

Geothermal Technologies Program Research and Development

July 17, 2012

Hidda Thorsteinsson
Geothermal Technologies Program
Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy

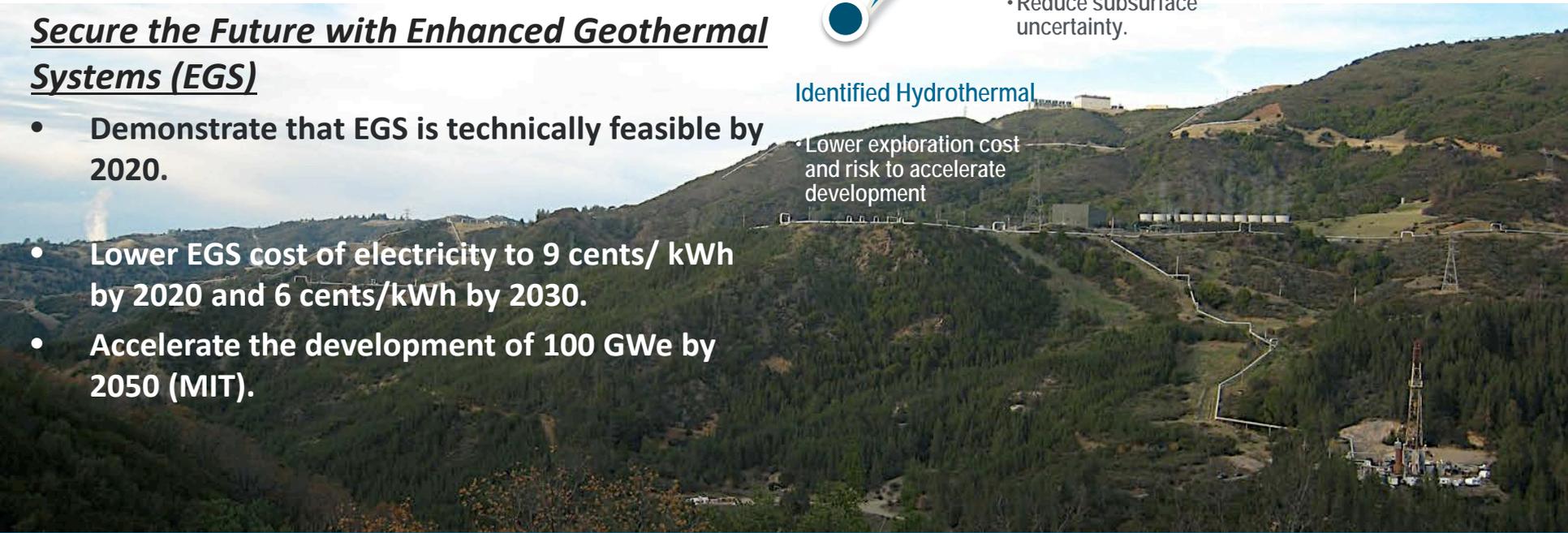
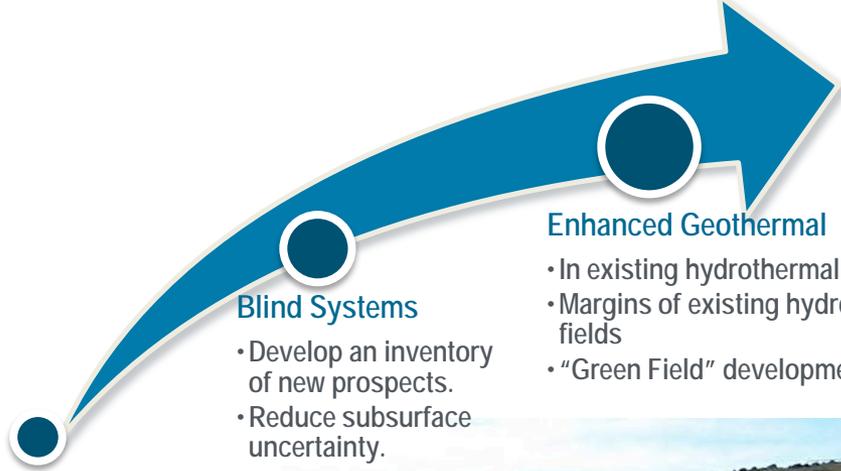
Vision: Geothermal will be a major contributor to the nation's baseload energy supply

Accelerate Near Term Hydrothermal Growth

- Decrease exploration risks and costs.
- Lower cost of electricity to 6 cents/kWh by 2020.
- Development of 30 GWe of undiscovered resources.

