



Sandia
National
Laboratories

Exceptional service in the national interest

SAND2018-8267PE



GEOMECHANICS R&D IN SANDIA NATIONAL LABORATORIES

Moo Lee



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SAND

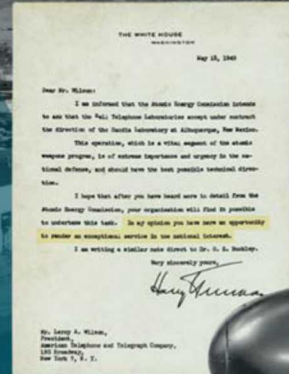


SANDIA NATIONAL LABORATORIES OVERVIEW

SANDIA'S HISTORY IS TRACED TO THE MANHATTAN PROJECT

...In my opinion you have here an opportunity to render an exceptional service in the national interest.

- July 1945
Los Alamos creates Z Division
- Nonnuclear component engineering
- November 1, 1949
Sandia Laboratory established
- AT&T: 1949–1993
- Martin Marietta: 1993–1995
- Lockheed Martin: 1995–2017
- Honeywell: 2017–present



SANDIA HAS FACILITIES ACROSS THE NATION



Activity locations

- Kauai, Hawaii
- Waste Isolation Pilot Plant, Carlsbad, New Mexico
- Pantex Plant, Amarillo, Texas
- Tonopah, Nevada

