

Well Construction and Reservoir Research Efforts of the United States Department of Energy National Laboratories



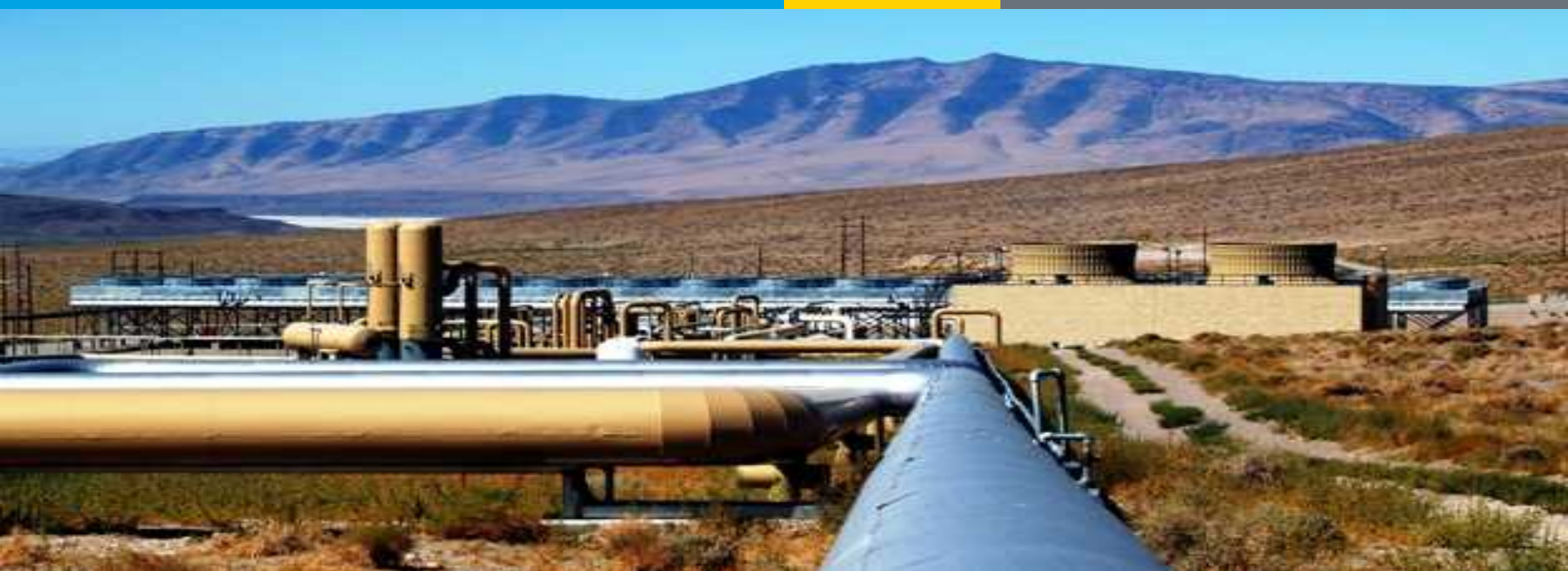
U.S.-Africa Geothermal Partnership Kickoff Meeting

