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Digital Rock Physics for Experiments and Modeling of Fractured Porous Media

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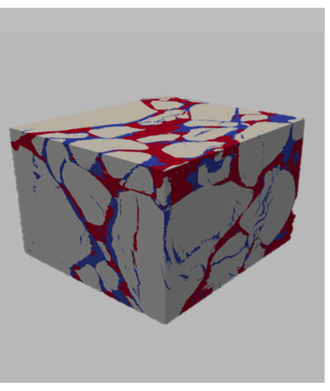
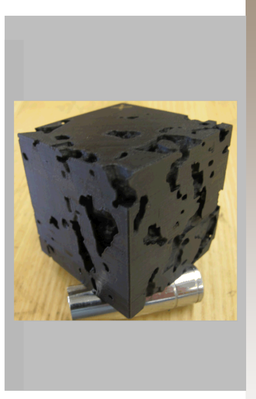
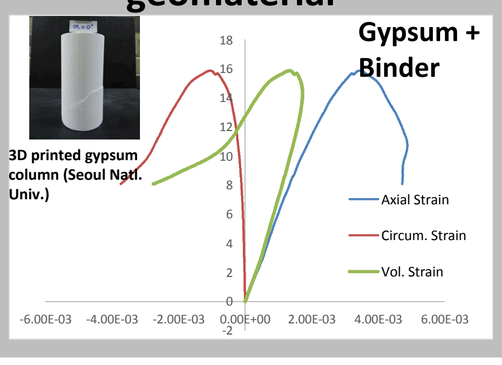




3D printed core behaves like geomaterial



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Exceptional service in the national interest

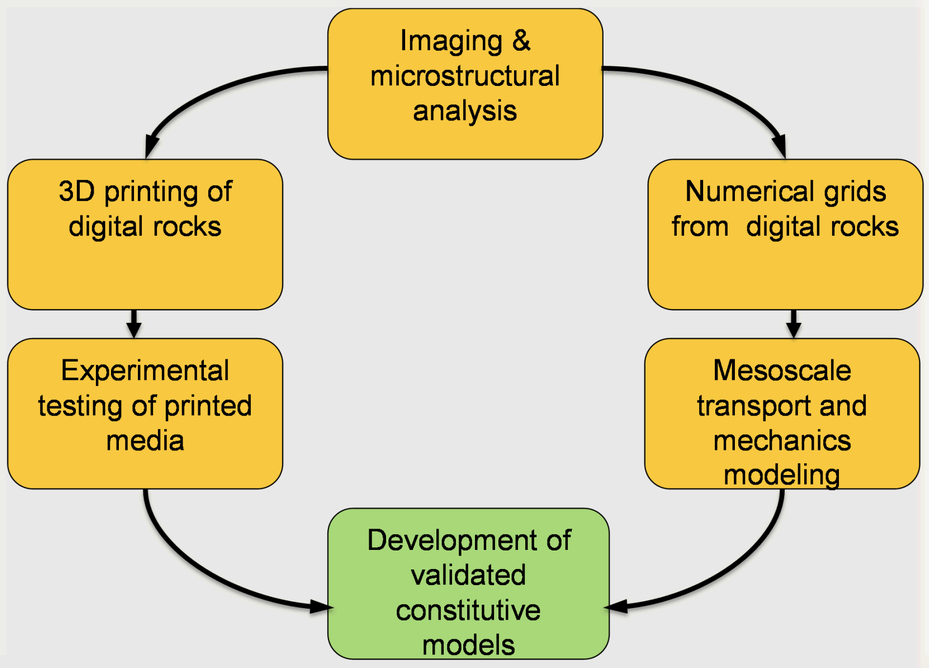
Prospectus

Digital rock schema could be improved with 3D printing

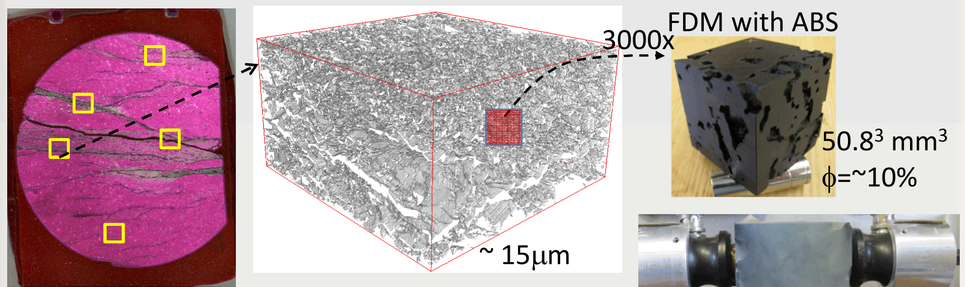
3D printing enables us to:

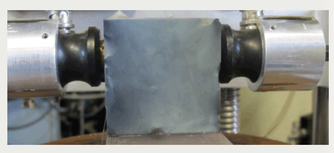
- surmount problems with sample-to-sample heterogeneity
- to test material response independent from pore-structure variability
- develop functional porous structures
- print porous specimen with integrated test frame
- addresses issues of scale-up