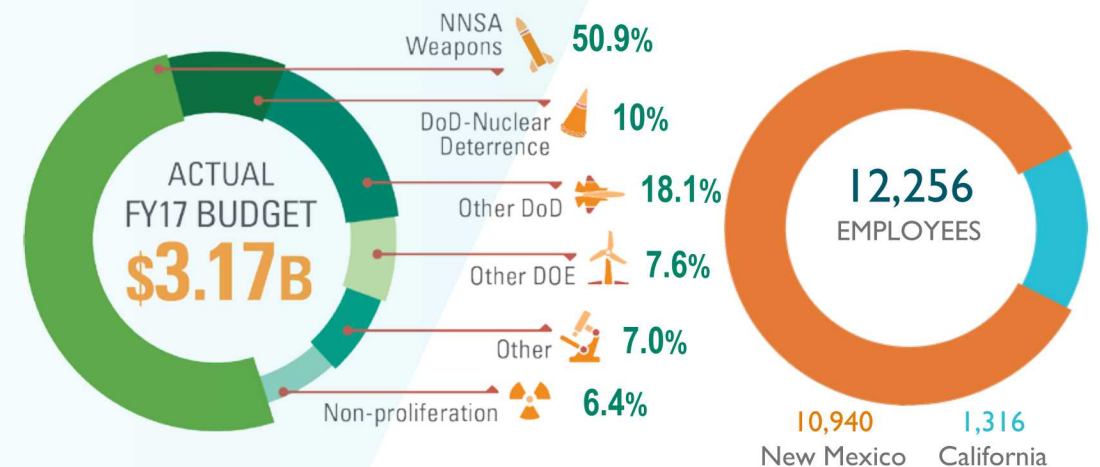
Main sites

- Albuquerque, New Mexico
- Livermore, California

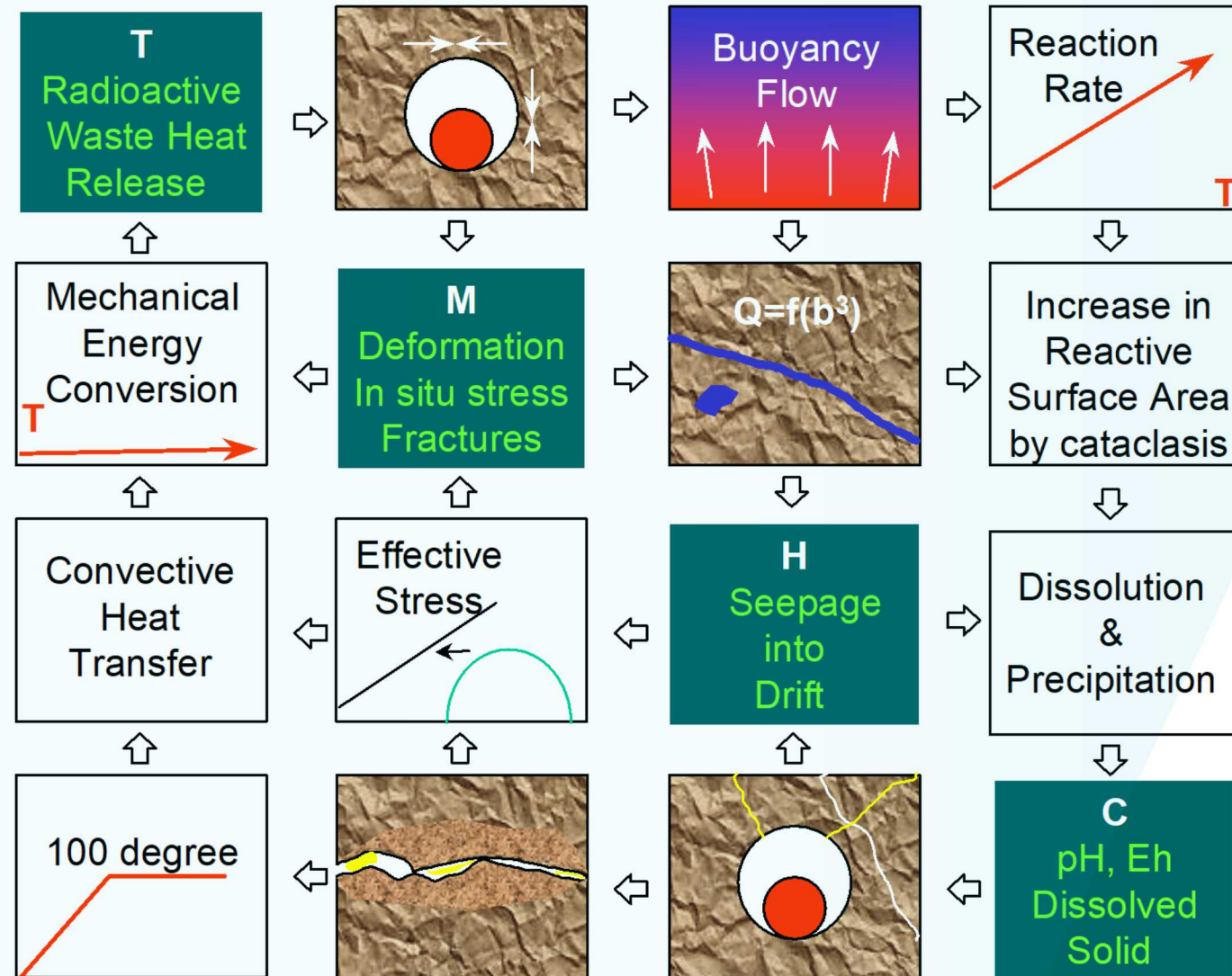
SANDIA ADDRESSES NATIONAL SECURITY CHALLENGES



SANDIA'S BUDGET and WORKFORCE



COUPLED MECHANISMS IN HIGH LEVEL WASTE REPOSITORY ROCK





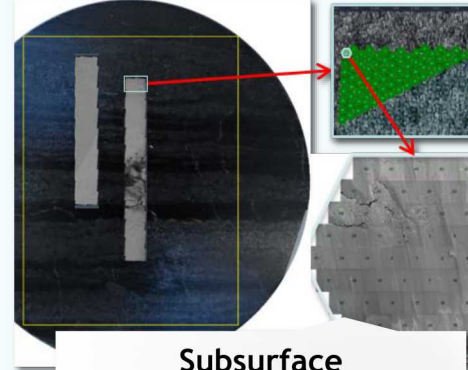
GEOSCIENCE RESEARCH & APPLICATIONS



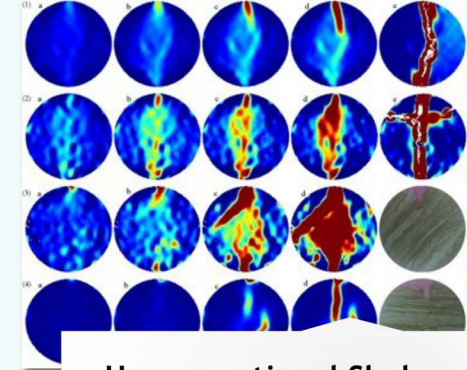
Yucca Mountain Project



Waste Isolation Pilot Plant



Subsurface
Characterization &
Engineering

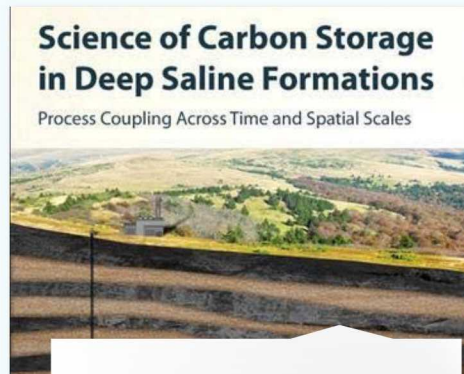


Unconventional Shale
Science



National Emergency
Responses

Columbia Accident, 2003
Deep Water Horizon, 2010
Aliso Canyon Gas Leak, 2015



Science of Carbon Storage
in Deep Saline Formations

Process Coupling Across Time and Spatial Scales

CO₂ Sequestration



Drilling Technology &
Downhole Tools

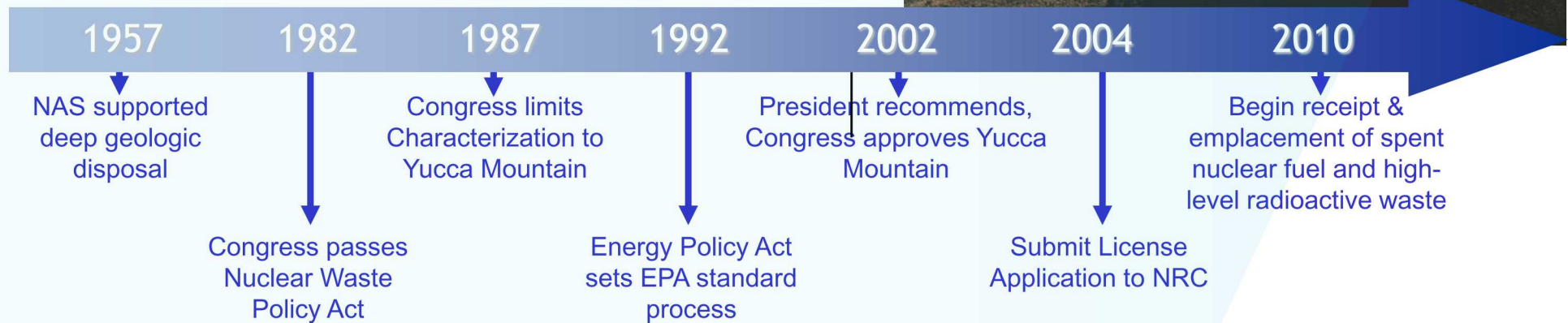


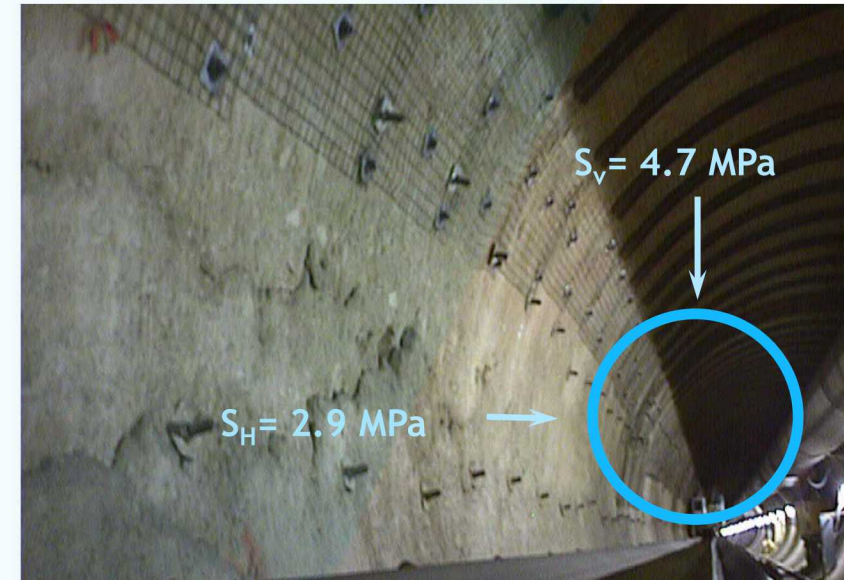
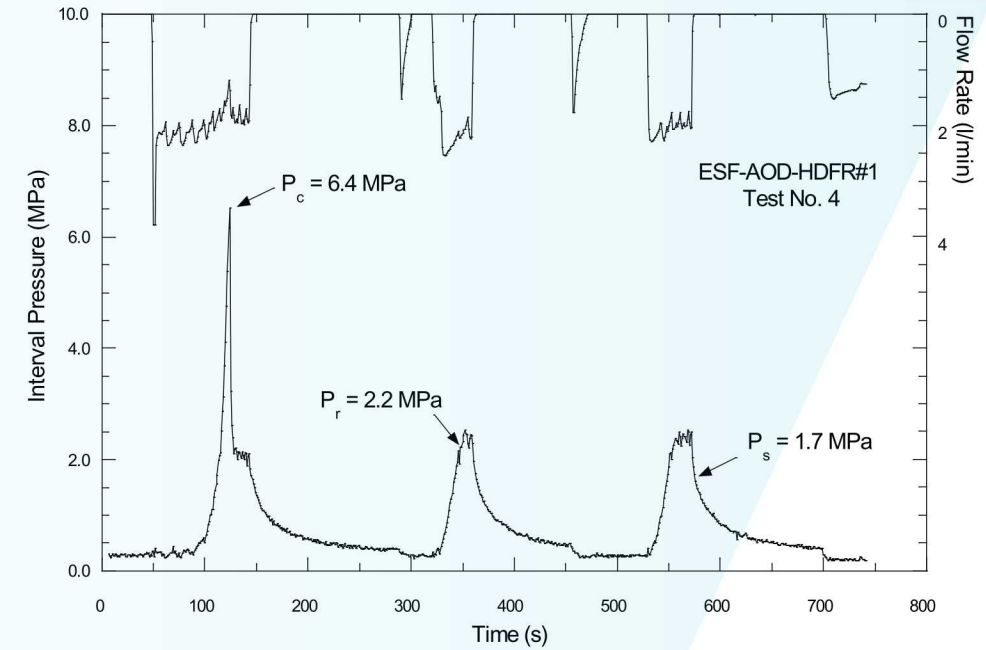
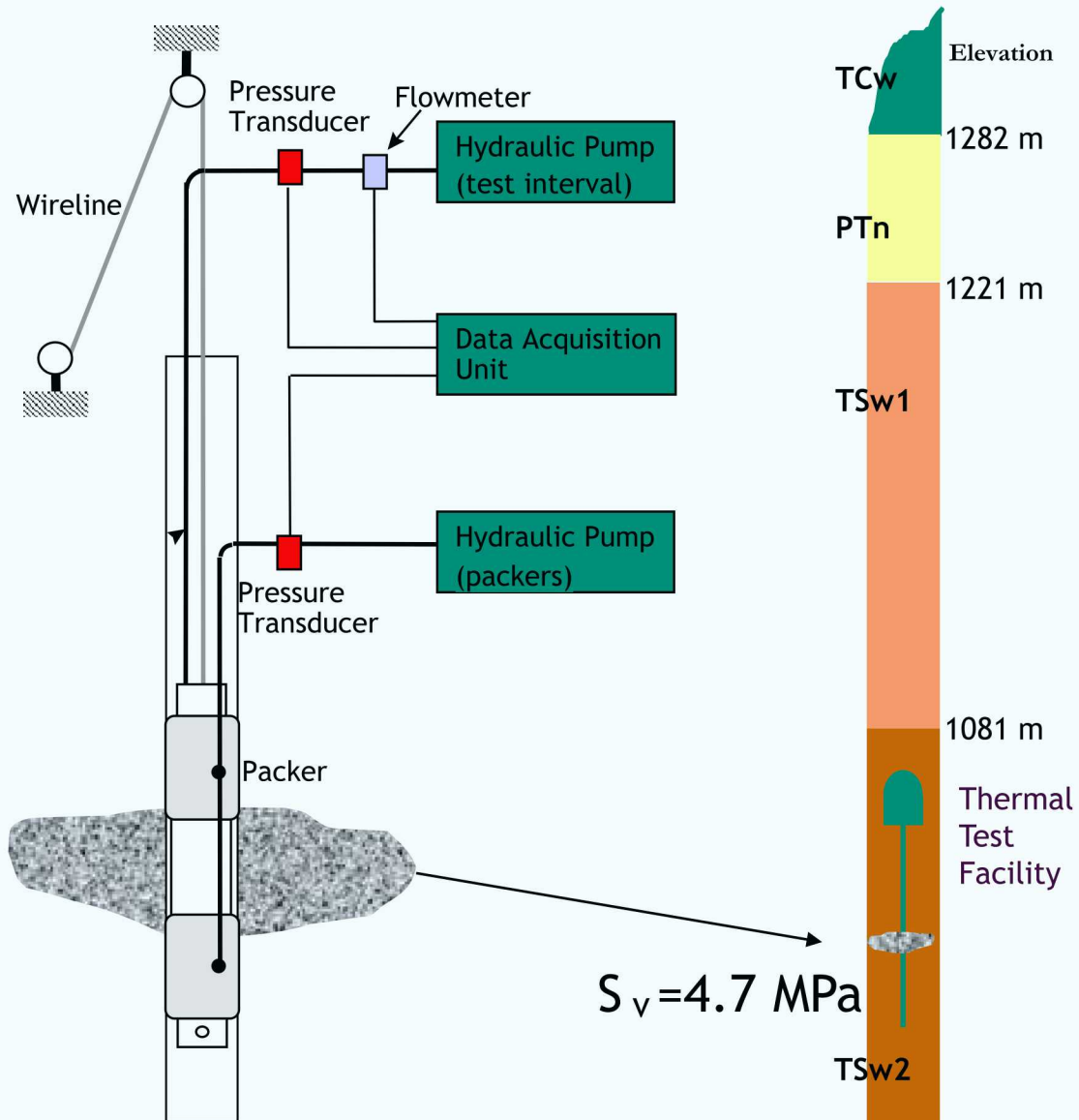
Strategic Petroleum
Reserve

