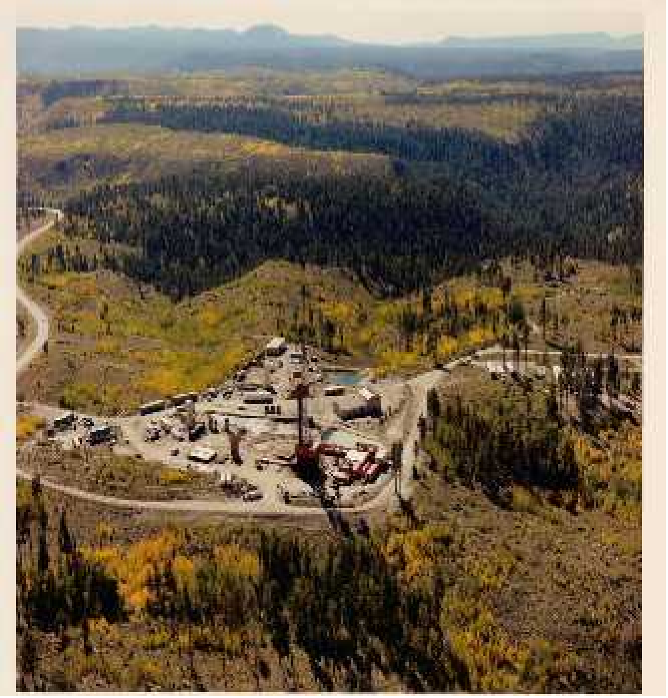
Geothermal Energy Research at Los Alamos National Laboratory Past, Present, and Future