September 28, 2014

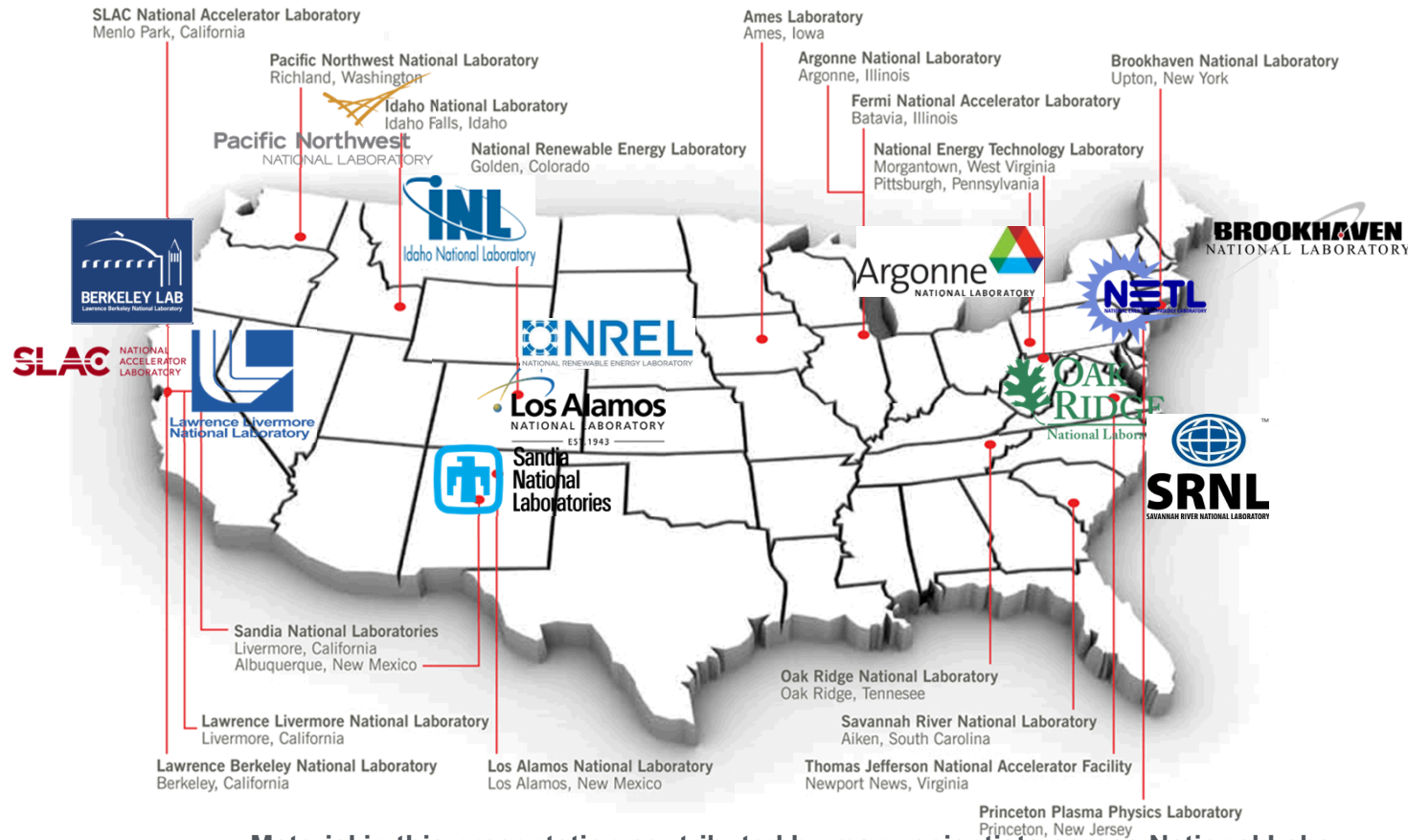
**Douglas Blankenship
Sandia National Laboratories**



Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.



- **Provide an overview of US DOE National Laboratory capabilities related to resource development**
- **Broad portfolio – Description necessarily incomplete**
- **Examples are provided but biased by presenter's area of understanding**

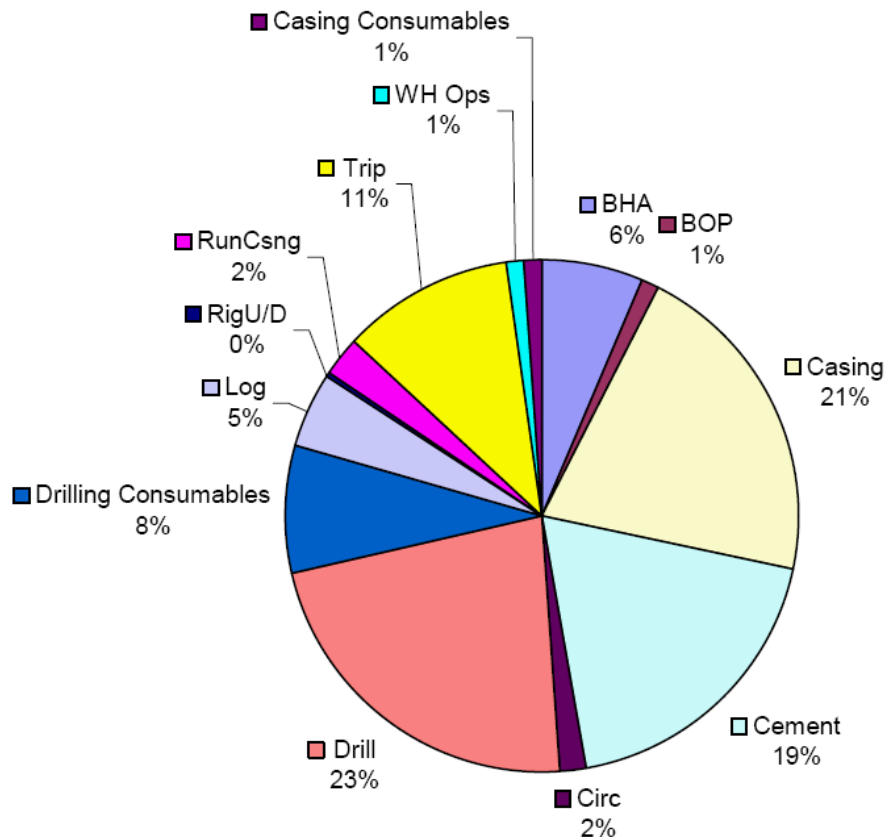


Material in this presentation contributed by many scientists across National Labs.