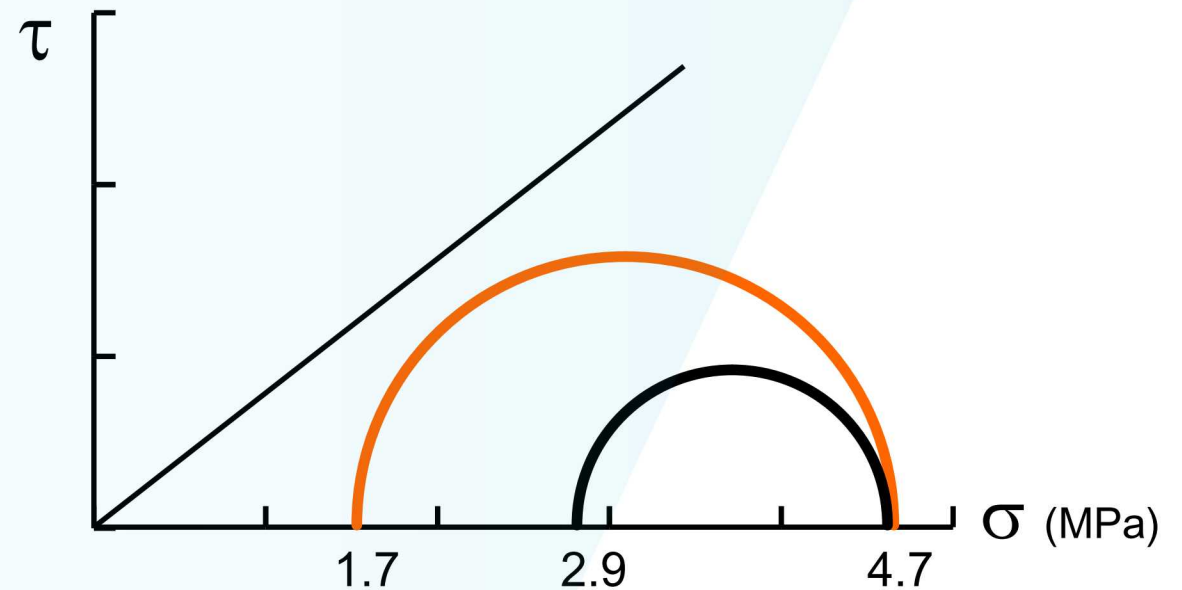
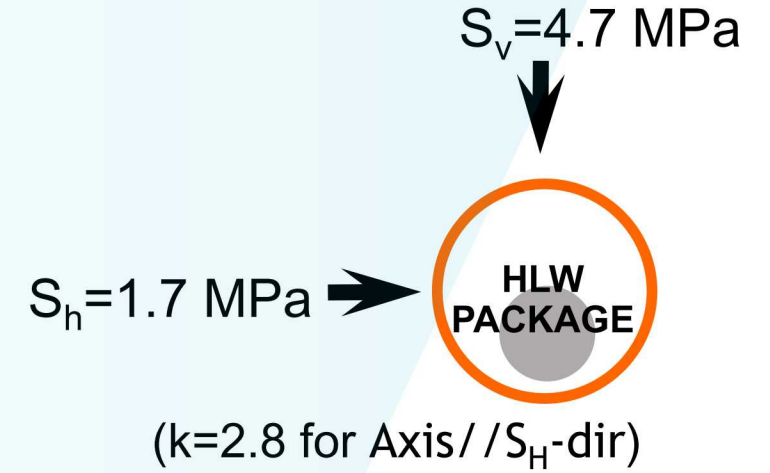
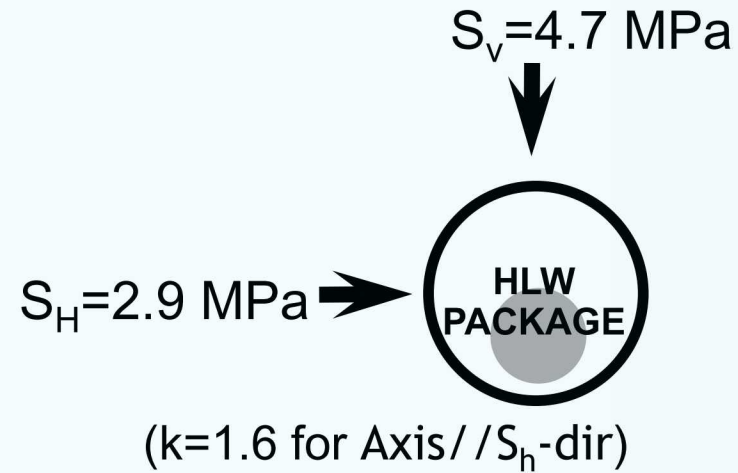
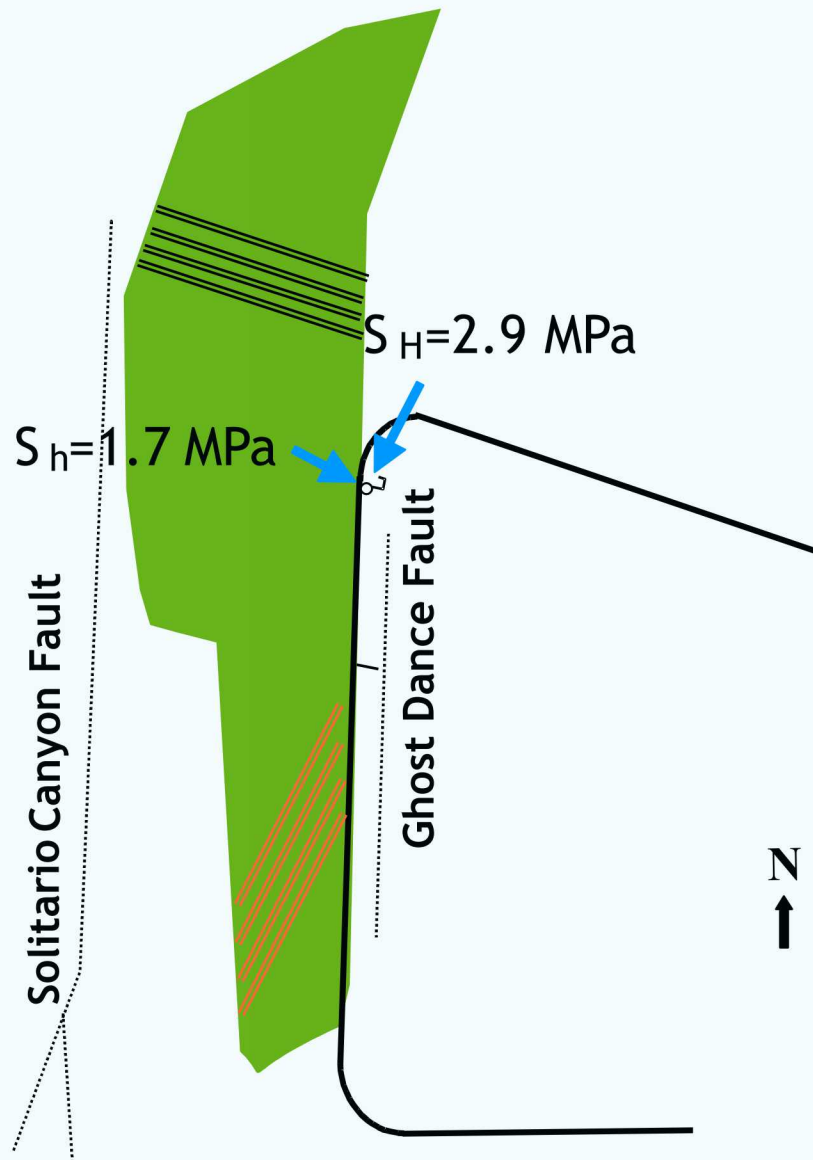