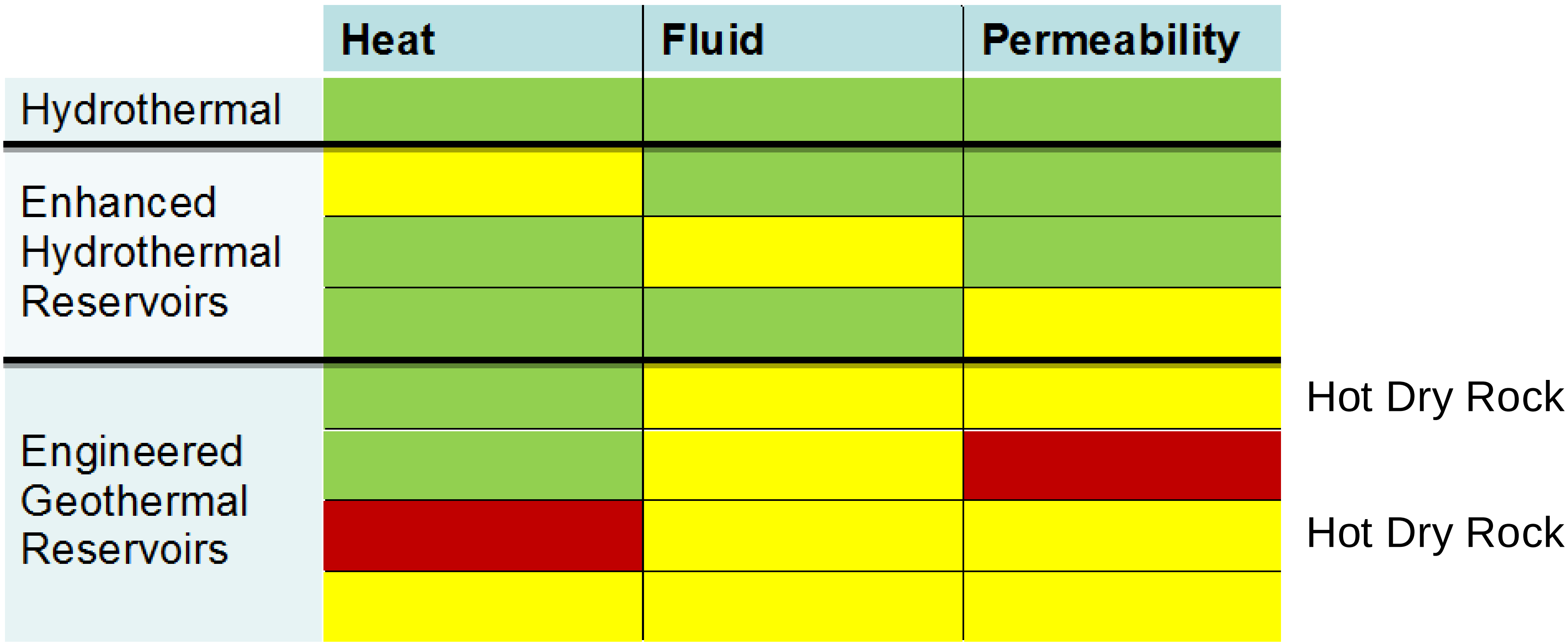
Presented by

Kenneth Rehfeldt

Los Alamos National Laboratory

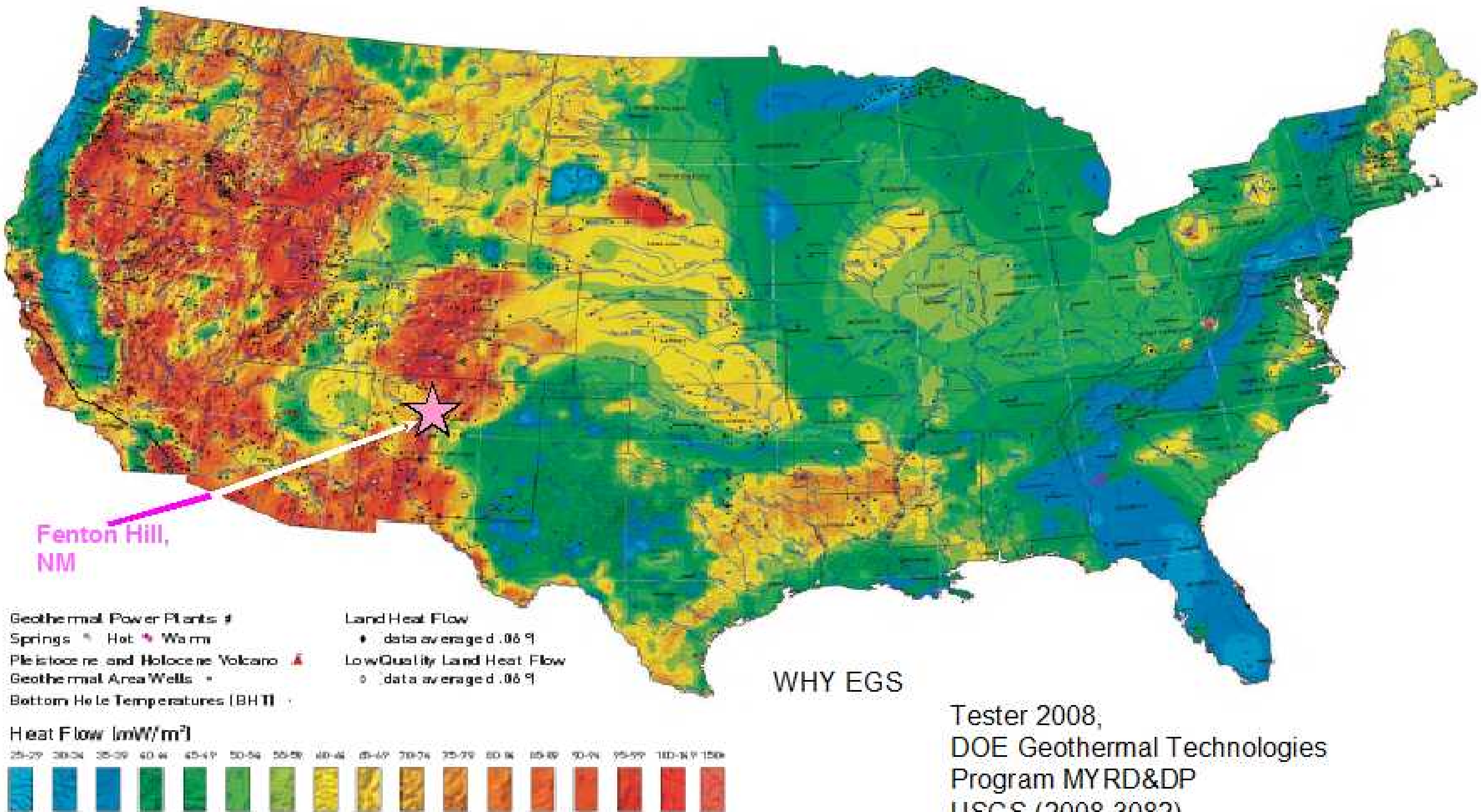
LA-UR 09-07406

Definitions – Geothermal Reservoirs



Permeability is generally in joints and fractures, working fluid can be water or CO_2