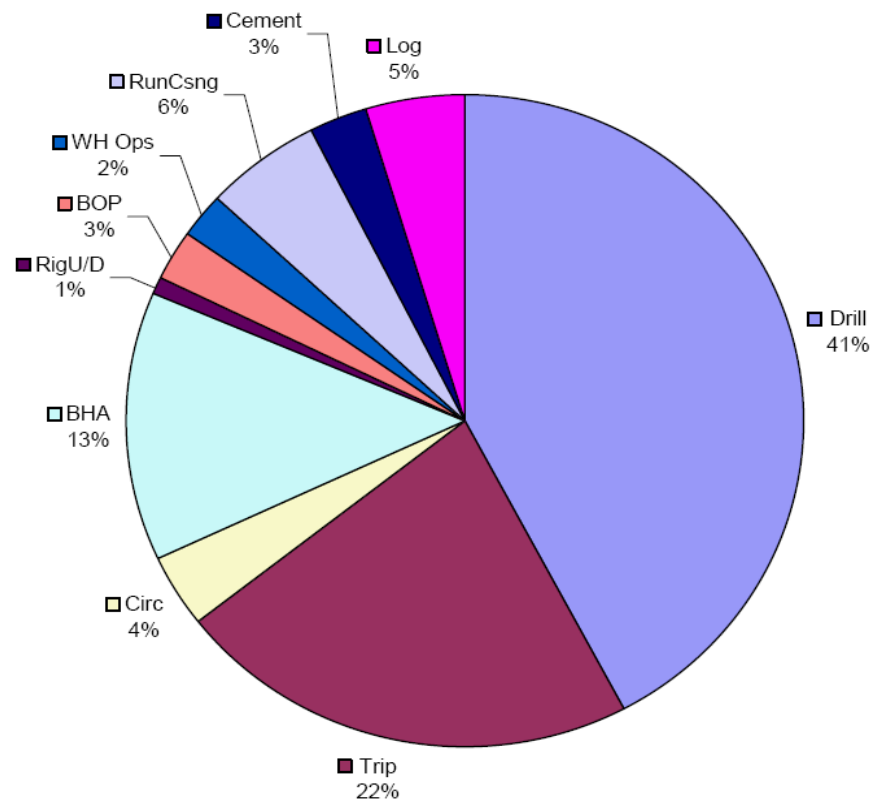
Mark Nutt (ANL); Martin Schoonen (BNL); Earl Mattson, Hai Huang (INL); Rajesh Pawar, Melissa Fox, Andy Wolfsberg (LANL); Susan Hubbard (co-lead), Curt Oldenburg (deputy), Jens Birkholzer (LBNL); Roger Aines, Jeff Roberts, Rob Mellors (LLNL); Charles Visser (NREL); George Guthrie, Grant Bromhal (NETL); Eric Pierce, Yarom Polsky (ORNL); Alain Bonneville, Dawn Wellman (PNNL); Gordon Brown (SLAC); Marianne Walck (co-lead), Doug Blankenship (deputy), Susan Altman (SNL); Lisa Oliver, Ralph Nichols (SRNL)

Well Construction

SAND2008-7866 (2008)



Well cost (%) breakdown by task.



Well construction task time percentages.

Well Constuction Research Portfolio Intended to Address Major Cost Drivers

- ☐ Pressure/Temperature Gradient Induced Drilling
- ☐ Wear-Resistant NanoComposite Coatings
- ☐ Field Trials of Drilling Systems
- ☐ HT Auto Indexers for DTHH
- ☐ HT Downhole Motors
- ☐ Casing Material Corrosion/Erosion Studies
- ☐ Multi-Function Cement For Geothermal Wells – Self Degrading and Expandable Cements
- ☐ Temporary Sealer to Address Fluid Loss
- ☐ Geopolymer Sealing Materials
- ☐ Drilling Cost Reduction Opportunities
- ☐ Controlled Rapid Wellbore Pressurization
- ☐ Advance Bit Deployment



Motor Evaluation

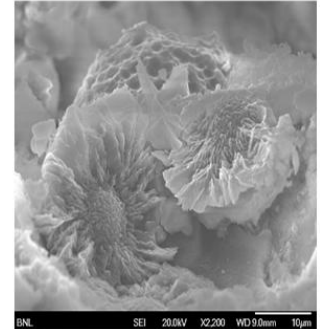


Down the Hole Hammer

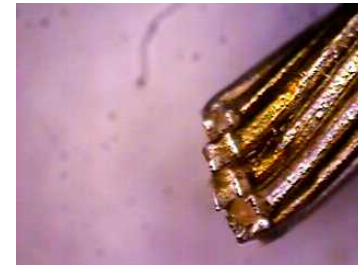


PDC Bit

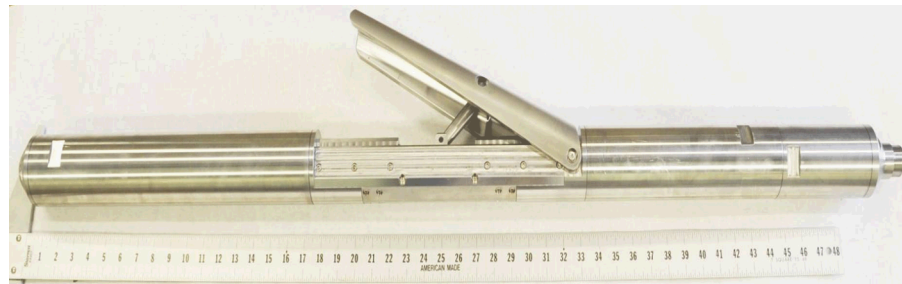
- ☐ HT MWD Components
- ☐ HT Borehole Seismic Monitoring Tool
- ☐ HT Fiber Optic Data Transmission System
- ☐ Distributed Acoustic Temperature Sensing
- ☐ MCM Development for HT Accelerometer Measurements
- ☐ SiC Sensor Technologies
- ☐ HT Circuit Boards
- ☐ HT Neutron Imaging
- ☐ Acoustic Sensors for Fluid Monitoring
- ☐ Far Field Downhole EM



