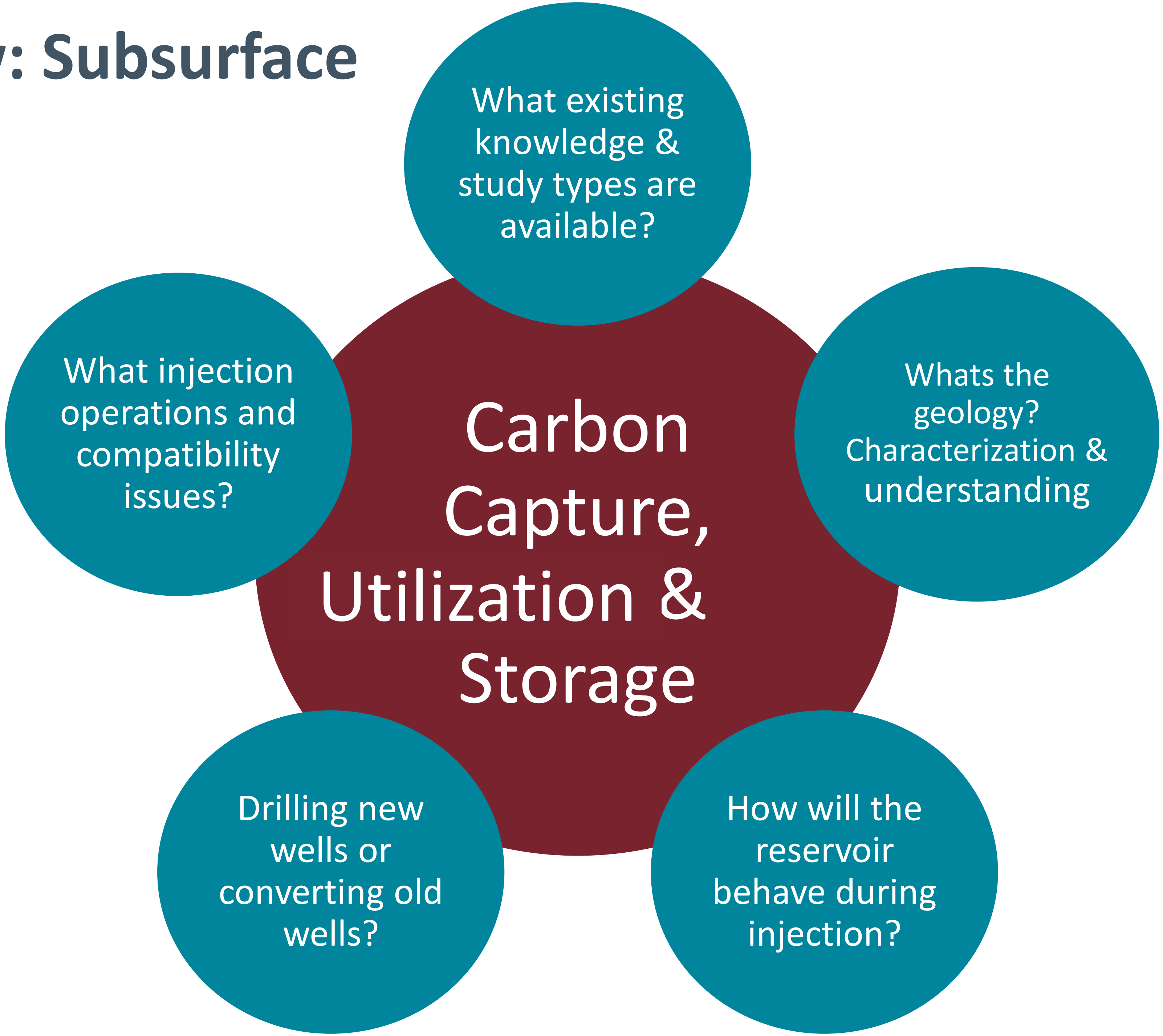
Core Analysis for Carbon Capture, Usage & Storage

Jules Reed
Global Technical Manager,
Premier Corex

Joel Walls
Geoscience Advisor,
Premier Corex

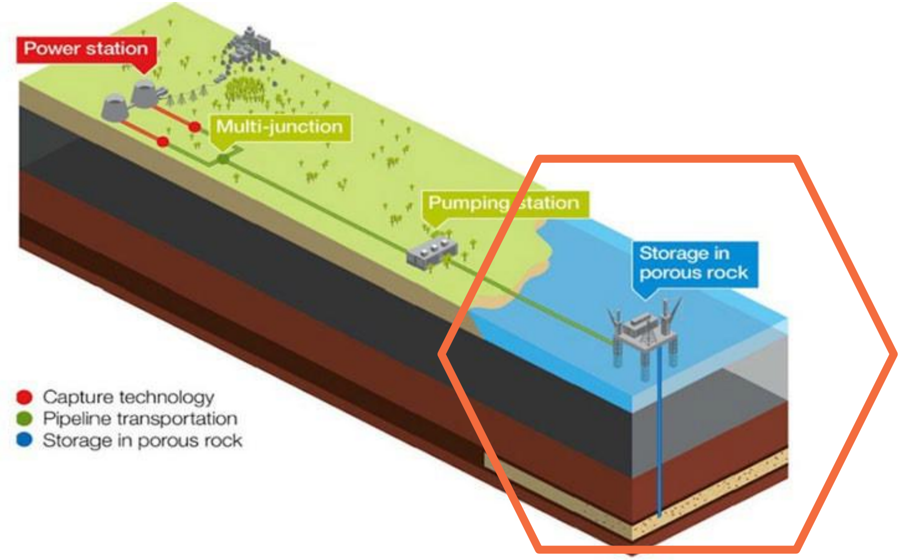
Overview: Subsurface

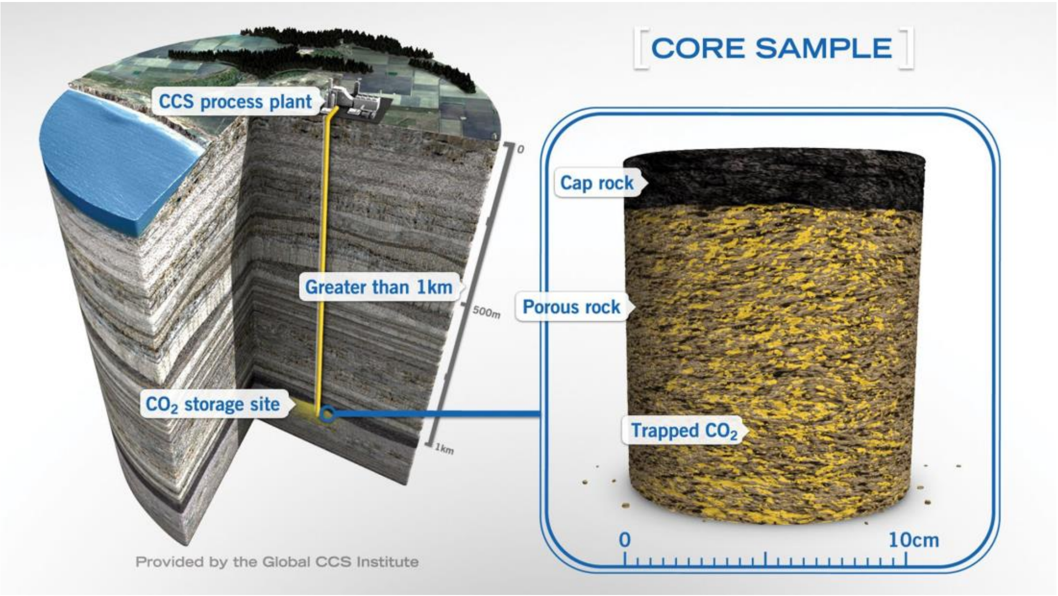


Can existing reservoir experience be used?