Secure the Future with Enhanced Geothermal Systems (EGS)

- Demonstrate that EGS is technically feasible by 2020.
- Lower EGS cost of electricity to 9 cents/ kWh by 2020 and 6 cents/kWh by 2030.
- Accelerate the development of 100 GWe by 2050 (MIT).



Hydrothermal:

Using innovative technologies to find hot rock with fluid and permeability

- Discover and characterize “blind” hydrothermal systems
- Drill and log wells— temperature, fluid volumes, rock properties
- Reservoir sustainability
- Power conversion

Path Forward:

- Reduce risk through RD&D portfolio and identification of new geothermal prospects

EGS:

Develop and validate technologies to characterize and create subsurface heat exchange systems

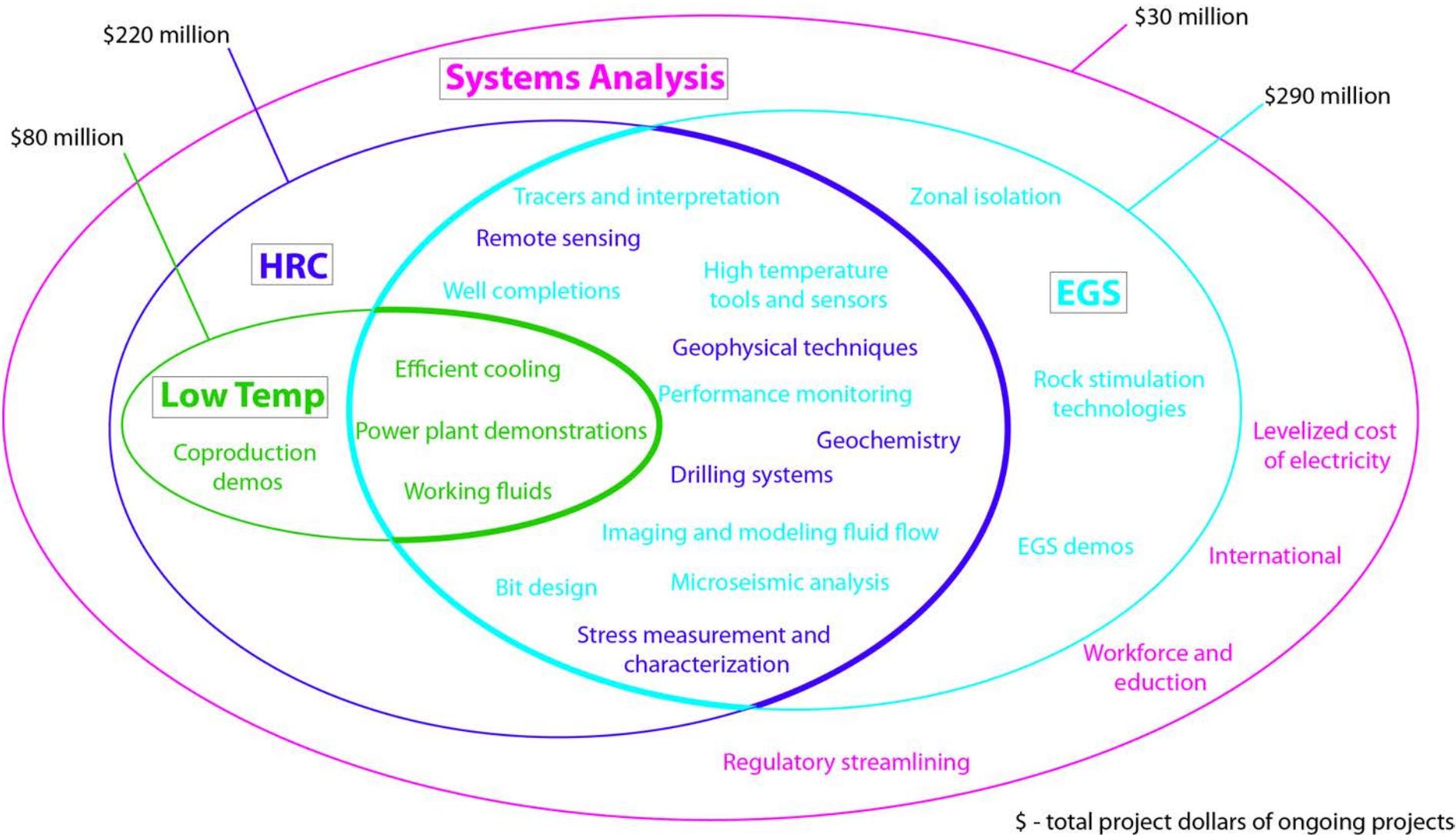
- Drill and log well(s) to characterize rock parameters, stress regime, initial injectivity, temperature, pressure, etc.
- Perform multi-well injection and assess long-term production
- Develop well field and scale- up reservoir