Safe Oil & Gas Transport

YUCCA MOUNTAIN PLANNED SCHEDULE



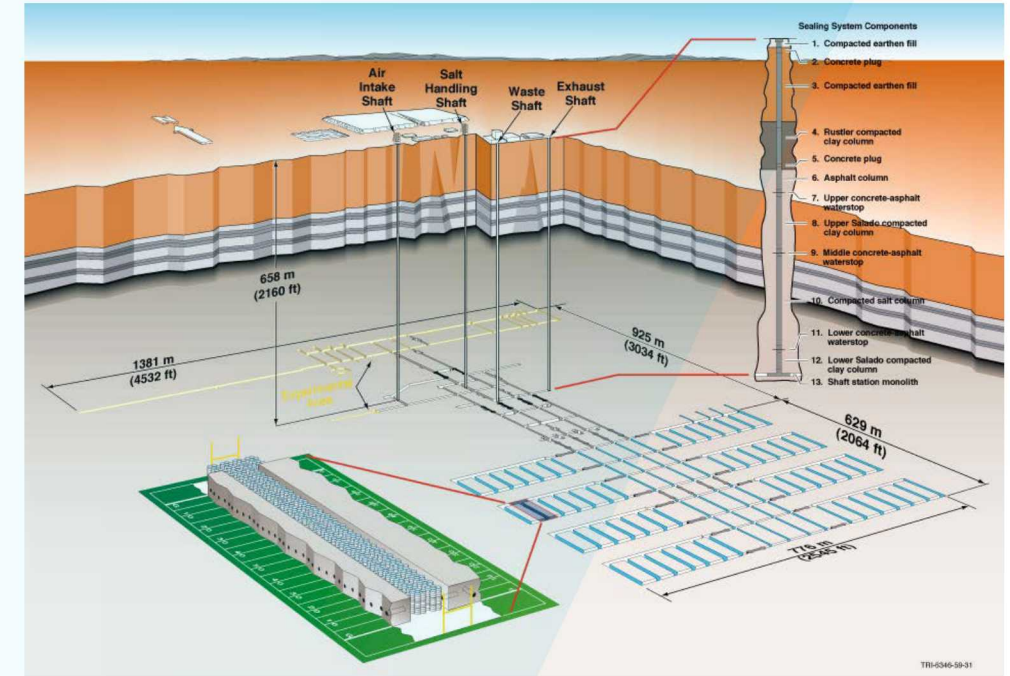




WIPP (WASTE ISOLATION PILOT PLANT)