Similar principles apply in subsurface CCUS vs other reservoirs

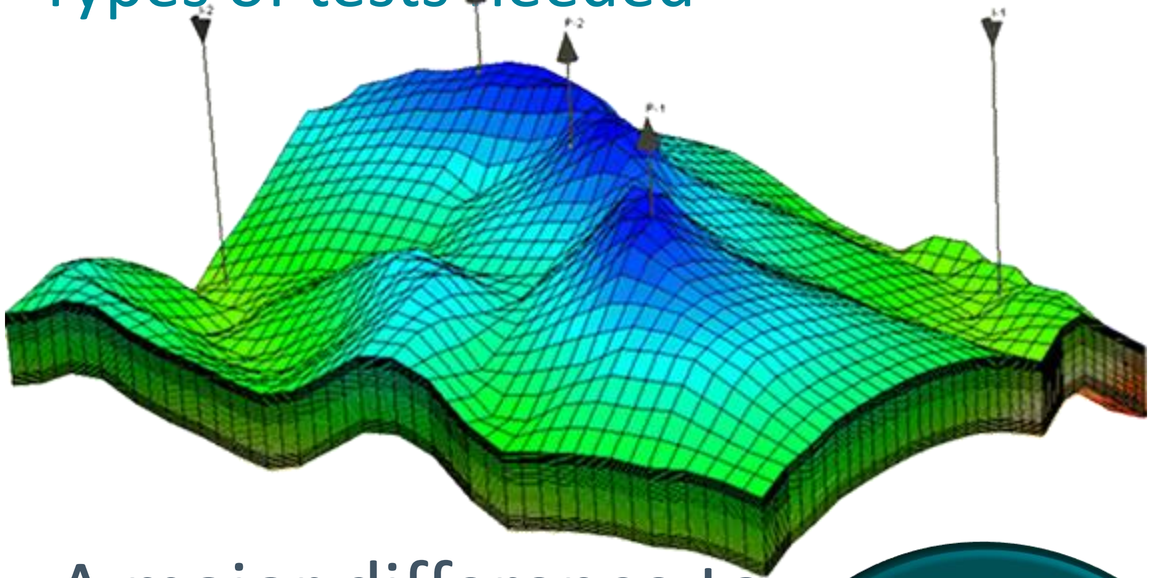
- Understanding the petrophysical, geomechanical, and geological properties of the injection target formation
- Identifying the capacity of the overlying seal unit
- These are often the same reservoirs that have been previously studied and documented.



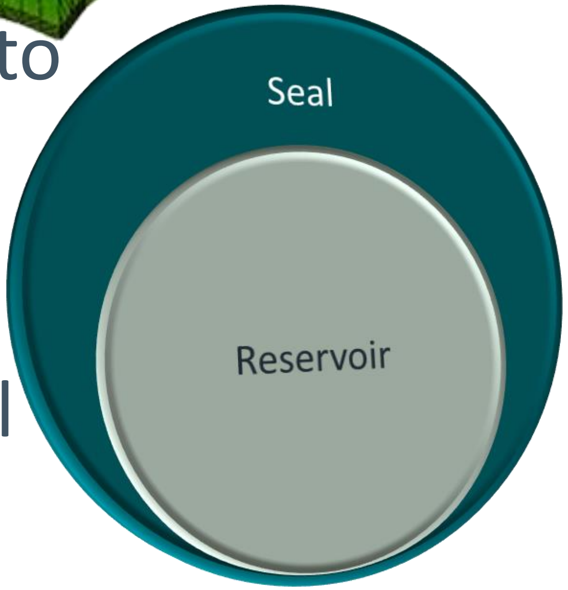


Characterizing and understanding the rocks

Types of tests needed



A major difference to standard core analysis is the requirement to understand the seal unit

