SAND2016-4829

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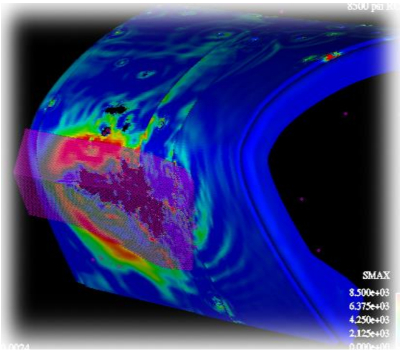
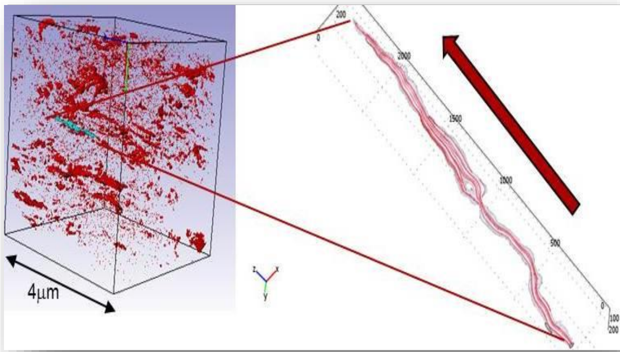


Sandia Geomechanics Capabilities

Erik K. Webb, Geoscience Group, Senior manager
Moo Y. Lee, Geomechanics Department, Manager

U.S. DEPARTMENT OF ENERGY
NNSA National Nuclear Security Administration

Erik K. Webb

Dr. Erik K. Webb manages Sandia National Laboratories' Geoscience Research & Applications Group consisting of six departments implementing basic to applied research, implementing complex monitoring systems and for national security and energy development.

Erik has a PhD in hydrogeology with emphasis in applied mathematics from the University of Wisconsin, has worked on an array of earth science problems with commercial (UNOCAL) and US Government agencies (USGS, ORNL, DOE, NRC and the EPA).

Erik served a fellowship with the Japanese Atomic Energy Agency and helped co-author the year 2000 Report on High Level Waste to the Japanese Diet, oversaw hydrological research at Sandia National Laboratories, served two years as a Congressional Fellow on the Senate Energy Committee and three years on the personal staff of Senator Pete Domenici focusing on western water policy and energy issues.

Erik served as assistant to Sandia National Laboratories Chief of Staff, and as the SNL Government Relations manager for the nuclear weapons program through ratification of the third START treaty with Russia.

T: 505-844-9179 C: 505-263-1011 EKWEBB@sandia.gov

Moo Y. Lee

Dr. Moo Y. Lee is the manager of the Geomechanics Department, Sandia National Laboratories. He has over 30 years of experience in hydraulic fracturing in situ stress measurements and complex laboratory / numerical simulations of boreholes subjected to poly-axial stress conditions. He has been working on cross-cutting issues in geosciences and geoengineering related to basic energy sciences, nuclear waste disposal, geomaterial characterization, and underground storage of air/hydrocarbon.

He received the Applied Research Award from the US National Committee for Rock Mechanics in 1994 by conducting a laboratory simulation of the Borehole Breakouts in Underground Research Laboratory located in Canada. He also characterized and provided the crucial materials data for Columbia Investigation and received Lockheed Martin Nova award.

He received his B.S. degree in Mineral and Petroleum Engineering from the Seoul National University, Korea in 1980. After graduation, he came to the U.S. to begin his graduate studies at the University of Wisconsin-Madison, where he received his M.S. and Ph.D degrees in Mining Engineering specialized in Rock Mechanics and Statistics.

T: 505-844-2366 C: 505-917-3453 MYLEE@sandia.gov

Energy & Climate PMU Program Areas

Sandia National Laboratories

Renewable Systems & Energy Infrastructure

PAD: Carol Adkins
Deputy: Juan Torres

- **Renewable Energy** – Juan Torres
- **Energy Efficiency** – Art Pontau
- **Grid Modernization** – Charles Hanley

Climate & Engineered Earth Systems

PAD: Peter Davies
Deputy: Amy Halloran

- **Climate Modeling & Measurement** – Scott Collis
- **Energy & Water** – Stephanie Kuzio
- **Fossil Energy Management** – Erik Webb
- **Biofuels** – Anup Singh
- **Back End of the Fuel Cycle** – Tito Bonano
- **DOE Managed Nuclear Waste** – Paul Shoemaker

Nuclear Energy & Fuel Cycle Programs

PAD: Susan Pickering
Deputy: Patrick Mattie

- **Commercial Nuclear Power Generation** – Tito Bonano
- **Nuclear Energy Safety & Security** – Richard Griffith

Transportation Energy & Systems

PAD: Bob Hwang
Deputy: Art Pontau

- **Vehicle Technologies** – Paul Miles
- **Biomass Technology** – Ben Wu
- **Fuel Cells/Hydrogen Technology** – Chris San Marchi