Geothermal Gradient Map of the USA



SMU Geothermal Lab, Geothermal Map of United States, 2004

WHY EGS

Tester 2008,
DOE Geothermal Technologies
Program MYRD&DP
USGS (2008-3082)

(mean electric generation potential [MWe])
Known hydrothermal ~9,000
New (unknown) hydrothermal ~30,000
EGS ~ 520,000

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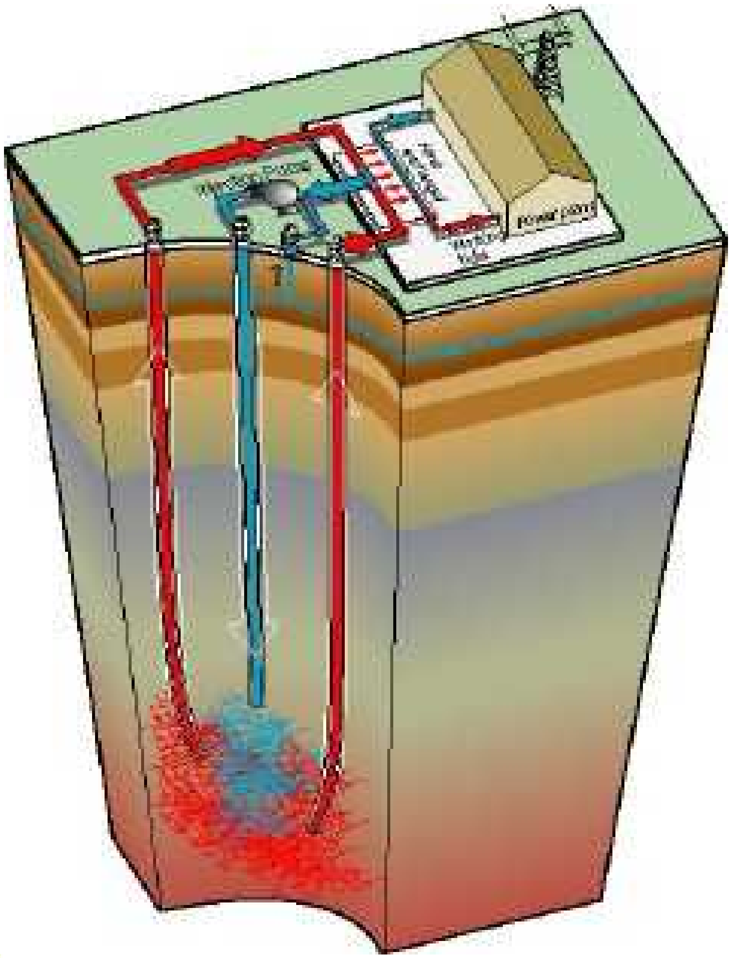
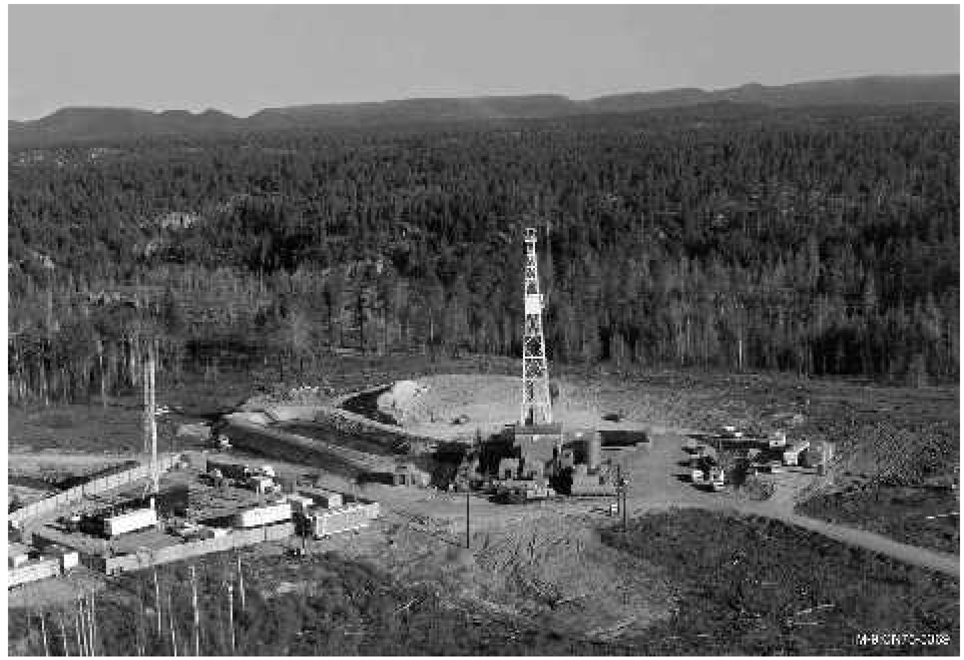
Earth & Environmental Sciences

