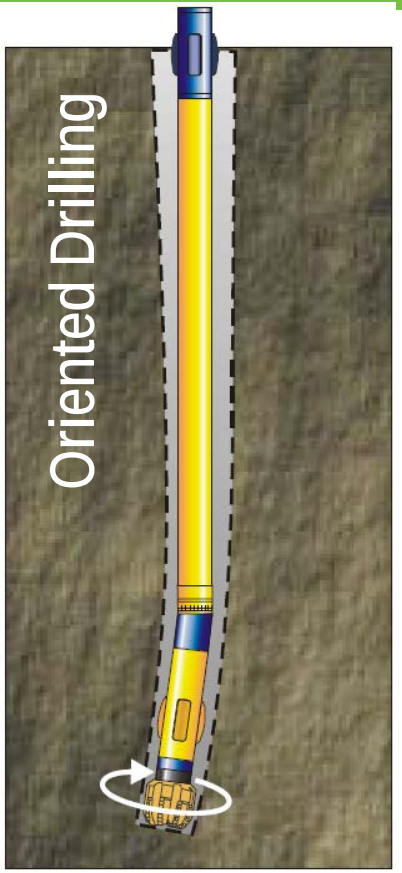
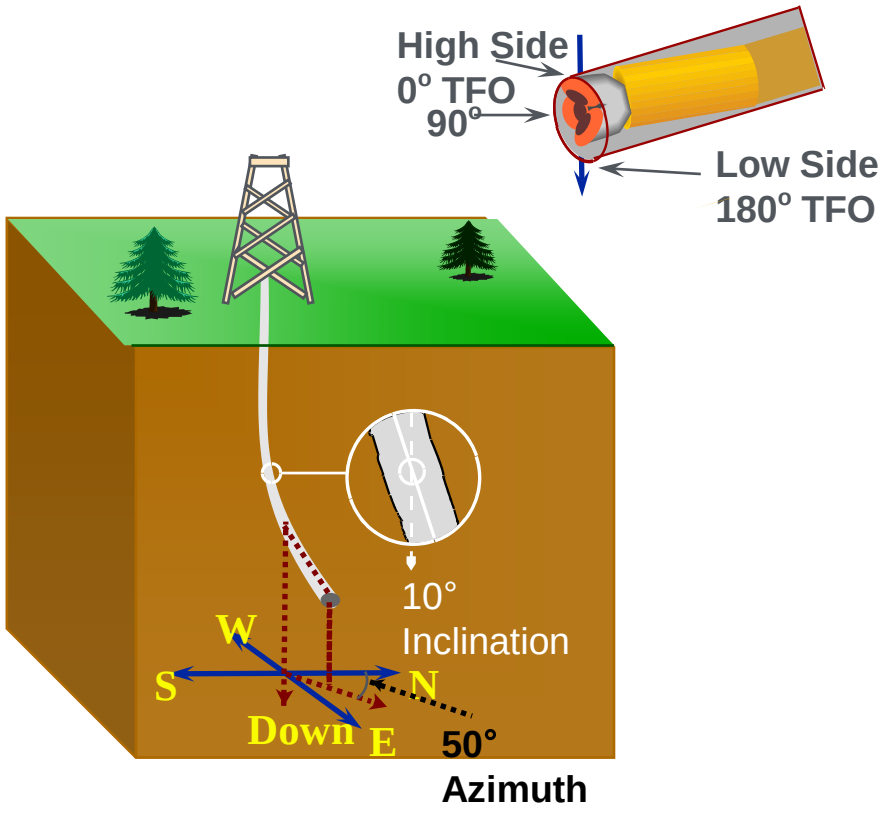




300ºC DDS + 300ºC MWD

Project Officer: Bill Vandermeer

Total Projects Funding: $6.25 MLN + $6.25MLN

April 24, 2013

Principal Investigator (always include)

