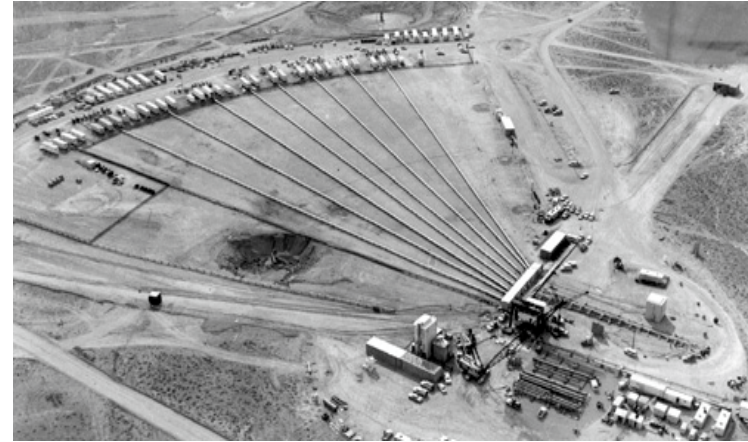


Sandia Geomechanics Department Capabilities

Moo Y. Lee, Geomechanics Department

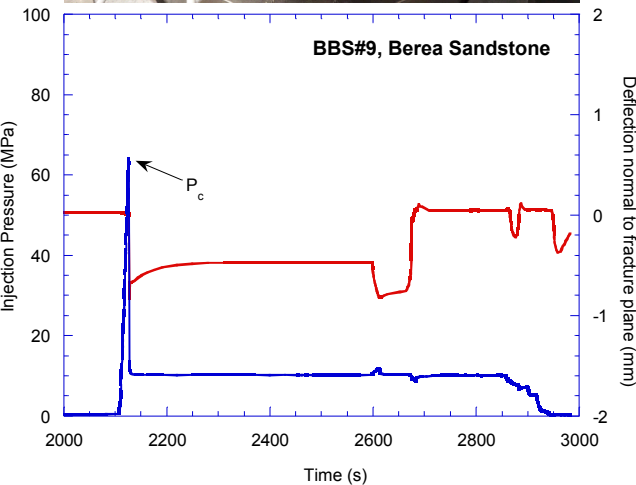
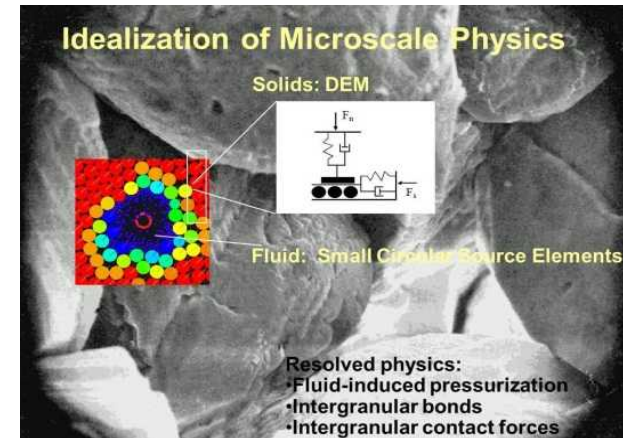
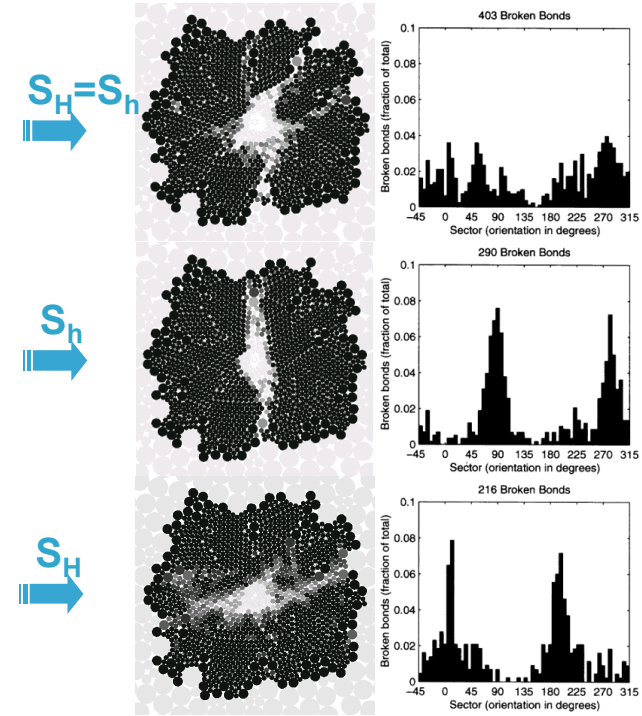
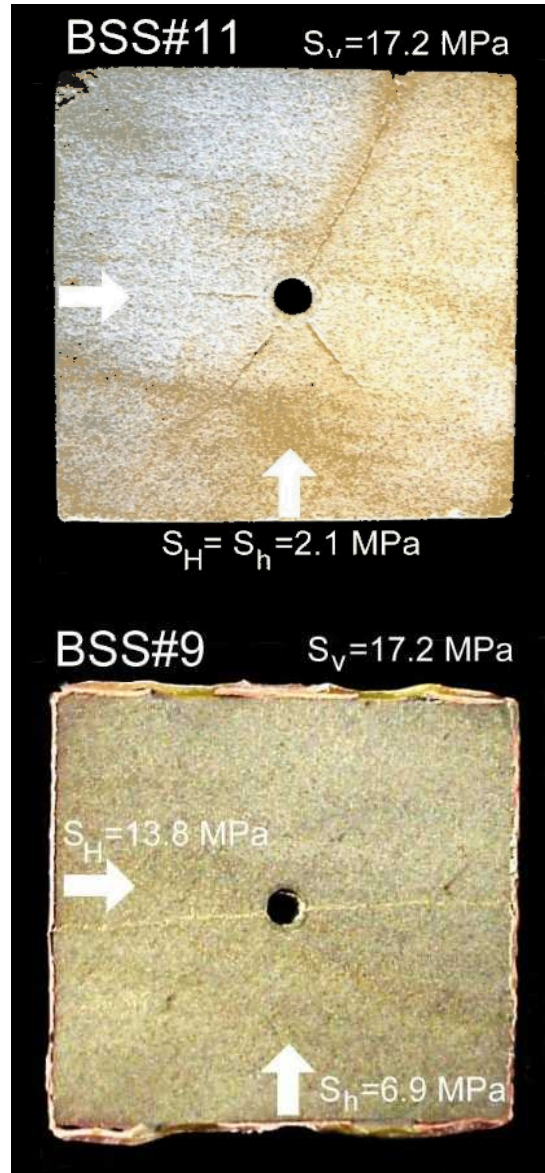
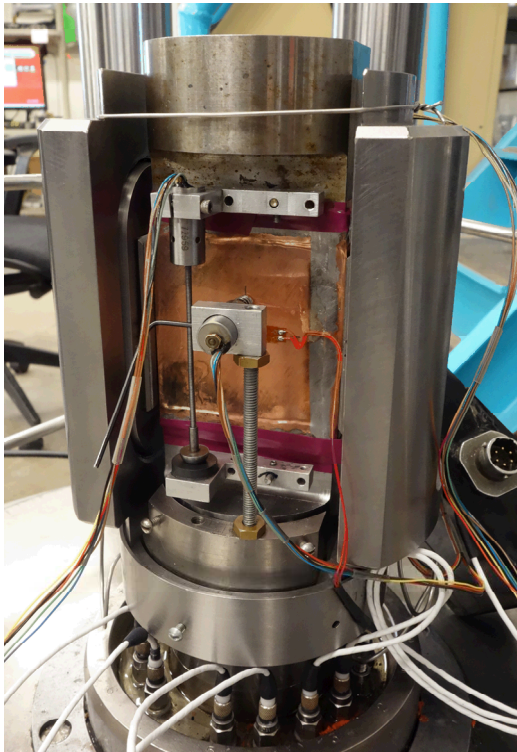
Sandia Geomechanics Capabilities