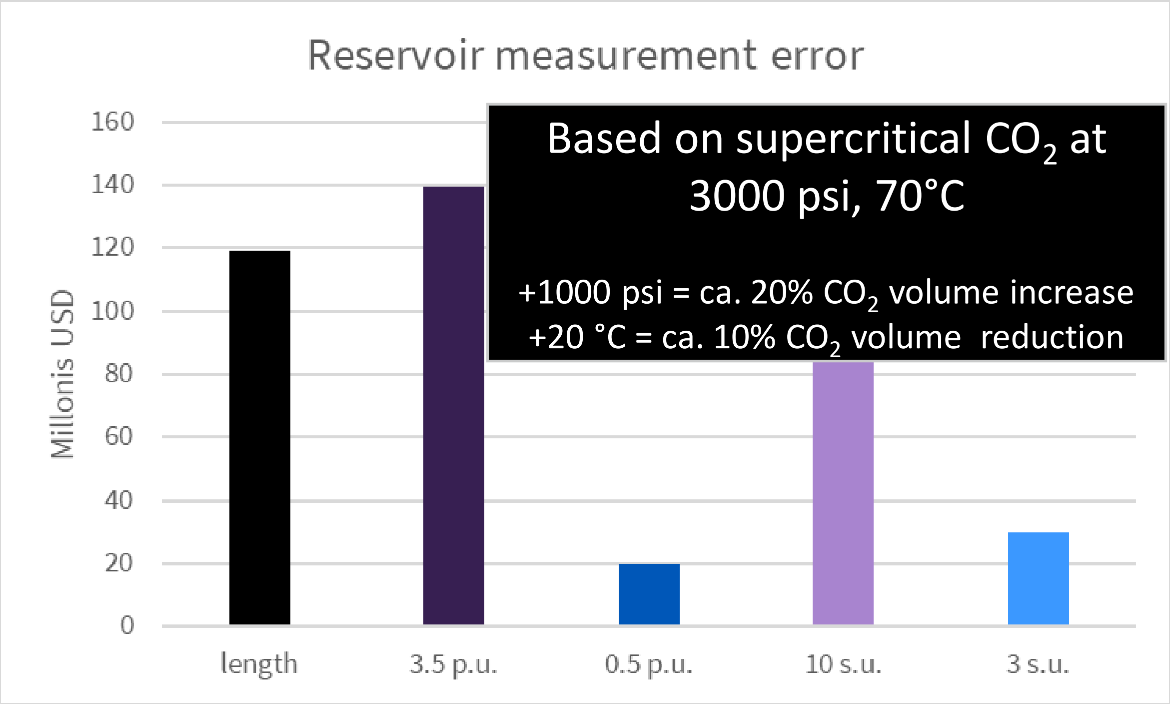


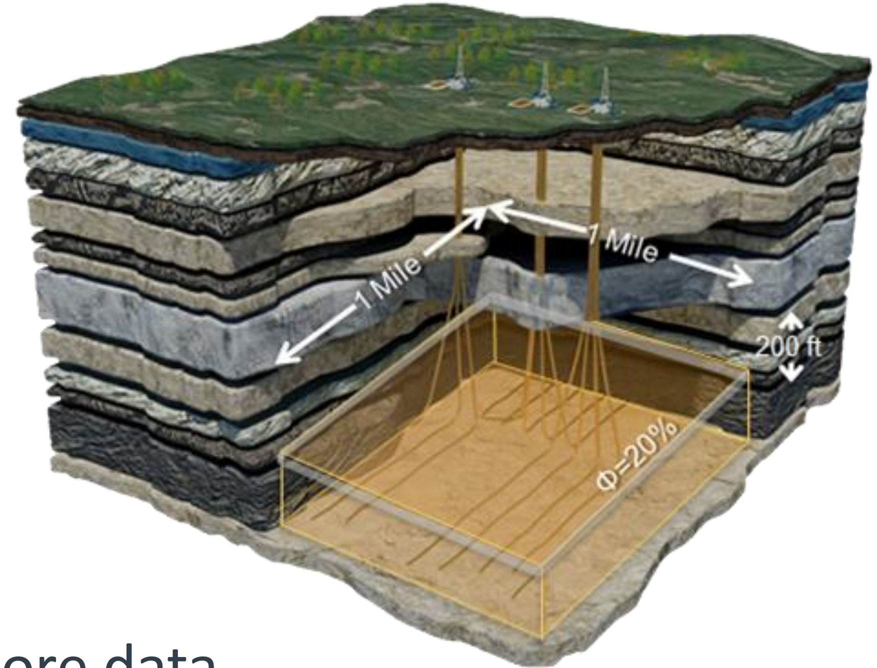
Density	Porosity	Permeability	Mineralogy
Grain size distribution	Pore size distribution	Relative permeability	Scaling
Rock mechanics	Capillary Pressure	Wettability	Fluid analysis
Rock-Fluid interactions	Residual saturations	Enhanced oil recovery	Formation damage

Characterizing and understanding the rocks

Reducing uncertainty

- Seismic height error – ca. ± 15% length
- Log porosity ≈ ± 3.5 porosity units (p.u.)
- Log saturation ≈ ± 10 saturation units (s.u.)





- Controlled core data
  - Core porosity - ± 0.5 p.u.
  - Core saturation - ± 3 s.u.

Possible uncertainty reduction:

100 MM$ - based on $50 /ton CO_2

& injection to 3000 psi, 70°C

Characterizing and understanding the rocks

Protect and preserve

1 m liners and transport container

Appropriate wellsite handling is critical

May require specialised stabilization

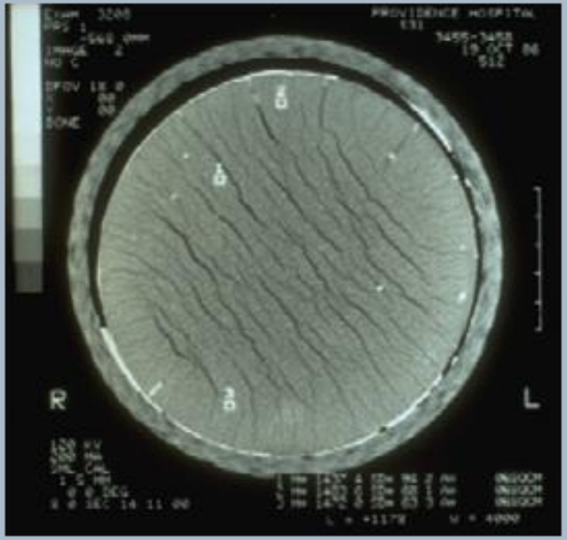
– fluid & core dependent

Sealing top of barrel

Some images per McPhee et al 2015

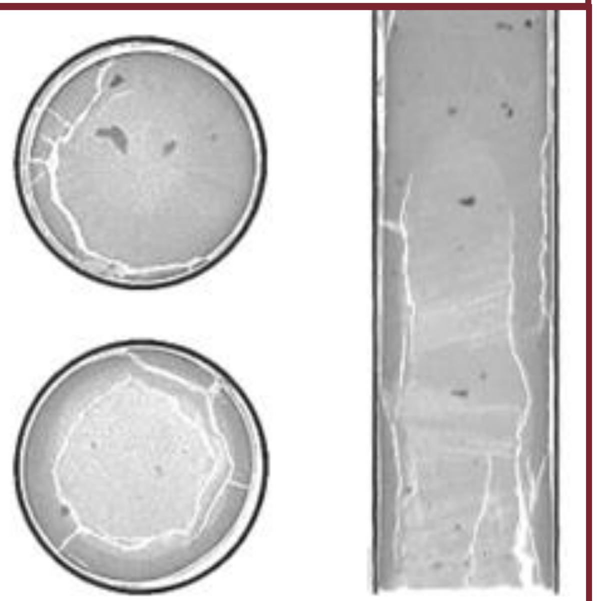
Characterizing and understanding the rocks

Longitudinal Fracturing
(no lifting support – cradle)

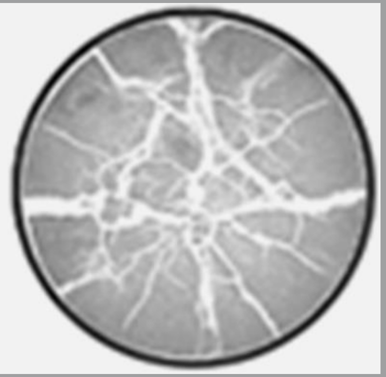


- Essential to understand potential core damage
  - assess sample selection
  - evaluate core analysis results
  - rotary sidewall samples are often intact and undamaged but their small size can be a disadvantage for some tests.

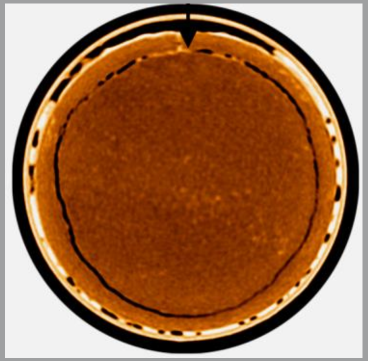
Cylindrical Shearing
(coring)



Gas Expansion (POOH)