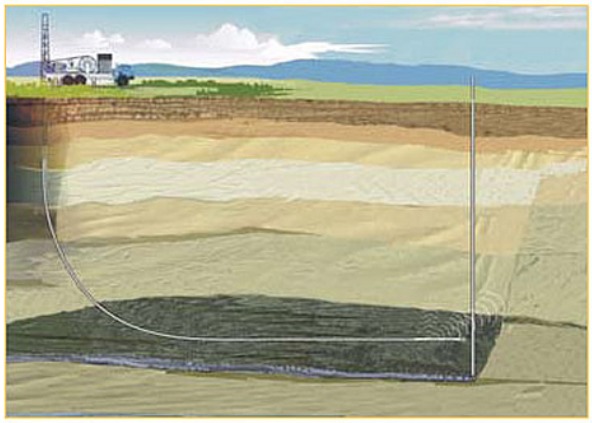
Aaron Dick and Jochen Schnitger

Baker Hughes

Track Name: EE0002782 + EE0005505

Relevance/Impact of Research (1/2)

- A directional drilling system (DDS; EE0002782) and directional measurement-while-drilling system (MWD; EE0005505) for geothermal applications will operate in hard rock at depths as great as 10,000 meters and temperatures as high as 300ºC.
- Enhancing productivity of EGS
  - Known
    - Geology
    - Local heat capacity
  - Design wellbore
    - Placement in the fractured system
    - Increase volume productive zones
  - Commercial DDS and MWD are functional up to 200ºC



From www.netl.doe.gov

- Aligned with GTP R&D goals:
  - Drilling systems: 3x faster rate of drilling than conventional rotary drilling, depths up to 10,000 meters and temperature up to 300ºC
  - Downhole tools: Depths of 10,000 meters and temperature up to 300ºC

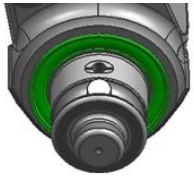
Relevance/Impact of Research (2/2)

- Components
  - Drill bit
  - Steerable motor
  - Drilling fluid / equipment
  - Telemetry device
  - Power module
  - Downhole electronics
  - Navigation instrument
- Impact
  - Combining tools of both projects will deliver a complete directional drilling system with MWD navigation, that is capable of 300ºC operating temperatures

300C Drill Bits

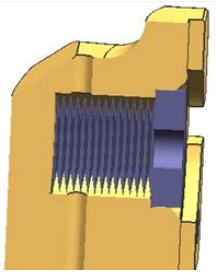
Cutting structure for EGS lithologies (AltaRock, Geodynamics)

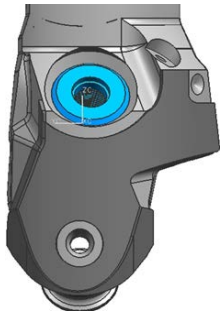
300C mechanical face seals



300C bearing grease

300C metal bellows grease pressure compensator





Scientific/Technical Approach

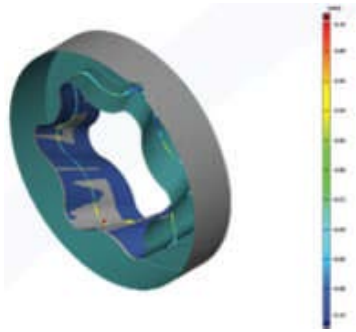
300C Directional Motor

Metal-metal rotor stator power section with wear-resistant coating system

300C flow diverter seals

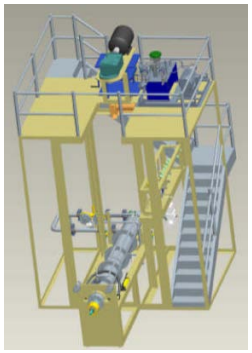
Flex shaft engineered for fatigue resistance