Energy Research

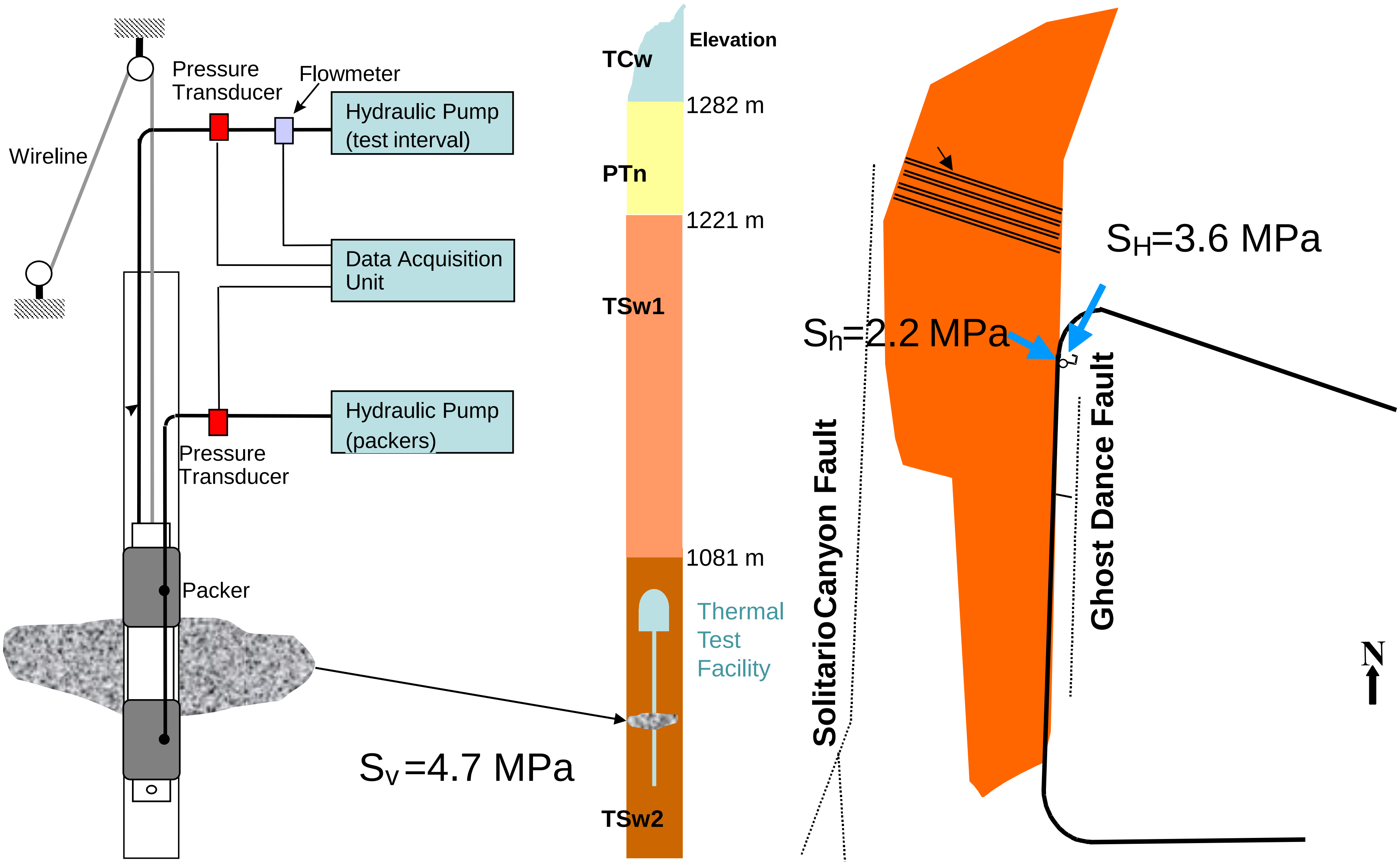
PAD: Grant Heffelfinger
Deputy: Wahid Hermina

- **ARPA-E** – Wahid Hermina
- **SC BES CHEMSCIENCE** – Dave Chandler
- **SC ASCR** – Scott Collis
- **SC BES CINT** – Sean Hearne (Acting)
- **SC BES GEO** – Moo Lee
- **SC BES MATERIALS SCIENCES** – Jeff Nelson

Materials Testing and Modeling Capabilities

- Constitutive testing
  - Hydrostatic compression (< 145,000 psi)
  - Uniaxial compression (< 1,000,000 lbs)
  - Triaxial compression (< 145,000 psi)
  - True Triaxial compression (s_1<200,000 psi, S_2<40,000 psi, s_3<15,000 psi)
  - Uniaxial strain (< 300,000 psi)
  - Triaxial extension (< 70,000 psi)
  - Creep to SHPB ($10^{-10} < d\varepsilon/dt < 10^3$/s)
  - Cryogenic to Geothermal (-65 to 200^{o}C)
  - Length Scale (10^{-6}m to m)
- Phenomena simulation & modeling
  - Compaction band
  - Powder compaction
  - Slurry injection
  - Phase transformation in ceramic
  - Flow-visualization
  - CO_2 sequestration
- 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
- Large scale field testing & modeling
  - WIPP, YMP