- Sandia Geomechanics Department was started in early 1970s to support primarily nuclear testing, effects and containment studies at the Nevada Test site.
- Unique Geomechanics laboratory under DOE capable of testing Geo- and Engineered-materials in all scales (nano to field) with extremely high confining pressures (1 GPa)
- World-class testing capabilities: from cryogenic to geothermal; salt creep to shock physics; up to 1,000,000 lbs loading; uniaxial to polyaxial loading; and phenomena simulations (hydraulic fracturing, borehole breakouts, and hydroshear).
- Subsurface Characterization Letter Report by JASON(2014) singled out Sandia Geomechanics Laboratory as differentiating capability that should be available as the future DOE user facility



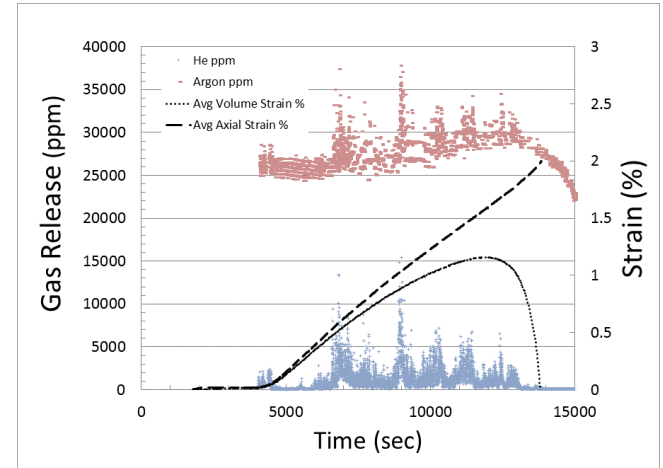


Laboratory Testing and Modeling of Hydraulic Fracturing

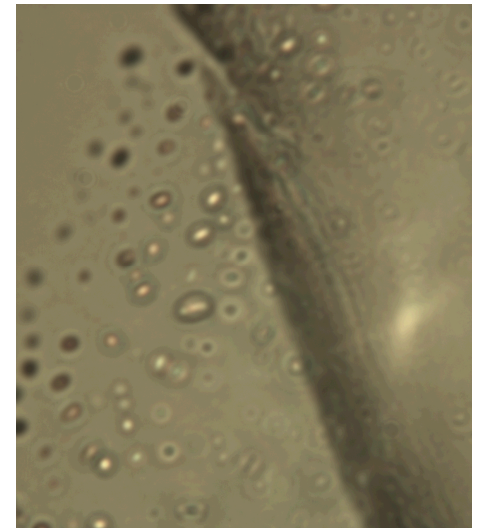


Real-Time Degassing of Rock during Deformation

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



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



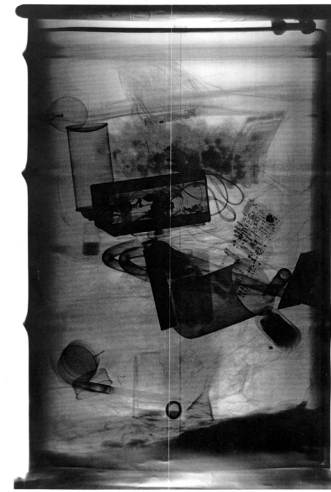
Stress induced microfracture intersecting gas bubble array in quartz in experimentally deformed Westerly granite