High-capacity diamond thrust bearings for high weight-on-bit hard rock drilling



New manufacturing methods

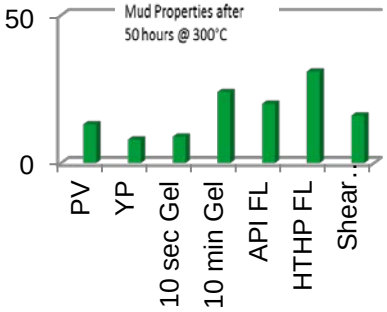
4¾-in. metal-metal motor flow loop test



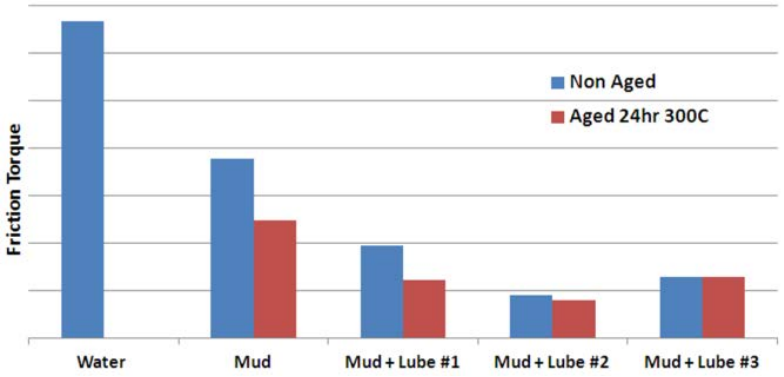
4¾-in. 300C test stand

300C Drilling Fluid

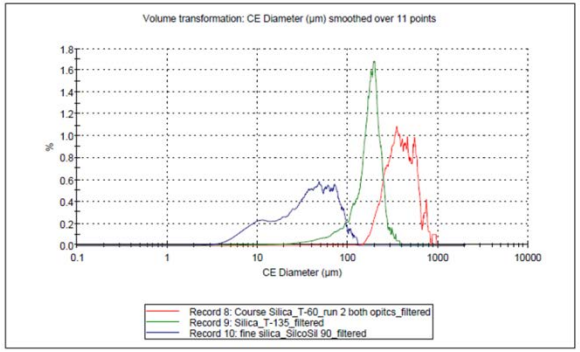
- Thermally stable drilling fluid aging @ 300℃