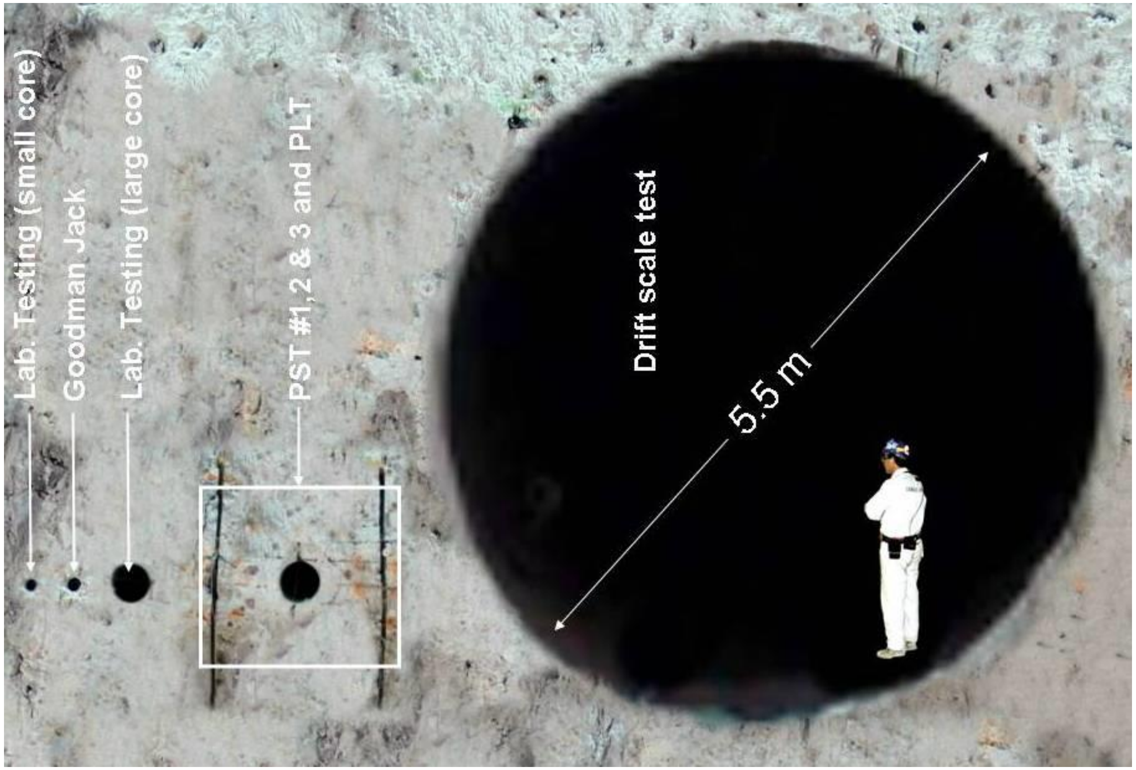
Hydrofrac In Situ Stress Measurement

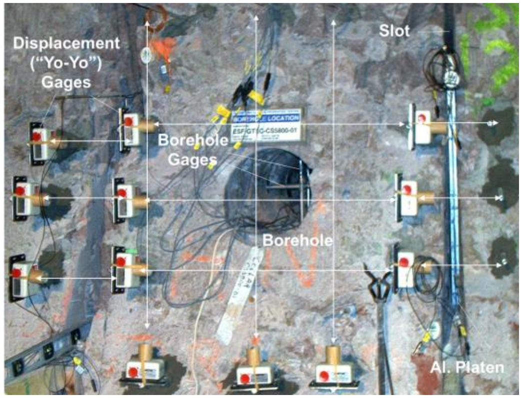


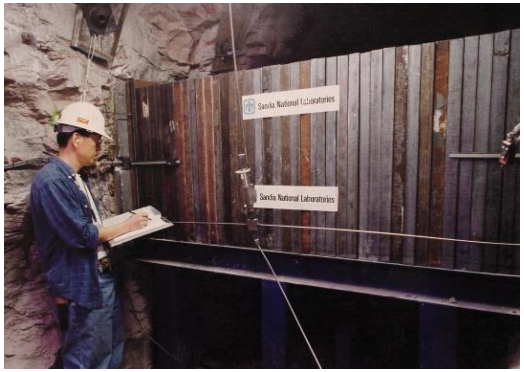
Initial stress measurements in the Exploratory Studies Facility Yucca Mountain, Lee and Haimson,1999

Rock Mass Deformability Measurements

- Laboratory core testing
- Goodman Jack
- Pressurized Slot Testing (PST)
- Plate Loading Test (PLT)