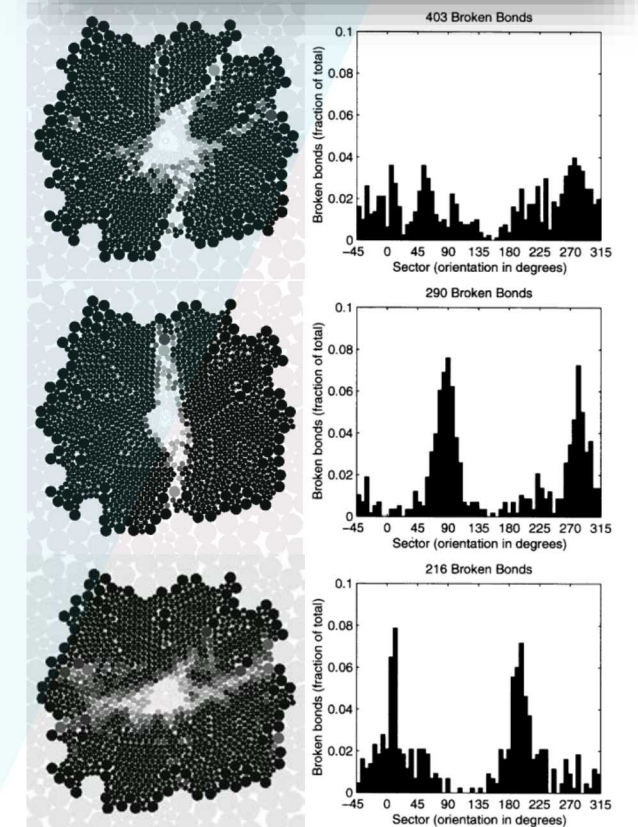
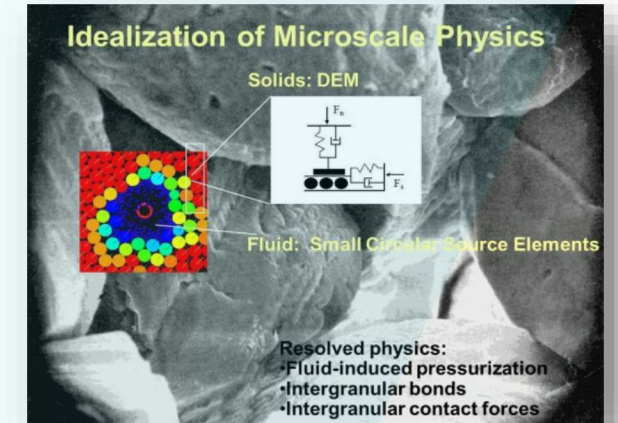
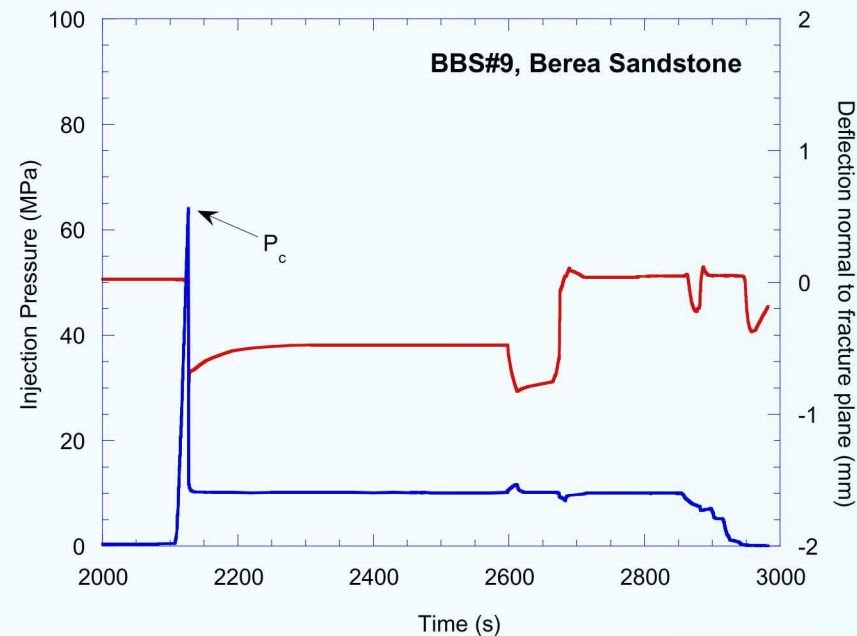
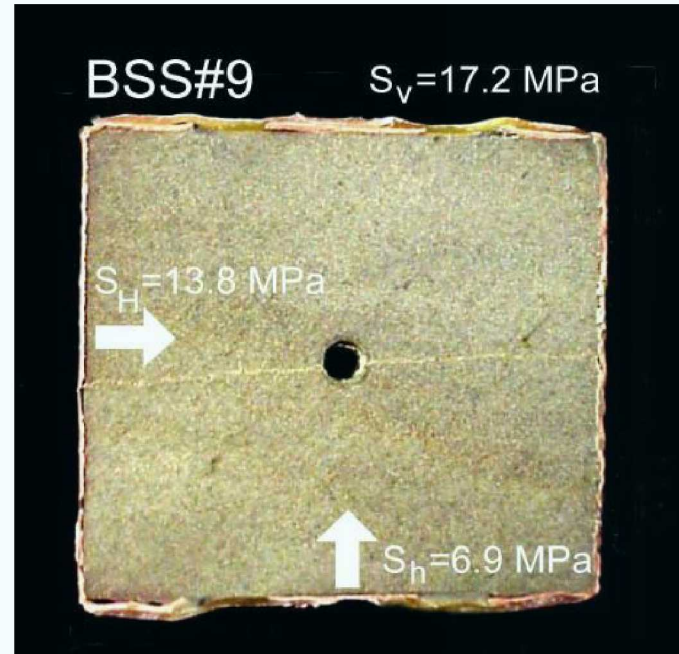
- The Nation's only deep geologic repository for defense-related transuranic nuclear waste
 - 1975 - Present WIPP site selected for further characterization
 - 1998 - In May, EPA certified WIPP's Compliance
 - 1999 - In March, WIPP received its first transuranic waste shipment
- Located in semiarid desert of SW New Mexico
- Repository in bedded salt beneath water table provides primary isolation of nuclear waste