- Lubricant / Wear reduction – Increase motor run time

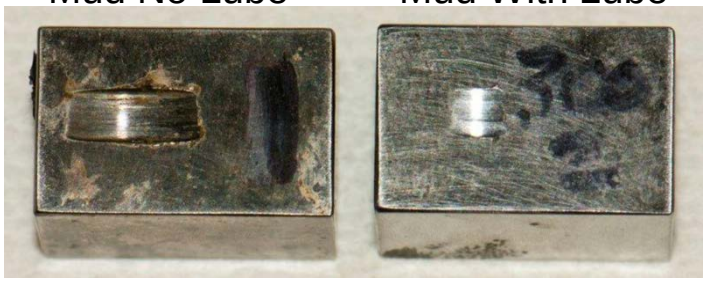


- Test fluids with abrasive particles for metal-metal motor coating tests

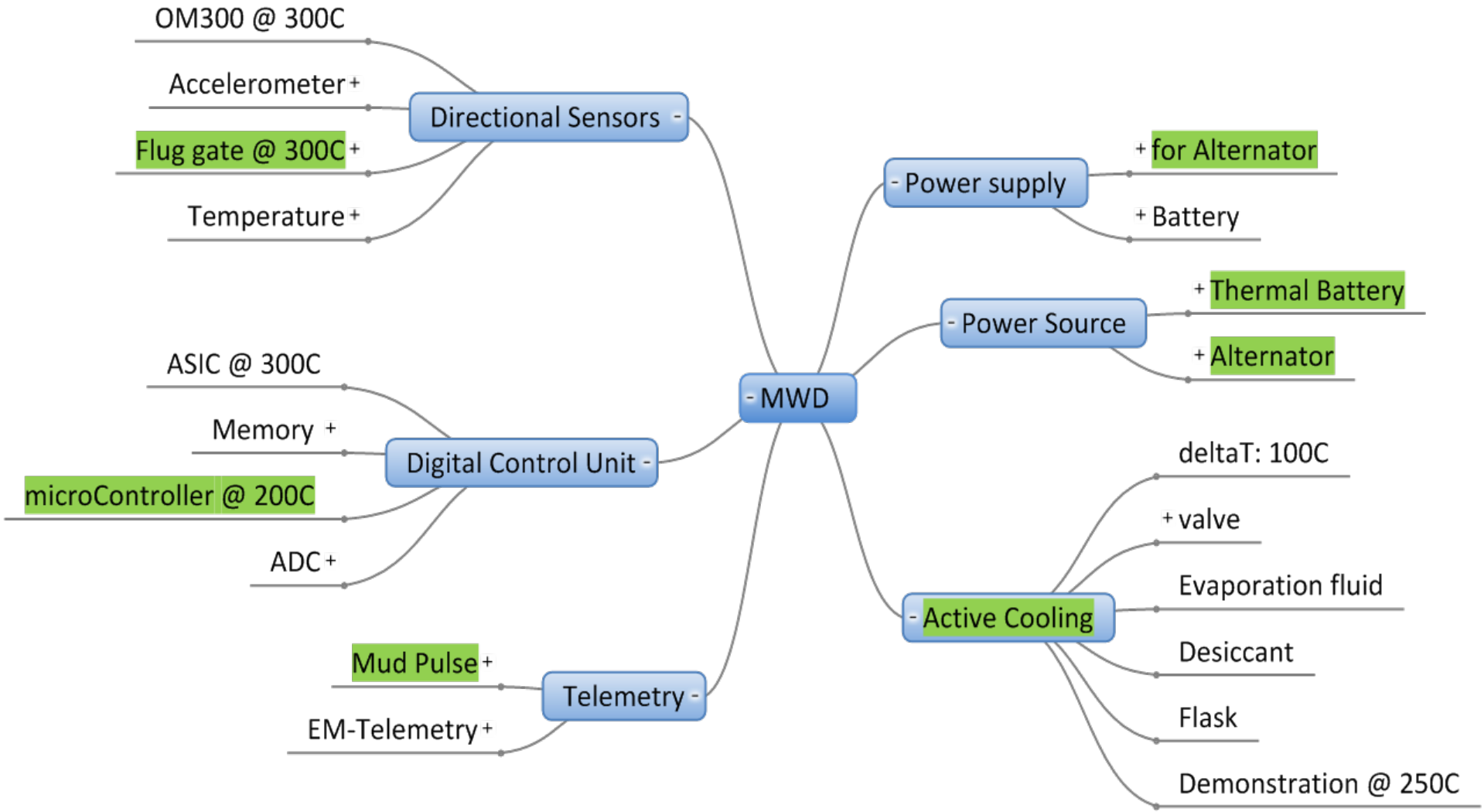


- Block on ring wear test

Mud No Lube Mud With Lube

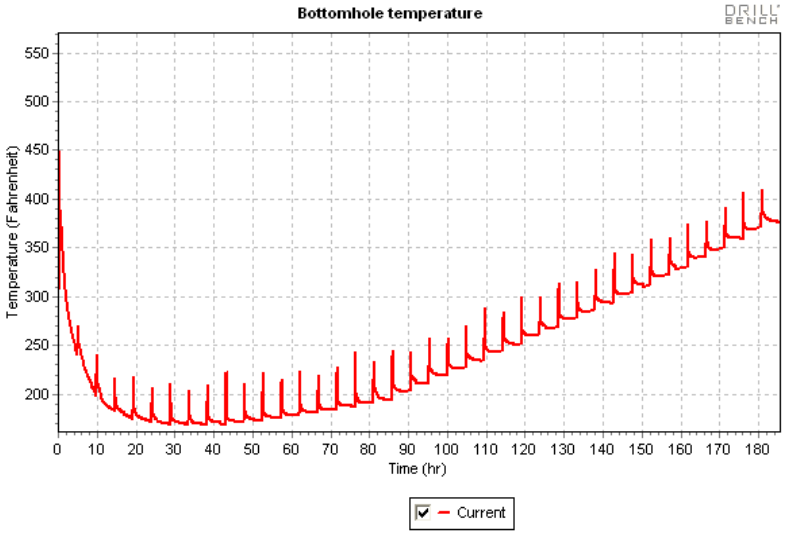


Scientific/Technical Approach



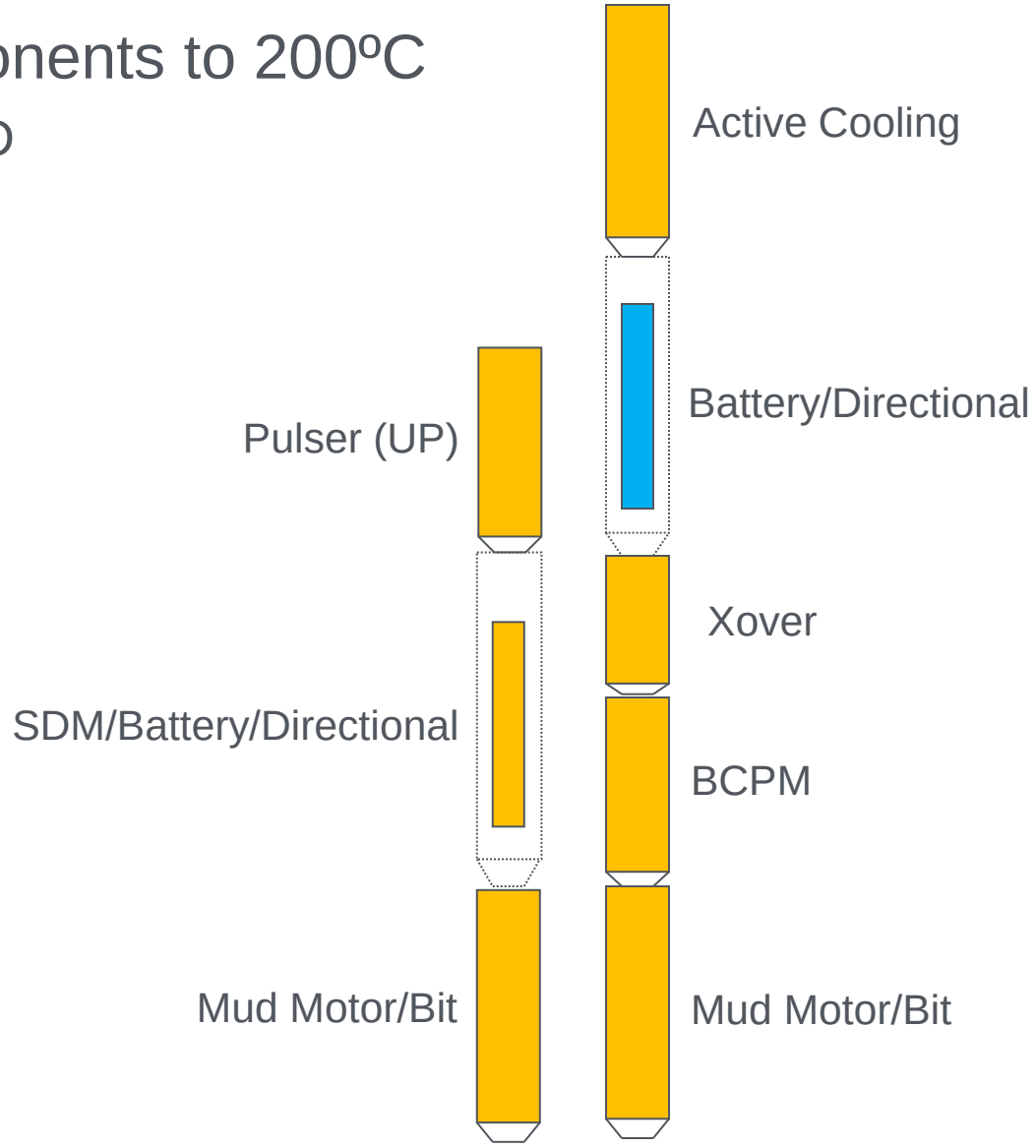
Scientific/Technical Approach

- Description of EGS environment
  - Lithology
    - Hard fractured rock strengthened by hydrostatic pressure
  - Temperature
    - Static formation temperatures to 325ºC (Newberry)
    - PresMod simulation of circulation temperature
    - Temperature at BHA
    - Temperature variation at BHA
- Evaluation of components
  - Data sheets
  - Independent tests
  - Development of demonstrators



Scientific/Technical Approach

- Cooled modules/components to 200ºC
  - Directional sensors, RTD
  - Digital control unit
  - (control valve)
- 300ºC modules
  - Telemetry
  - Power source
  - Power supply
  - Active cooling