Path Forward:

- Remaining gaps are the foundation of the EGS portfolio

Subprograms RD&D Interactions

Most research cuts across areas



20 validation of innovative exploration techn. projects

- Aim to confirm 400 MW of new hydrothermal resources by 2014

27 R&D projects to increase exploration success and advance power conversion

- Advanced geophysical surveys and processing
- New geochemical signals and improved analysis
- Innovative drilling systems
- Advanced working fluids and more efficient cooling

17 power production demonstration projects

- Providing lessons learned and preliminary cost data for low temperature and co-production



What's Ahead in 2013

Continued RD&D to lower exploration risk and development costs

- Phase II funding for successful RD&D projects that accomplish technical milestones
- Coproduction demonstration in commercial field

Regional Data Gathering and Analysis to identify new opportunities

Target: Lower hydrothermal LCOE to 6 cents/kWh by 2020

Six EGS demonstrations

- To validate reservoir creation in different geologic conditions

110 R&D projects related to

- Fracture characterization
- Coupled modeling
- High temperature tools and sensors
- Advanced drilling and well completion technologies
- Zonal isolation, etc.

What's Ahead in 2013

EGS field test sites effort initiated

- Multi-user pre-competitive R&D environment for EGS testing and validation
- Up to three geologically unique sites



Targets: *Demonstrate technical feasibility of EGS at commercial scale by 2020 and lower LCOE to 6 cents/kWh by 2030*

Enhanced Geothermal Systems Demonstrations



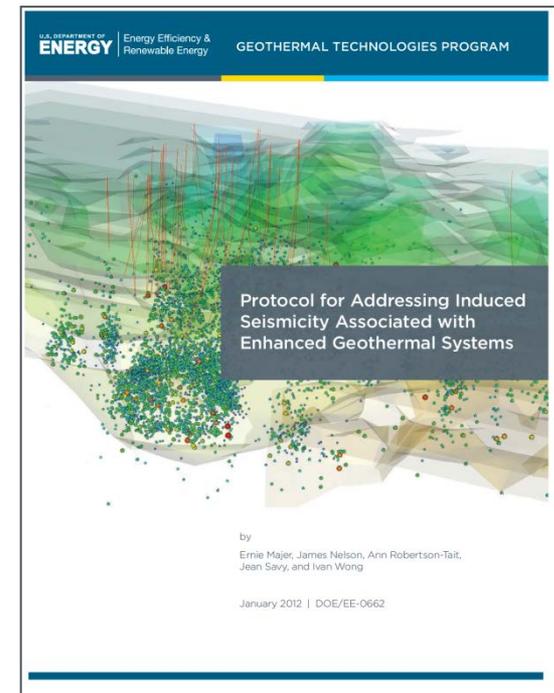
Performer	Project Site	Site Information	Stimulation Timeline	Funding
Ormat Technologies Inc.	Desert Peak, NV	Adjacent to existing hydrothermal sites	Multiple phase stimulation completed	\$ 4.3 M
Geysers Power Company, LLC	The Geysers, CA	Two existing wells will be reopened and deepened for injection and stimulation	Currently stimulating	\$ 6.2 M
Ormat Technologies Inc.	Bradys Hot Springs, NV	Improve the performance of the existing geothermal field	Initiating in late FY12	\$ 3.4 M
AltaRock Energy Inc.	Newberry Volcano, OR	High potential in an area without existing geothermal development	Initiating in late FY12	\$ 21.4 M
University of Utah	Raft River, ID	Improve the performance of the existing Raft River geothermal field	Initiating in early FY13	\$ 8.9 M
NakNek Electric Association	NakNek, AK	Located in remote location in Alaska without existing geothermal development	Project on Hold	\$ 12.4 M