SEM image for $\text{Mg}(\text{OH})_2$ crystal grown in the expanded alkali activated cement sealers



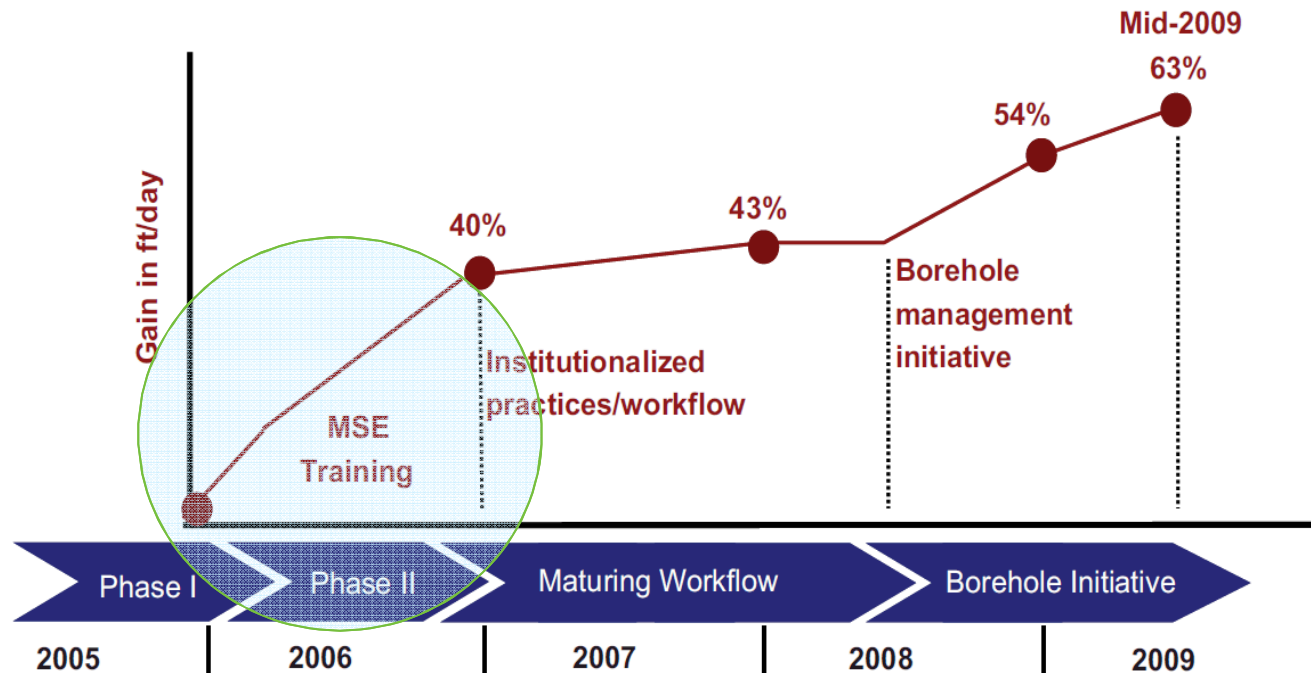
HT Solder Evaluation



HT Seismic

- Processes
 - Shell, “Drilling the Limit”
 - ExxonMobil, “FastDrill” / “Limiter Redesign”
 - 40% increase in ft/day in one year using drilling efficiency measures