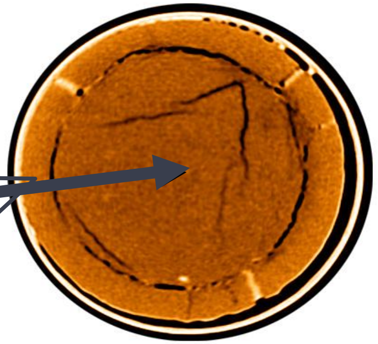


Dendritic =
Gas Expansion



Onion-layer peel-off
Invasion ring gas-block

Shock/Handling
Damage

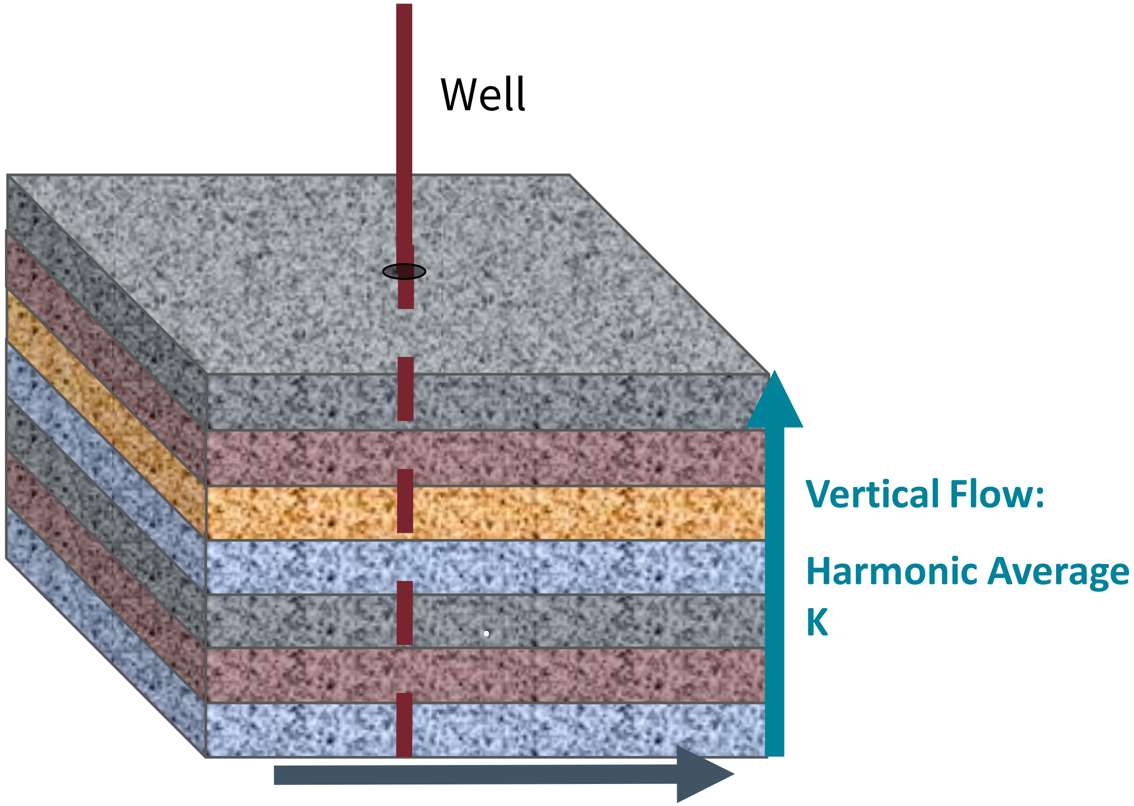


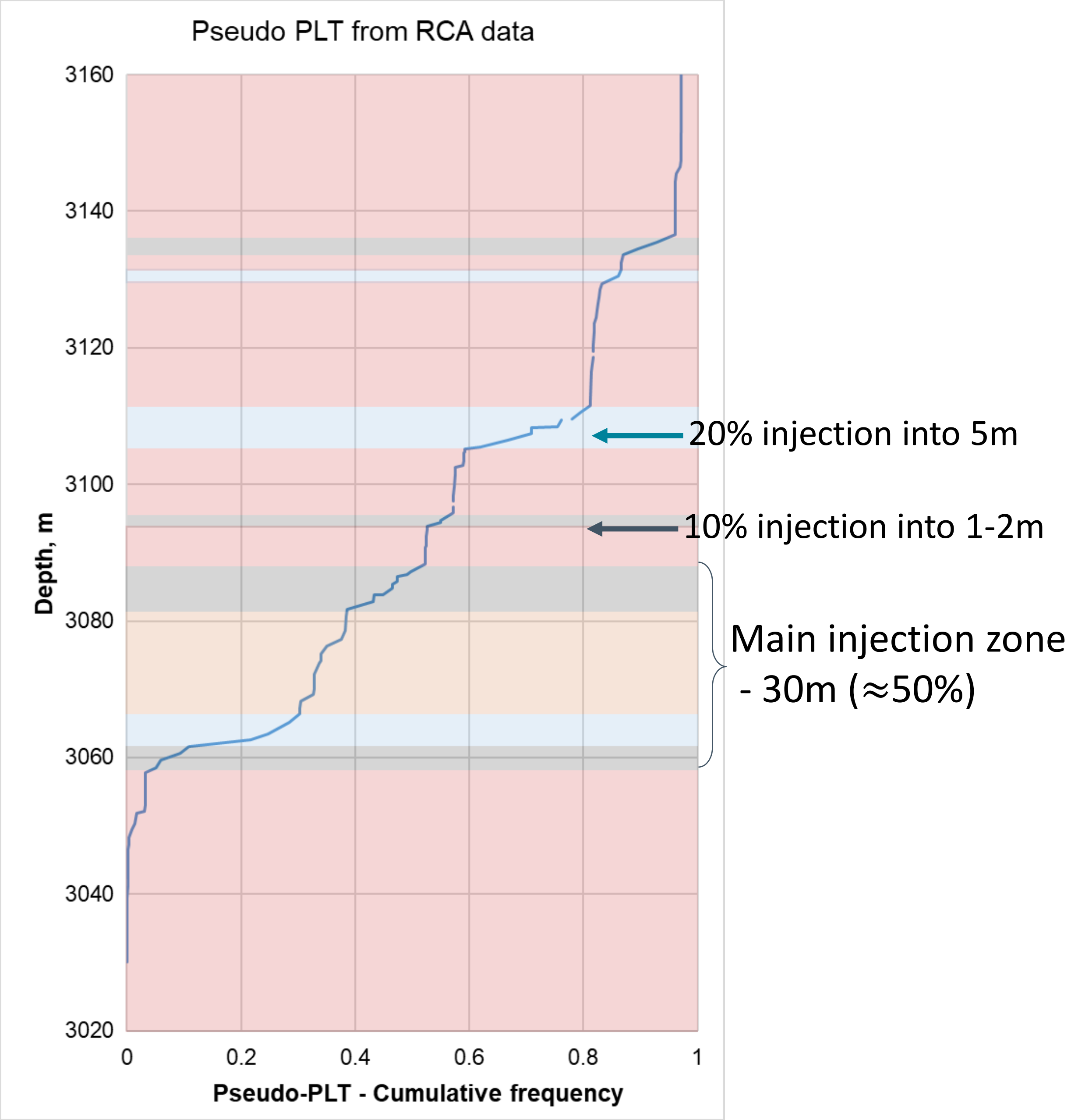
Chevron pattern =
transit/handling
damage