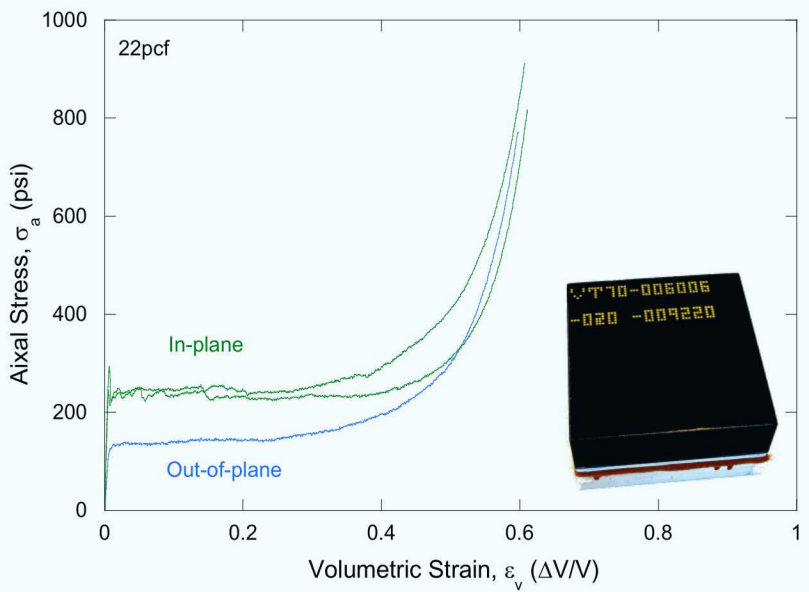
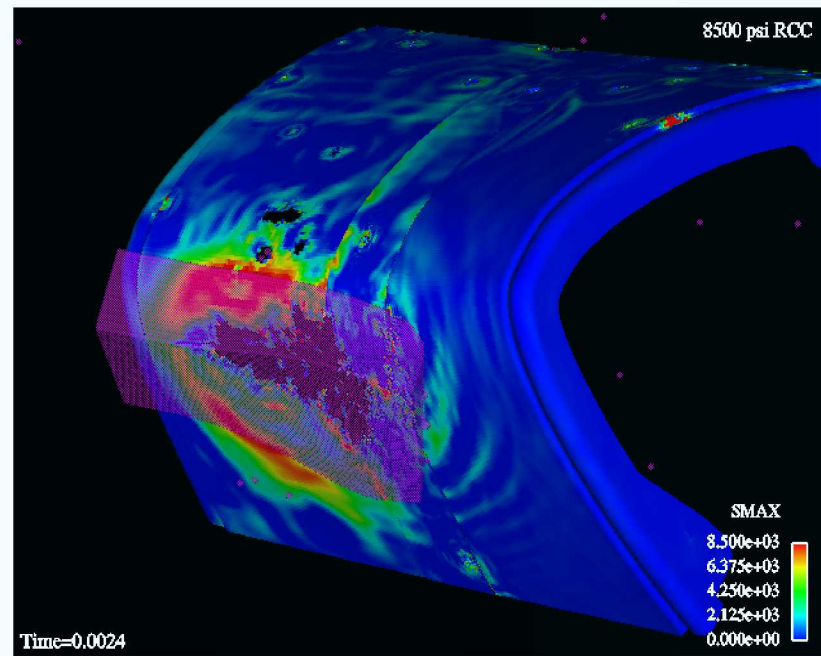
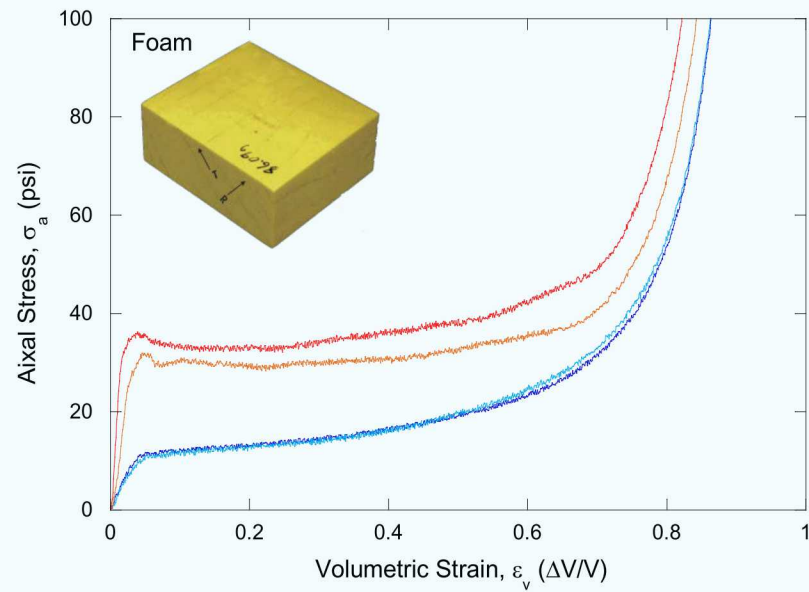


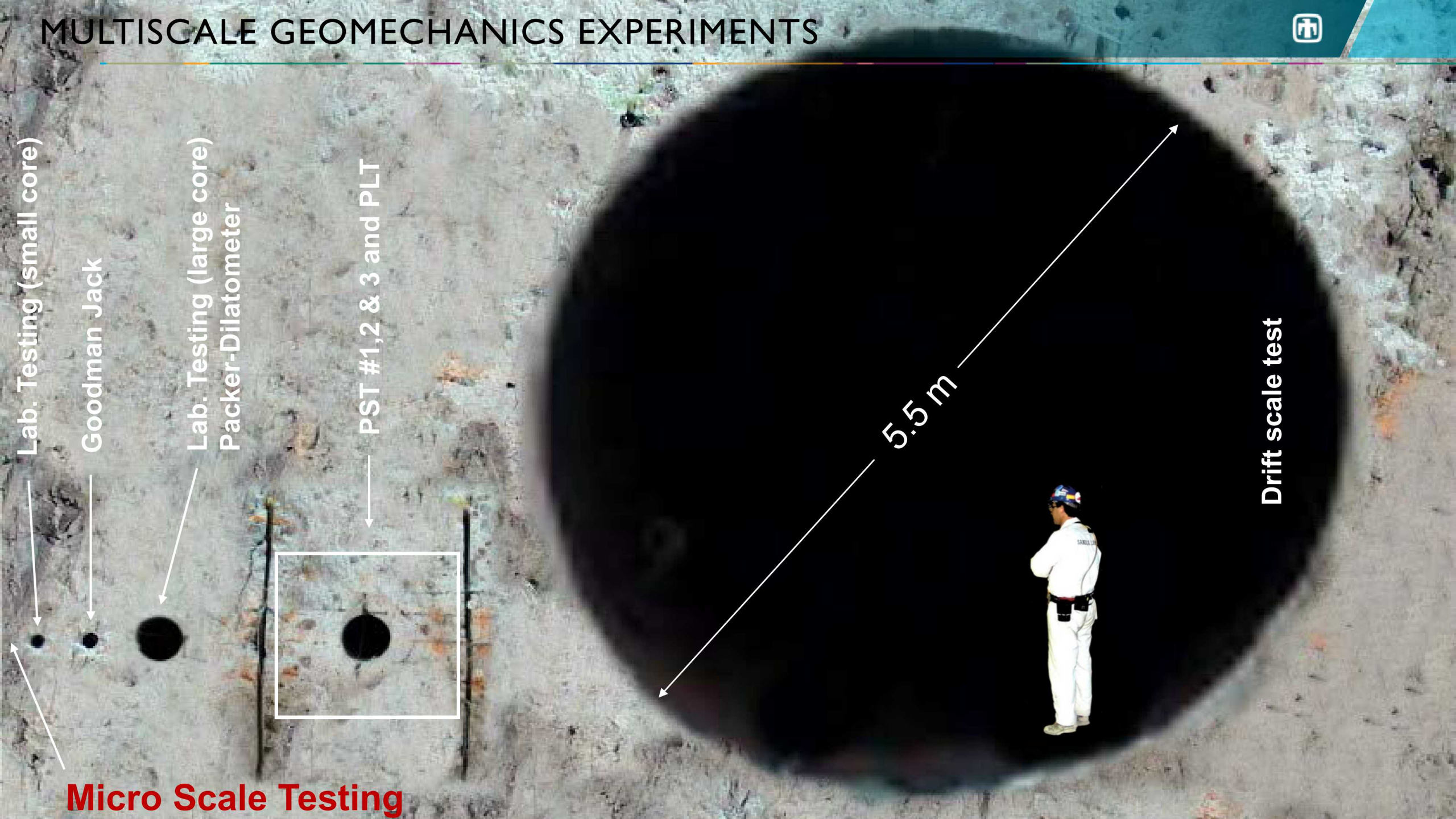
**TRUE-TRIAXIAL
PRESSURE CELL**





COLUMBIA ACCIDENT INVESTIGATION





Lab. Testing (small core)