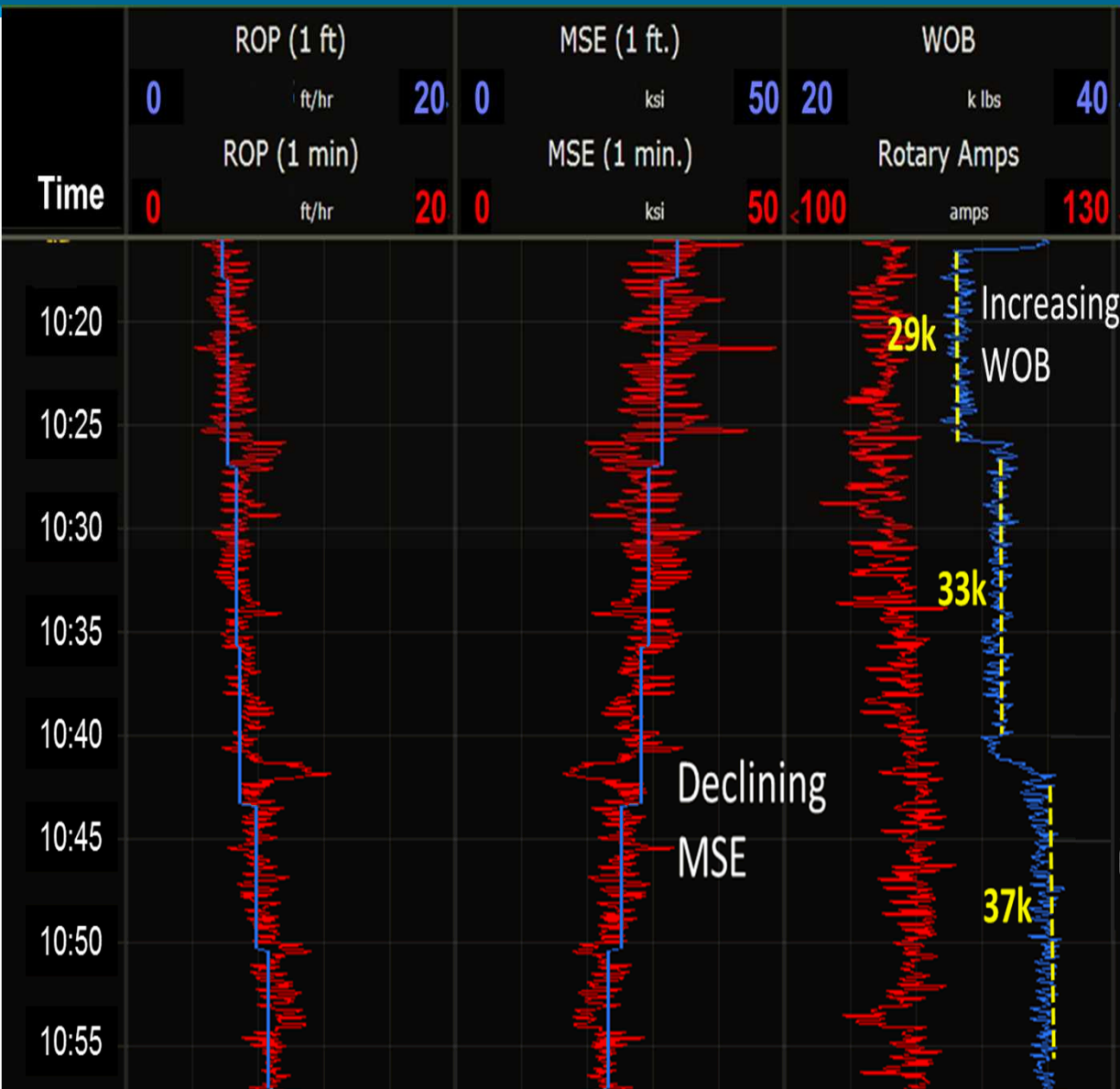
Dupriest F., et al.,
Borehole-quality design and drilling practices to maximize drill-rate performance, in SPE Annual Technical Conference and Exhibition 2011: Florence, Italy.



- ☐ Apply mature/proven rock penetration systems used in Oil & Gas/Minerals industry to improve geothermal drilling technology
- ☐ Partner with
 - ☐ Ormat Technologies
 - ☐ Navy Geothermal Program
 - ☐ Barber Drilling
 - ☐ National Oilwell Varco Reed Hycalog
 - ☐ Baker Hughes
- ☐ Doubled ROP and Reduced Costs with PDC Bits



Use Mechanical Specific Energy (MSE) to Maximize WOB – Geothermal Example

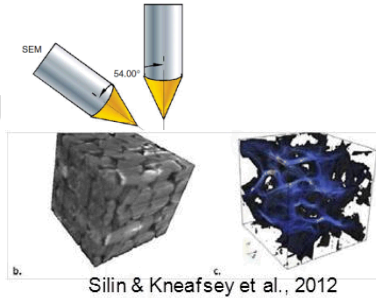


- **WOB step tests show declining MSE (reduce whirl).**
- **Workflow to maximize performance is to raise the WOB in steps:**
- **If MSE declines, continue raising WOB**
- **If MSE increases, stop and go the other way**
- **Run inclination survey at normal intervals, or when new WOB exceeds prior experience**

Reservoir Capabilities

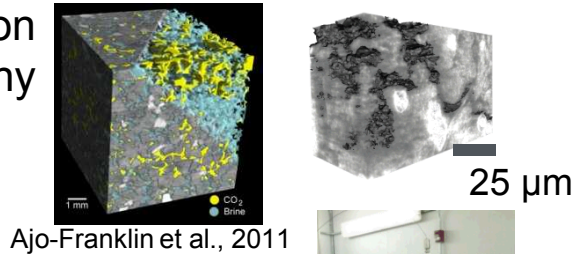
Capabilities related to Exploration and Production PETROPHYSICS

FIB/SEM imaging

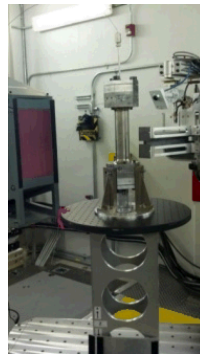


- Investigate heterogeneous rock responses to stress across scales
- Quantify stress/material property relationships and resulting effects on reservoir performance
- Improve interpretation of subsurface responses

