Fracture Toughness of Sandstone and Shale at In Situ Conditions for CCS

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Sustaining Injectivity

Changes in rock strength could lead to development of fracture networks, creating high permeability pathways into the reservoir

Increases in fracture toughness in the presence of $scCO_2$ could lead to higher injections rates and pressure while maintaining wellbore integrity

Storage Efficiency

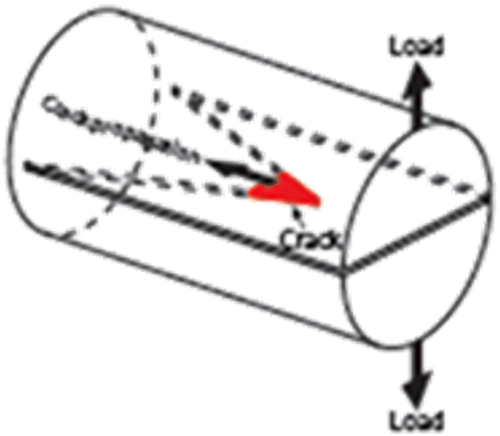
Induced fractures and dilatant deformation create additional porosity for storage and improved sweep

Controlling Emergence

Movement along induced fractures and faults could pierce overlying seal

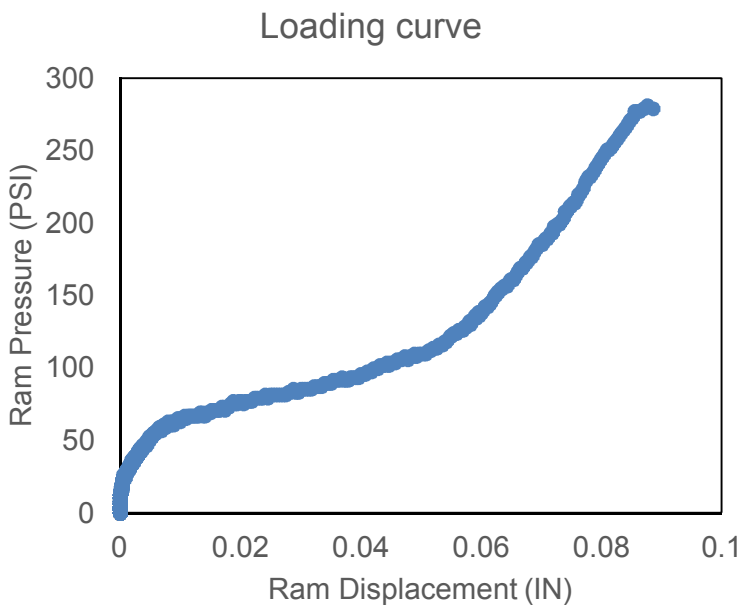
Objectives and Methods

- Experiments were conducted using partial humidity and fully saturated $scCO_2$ on analog reservoir rock, Boise SS
  - 29% porosity; quartz, albite, microcline, illite-smectite, and calcite
- Instantaneous changes in rock strength due to the presence of hydrous $scCO_2$
- Boise short rod samples loaded in fracture toughness tester inside pressure vessel
  - Ability to control load and loading rate, measure displacement and ram pressure
- Hydrous $scCO_2$ generated using pressure vessel, recirculating pump, at 70C and 2000PSI
- Partial humidity $scCO_2$, water added in 5mL increments via Rheodyne injector valve, 0-40 mL total
- Samples exposed for 4 hours total
- Samples deformed at moderate strain rates
- After deformation and depressurization, fracture faces analyzed on white light 3d profilometer



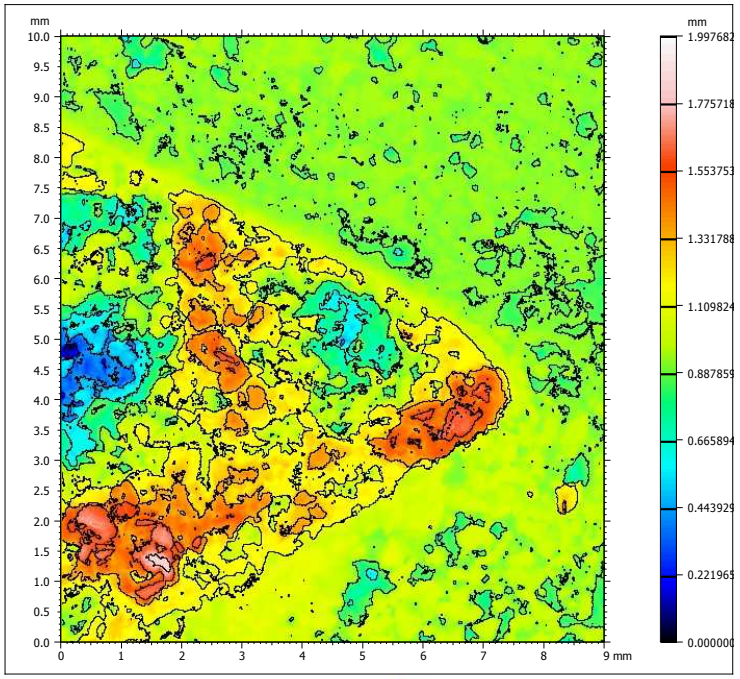
Results

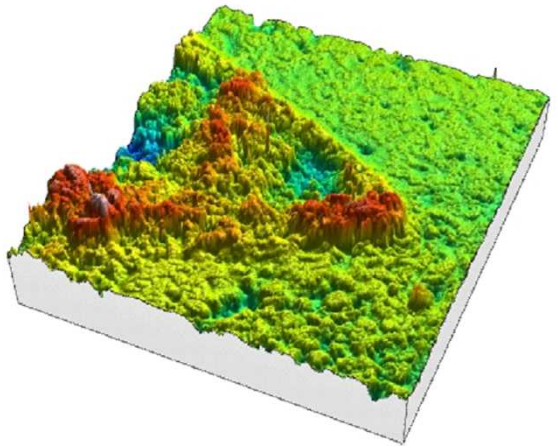
- Experiments were conducted using partial humidity and fully saturated $scCO_2$ on Boise Sandstone
- Preliminary experiment on dry samples loaded at room temperature conditions
- Fracture toughness calculated as a function of total force on the grips and geometry of the crack
- $fracture\ toughness = 24 * \frac{\max load}{Diameter^{1.5}} * geometry\ correction\ factor$
  - ISRM: *Suggested methods for determining the fracture toughness of rock*
- Fracture toughness: 850 PSI IN^{-2}



Results

- Nanovea ST400 non contact 3d surface profilometer
  - Chromatic confocal optical technology, white light LED
- Height ranges available from 110 microns to 20 mm
- Profile fracture faces to investigate if hydrous $scCO_2$ affects growth pattern, fracture face roughness
- Dry experiment: wave like fracture face
  - Growth asymmetric around center line





Planned Manuscripts

The Effect of Hydrous scCO2 on the Fracture Toughness of Boise Sandstone
Choens, Dewers, Eichubl, Majors, Espinoza, Aman

The Effect of Hydrous scCO2 on the Fracture Toughness of Mancos Shale
Choens, Dewers, Ilgen, Espinoza, Aman