



Silver Peak Innovative Exploration Project

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Sierra Geothermal Power

Validation of Innovative Exploration Technologies

Silver Peak Innovative Exploration Project Summary

- Awardee: Sierra Geothermal Power (SGP)
- Timeline
 - Started: October 2009
 - Award Effective Date: January 21, 2010
 - Planned finish: August 2011
 - 10% complete on a budgetary basis
- Budget
 - DOE Share: \$5,000,000.00
 - SGP Share: \$7,356,546.00
 - Total: \$12,356,546.00

- Multi Year RD&D Plan Barriers addressed
 - Barrier C: EGS Well Construction Capability
- Partners
 - Conrad Wright, SpecTIR LLC
 - Chris Kratt, Desert Research Institute
 - Roger Henneberger, Chris Klein, Eduardo Granado, and Rob Stacey; GeothermEx, Inc.
 - Jerry Hamblin, Thermasource
 - John Deymonaz
 - Stephen Hallinan, Western Geco
 - William Cumming, Cumming Geoscience
 - Joe Moore, EGI

Objective #1: Confirm the presence and characteristics of the geothermal resource at Silver Peak

- Sierra Geothermal Power's corporate goal is to bring 23 MW of geothermal power online at the Silver Peak project site in 2013

Objective #2: Validate new exploration techniques

- Hyperspectral imaging survey
 - Identify surface geothermal indicator minerals from the Visible-Near Infrared (VNIR) region of the spectrum at spatial resolutions of 3 - 5 m²
 - Access the value of hyperspectral imaging for the discovery of blind geothermal resources
- Coiled-tube drilling
 - Demonstrate coiled tube drilling in a geothermal environment

- The airborne hyperspectral survey will be validated through the comparison of identified mineral anomalies to the temperature anomalies identified by:
 - Airborne thermal infrared survey,
 - Shallow (6 foot) temperature probe survey and
 - the results of temperature gradient drilling.
- Coiled-tube vs Core Drilling
 - Keep detailed records of the time and cost of drilling
 - Side by side comparison of
 - Cost
 - Time
 - Geologic information obtained

- Geological and geophysical techniques used to assist in identifying deep geothermal drill targets for Phase 2 drilling are:
 - Detailed geologic and structural mapping
 - 2D & 3D modeling of gravity and magnetic data
 - 2D & 3D modeling of magnetotelluric and ZTEM data
 - 2D seismic reflection survey
- Improve selection of deep geothermal drill targets by
 - the integration and interpretation of the results of the above datasets
 - combine with detailed geologic and structural mapping and temperature data from TG holes and slimwells

- Resource and well targeting risk management
 - Use standard resource decision tools adapted to the geothermal industry's sparse case history data sets.
 - Drilling target alternatives based on the conceptual model(s) inferred from geology and geophysics will be tested using decision tables.
 - Complete risk analysis that illustrates temperature and permeability uncertainty in exploration and resource capacity uncertainty in development.
 - Resource capacity uncertainty will be characterized using a small number (~5) of realistic cases consistent with injection capacity case histories and a lognormal distribution of resource sizes based in part on a volumetric heat-in-place approach.

Task #	Milestone	Date	Status
Task 1.0	Surface and near surface Investigations	June 2010	Arial thermal survey pending dry weather.
Task 2.0	Build 3D model	June 2010	Modeling pending staff availability.
Task 3.0	3D subsurface resistivity study	Complete	
Task 4.0	Slimwell drilling of a coiled tube and core well	August 2010	
Subtask 4.1	Drill slimwell with coiled tubing drill rig	August 2010	Pending results of exploration.
Subtask 4.2	Drill slimwell with coring rig	Complete	Well 38-11 was completed to depth of 1,649 m.
Task 5.0	Integration of exploration data	August 2010	
Task 6.0	Phase 1 Report / Go No Go decision point	September 2010	

Geothermal exploration surveys completed:

- Airborne hyperspectral imaging survey
- Shallow (6 foot) temperature probe survey
- Collection of field data on the magnetic susceptibility and density of major rock types
- Ground-based magnetotelluric survey
- 2D seismic survey
- Airborne ZTEM survey

Analysis/modeling completed:

- One 3D resistivity inversion block model derived from magnetotelluric data
- Twenty-three 2D resistivity profiles derived from 2D inversion of ZTEM data

Drilling completed:

- Drilled 13 temperature gradient holes, collected and analyzed eight fluid samples and collected 51 m of core
- Well 38-11 was cored to depth of 1,649 m

- **Project Responsibility Matrix**
 - Summarizes participants involvement in each task
- **Project Schedule**
 - Maintained in project management software
 - Schedule is aggressive
 - Project is one of SGP's Tier 1 projects and corporate objectives are major schedule driver
- **Project Budget**
 - Maintained in spread sheet software linked to project management software
- **Risk Assessment**
 - Performed during well planning
 - Resource risk assessment for Phase Gate 1

- Inter-comparison of near-surface techniques with results from temperature gradient (TG) holes to validate the usefulness of these methods in selecting TG drill sites
- Integration of geophysical and geological data to create a 3D model of the subsurface
- Synthesis of temperature data with the 3D geologic model to identify deep drill targets
- Drilling and flow testing of slim and/or production wells to test the validity of the geothermal exploration methodology

Near-surface techniques

1. Complete thermal survey
2. Assess the usefulness of the near-surface methods in selecting TG drill sites

Phase 1 Drilling

1. Review experience with coiled-tube rig at Alum assess capability at Silver peak
2. Select coiled tube well location
3. Design review and risk assessment of well
4. Drill well location

3D model of the subsurface

1. Integrate geophysical and geological data
2. Conduct synthesis of temperature data with the 3D geologic model
3. Develop conceptual model(s) and identify deep drill targets
4. Complete risk analysis

- Large and diverse, well-qualified team
- Project incorporates several innovative techniques
 - Coiled-tube drilling
 - Hyperspectral survey
 - ZTEM
- Combination of innovative and proven techniques being applied which assists in the validation of the innovative techniques
- Aggressive schedule with some tasks already completed