  - DOE Phase-II go decision (March 2013)

- Evaluation of Phase 2 Stimulation Results
  - Go/No-Go Decision to test well for commercial use or design follow-up stimulation plan Q4 2013

2012-2013 activity: Permitting Process

- January, 2012 - Submitted Sundry and plan for stimulation to BLM.
- January, 2012 - BLM sent a request for additional and very detailed information.
- March, 2012 - Ormat provides the Phase-I summary report and Induced Seismicity protocol reports to DOE and BLM. The documents address all of the BLM analysis requests.
- June, 2012: DOE and Ormat present the project in BLM office in Winnemucca
- August, 2012: BLM decides to initiate a focused, down hole EA.

"Focused Environmental Assessment"

- BLM kicked off the EA internally in late August, 2012.
- Issues analyzed in the Environmental Assessment:
  - Water Quantity and Quality
  - Geology
  - Native American Religious Concerns
  - Hazardous Materials
- During the NEPA process, there were two (30) day public comment periods.
- Decision Record and FONSI signed by BLM on January 11, 2013
- DOE approved project through Cat/Ex on March 13, 2013.

Summary Slide

	FY2011	FY2012	FY2012	FY2013
Target/Milestone	Complete Feasibility Evaluation	Detailed Stimulation Plan	BLM EA	Execute Stimulation Plan
Results	Completed Q1 FY2012	Completed Q2 FY2012	Completed Q1 FY2013	In-Progress

- The Bradys EGS Project Emphasizes the Importance of:
  - Diverse research team plus dedicated field operations partner
  - Integration of tectonics, geology, petrology, rock mechanics and stress
  - Well designed MEQ system that has been deployed early in the project
  - Protocol for monitoring and managing Induced Seismicity
  - Leveraging successes & lessons learned from Desert Peak experiences
- Our Goal: Enhance permeability in 15-12 ST1 to increase generation at the Bradys power plant by 2-3 MW