- Drift Scale Testing





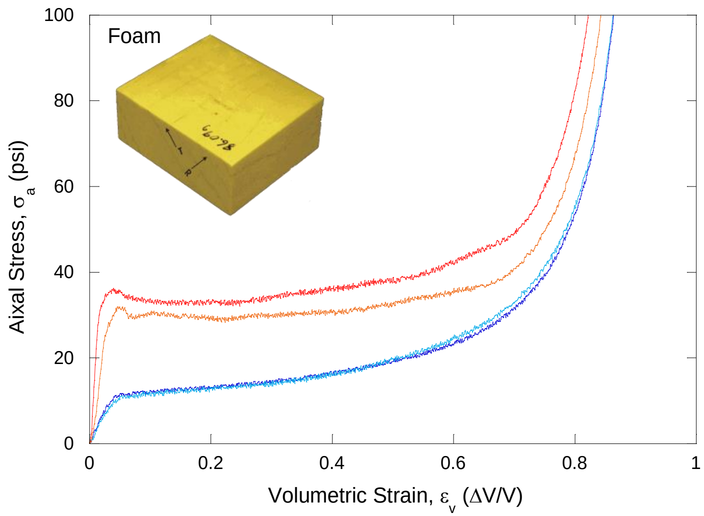


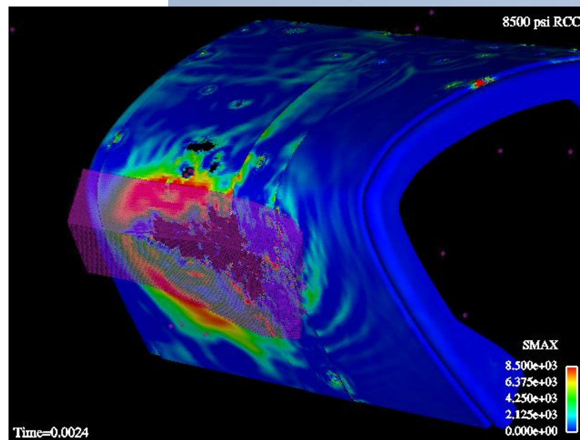
WIPP Surrogate Waste Materials Testing

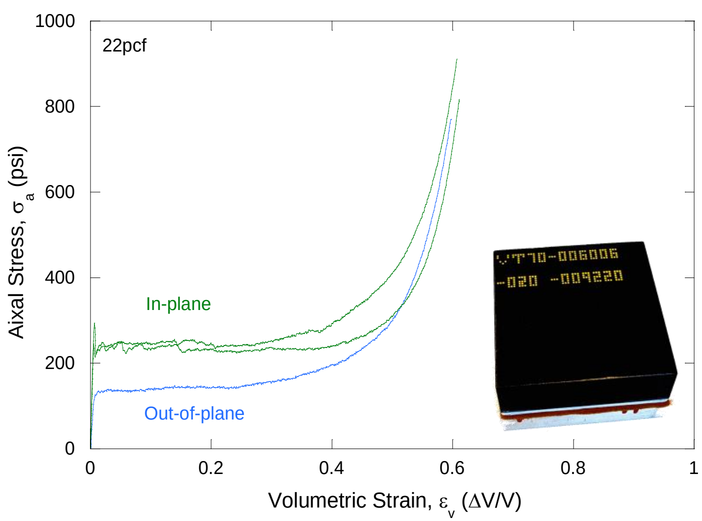
The container contains a surrogate recipe representing the average baseline inventory at the Waste Isolation Pilot Plant.

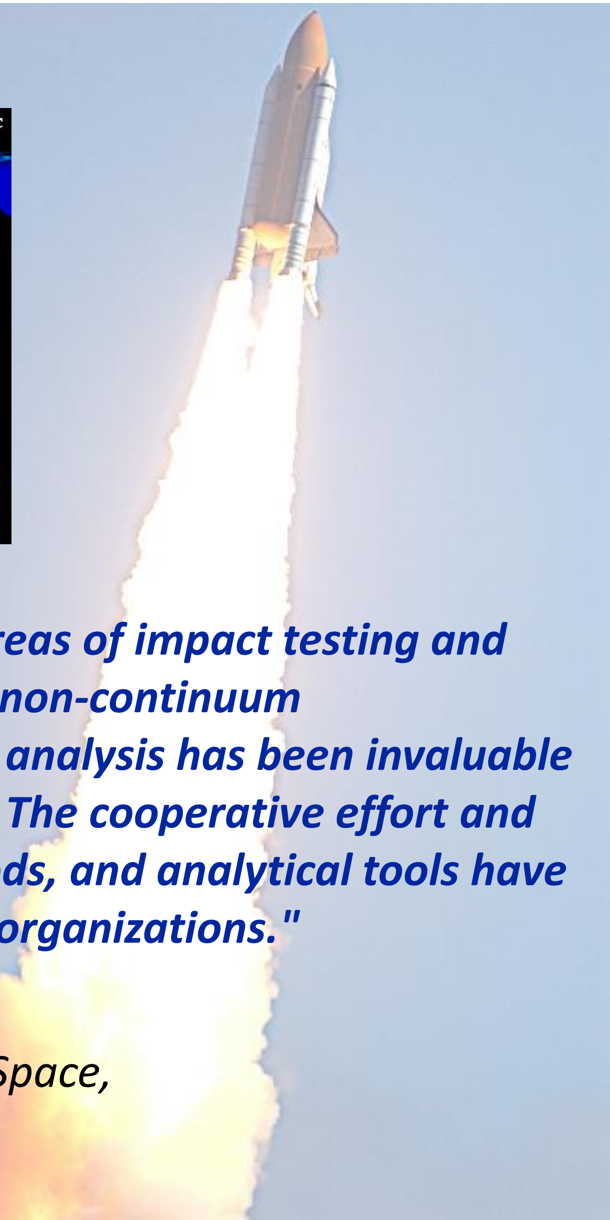
For more information contact Scott Bloom (stbroom@sandia.gov)

