U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

A 3D-3C Reflection Seismic Survey and Data Integration to Identify the Seismic Response of Fractures and Permeable Zones Over a Known Geothermal Resource at Soda Lake, Churchill Co., NV

May 14, 2010

Dick Benoit, Principal Investigator
James F. Echols (Presenter)
Magma Energy (U.S.) Corp.

Validation of Innovative Exploration Technologies

Overview

- Timeline
  - Project start date: 01-29-2010
  - Project end date: 10-31-2012
  - Percent complete: 1.7%
- Budget
  - Total project funding: $14,336,380
  - DOE share: $5,000,000
  - Magma Energy share: $9,336,380
  - Funding received in FY09: $0
  - Funding for FY10: $500,000
- Barriers: surface constraints limiting full coverage; structural complexity exceeding capability of technology; signal absorption and irresolvable statics due to near surface conditions
- Partners: Dawson Geophysical Company;
  University of Nevada, Reno;
  Experimental Geophysics Laboratory, Bureau of Economic Geology, University of Texas

Relevance/Impact of Research

3D 3C Reflection Seismic in geothermal development

- Use existing well data over producing geothermal field to calibrate seismic response of productive and non-productive horizons
- Resolve structures and faults as potential drilling targets
- Improve well planning to optimize well trajectory at a cost of <50% of one production well
- Identify seismic attributes of fracture porosity in volcanic rock through anisotropy
- Determine relative value of p-wave vs converted shear-wave (single component vs three component)
  - Test techniques to identify fracture-porosity with p-waves through absorption and Cepstrum domain
  - Benefits would be >40% savings over conventional acquisition and processing

Scientific/Technical Approach

Soda Lake Expansion – Increase Geothermal Resource Capacity

- Incorporate all previous surface and sub-surface data into comprehensive 3D GIS data base to reveal subtle relationships
- Utilize remote sensing technologies in sequence(s) to minimize costs and maximize useable data
  - Gravity to map shallow structures
  - CSAMT to map shallow thermal aquifer
  - MT to map deeper conductivity structures
- Apply recognition of in-field anomalies to drilling targets outside known productive area
- Incorporate 3D reflection seismic into 3D GIS to provide eyes beyond the well bore

Schedule

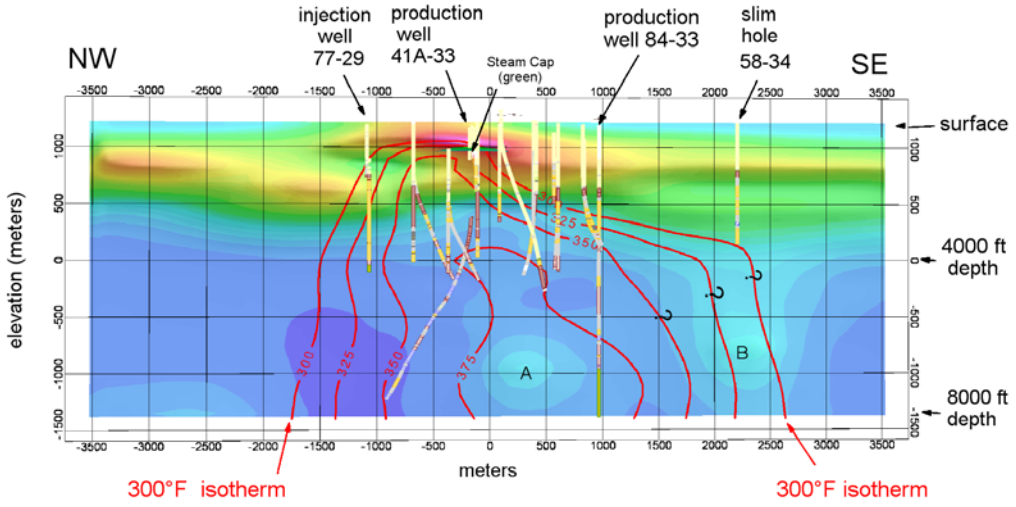
• Receive BLM Permit for seismic survey	May 2010
• Acquire seismic data	June 2010
• Process p-wave data	July - Sept 2010
• Process converted-wave data	Aug-Oct 2010
• Specialized data processing	Oct 2010
• Integrate data sets into 3D GIS	Sept-Oct 2010
• Identify well targets	Nov 2010
• Review meeting (go-no decision)	Dec 2010

Technical Accomplishments

- Input all surface and sub-surface data into comprehensive 3D GIS database
- 3D survey design and acquisition contractor
- Class III Cultural Resource Survey and draft report submitted to BLM
- Completed temperature model from existing well control
- Map shallow conductivity feature through combination of CSAMT and MT
- Precision gravity survey

Team Members

- Dick Benoit, PI
- Gary Oppliger, Ch Geop
- Jim Echols, Explorationist
- Mary Ohren, Geologist



Project Management/Coordination

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	Pre-award Spending Authorization			Effective Date			Fully Exectured Contract	Peer Review Meeting							
	10/09	11/09	12/09	01/10	02/10	03/10	04/10	05/10	06/10	07/10	08/10	09/10	10/10	11/10	12/10
Surface access permits															
Cultural Survey															
Magnetotelluric Survey															
Environmental Assessment															
BLM Permit															
3D-3CSurvey															
Field Processing Tests															
P-, Converted-wave 3D processing															
Re-processing selected anomalies															
Seismic Interpretation Consultant and 3D															
Integrate data sets with existing well data															
Identify well targets															
Review Meeting															

Project Management Plan

- Experienced geothermal and seismic exploration team in place
- BLM permitting process creates uncertainty in scheduling; NOI submitted Feb 2009
- Seismic data processing and interpretation proposals under review
- Data compatibility confirmed with Geosoft platform

Future Directions

FY 2010

- Acquire 3D-3C reflection seismic survey
- Process seismic data
  - Maximize structural content of p-wave data
  - Determine if converted-wave data provides useful fluid content
- Integrate interpretation with well field data
- Identify four drilling targets

FY 2011

- Drill two production-capable reservoir tests
- Well testing
- Go/no-go decision for two additional wells

Summary

Understanding geothermal reservoirs requires multi-discipline, integrated 3D GIS

- Access down hole geophysical logs, surface geophysics, isotherms, isoresistivity surfaces, seismic data, cross-sections, etc. instantaneously
- Wells tell where you've been
- MT shows the direction to go
- Seismic provides the map
- Be prepared for discoveries