Use of Geophysical Techniques to Characterize Fluid Flow in a Geothermal Reservoir

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This presentation does not contain any proprietary confidential, or otherwise restricted information.
Project Overview

- **Use of Geophysical Techniques to Characterize Fluid Flow in a Geothermal Reservoir:**
  - Budget
    - Total project DOE funding $ 832,433
    - Funding received in FY09 $ 335,339
    - Funding for FY10 $ 255,261
    - Project total cost $1,137,567
  - Partners
    Boise University,
    Flint LLC, Mt. Princeton Geothermal, LLC
Joint inversion of geophysical data for ground water flow imaging

- Reduced the cost in geothermal exploration and monitoring
- Combining geophysics with hydromechanical codes: new science
Scientific/Technical Approach

Objectives of your project

• Joint inversion of geophysical data for ground water flow imaging
• Reduced the cost in geothermal exploration and monitoring
• Combined passive and active geophysical methods
• Proof-of-concept mainly at Mount Princeton geothermal field, CO
• Methodologies can be easily transferred to other DOE test sites.

• Numerical modeling with TOUGH and eTOUGH
• Stochastic and deterministic joint inversion
  – Use seismic to provide the architecture of the system plus wells,
  – Use EM/resistivity, self-potential to model ground water flow
  – Technical feasibility at Mount Princeton and Poncha Springs
Accomplishments, Expected Outcomes and Progress

- FY09 First data set: done Joint inversion T and SP: done
- FY10 Joint inversion of seismic and SP/resistivity/temperature
- FY11 Ground Water flow model at three geothermal sites in the Upper Arkansas valley

**TEAM:**
- CSM. André Revil (EM, SP, resistivity)
- Mike Batzle (petrophysics, seismic)
- Boise: Kasper vanWijk and Lee Liberty (Seismic).

**Recognition received**
- Best poster award at the 2009 SEG in Houston.
• **Organization:**
  - Meeting once a month (skype) + field camp in May
  - Application of resources and leveraged funds/budget/spend plan
  - Connection to ORMAT, ENREL, State of Colorado

• **The new methodology is applicable:**
  - To other geothermal prospects
  - To monitoring (seismic and electrical monitoring of fracturing)

• **Possibility to develop a geothermal program at Mines**
  - Connection with ORMAT
  - Connection with ENREL
Localization and geology

- Buena Vista
- Mount Princeton
- Arkansas valley
- Chalk cliff
- MPHS
- HHS
- Mt Princeton
- Hot Springs
- BV
- Hecla Jct.
- Salida
- Poncha Sp
Deep seismic

Stacked seismic profile

Interpreted profile

Seismic Acquisition (CGG Veritas)
Passive seismic

Chalk Cliff Stations (night)
DC resistivity and self-potential
4 \pm 1 \times 10^3 \text{ m}^3/\text{day of thermal water upwelling}
3D seismic: preliminary results
Educational component
Field camp - Colorado School of Mines
Future Directions

2011. Joint inversion of seismic and electrical tomographies

- Passive seismic
- Temperature
- self-potential
- DC resistivity
- EM methods
- Active seismic

- Reactive transport code modeling
- Hydromechanical behavior

-3D DC resistivity tomography of a volcano (Revil, Johnson and Finizola, in preparation)
Summary

- Joint inversion/integration of geophysics, geology, geochemistry
- Joint inversion temperature / self-potential / resistivity: done
- Joint inversion with seismic: in progress (2010)
- Application at Mount Princeton: shallow part done (2009)
- Application to Poncha Springs (target summer 2010)
- Development of a ground water flow model (2011-2012)
  Mount Princeton
  Poncha Springs
  The Upper Arkansas valley
List any publications and presentations

3 papers


7 Presentations.