Columbia Accident Investigation





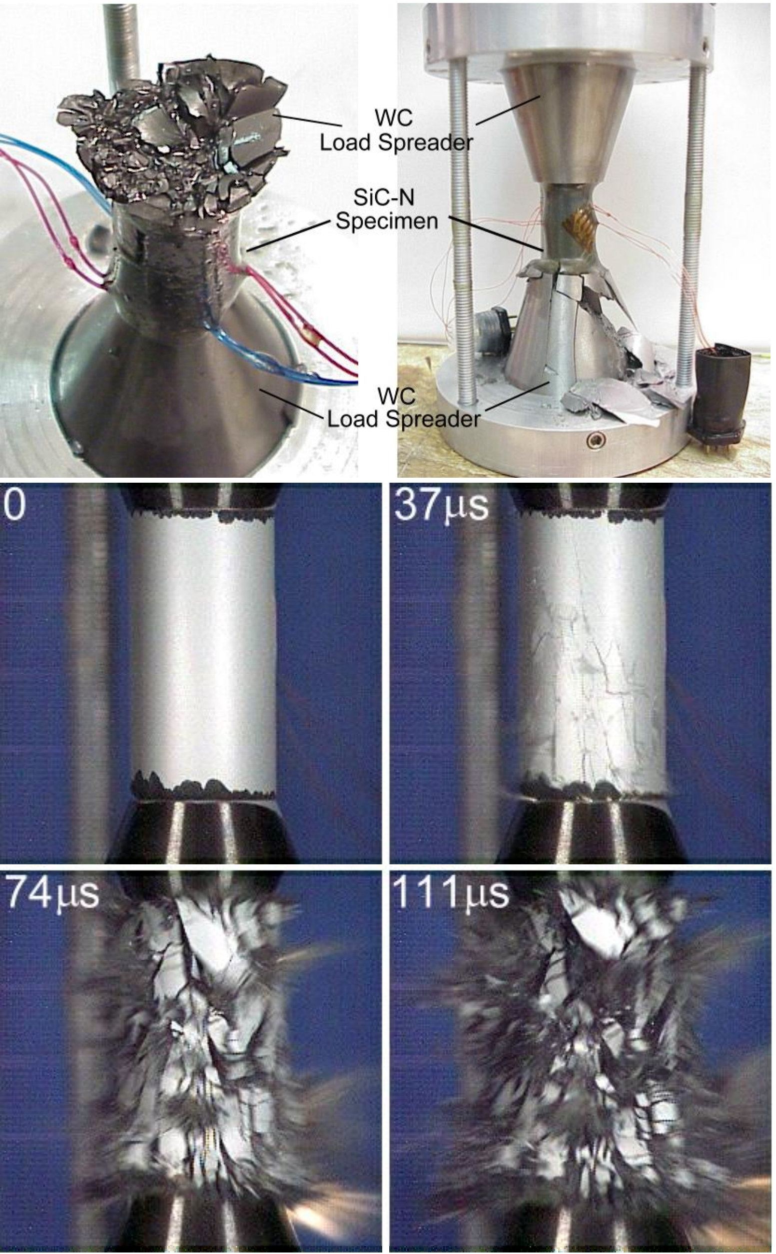




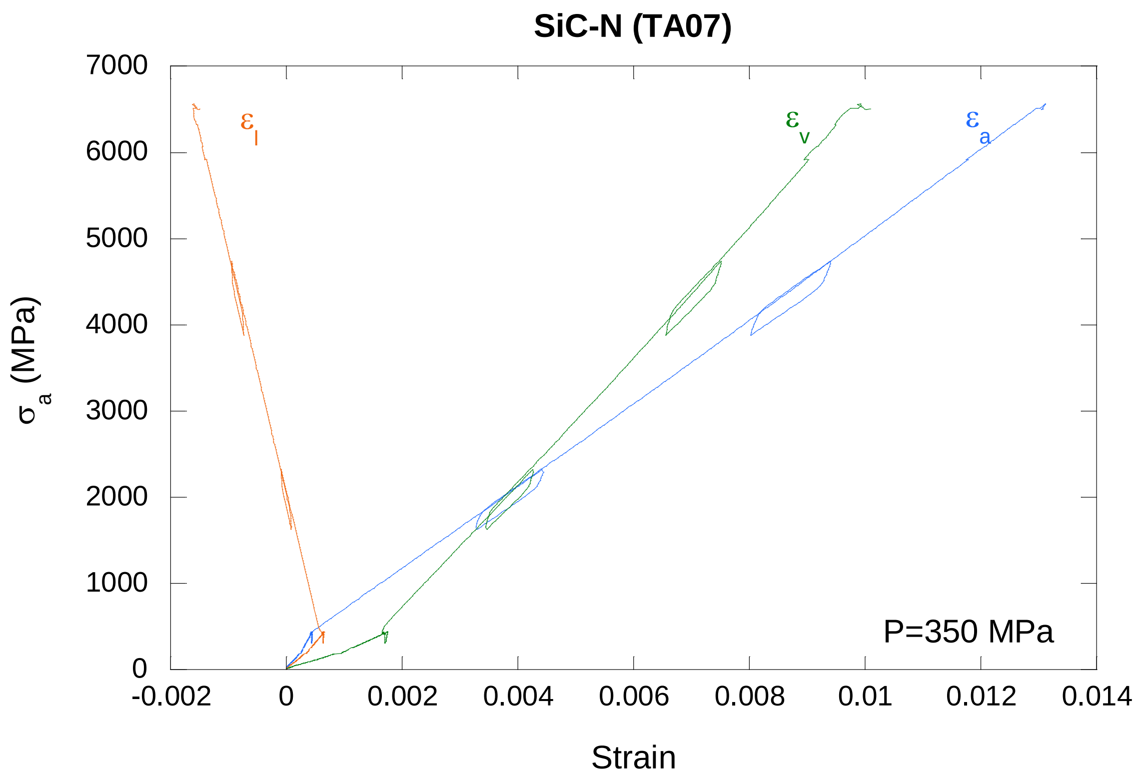
"Sandia's expertise in the areas of impact testing and modeling, material testing, non-continuum aerodynamics, and thermal analysis has been invaluable to our investigation teams. The cooperative effort and sharing of ideas, test methods, and analytical tools have been beneficial to both our organizations."