WIPP Surrogate Waste Materials Testing

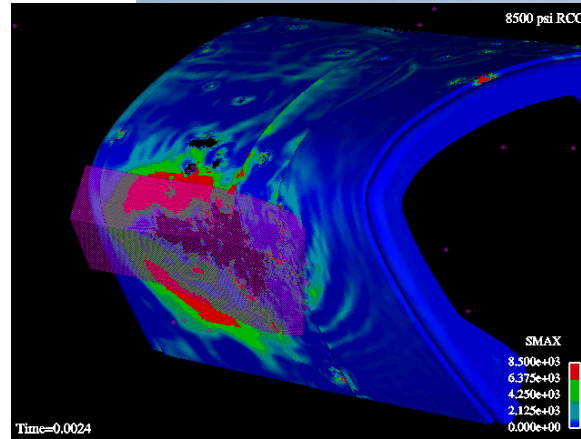
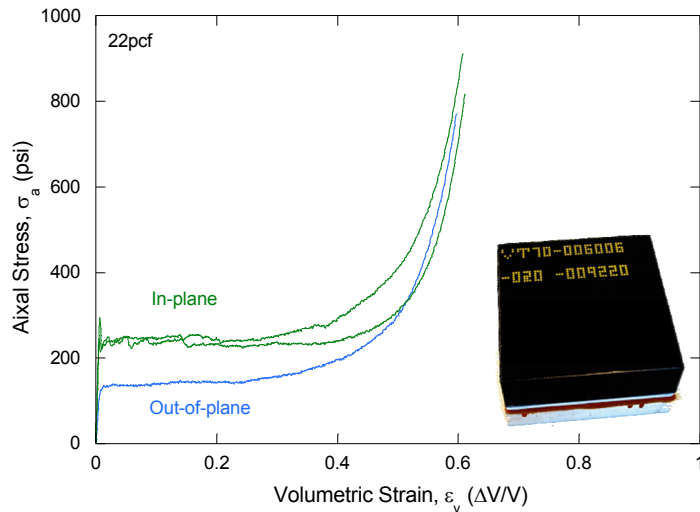
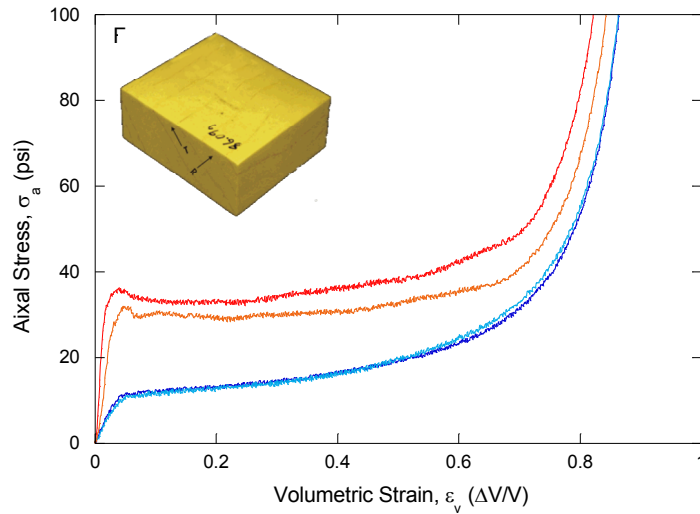
The container contains a surrogate recipe representing the average baseline inventory at the Waste Isolation Pilot Plant.