Systems Analysis assesses geothermal resources, cost drivers, barriers, the impact of policy, and progress toward goals.

- Regulatory Roadmap Initiative
- National Geothermal Data System design, testing and population
- EGS field test site planning, analysis and initial scoping
- Extensive techno-economic modeling

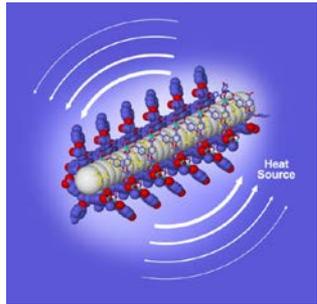
What's Ahead in 2013

- Techno-economic, environmental and financial analysis
- Geothermal data provision
- Intergovernmental and international coordination

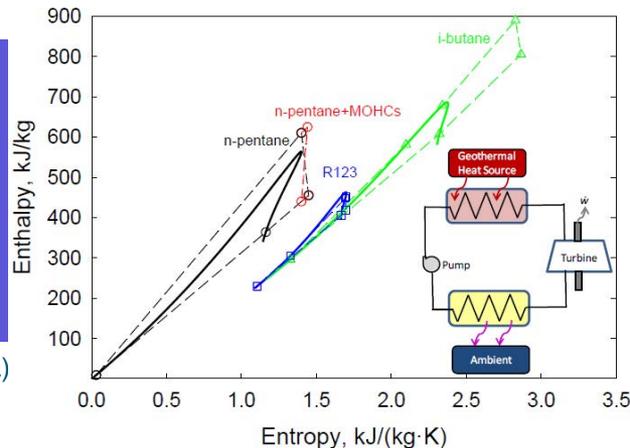


New U.S. based Protocol
2012

Solutions that increase deployment and decrease risk.



(Photo provided by PNNL)



Metal Organic Working Fluids

Organization: PNNL

Objective: Improve ORC efficiency through working fluid additives

Successes:

- Metal organic heat carriers identified and tested for better thermal conductivity and improved heat transfer coefficient.
- Economic modeling indicate less than 100 days payback period when used with R123.



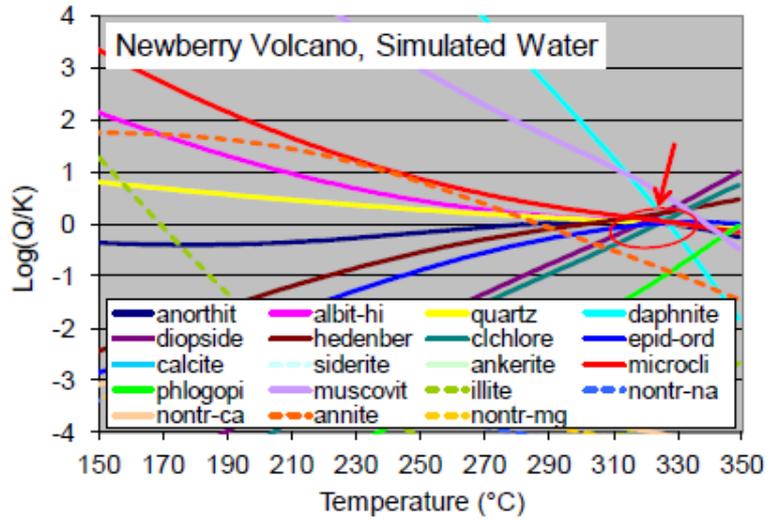
Mineral Extraction from Geothermal Brines