Goodman Jack

Lab. Testing (large core)
Packer-Dilatometer

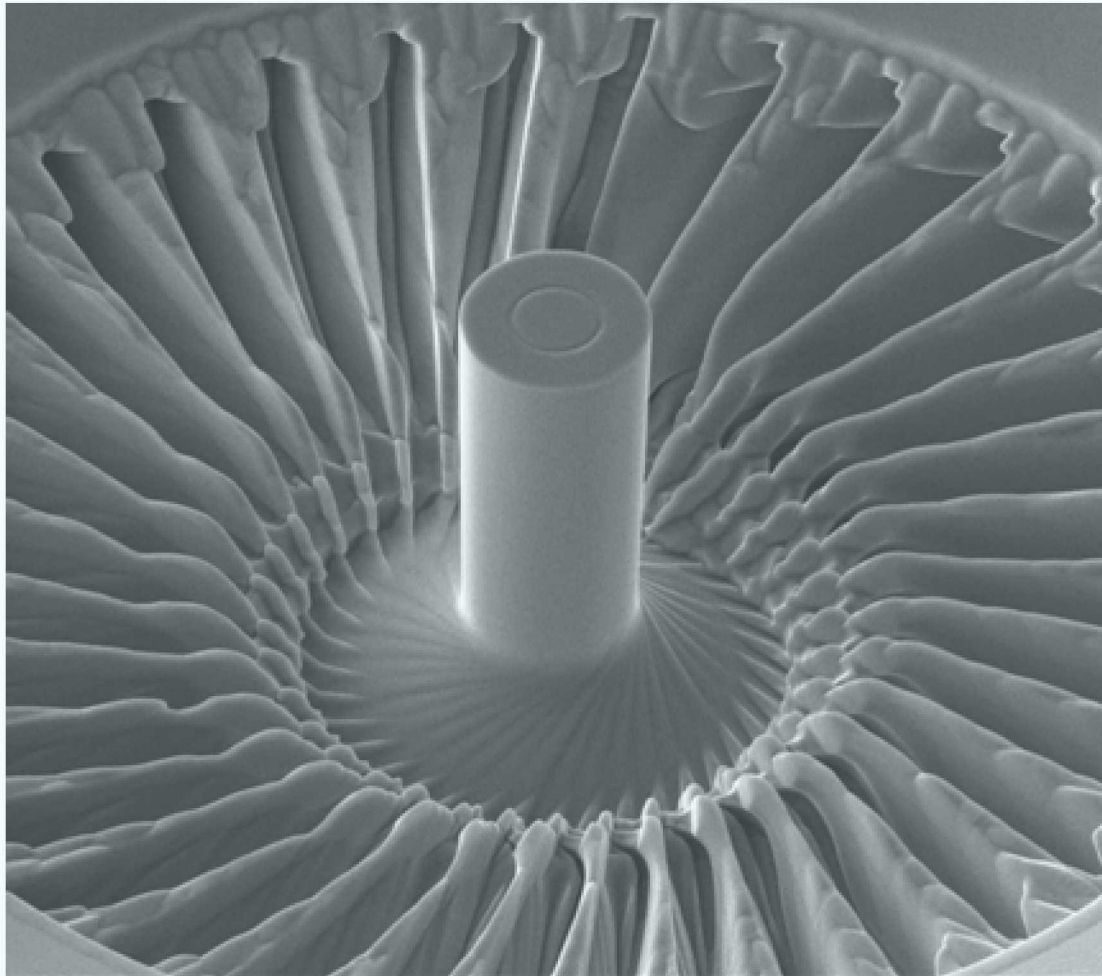
PST #1, 2 & 3 and PLT



Micro Scale Testing

5.5 m

Drift scale test

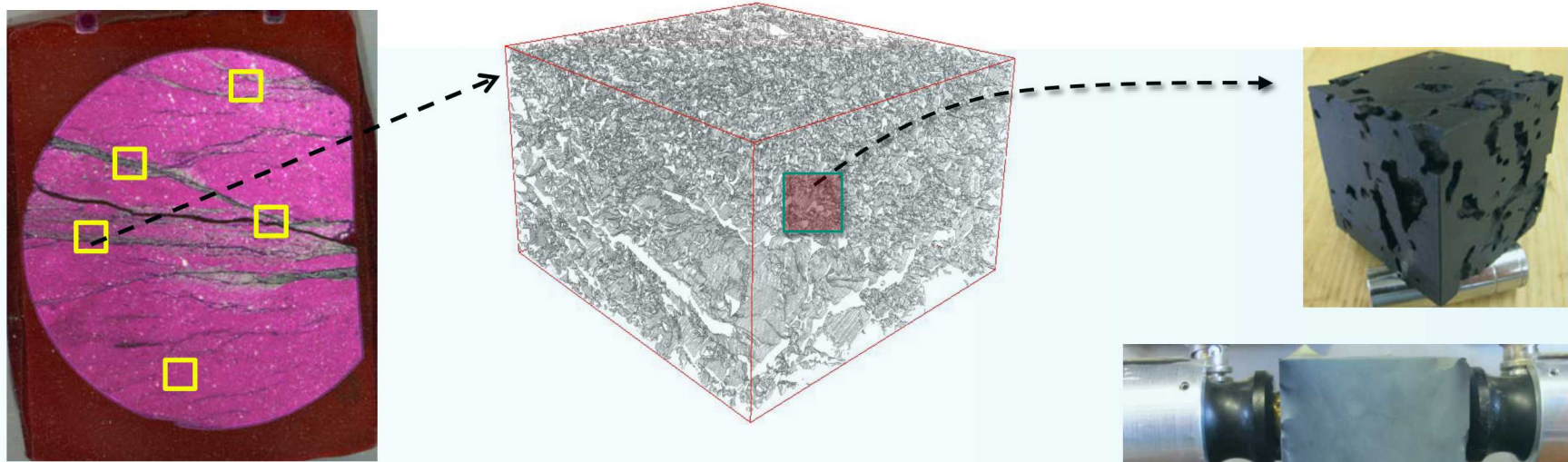


E-Beam	Det	Spot	FWD	Tilt	Scan	Mag	
5.00 kV	CDM-E	3	4.917	45.0°	H 6.337	10.0 kX	5 μm

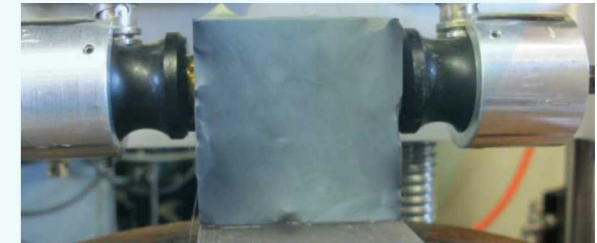
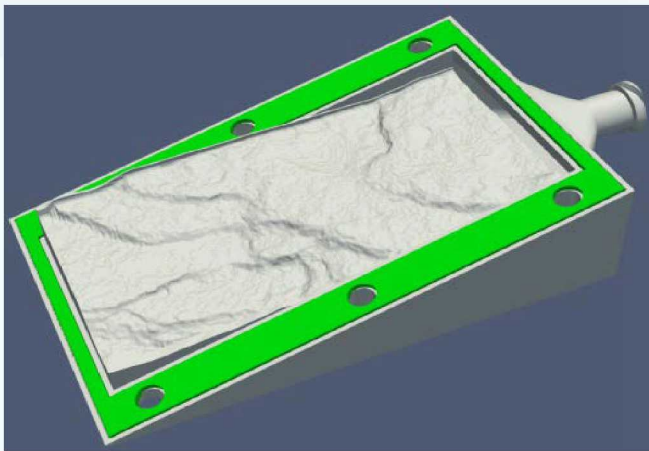


E-Beam	Det	Spot	FWD	Tilt	Scan	Mag	
5.00 kV	CDM-E	5	5.039	45.0°	H 28.51	5.00 kX	10 μm