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

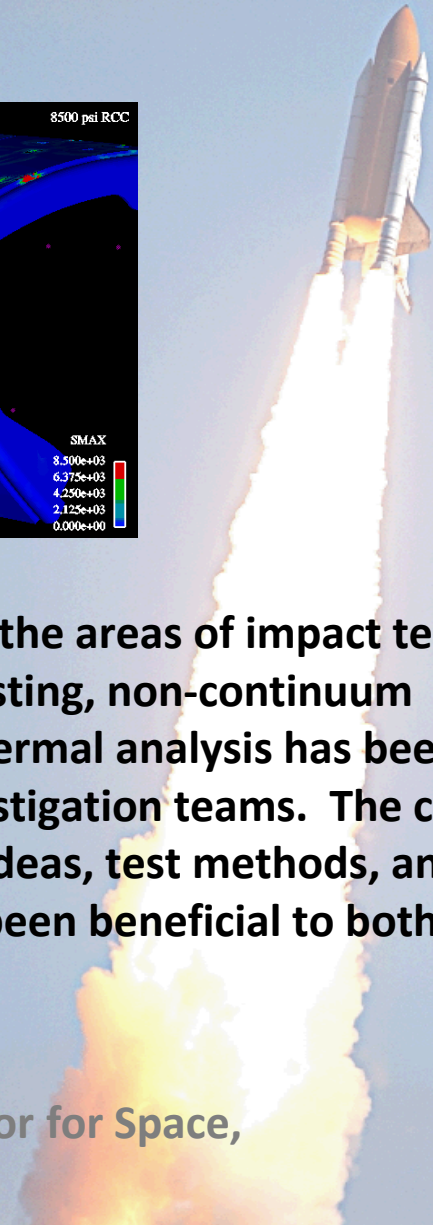


Columbia Accident Investigation

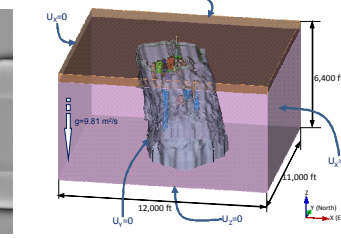
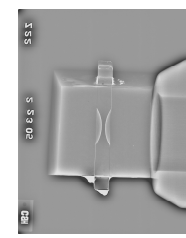
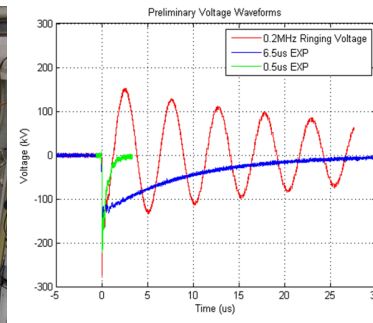
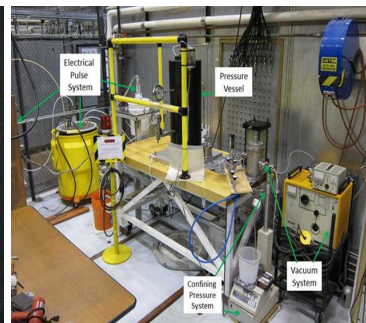
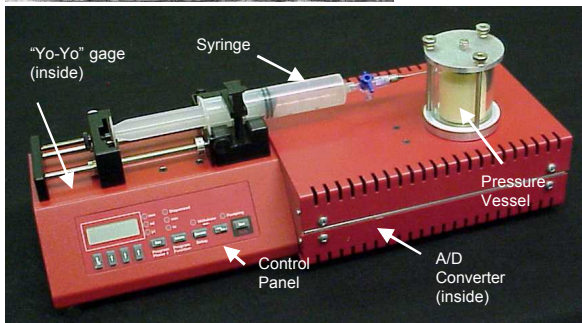
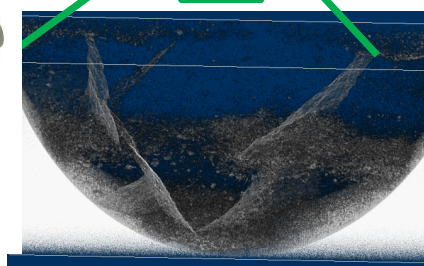
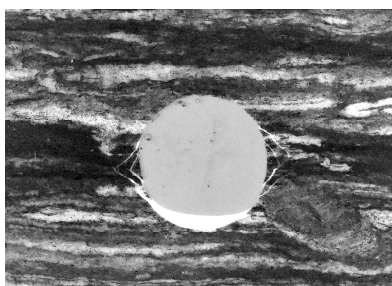
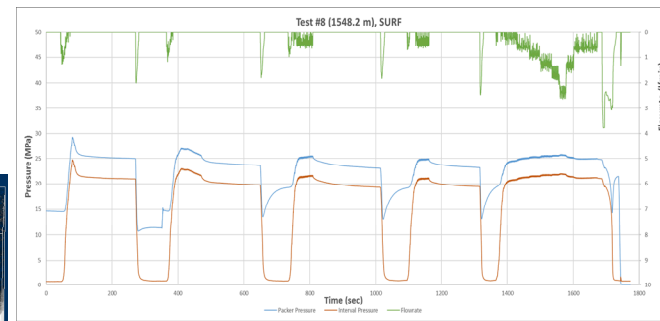
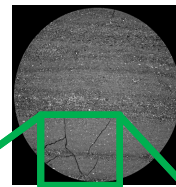
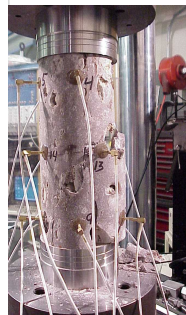
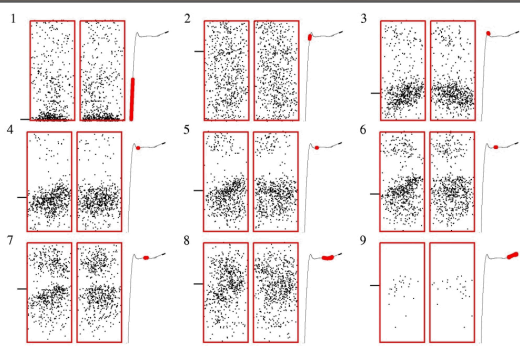
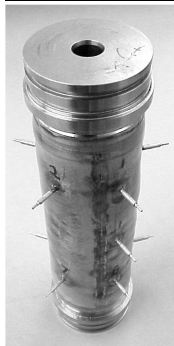
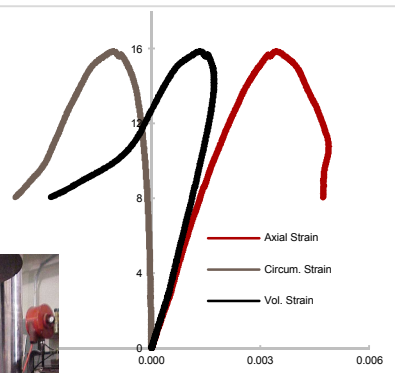


"Sandia's expertise in the areas of impact testing and modeling, material testing, non-continuum aerodynamics, and thermal analysis has been invaluable to our investigation teams. The cooperative effort and sharing of ideas, test methods, and analytical tools have been beneficial to both our organizations."