Fenton Hill HDR : 1970 to 1995

World's First Demonstration of an EGS Reservoir





Outside the Valles caldera
Intact crystalline bedrock

Fenton Hill Reservoirs

	Depth (km)	**Temp** (^{o}C)	**Volume** (m3) (modal volume)	**Energy** (MWt)	**Thermal drawdown** (^{o}C)	**Water loss** (%)
Phase I	**2-3**	**180-200**	**~2.5E05**	**3**	**3-5** (after 200 days)	**7**
Phase II	**3.5-4**	**235-265**	**~2.0E07**	**4** (10@15 d)	**None** (after 115 days)	**7** (declining)

Sponsor: DOE

Collaborators: Japan, Germany

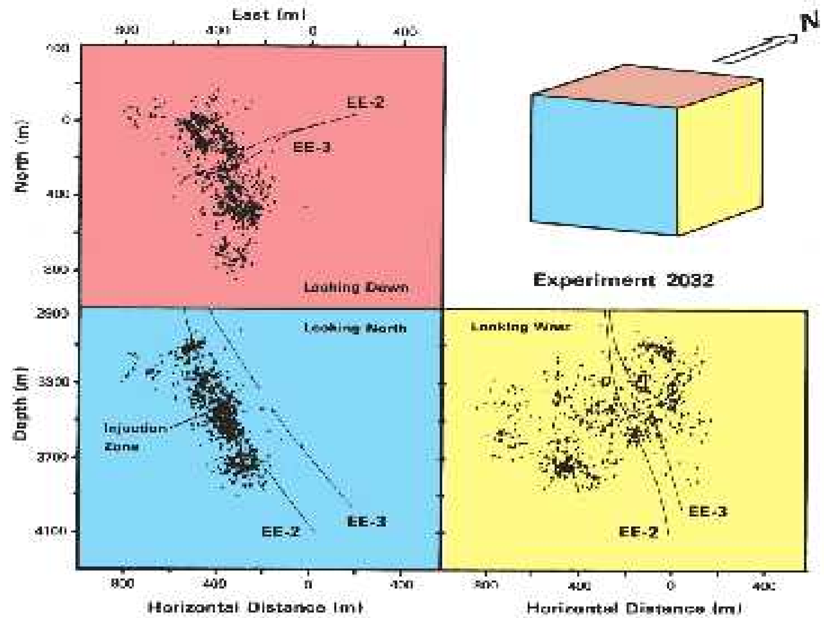
Confined reservoirs

Benign hydrochemistry

No adverse seismicity at the surface or subsurface

Selected Lessons Learned from the Fenton Hill Hot Dry Rock Experiments

- **The systematic process that should be used in developing HDR reservoirs is to drill and stimulate one well first, with downhole monitoring of microseismic events to map fractures, then drilling the subsequent wells to intersect the created reservoir**
- **Site selection is critical for HDR – low permeability, confined**
- **Two upcoming summary reports**
  - **Hot Dry Rock Geothermal Development Program Final Report for Years 1970 – 1995 (LANL)**
  - **Mining the Earth's Heat: Hot Dry Rock Geothermal Energy (Brown, Duchane, Heiken, and Hriscu)**