Some images per
McPhee et al 2015

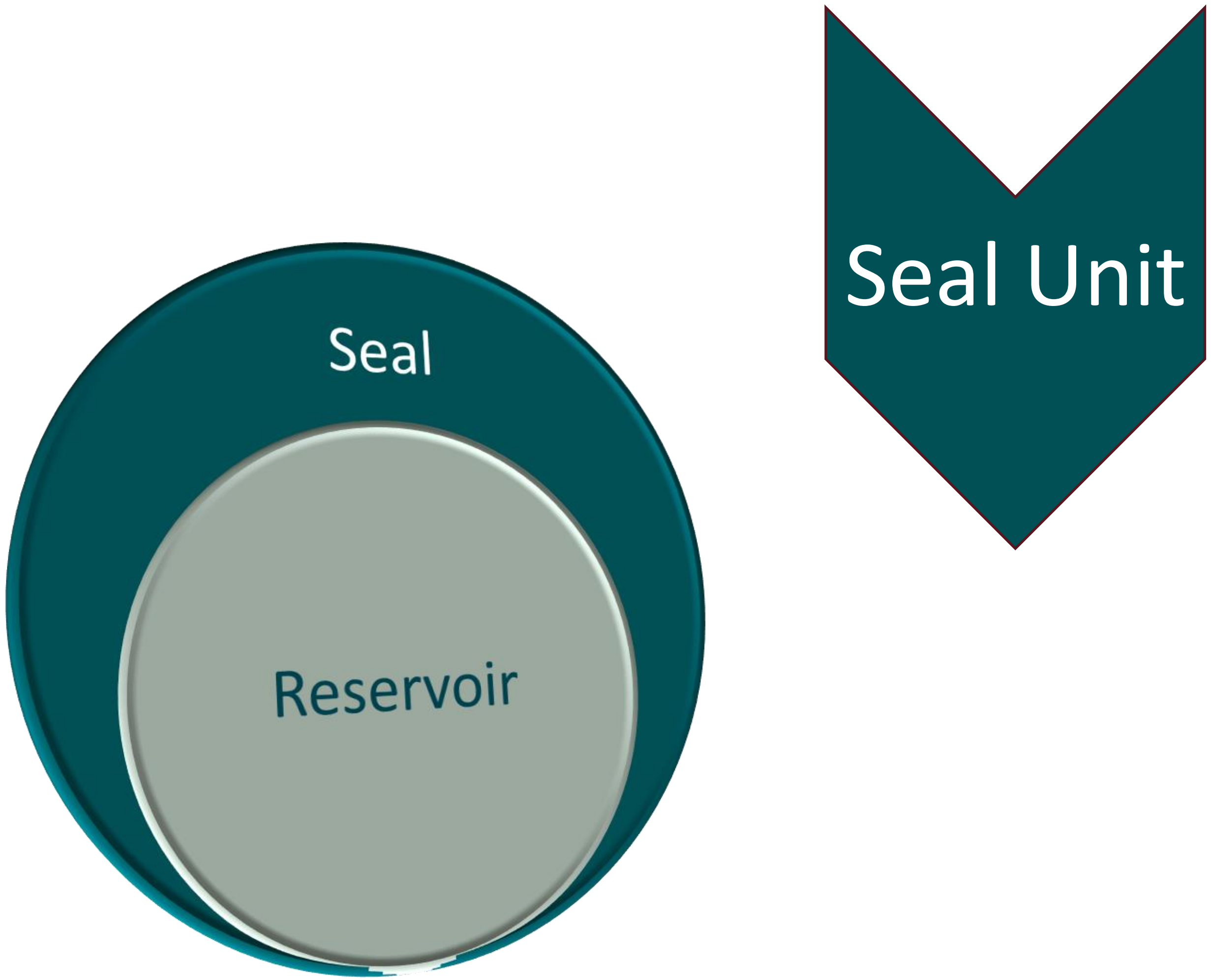
Characterizing and understanding the rocks

Where is the CO_2 really going?

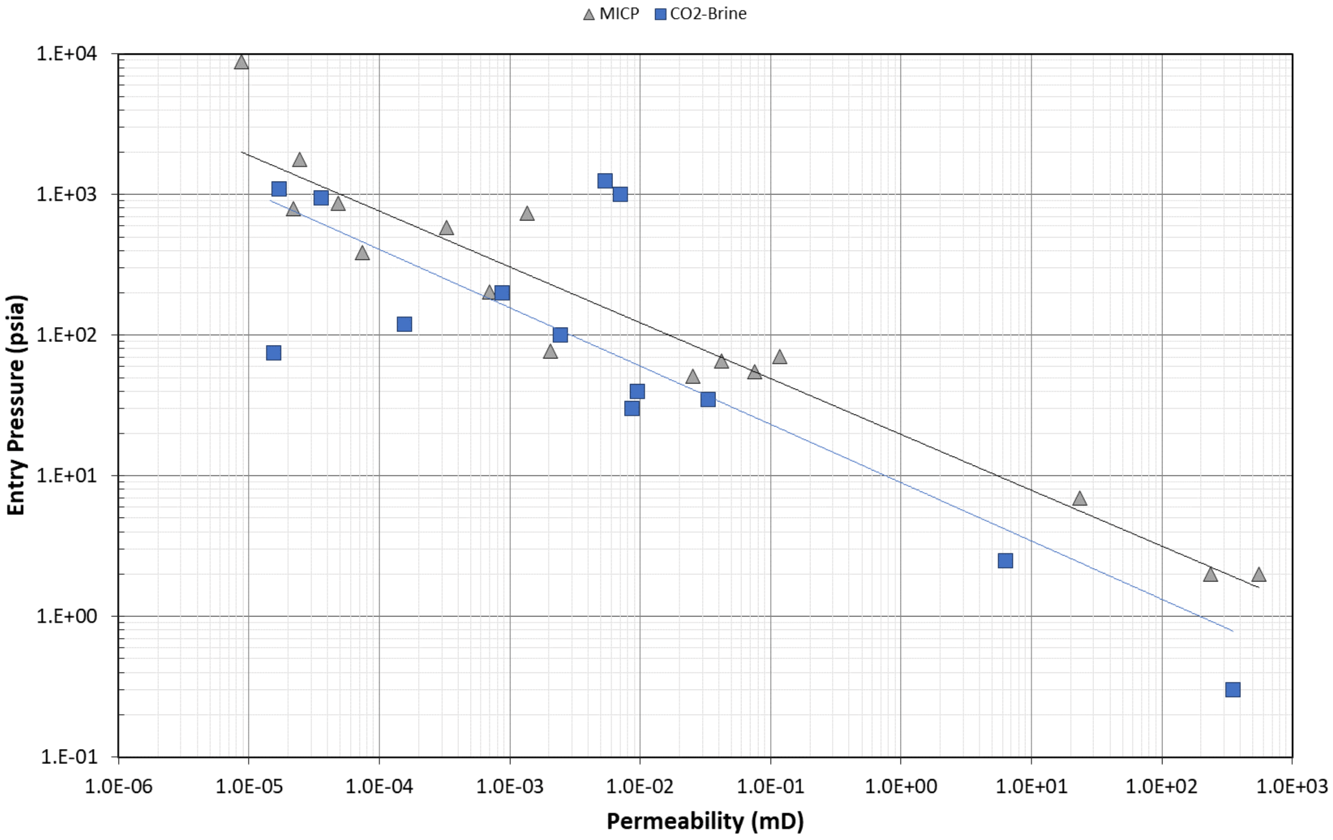




Core Analysis and Petrography



MICP and CO_2- Brine Threshold Pressure vs Perm



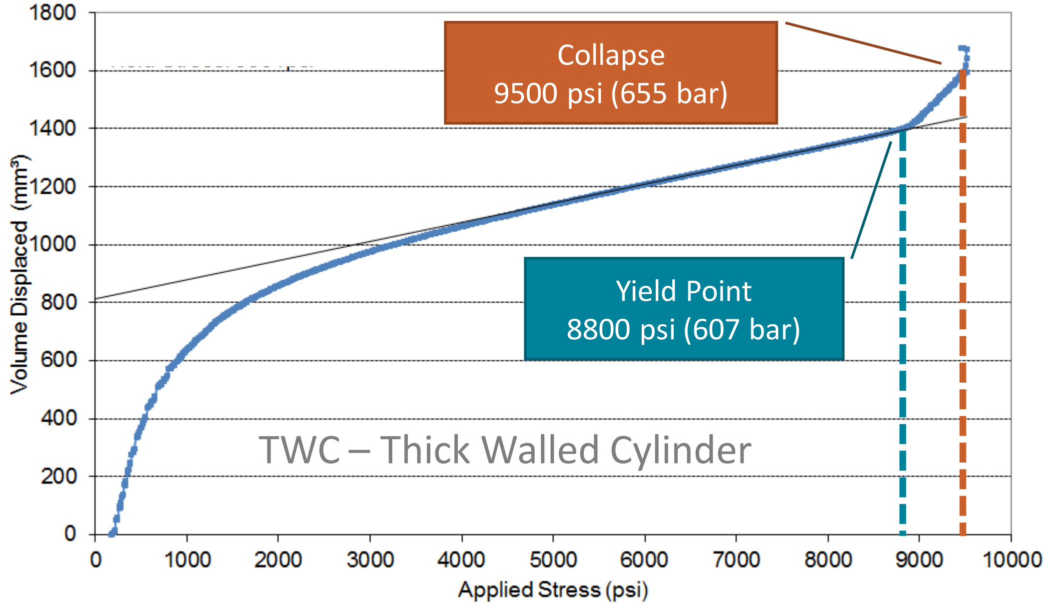
- Multiple Formations (Seal & Fm)
- Different k measurements
  - MICP = kg
  - CO2-Brine = kw
  - Kw can be significantly lower for high clay content