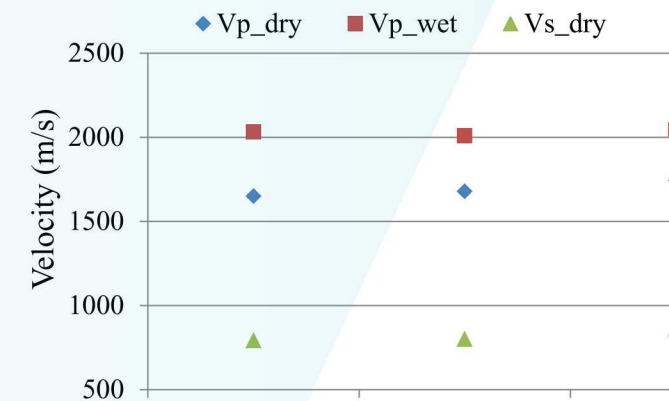
GOTHIC Shale UCS: 4 GPa vs 90 MPa and E: 40 GPa vs 20 GPa



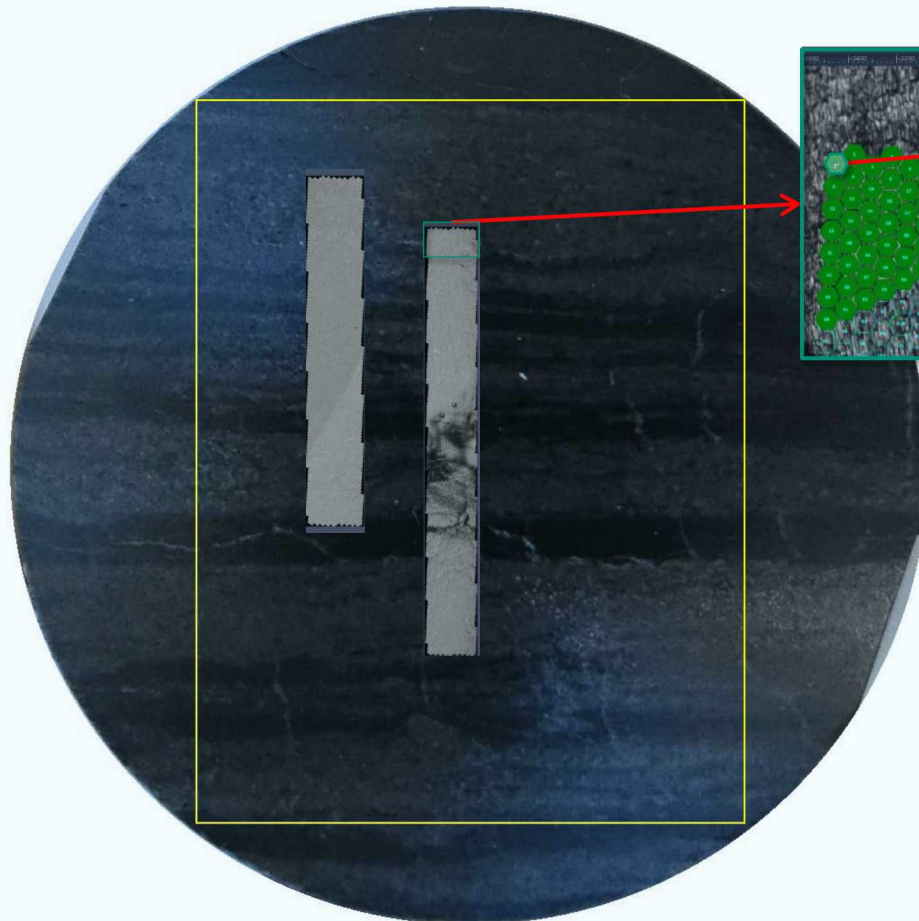
Reproducible synthetic media that mimic natural media, potentially enabling a limitless set of experiments benefiting all manner of scientific research



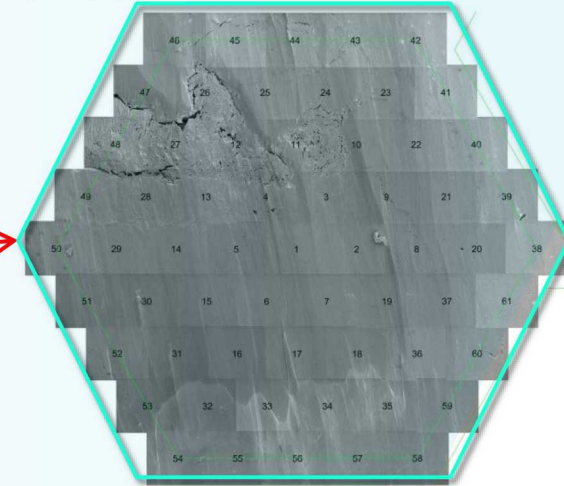
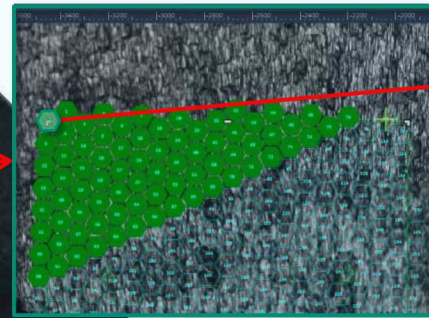
Vp and Vs Measurements



- Integrated Characterization of Shale Poromechanics
- MultiSEM (World's fastest scanning electron microscopes) Application
- Mineralogy Mapping & Nano-indentation



*Ion-milling polished Mancos shale sample
(1" dia, yellow box for mineralogy mapping)*



(~100 μm x 90 μm hexagon)

MultiSEM scanning of two large areas at 4 nm resolution (example)

- 1.5 mm $\times$ 14 mm scanning area
- 3,122 hexagons (green)
- Each hexagon consists of 61 images
- Each image consists 3128 x 2724 pixels
- Total 190,442 images (1.47 TB)

Constitutive testing

- Hydrostatic compression (< 1 GPa)
- Uniaxial compression (< 4.5 MN)
- Triaxial compression (< 1 GPa)
- Uniaxial strain
- Creep testing ($> 10^{-10}$ /s)
- SHPB ($< 10^3$ /s)

Phenomena simulation

- Compaction band
- Slurry injection
- PZT phase transformation (-65 to 150°C)
- HV breakdown (< 10 KV)

Material parameter measurement

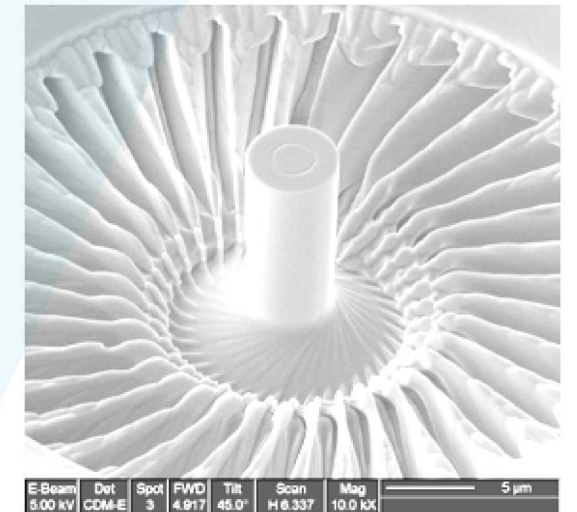
- Density, Porosity, Permeability
- E and ν or (G and K)
- Thermal expansion, thermal conductivity
- V_p , V_s , and AE source location

Micro-Nano Scale testing

- FIB/SEM

Large scale field testing

- WIPP, YMP





New Trend and Future(?)

ML

Thank You

TECHNICAL CONTRIBUTORS



Thomas Dewers

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Scott Broome

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Jason Heath

Mario Martinez

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David Bronowski

Perry Barrow

Michael Hileman

Michelle Williams

Ron Taylor

Ben Cook

And Others