William Readdy
Associate Administrator for Space,
NASA

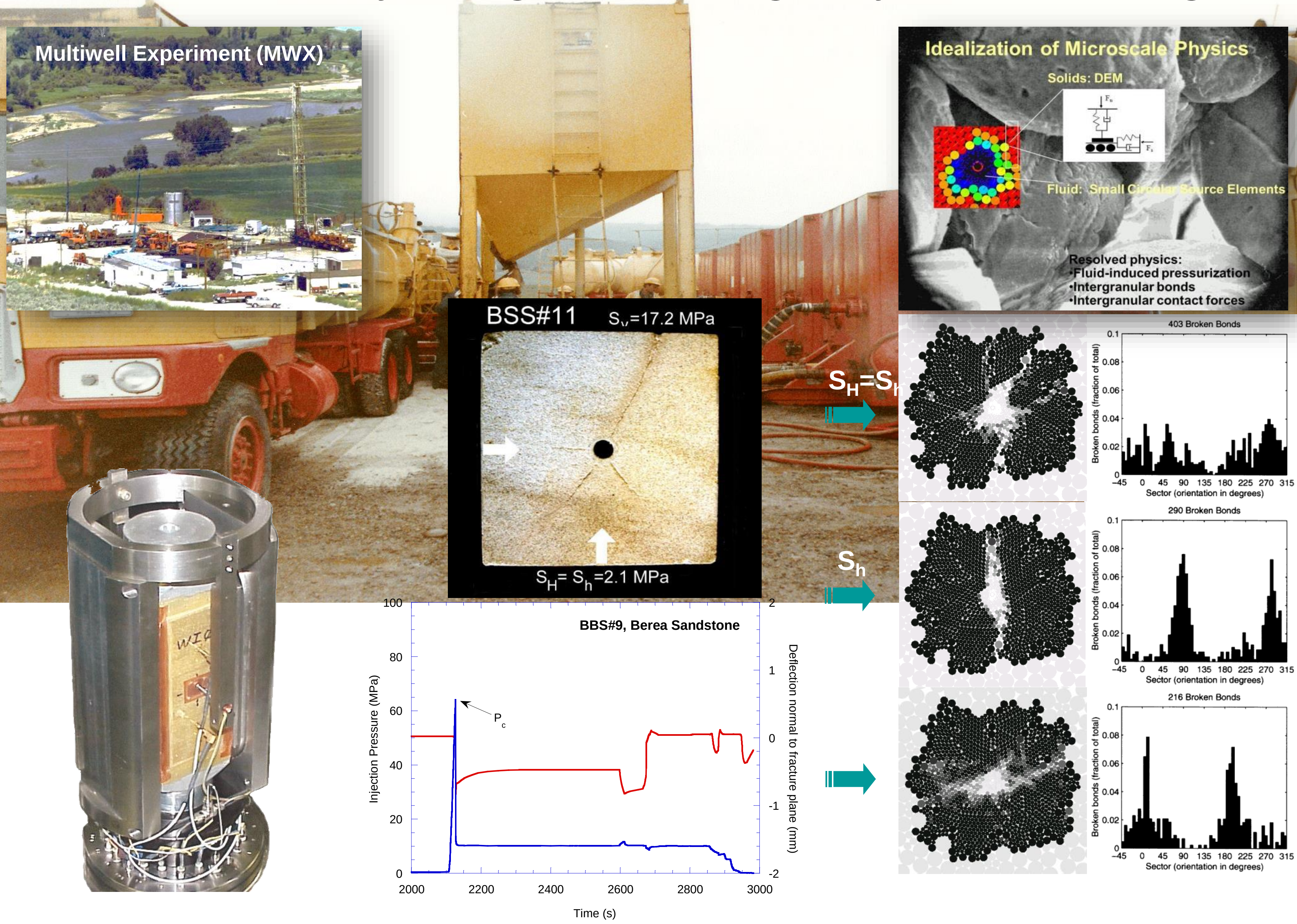
Triaxial Compression Tests of SiC-N

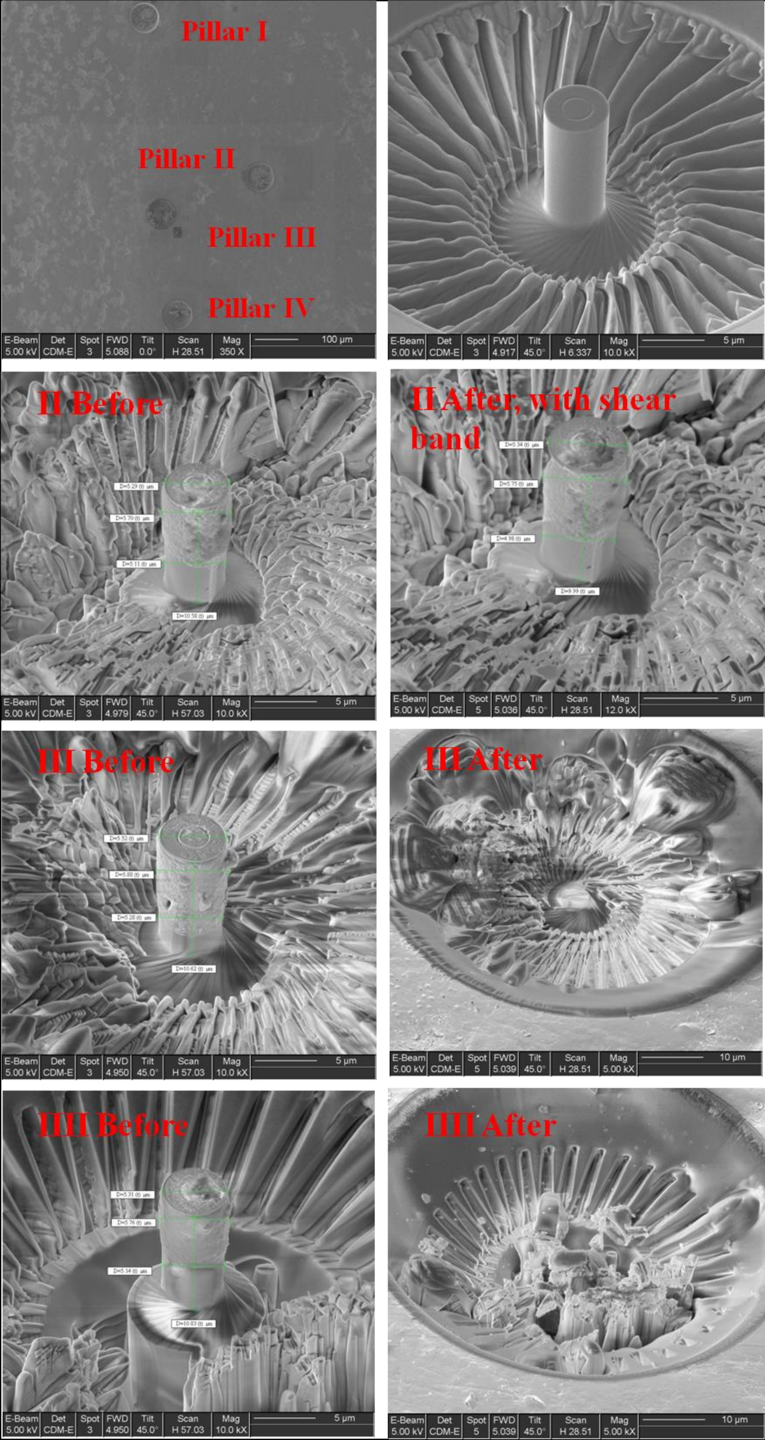


- Provides quasi-static experimental data needed to parameterize the models to be used in ALEGRA.
- Gives insight into the failure phenomena of SiC-N under different loading conditions.

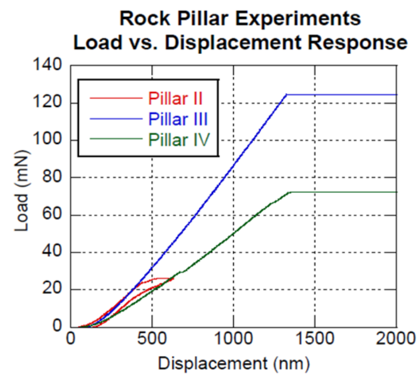


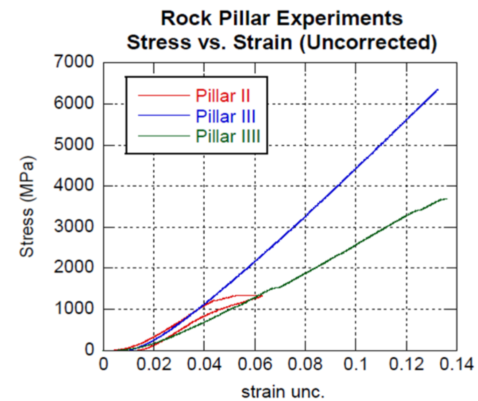
Laboratory Testing and Modeling of Hydraulic Fracturing