- CO_2-Brine = reduced IFT → Pc
- CO_2-Brine = more accurate stress
  - MICP will apply OB stress until threshold pressure
    - May overstress the sample

- MICP is faster to run than CO_2-Brine

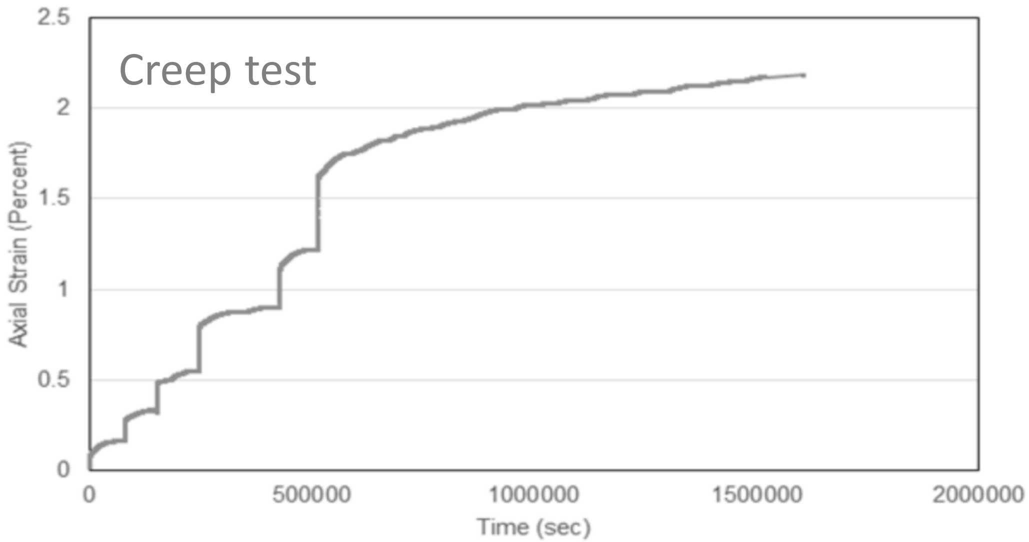
Rock Mechanics

Reservoir integrity and compaction-expansion



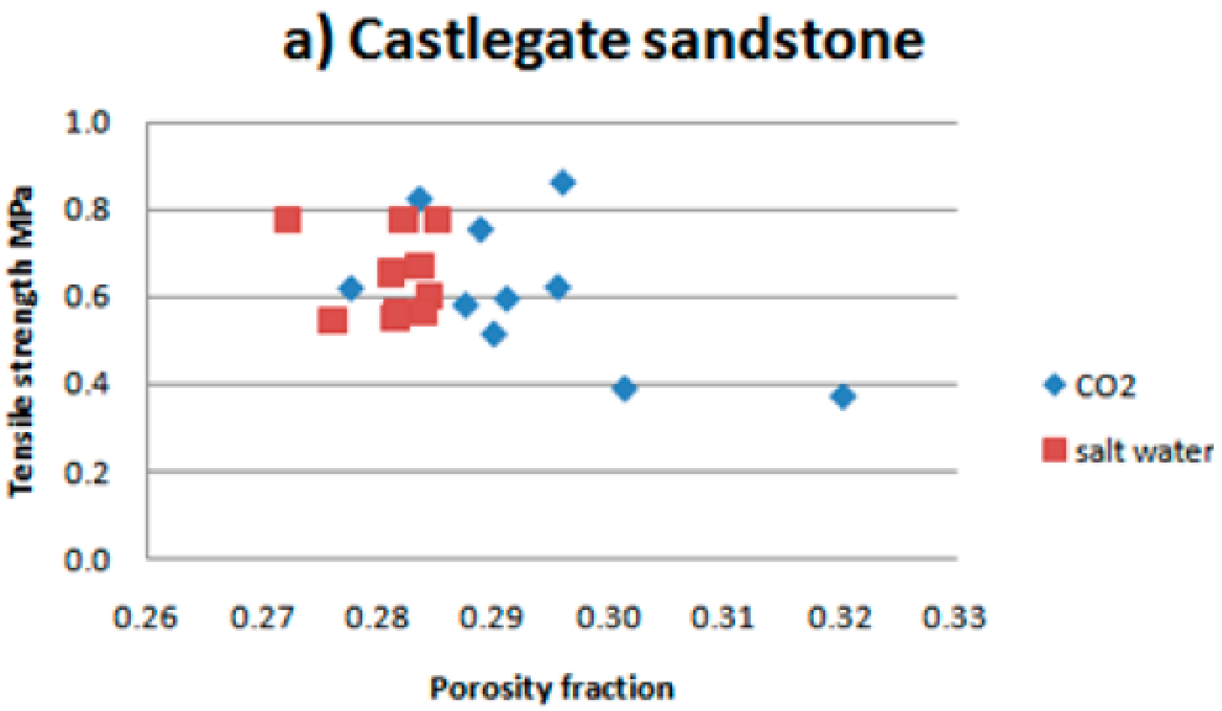
- Thick Walled Cylinder (TWC)
- Uniaxial Stress (Creep)
- P and S wave velocity
- Tensile strength

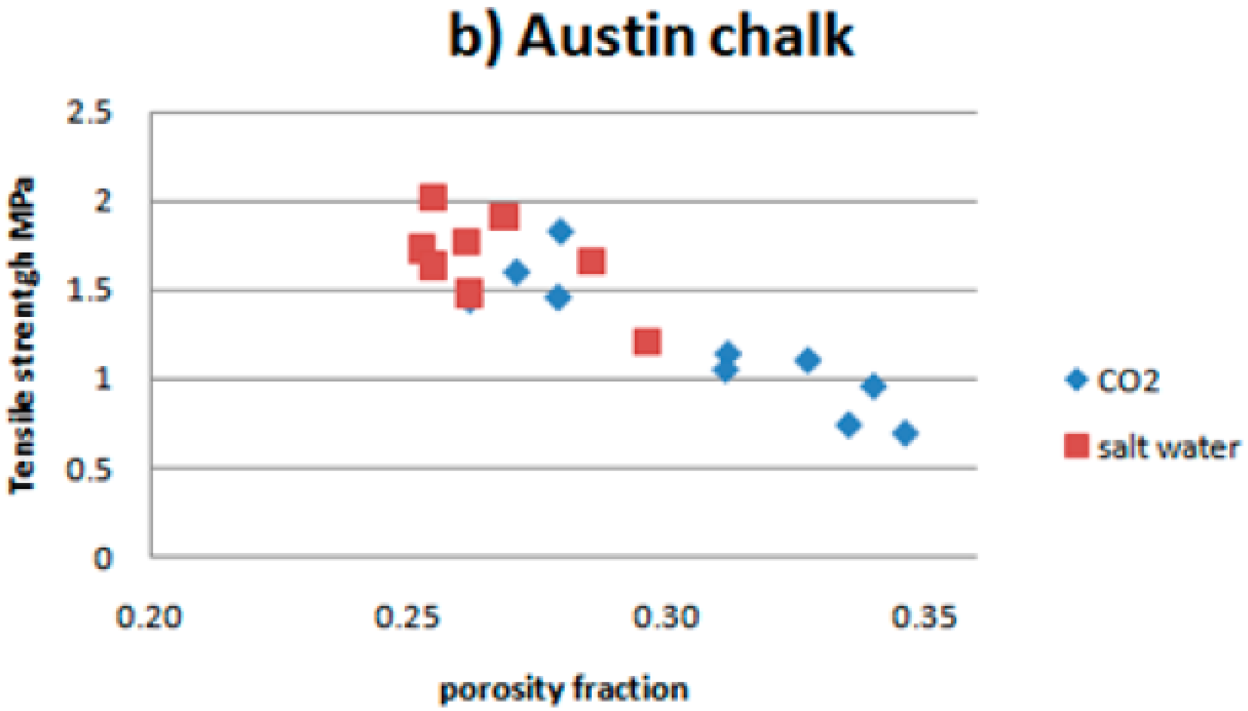
- Triaxial Compressive Strength
  - Single stage
  - Multi-stage
- Pore volume compressibility