William Readdy
Associate Administrator for Space,
NASA

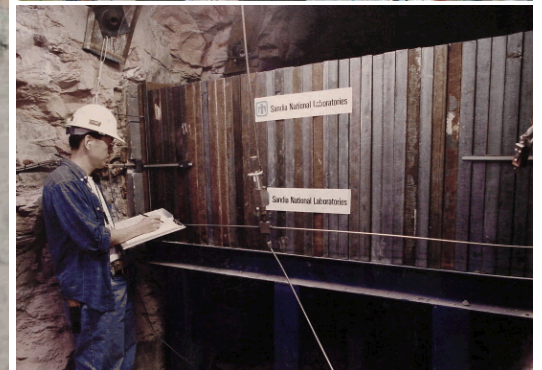
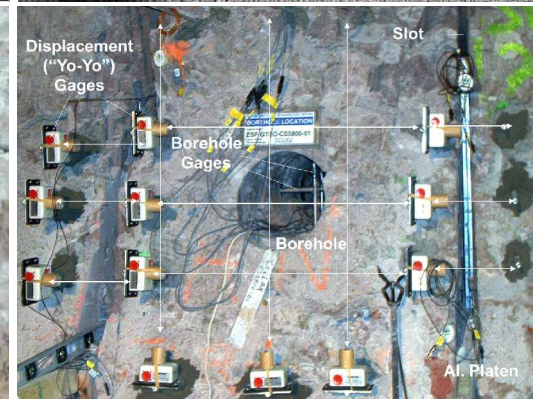
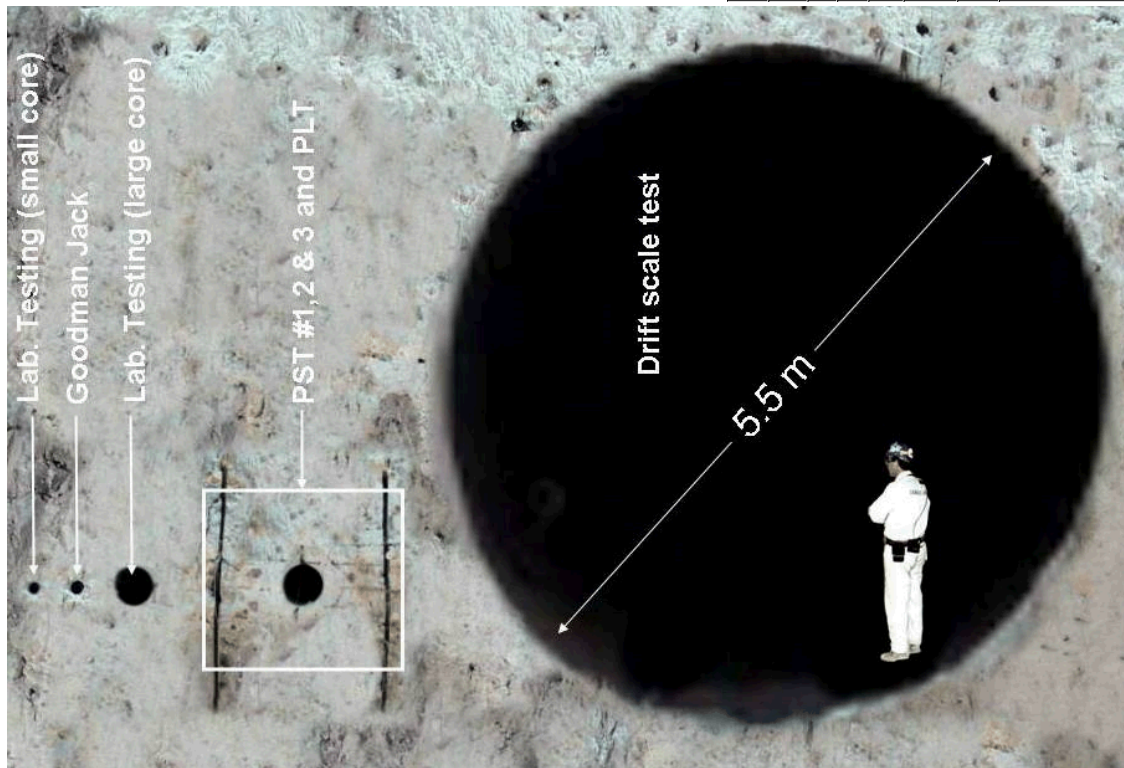
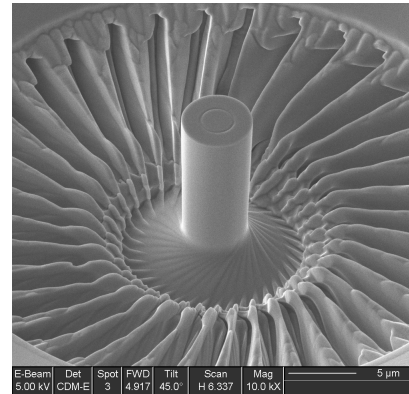


Geomechanics Projects Portfolio (DOE, SPP, LDRD, CRADA)