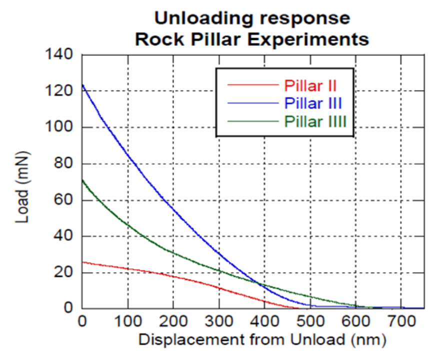


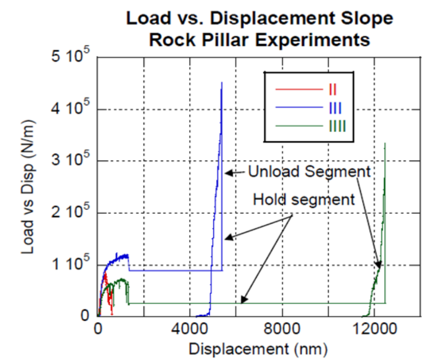


Micro-pillar Compression







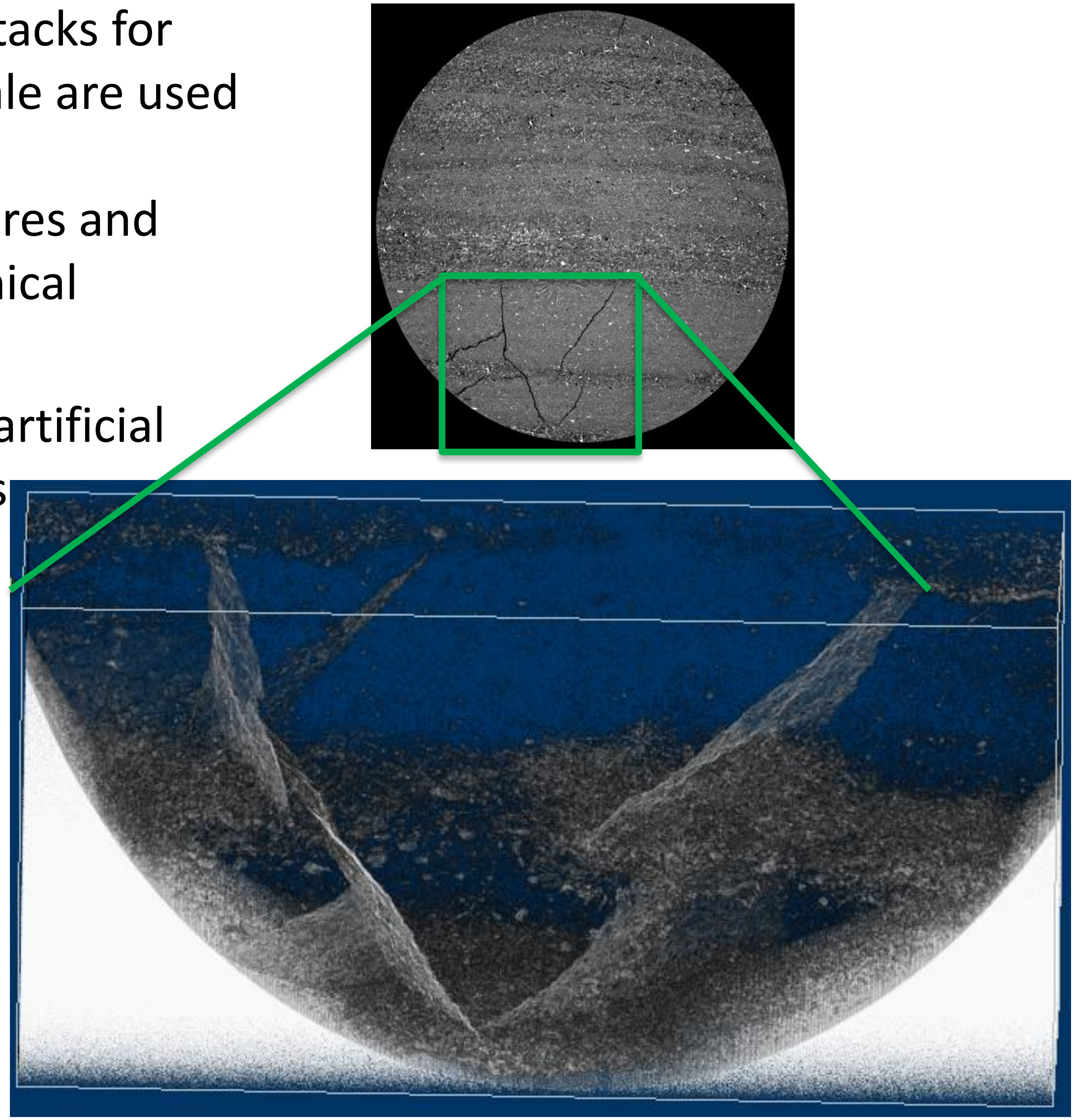


	UCS (GPa)	E (GPa)
Pillar II	1.1	29
Pillar III	3.8	37
Pillar IIII	6.3	44
Quartz single crystal	6.9 – 8.3[1]	76-97[2]
Gothic Core Plug	0.088	18

Thomas Dewers, 2016

Micro-CT Imaging

- Multiple scale micro-CT image stacks for Mancos shale and Marcellus shale are used to characterize the impact of heterogeneous materials (fractures and laminated materials) on mechanical properties of shale.
- 2D and 3D views of natural and artificial fractures in clay-rich weak layers terminated by stiff layers. Relatively large white spots represent pyrite minerals that are used as the markers to estimate 3D deformation of shale during mechanical testing.

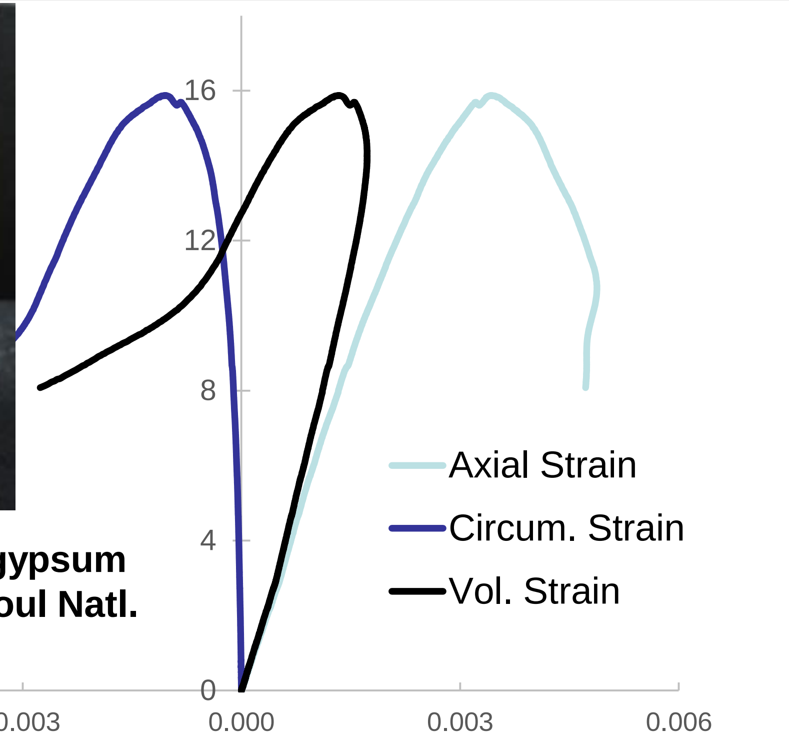


MicroCT Image of 1” diameter core of Mancos shale specimen.

Digital Rock Physics for Fractured Porous Media

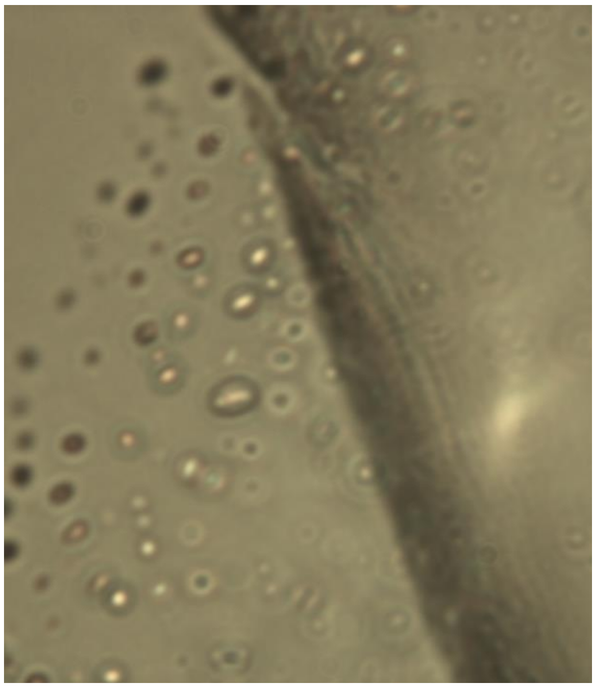
- Why 3D printing?
  - Ability to design and realize complex geometries
  - Engineered material control at new regimes
  - Feature-based pore structure for proof of concept testing
- Extensive SNL additive manufacturing capabilities and emerging 3D printing techniques with various materials will be leveraged for Geo application

3D printed gypsum column (Seoul Natl. Univ.)