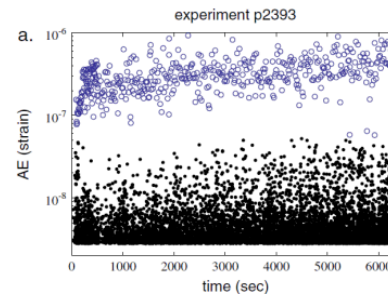
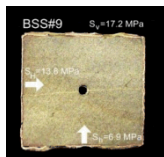
Synchrotron
microtomography



Neutron diffraction-
based strain
(Polsky, 2013)

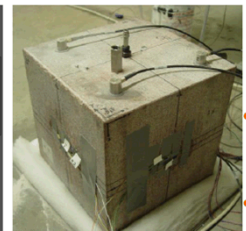
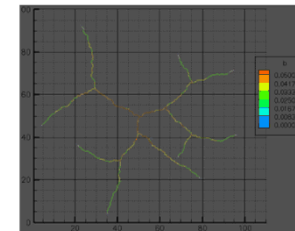


Triaxial
lab experiments
and associated
measurements



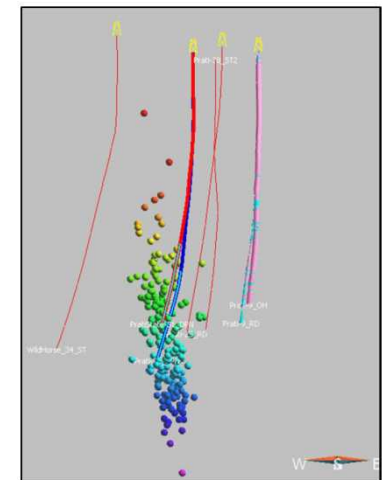
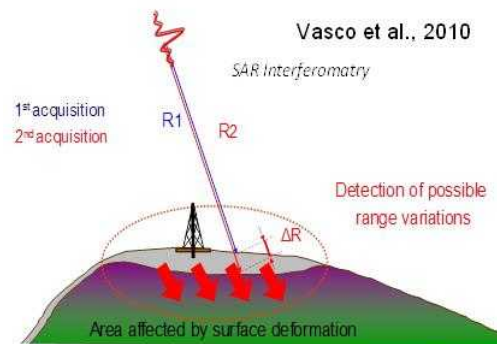
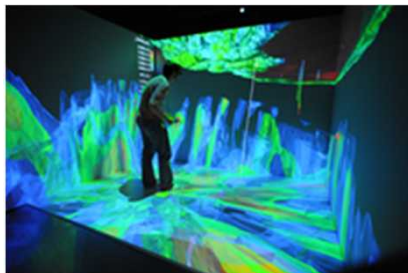
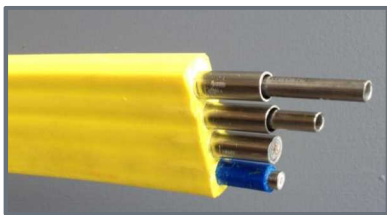
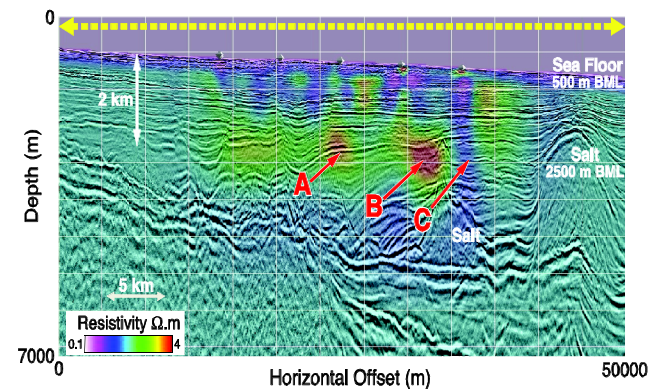
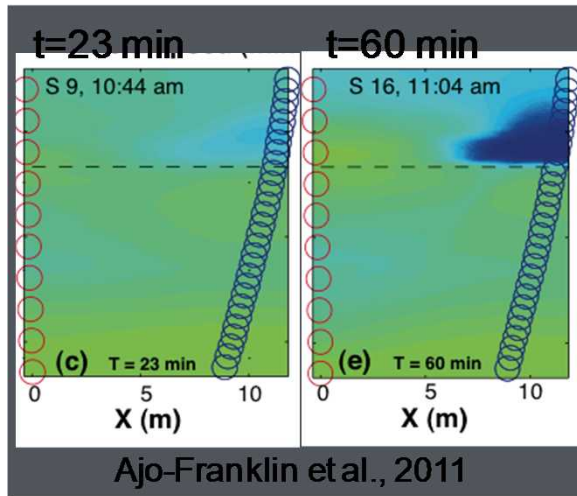
Acoustic emissions
Johnson et al., 2013