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

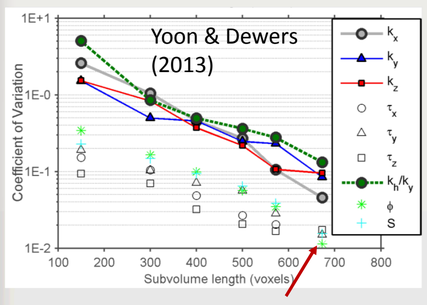


Digital Rock Physics with 3D printing

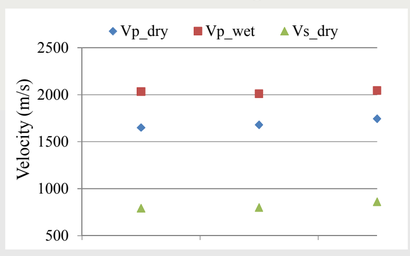




AE testing



FIB-SEM sample volume has a size of statistical elementary volume at ~ 10 µm



Science Challenges

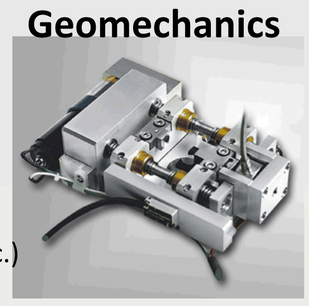
Areas of impact to frontiers of science:

- Ability to relate microstructure to bulk measurable properties and performance
- Understanding how to control flow in fractured media
- Understanding how to manipulate fracture morphology for flow path control
- Testing scale-up of digital rock properties
- Develop the methodology for experimental utilization of additively manufactured copies of real rock, a potentially disruptive technology for geosciences.
- Establish framework for future S&T investments.

Experimental Facilities

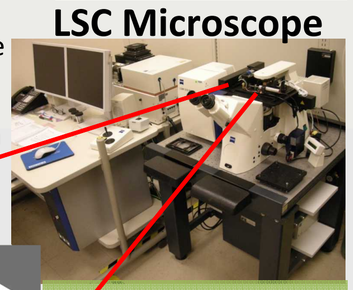
- Fullam 1-ton compression/tension load frame
- Core Labs coreholder with sonic velocity, acoustic and X-ray CT imaging capability (15,000 psi and 150°C)
- Associated pressure systems for petrophysics measurements (Pc, perm, etc.)

Geomechanics



LSC Microscope

- Zeiss laser scanning confocal microscope
- Microscope stage for real time imaging
- Tension and compression, loads to 1 ton
- Digital image correlation for strain
- Microfluidic cells for multiphase flow and transport



Zeiss 510 meta Laser Scanning Confocal Microscope

3D Printing of digital rocks

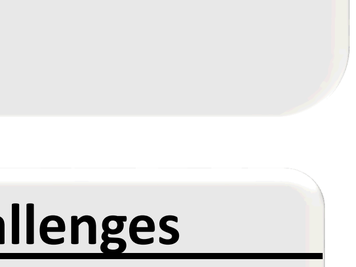
Why 3D printing?

- Ability to design and realize complex geometries
- Engineered material control at new regimes

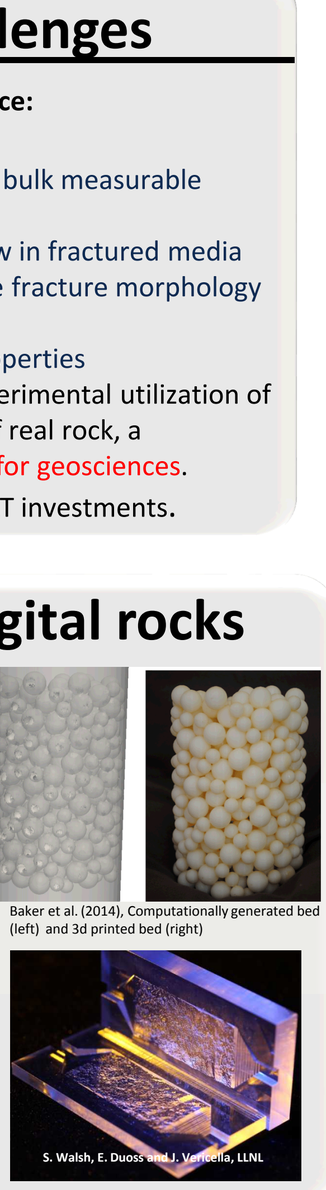
Porous structure features for this project:

- Real pore structure on specimens ~ 2 cm³
- 25-100 micron pores, 100+ micron fractures

Extensive SNL additive manufacturing capabilities will be leverages for Geo application



Baker et al. (2014), Computationally generated bed (left) and 3d printed bed (right)



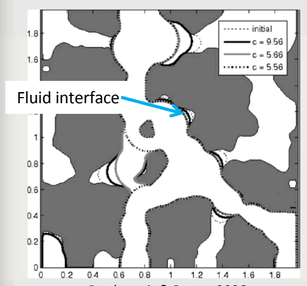
Collaborations with UNLV, UTEP

Impact:

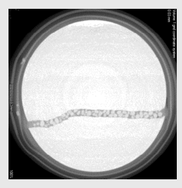
- Science-based approach to develop advanced constitutive models and materials
- Testing and modeling on the same reproducible pore topologies
- Scale dependence & model validation

Modeling at the Mesoscale

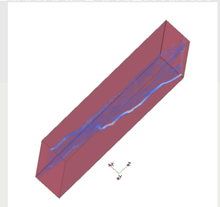
Multiphase flow with Level Set



Prodanovic & Bryant 2006

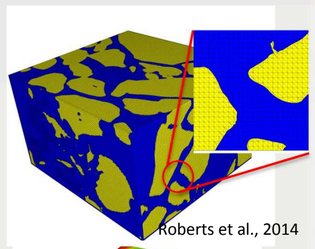


Lattice Boltzmann

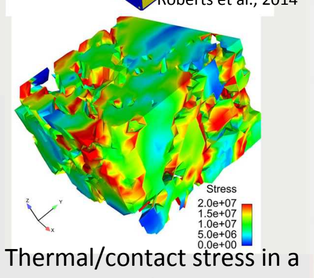


Flow of "frac" fluid in proppant-containing fracture

Sierra Mechanics/CDFEM



Roberts et al., 2014



Thermal/contact stress in a reconstructed porous electrode

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