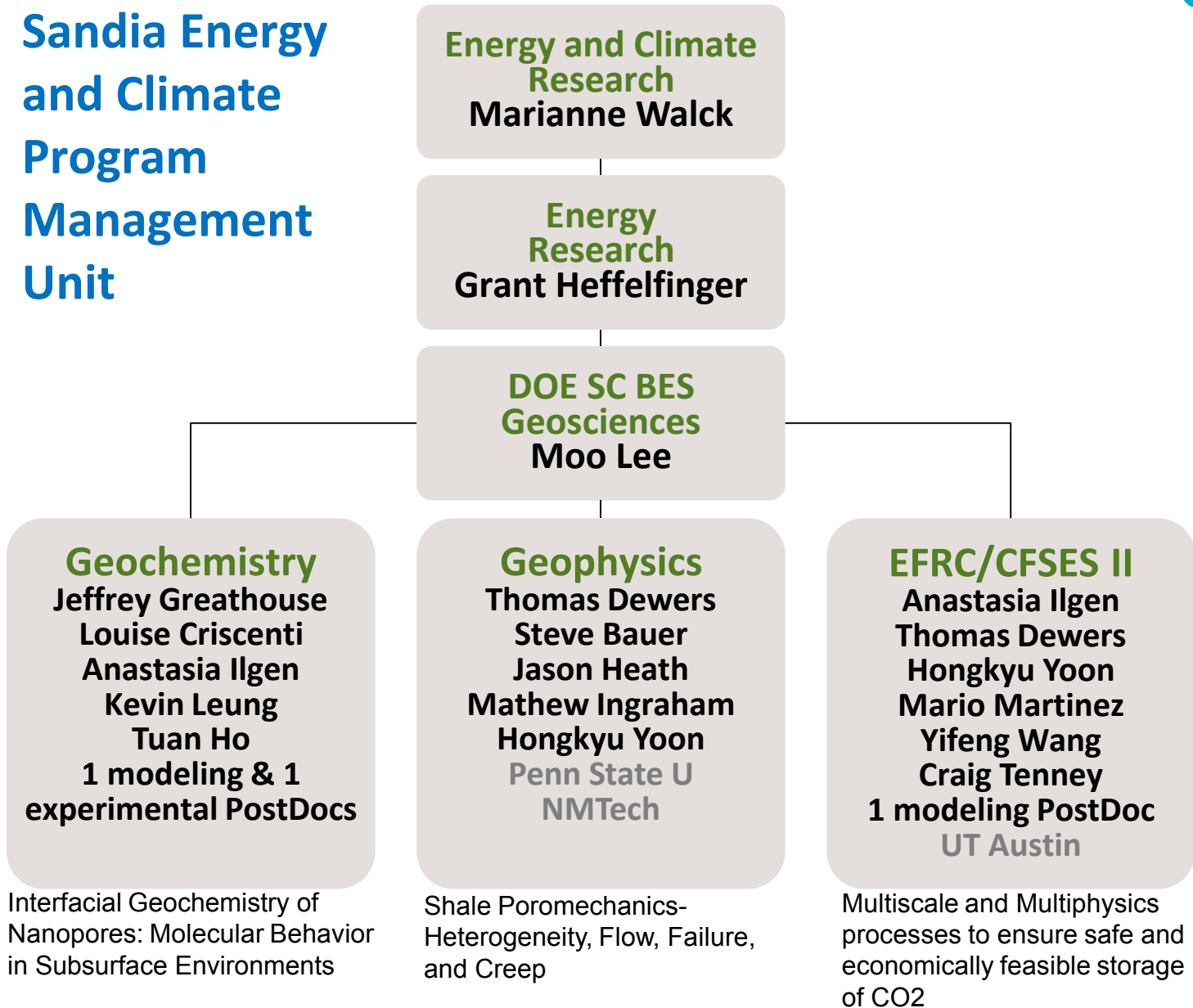


Deformability of Rock in Multi-Scales (10⁻⁶ to 10⁰ m)