Rock Mechanics

Reservoir integrity and compaction-expansion



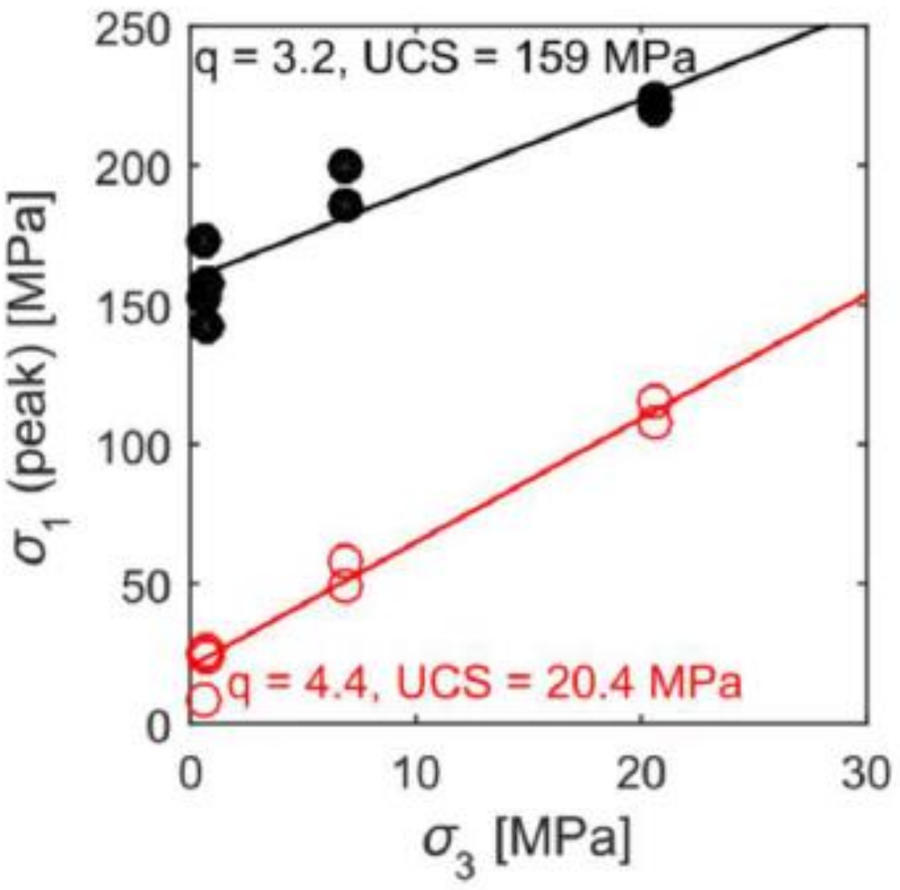


Ira O. Ojala, SINTEF, 2011, Energy Procedia 4

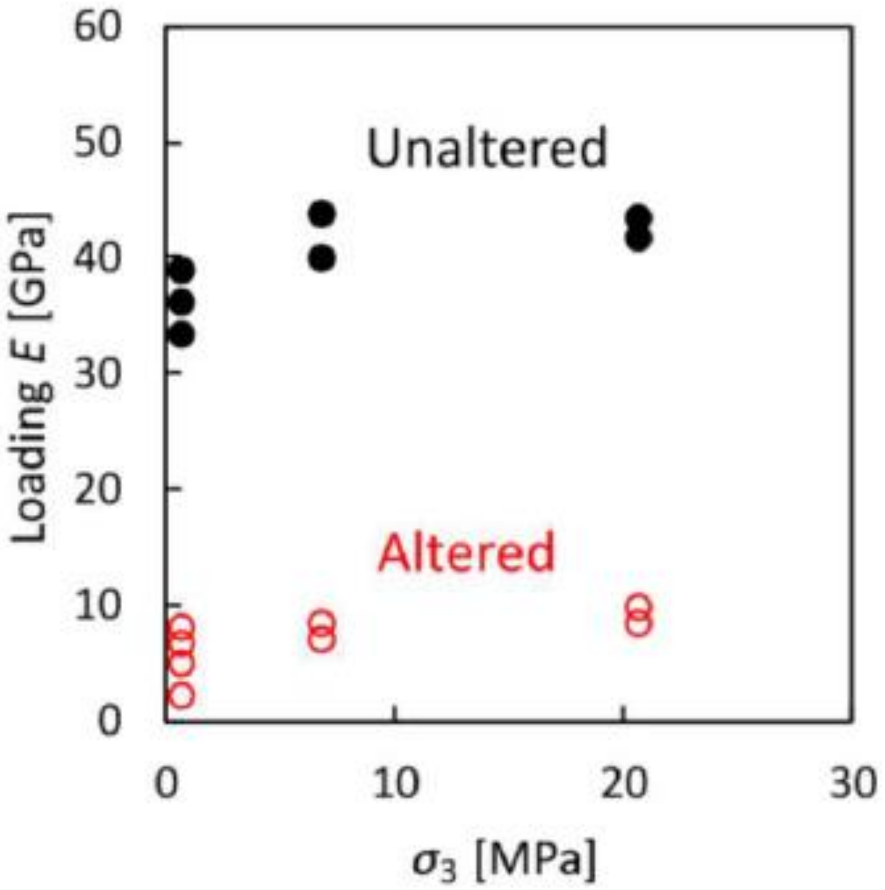
Rock Mechanics

Reservoir integrity and compaction-expansion

Shear Strength



Young's Modulus



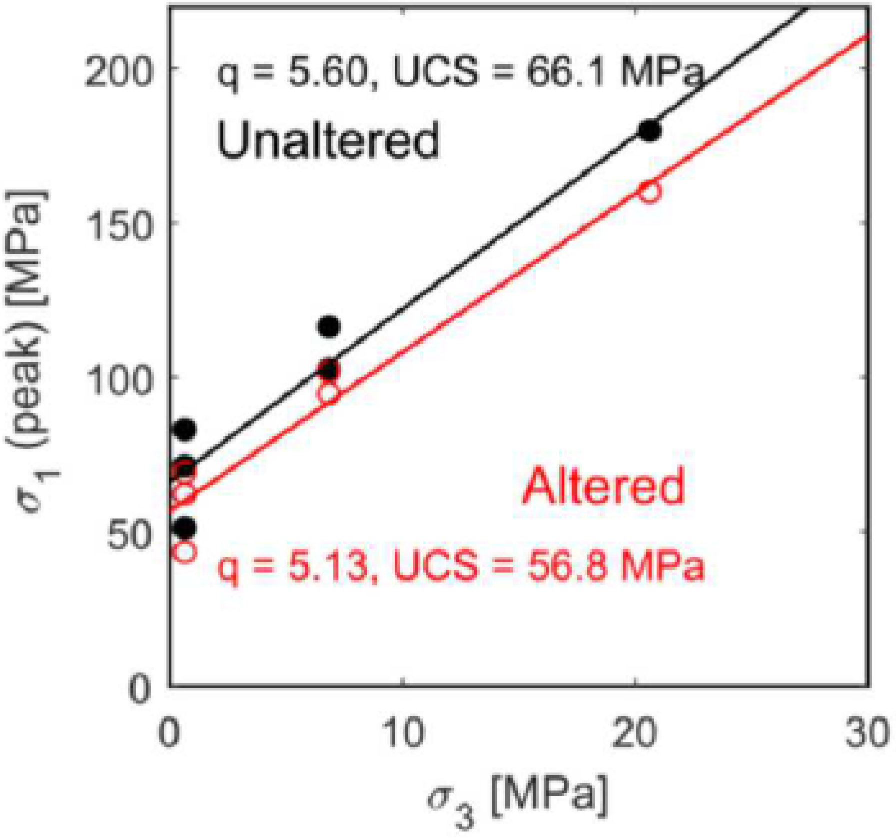