- Microseismic detections

Reservoir is elongate and grows off the ends

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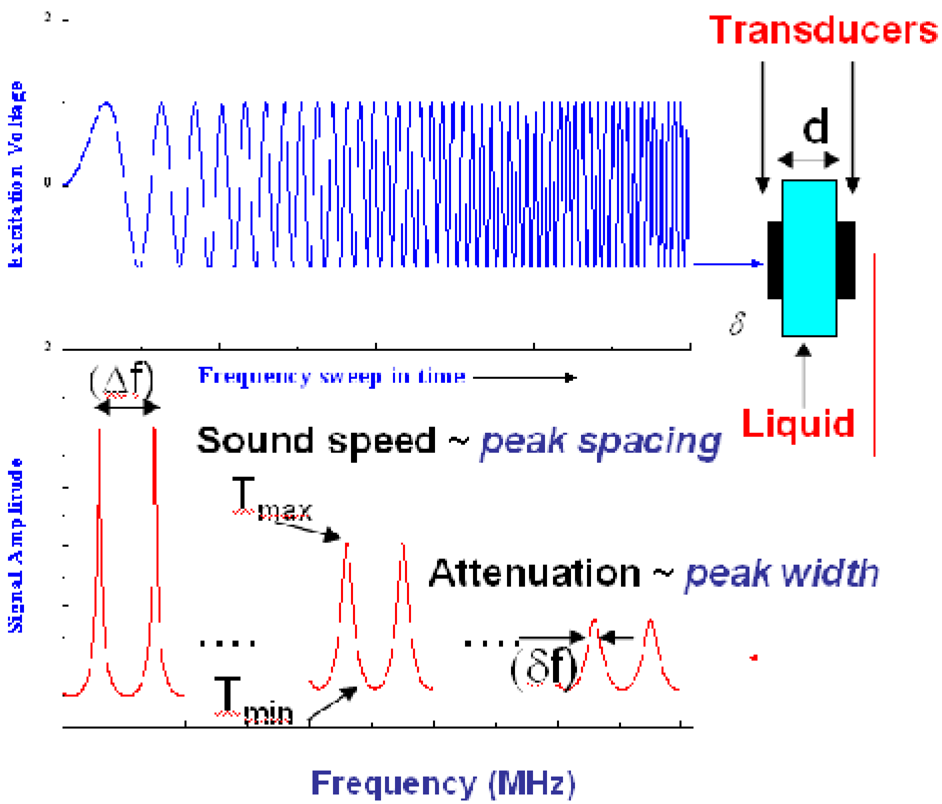
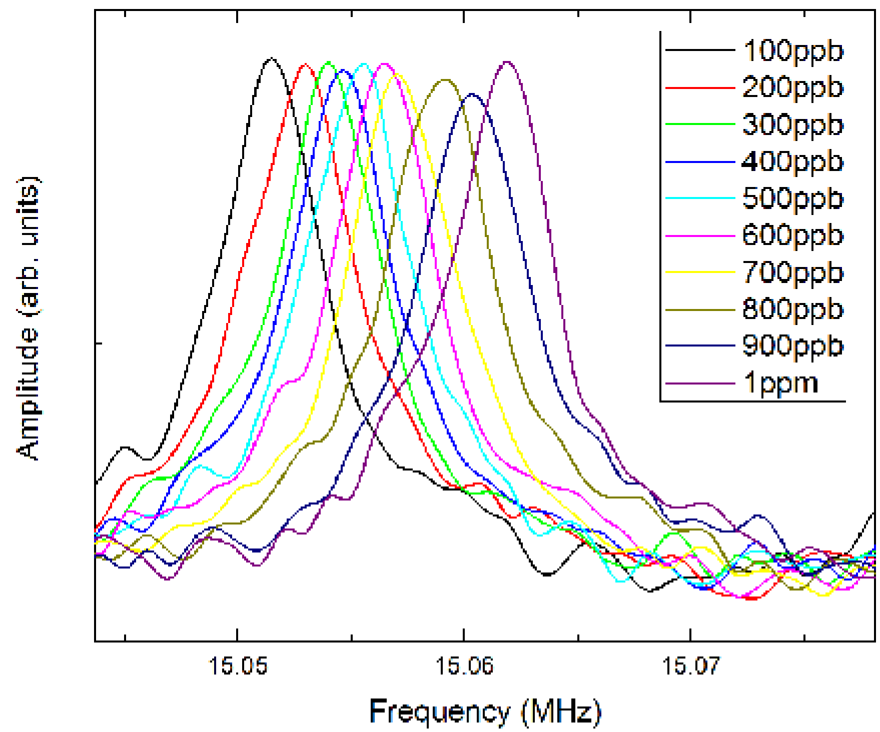
High Temperature Downhole Tool Multipurpose Acoustic Sensor