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

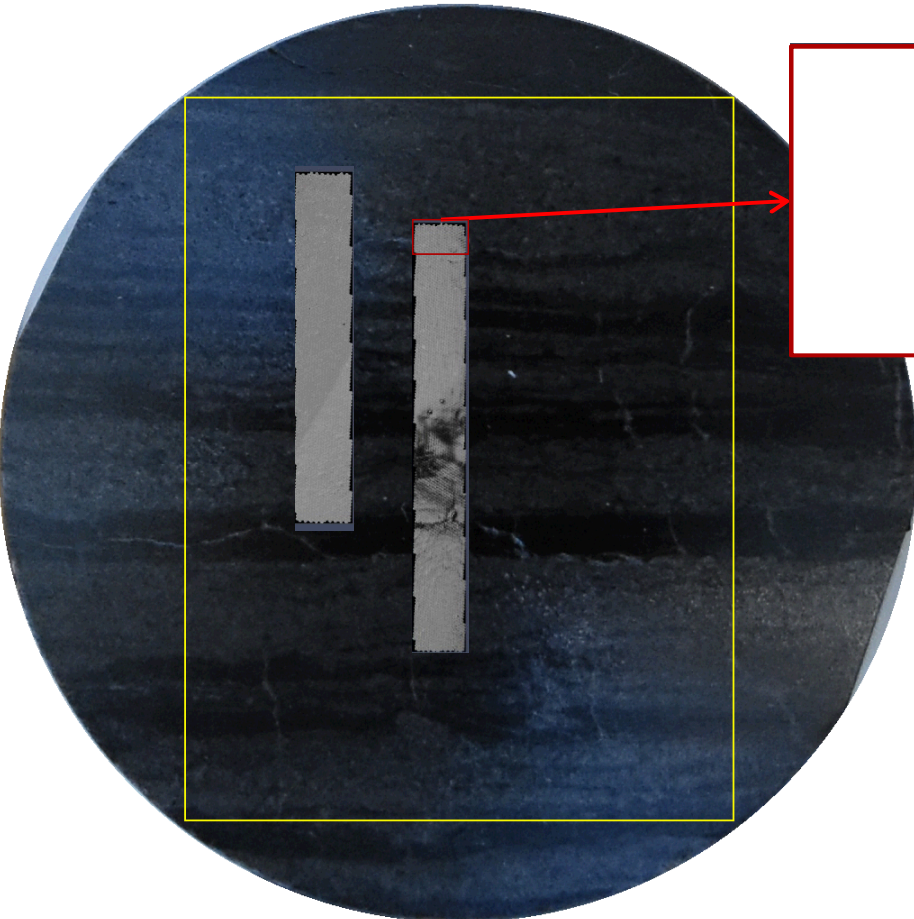


Sandia Energy and Climate Program Management Unit

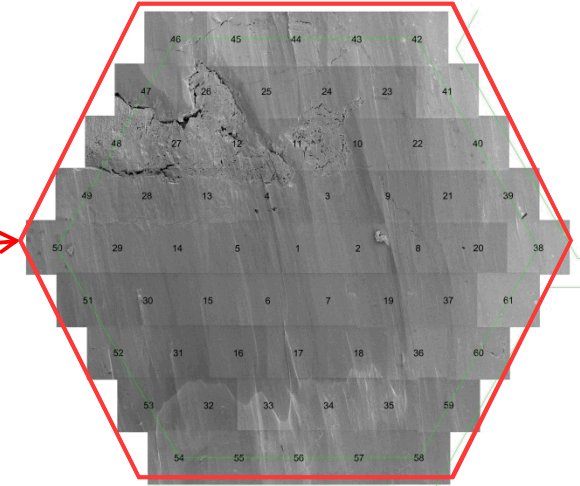


Characterization of Pore Structures using mSEM

- 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)

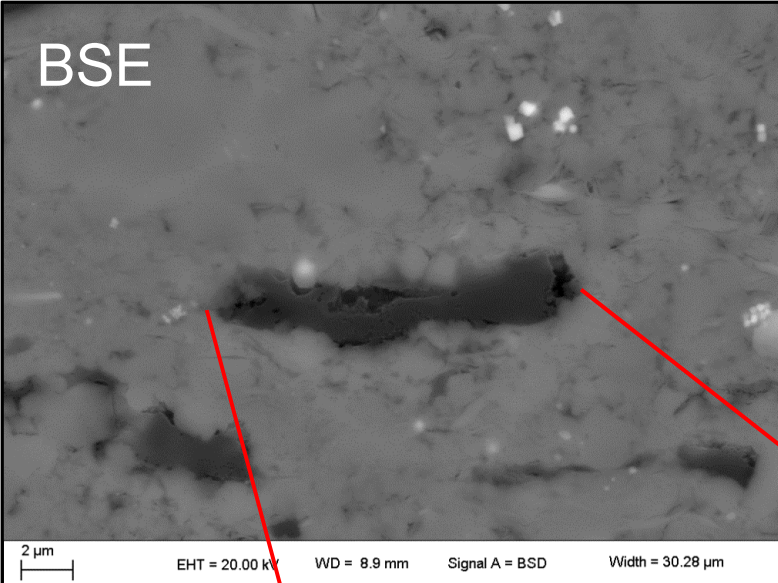


(~100 μm x 90 μm hexagon)

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)