Organization: Simbol Materials

Objective: Validate improved Li extraction technologies and develop technology to cost-effectively extract strategic materials from geothermal brines

Success:

- Li extraction demo plant operational for 1500 hours+, 95% Li extraction achieved.
- Producing electrochemical grade lithium carbonate of >99.5% purity.



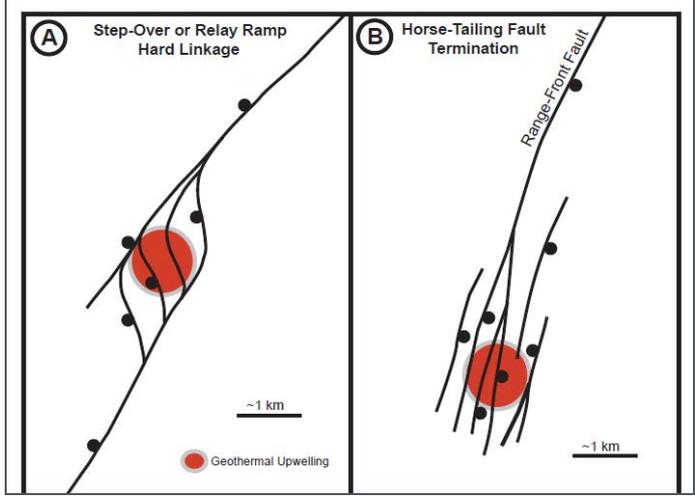
An Integrated Chemical Geothermometry System for Geothermal Exploration

Organization: LBNL

Objective: Develop a practical and reliable system to predict reservoir temps from integrated analyses of spring and well fluids

Accomplishments:

- Practical software tool (GeoT) developed to automate multicomponent geothermometry method.



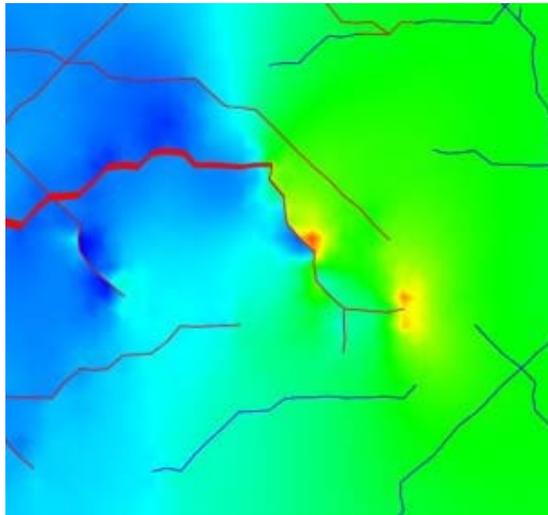
Characterizing Structural Controls of EGS and Conventional Resources in the Great Basin

Organization: University of Nevada, Reno

Objective: Characterize structural settings favorable for geothermal activity and conceptual structural models that can facilitate exploration

Success:

- Defined a spectrum of favorable structural settings for geothermal systems.
- Preliminary catalogue of structural settings for Great Basin systems completed.



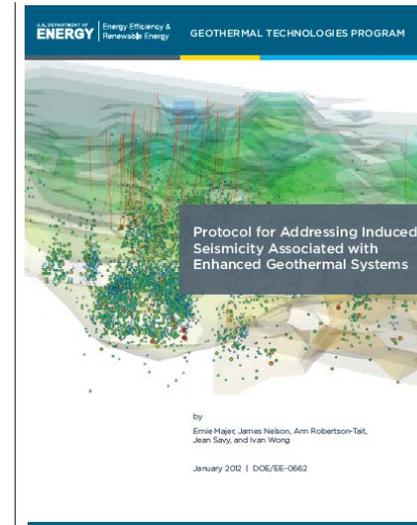
Predicting Stimulation Response Relationships for Engineered Geothermal Reservoirs

Organization: LLNL

Objective: Develop a computational test bed to produce realistic models of EGS stimulation-response scenarios.