Medical CT
Scanners

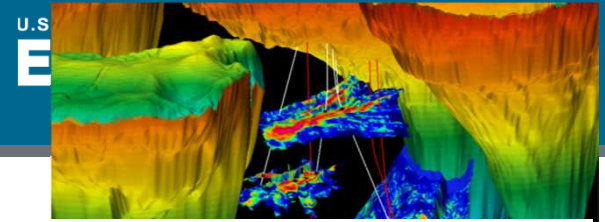


Block manipulations

- Many methods (including seismic, electromagnetic, InSar)
- New sensor developments (fiber optics, high temperature sensors)

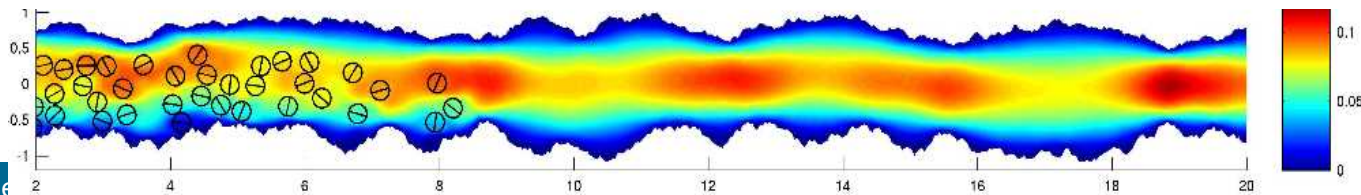


THMC SIMULATION CAPABILITIES

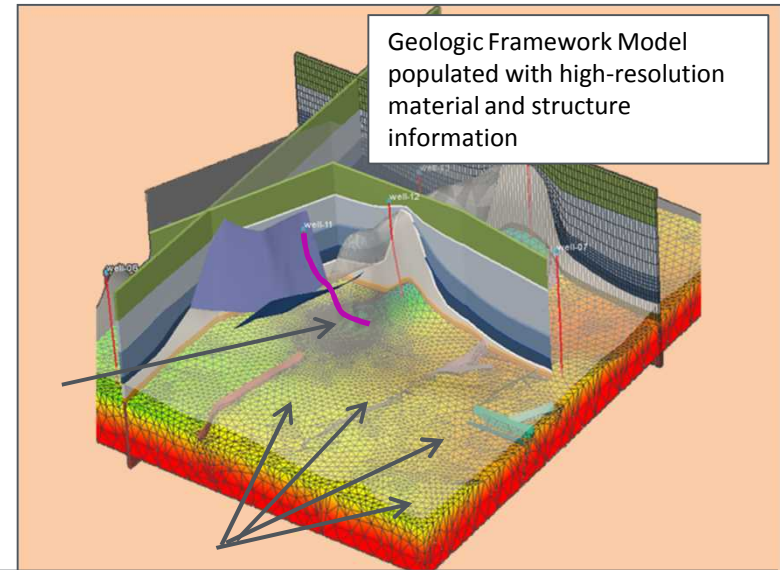
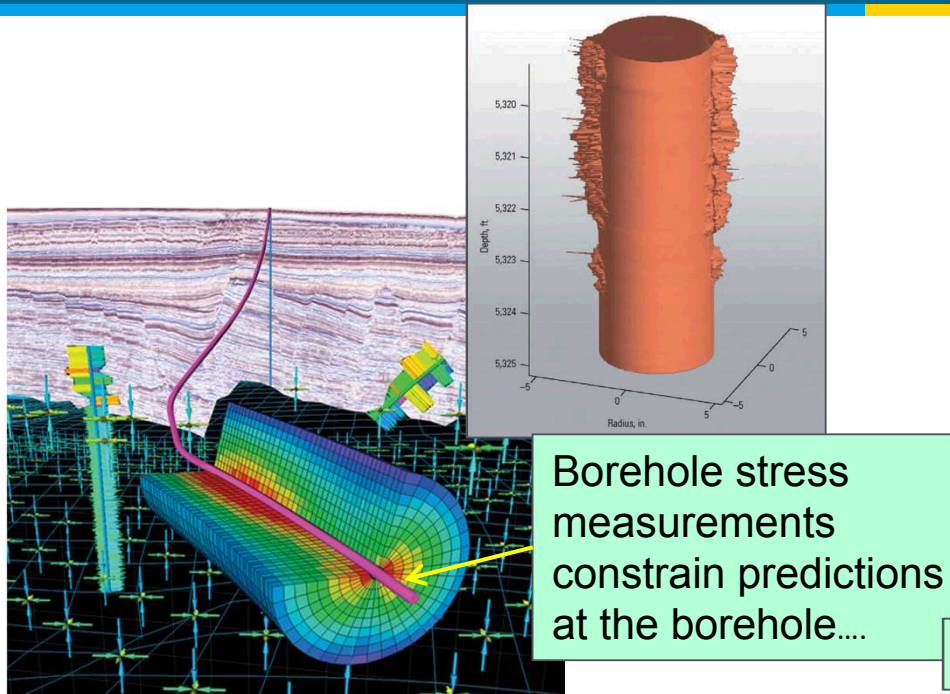