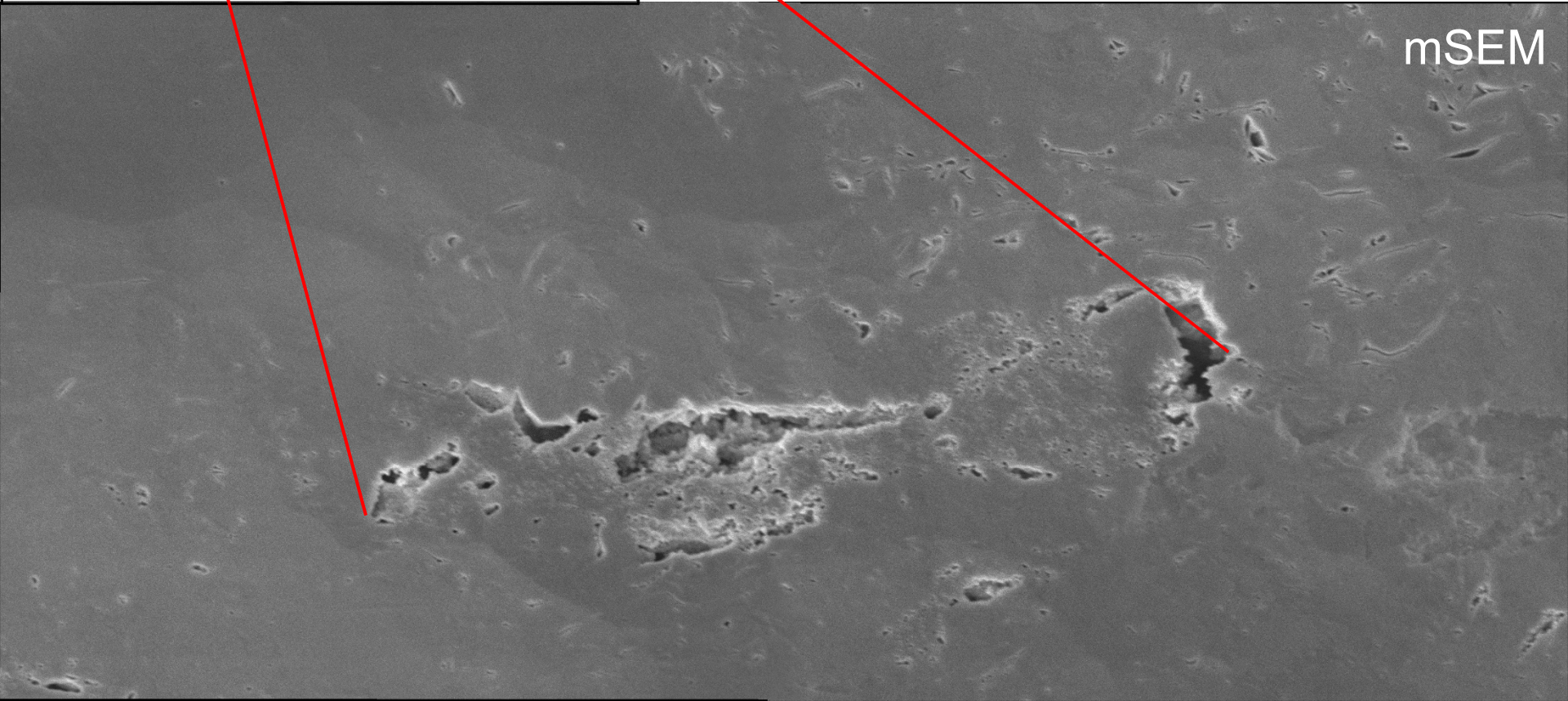
BSE



mSEM compared to BSE

- Pores on margins of organics in BSE
- Organics do not show up well at low keV in mSEM, but pores are clearly visible

mSEM



BES-Supported Geosciences Journal Publications in FY16

- Cygan, R.T. and Tazaki, K. (2014) Interactions of kaolin minerals in the environment. *Elements*, 10(3), 195-200. [invited and cover]
- Greathouse, J.A., Johnson, K.L., and Greenwell, H.C. (2014) Interaction of natural organic matter with layered minerals: Recent developments in computational methods at the nanoscale. *Minerals*, 4(2), 519-540.
- Greathouse, J.A., Geatches, D.L., Wilcox, J., Pike, D.Q., Greenwell, H.C., Johnston, C.T., and Cygan, R.T. (2015) Methylene blue adsorption on the basal surfaces of kaolinite: Structure and thermodynamics from quantum and classical molecular simulation. *Clays and Clay Minerals*, in press.
- Greathouse, J.A., Hart, D.B., Bowers, G.M., Kirkpatrick, R.J., and Cygan, R.T. (2015) Molecular simulation of structure and diffusion at smectite-water interfaces: Using expanded clay interlayers as model nanopores. *Journal of Physical Chemistry C*, 119(30), 17126-17136.
- Teich-McGoldrick, S.L., Greathouse, J.A., and Cygan, R.T. (2014) Molecular dynamics simulations of uranyl adsorption and structure on the basal surface of muscovite. *Molecular Simulation*, 40(7-9), 610-617. [invited]
- Teich-McGoldrick, S.L., Greathouse, J.A., Jové Colón, C.F., and Cygan, R.T. (2015) Swelling properties of montmorillonite and beidellite clay minerals from molecular simulation: Comparison of temperature, interlayer cation, and charge location effects. *Journal of Physical Chemistry C*, 119(36), 20880-20891.
- Zaunbrecher, L.K., Cygan, R.T., and Elliott, W.C. (2015) Molecular models of cesium and rubidium adsorption on weathered micaceous minerals. *Journal of Physical Chemistry A*, 119(22), 5691-5700. [cover]
- Zeitler, T.R., Greathouse, J.A., Gale, J.D., and Cygan, R.T. (2014) Vibrational analysis of brucite surfaces and the development of an improved force field for molecular simulation of interfaces. *Journal of Physical Chemistry C*, 118(15), 7946-7953.
- Torrealba, VA, Karpyn, ZT, Yoon, H., Klise, KA, Crandall, D (2015), Pore-scale investigation on stress-dependent characteristics of granular packs and the impact of pore deformation on fluid distribution, Available online in May 2015, *Geofluids*, D OI: 10.1111/gfl.12143
- M. Oostrom, Y. Mehmani, P.D.J. Romero-Gomez, Y. Tang, H. Liu, H. Yoon, Q. Kang, V. Joekar-Niasar, M.T. Balhoff, T. Dewers, E.A. Leist, N.J. Hess, W.A. Perkins, C.L. Rawkowski, M.C. Richmond, J.A. Serkowski, C.J. Werth, A.J. Valocchi, T.W. Wietsma, and C. Zhang, 2014, Pore-scale and continuum simulation of solute transport micromodel benchmark experiments, *Computational Geosciences*, doi: 10.1007/s10596-014-9424-0
- Rinehart, A. J., J. E. Bishop, and T. Dewers (2015), Fracture propagation in Indiana Limestone interpreted via linear softening cohesive fracture model, *Journal of Geophysical Research-Solid Earth*, 120(4), 2292-2308.
- Singh, R., H. Yoon, R. A. Sanford, L. E. Katz, B. W. Fouke, and C. J. Werth (2015), Metabolism Induced CaCO₃ Biomineralization During Reactive Transport in a Micromodel: Implications for Porosity Alteration, *Environmental Science & Technology*.
- Wang, Y., M. A. Chan, and E. Merino (2015), Self-organized iron-oxide cementation geometry as an indicator of paleo-flows, *Sci. Rep.*, 5.
- Yoon, H., Q. Kang, and A. J. Valocchi (2015), Lattice Boltzmann-Based Approaches for Pore-Scale Reactive Transport, *Reviews in Mineralogy & Geochemistry*, 80(1), 393-431.