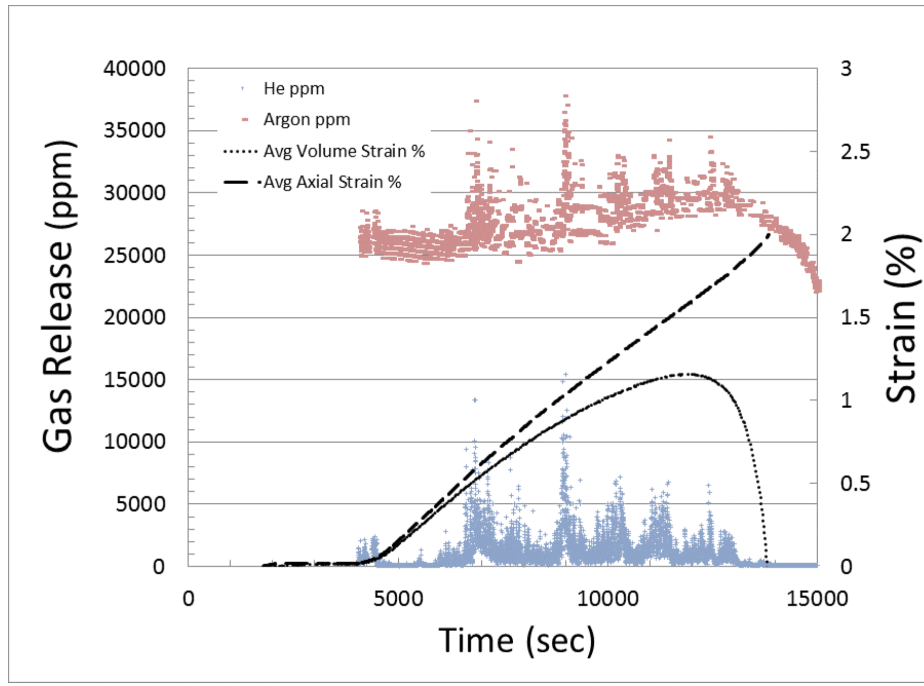
Real-Time Degassing of Rock during Deformation

- Discovery of *real-time* gas emission during rock fracture and relate to deformation
- Noble gas release may be related to deformation state of rock
- Natural or manmade rock deformation may be signaled/quantified by gas release



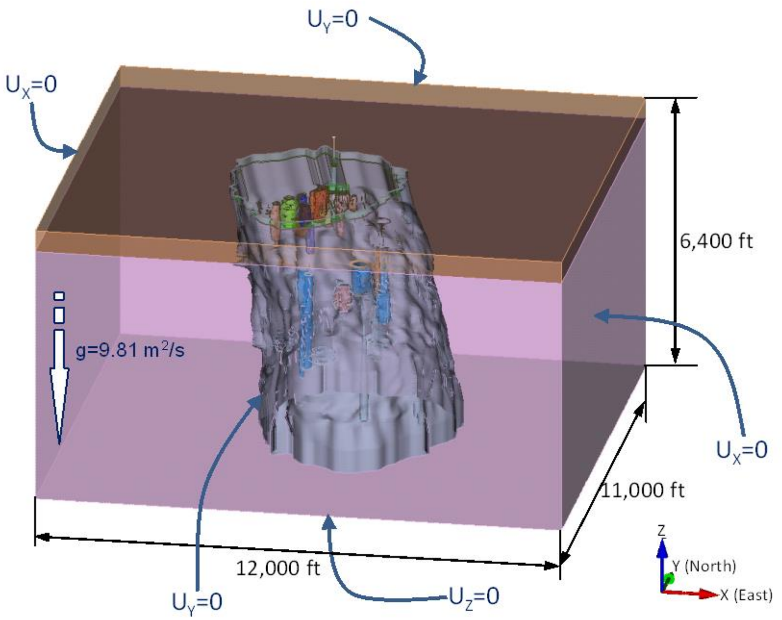
Stress induced microfracture intersecting gas bubble array in quartz in experimentally deformed Westerly granite

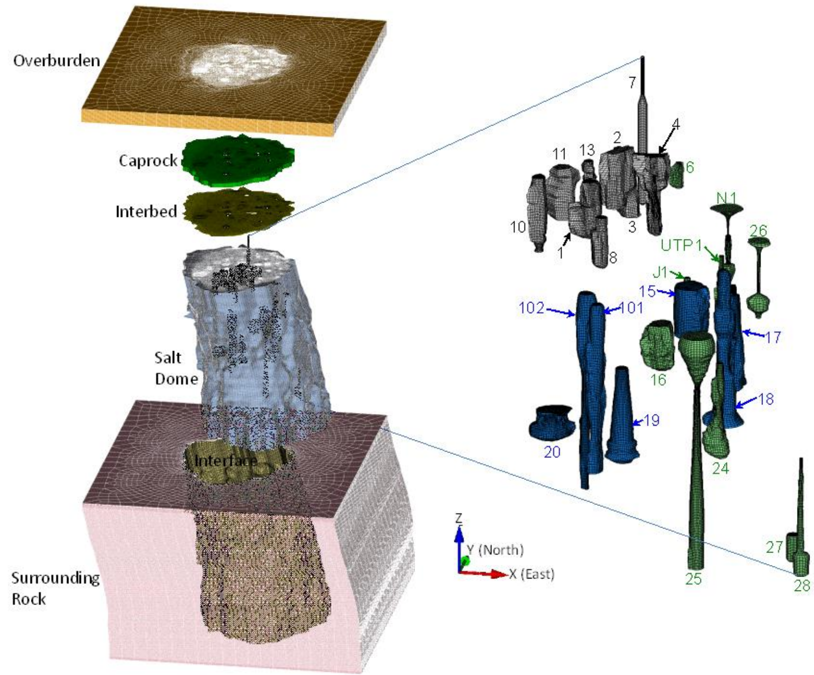
Project Volume and axial strain, and ^{4}He and ^{40}Ar release versus time.



Steve Bauer, 2016

Geomechanical Modeling for Strategic Petroleum Reserve





- Hexahedral mesh methodology captures the realistic geometries of caverns and dome at Bayou Choctaw Strategic Petroleum Reserve (SPR) Site. The caverns in black, green, and blue indicate the abandoned, commercial, and SPR caverns, respectively.
- Models predict stresses and strains in system, including cavern closure, surface subsidence, and stresses and strains on wellbore casings

Byoung Yoon Park, 2014