Swept Frequency Acoustic Interferometry (SFAI)

Provides data on fluid composition, temperature, pressure, viscosity, and fluid flow





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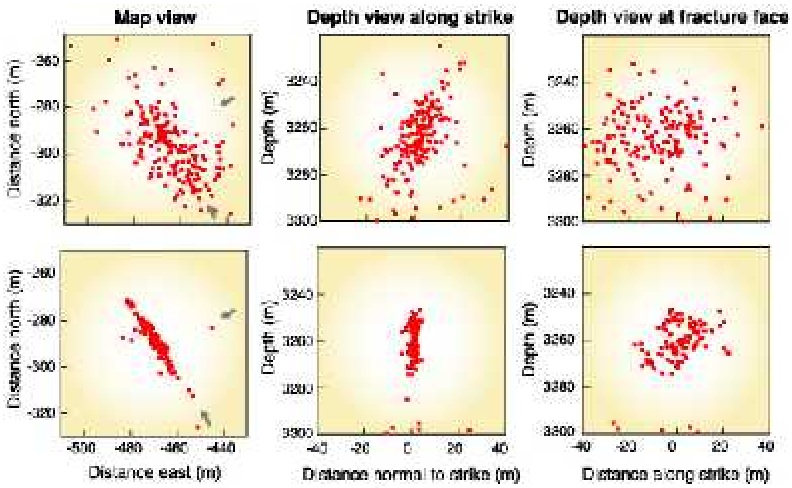
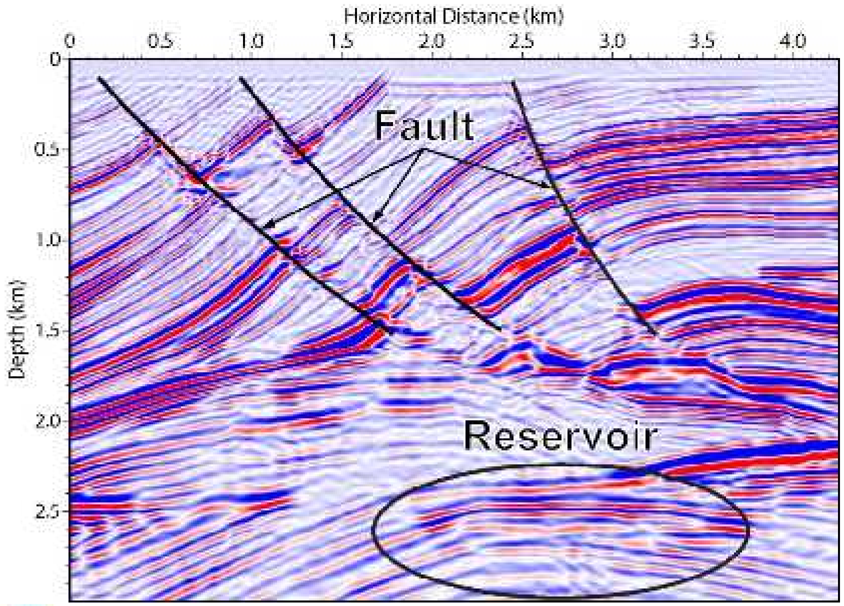
Subsurface Imaging





- High-Resolution Passive and Active Geophysical Imaging
  - Image fracture and fault zones
  - Assess microseismic source mechanism
  - Detect flow and temperature distribution
- Integration of imaging with reservoir modeling to enhance flow characterization and prediction
- Teamed with LBL, MIT, NETL, Chevron, Ormat