Accomplishments, Results and Progress

Original Planned Milestone/ Technical Accomplishment	Actual Milestone/Technical Accomplishment	Date Completed
Directional Drilling System Phase 1 **Concept** (Bit, Fluid, Motor)	System concepts created for Newberry and S. Australia EGS	6/22/2011
Directional Drilling System Phase 2 **Design** (Bit, Fluid, Motor)	Designs created for Tricone and Kymera hybrid bits, metal-metal motor, drilling fluid with lubricant additive	Bits – 9/28/12 Motor – 12/14/12 Fluid - pending
Directional Drilling System Phase 3 **Manufacture** (Bit, Fluid, Motor)	Drill bits –fabrication started Motor – 4¾-in. fabricated and tested, 6¾-in. started Fluids – recipes created and priced out	Bits – started Motor – started Fluid - started
Directional Drilling System Phase 4 **Test** (Bit, Fluid, Motor)	BETA test site – well cased to granite basement rock for system test	

Accomplishments, Results and Progress

Original Planned Milestone/ Technical Accomplishment	Actual Milestone/Technical Accomplishment	Date Completed
MWD - Concepts for active cooling system	Concept with and without active cooling; cooling different sub-systems	
MWD - Evaluate and select directional sensors	300℃ – OM300; 200℃ to 230℃ accelerometers and flux gates	
MWD - Evaluate and select electronics for active Cooling	200℃ multi-chip modules; packaging; single components	
MWD - Concept and selection for active cooling system	In collaboration with GEBO and Lower Saxony program, critical components identified	
MWD - Identify power supply and Telemetry concept	Concept phase for EM and mud pulse; Test of thermal batteries; Alternator wiring	

No decision made. Overall system must have the lowest risk!

Future Directions

Directional Drilling System (Bit, Motor, Fluid)

- Jan 2013 – Aug 2013: Manufacture
  - Complete manufacture of 9 bits (April), 3 motors (August)
  - 300ºC motor test stand installed at Houston facility in June
  - Procure materials for fluid batches

- April 2013 – March 2014: System Testing
  - Drilling simulator test of bit + fluid in granite in April
  - System testing - Baker Hughes Experimental Test Area (BETA)
  - Identify suitable field test opportunity to directionally drill hot hard rock and execute test
  - Forensic evaluation of tools
  - Project conclusions and commercialization.

Future Directions

Measure While Drilling (MWD) Tool

- Evaluation of concepts
  - Design and Manufacture experimental systems
  - Test and evaluate experimental systems
  - Analyze concept
  - Perform peer review
- System
  - Telemetry – Mud pulse – servo amplifier
  - Telemetry – EM – driver of a high current
  - Power source – alternator – testing of mechanical integrity of windings
  - Power source – thermal batteries – operational handling
  - Active cooling – test at 250ºC – upgrade components to 300ºC
- Go/No-Go gate in January 2014
  - Instead of May 2013
  - Delayed patent waiver
  - Joint development agreements

Mandatory Summary Slide

- MWD
  - Sub components evaluated
  - Several design concept are developed
- Directional Drilling Tools (Bit, Motor, Fluid)
  - Manufacture phase started
  - 9 ea. 8½-in. diameter bits, 3 ea. 6¾-in. motors and fluid recipe complete in August
  - BETA system test in September

Project Management

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

DDS

Timeline:

Planned Start Date	Planned End Date	Actual Start Date	Current End Date
4/1/2010	4/30/2013	4/1/2010	9/30/2013

Budget:

Federal Share	Cost Share	Planned Expenses to Date	Actual Expenses to Date	Value of Work Completed to Date	Funding needed to Complete Work
$5,000,000	$1,273,000	$3,543,000	$3,663,000	$3,849,750	$2,567,000

MWD

Timeline:

Planned Start Date	Planned End Date	Actual Start Date	Current End Date
1/1/2012	12/31/2014	1/5/2012	4/30/2015

Budget:

Federal Share	Cost Share	Planned Expenses to Date	Actual Expenses to Date	Value of Work Completed to Date	Funding needed to Complete Work
$5,000,000	$1,250,000	$854,000	$354,474	$377,475	$5,993,000

- Keep/establish contact to EGS operators
- Collaboration with international funded programs
  - GEBO – Germany
  - Lower Saxony program – Germany
- Project delays
  - Receiving patent waiver in May 2012 / Kick off meeting in June 2012
  - Joint development agreements