Accomplishment:

- Modeled a 10% enhancement in a stimulated fracture network;
- Developed model of hydro-fracture allowing interaction with pre-existing fracture network.



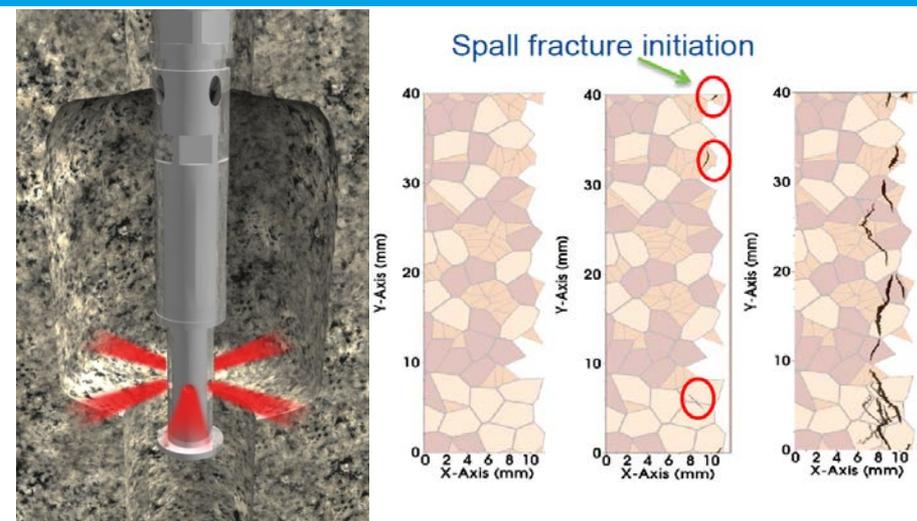
Induced Seismicity Protocol and Best Practices

Organization: LBNL

Objective: General guide for geothermal developer to address induced seismicity issues.

Accomplishment:

- 2011 Updated Induced Seismicity Protocol: ALL DOE funded EGS projects are required to adhere to the protocol
- 2012 Best Practices Document



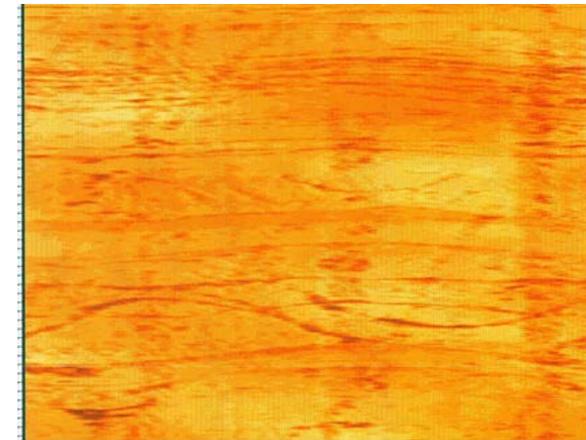
Spallation Drilling and Under-reamer

Organization: Potter Drilling Inc.

Objective: Development of a continuous drilling and under-reamer based on thermal spallation

Successes:

- Continuous steam jet downhole at 900C, with no downhole ignition source.
- Ability to bring cuttings to the surface
- Test results suggests ROP up to 15-20'/h; pathway to 30'/h



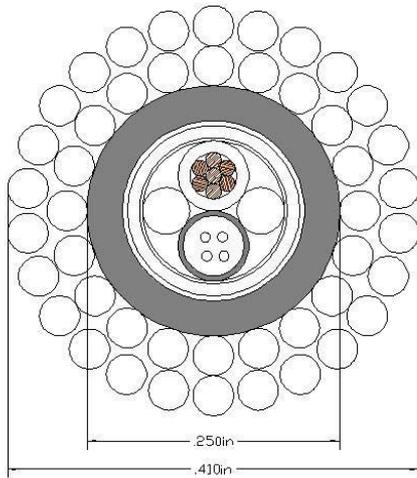
Geothermal Ultrasonic Fracture Imager

Organization: Baker Hughes

Objective: Development of a downhole wireline tool to characterize fractures in wells up to 300°C and depths up to 10,000 m