200 [THMC Simulation Capabilities](#)

Usability	Geomodel Construction Data Readers Meshing Property Mapping	Postprocessing Visualization Analysis Tools	
	Constitutive Models Rock Models Fluid Models Frac Propagation Criteria	Benchmarks Analytical Solutions Field Tests	
Physics			
Numerics	Discretizations Finite Element / Volume Mimetic Methods Boundary Element	Fracture Tracking Mesh Adaptation Embedded Discontinuities Static Mesh Methods	Coupled Solvers Multigrid / Multiscale Nonlinear Solvers
	Data Assimilation & Uncertainty Quantification Inverse Methods (Non-)Invasive UQ	High Performance Computing Load Balancing Hardware Tuning	

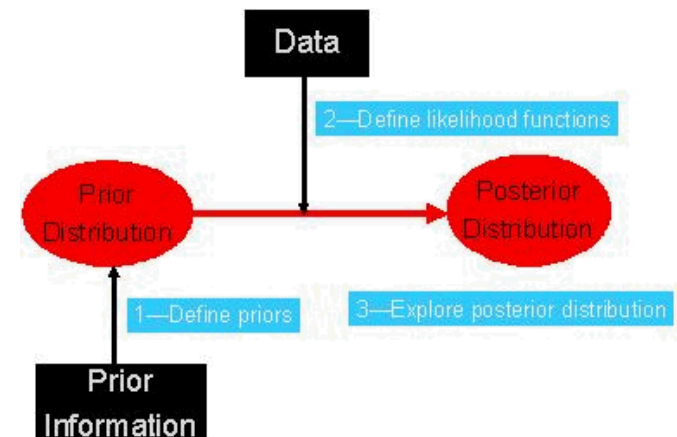


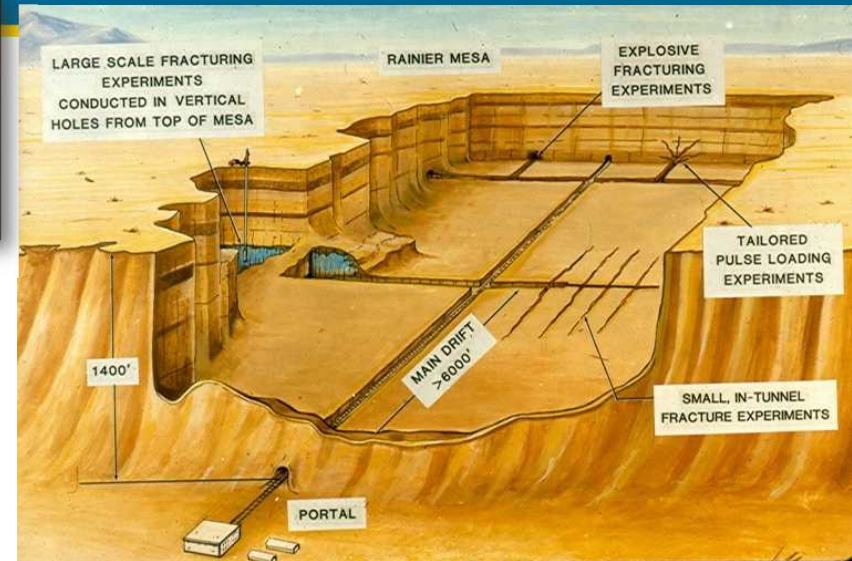
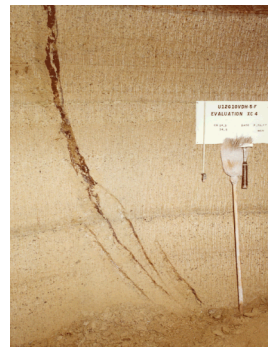
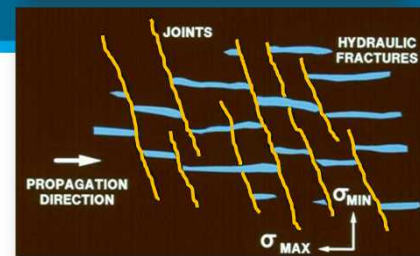
INTEGRATION & JOINT INVERSION



But stress estimates are needed here...

- Joint consideration of direct measurements, indirect measurements, knowledge of geologic framework, and theory
- Opportunity to estimate away from borehole, account for heterogeneities and inelastic behaviors, and to quantify uncertainty
- Needed to guide subsurface manipulations with confidence





- **Nevada Test Site, 1976-1985**
- Extensive characterization driven by coalbed methane:
 - Direct observation of fractures, cores, seismic, tiltmeters, geology



- **Multiwell Experiments, Rifle CO. 1981-1988**
- Stimulation experiments using 3 closely-spaced vertical wells to improve production from “tight” sands
- Results
 - Stress measurement techniques developed
 - Geology matters – extensive rock core collected
 - Fracture-height growth controlled by stress contrasts
 - Effectiveness of PDC bits for coring
 - Monitoring technologies initiated

Thank You