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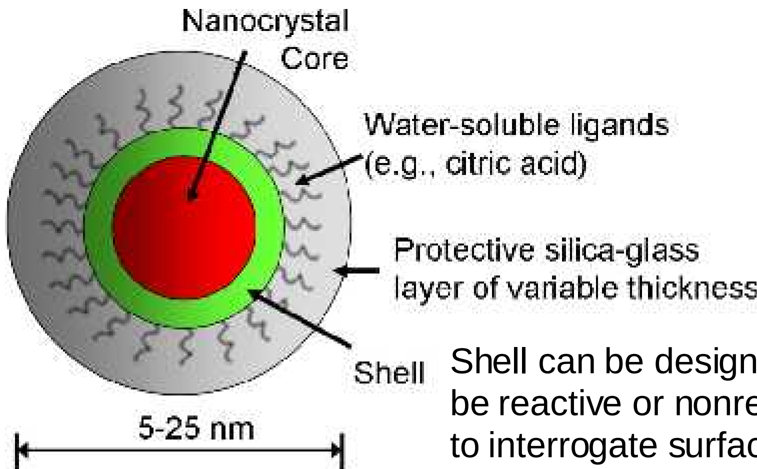
Smart Geothermal Tracers

Quantum-Dot Nanocrystal Tracer



Shell can be designed to be reactive or nonreactive to interrogate surface area

(teamed with University of Utah)

Temperature-Indicating Tracer

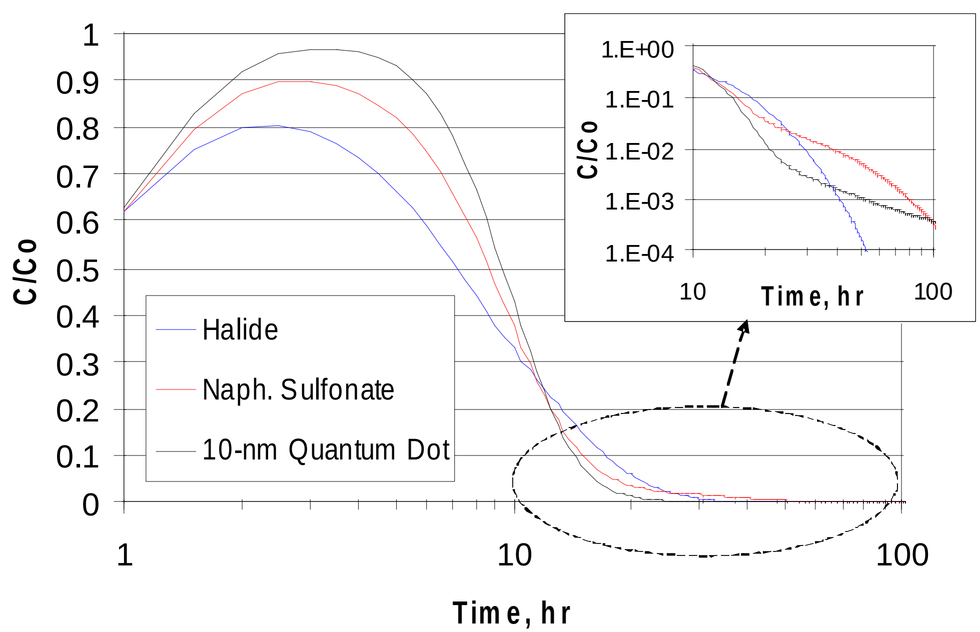
Example of Fracture Surface Area Interrogation in a Single-Well Tracer Test

Perfluorinated Hydrocarbon (PFH)

Smart shell degrades at specified temp and releases thermally-stable nonreactive tracer to indicate temp has been reached. PFH's have extremely low detection limits

Shell designed to degrade at temp

(teamed with NETL and BNL)



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Pueblo of Jemez

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Indian Springs geothermal well and Jemez students, Earth Day 2009

- Assist the Pueblo to expand resource
  - Geology (structurally complex)
  - Geophysics (seismic, gravity, electrical)
  - Well testing and formation characterization (tracers, VSP)

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(teamed with Pueblo of Jemez, New Mexico Bureau of Geology and Mineral Resources, University of Utah, Montana State University, University of Pittsburg)

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Future Areas

- FEHM (finite element heat and mass) enhancements to include mechanical deformation as a function of P and T
- Seismic triggering (dynamic and static) collaborating with other national laboratories and the USGS