Successes:

- Transducer 300°C demonstration test completed.
- 25KPsi/260°C test of Tool Transducer Assembly Completed Jan 2012



Current cable design per
TA – 121511

- Uses 1 conductor with the tube/armor as the return
- All polymeric material is DuPont Ecctreme polymer
- Metal tube wall thickness is currently 0.035", this could be reduced to 0.028 if larger conductor is needed.

Copper/Fiber Cable for Geothermal Well Monitoring

Organization: Draka Cableteq USA/Prysmian

Objective: Develop a cable/sensor for high temp geothermal wells (>250°C) via an optical fiber with better resistance to hydrogen darkening and longer life.

Success:

- Downselected 300°C coatings and completed H₂ testing.
- Developed Prototype cable that will be tested at EGS demonstration site



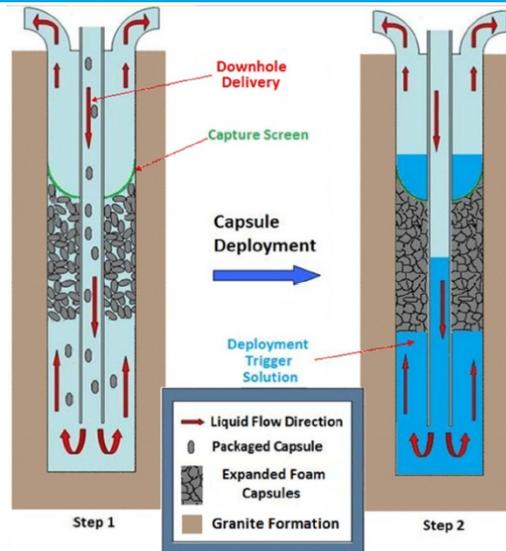
Imaging Fluid Flow in Geothermal Wells Using Distributed Thermal Perturbation Sensing

Organization: LBNL

Objective: Develop a new flow imaging tool - Distributed Thermal Perturbation Sensor, which consists of a fiber-optic DTS and a heat trace cable installed along the axis of a borehole.

Success:

- Successfully deployed DTS tool at EGS demonstration site in Idaho.



HT/HP Devices for Zonal Isolation in Geothermal Wells

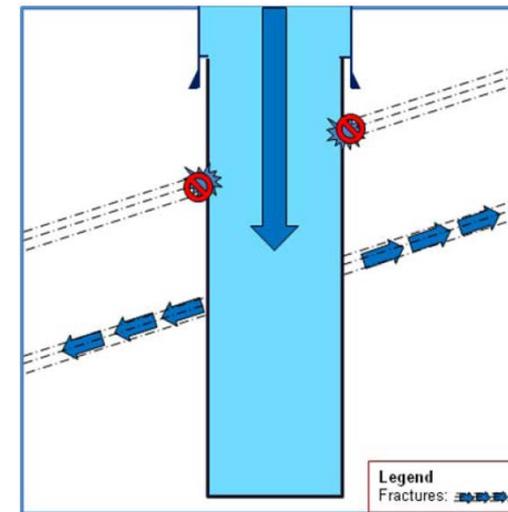
Organization: CTD Inc.

Objective: Seal off unwanted flow regions in high-temperature (>200°C) using both physical and chemical diverters.

- Will facilitate mini-fracs, elimination of fluid loss zones etc

Accomplishment:

- Component parts of the zonal isolation concept have been tested successfully- system assembly is the next step.



Chemical Diverters

Organization: AltaRock Energy, CSI Technologies

Objective: Facilitate multi stage fracturing using chemical diverters in >200°C environments to increase power production per well.

Accomplishment:

- Two successful field tests in high temperature reservoirs
- Transmissivity calculations post testing imply the material fully degraded.

Questions?