Summerville siltstone

Espinoza, et al., 2018; UT, BEG, Sandia

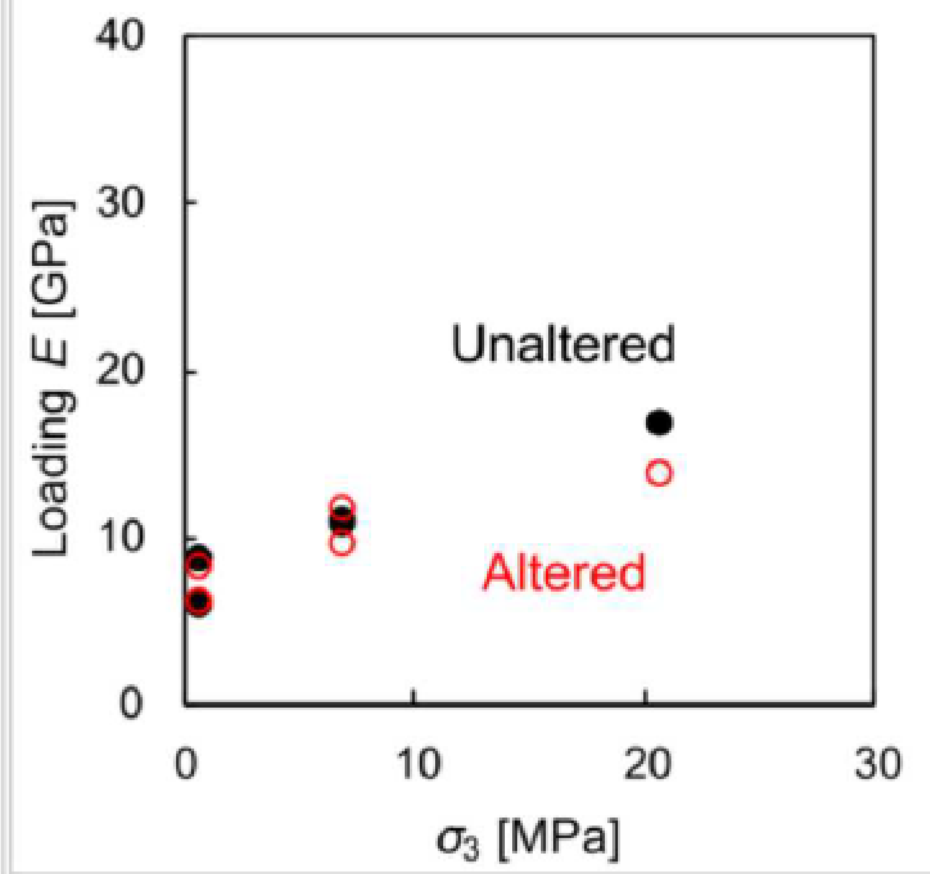
Rock Mechanics

Reservoir integrity and compaction-expansion

Shear Strength



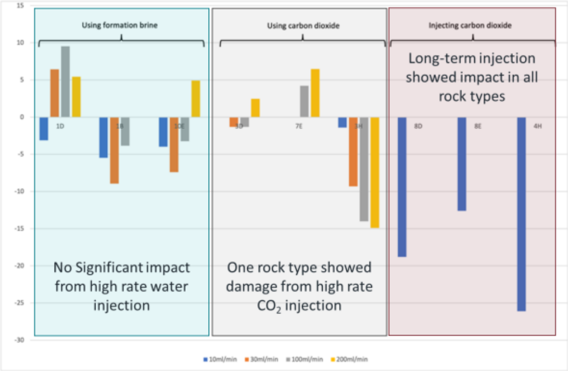
Young's Modulus

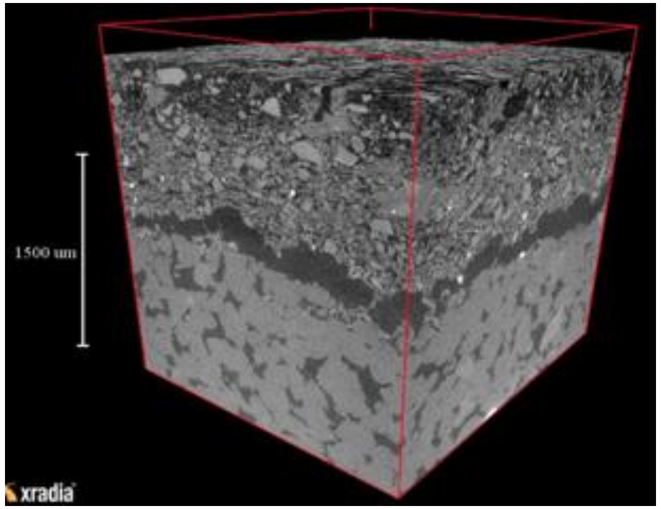


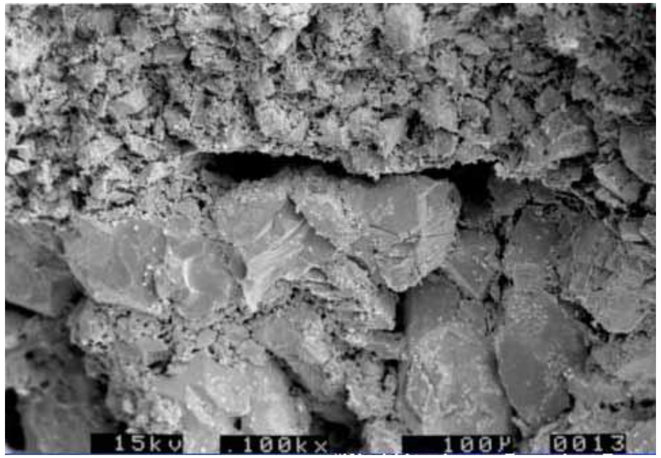
Entrada Sandstone

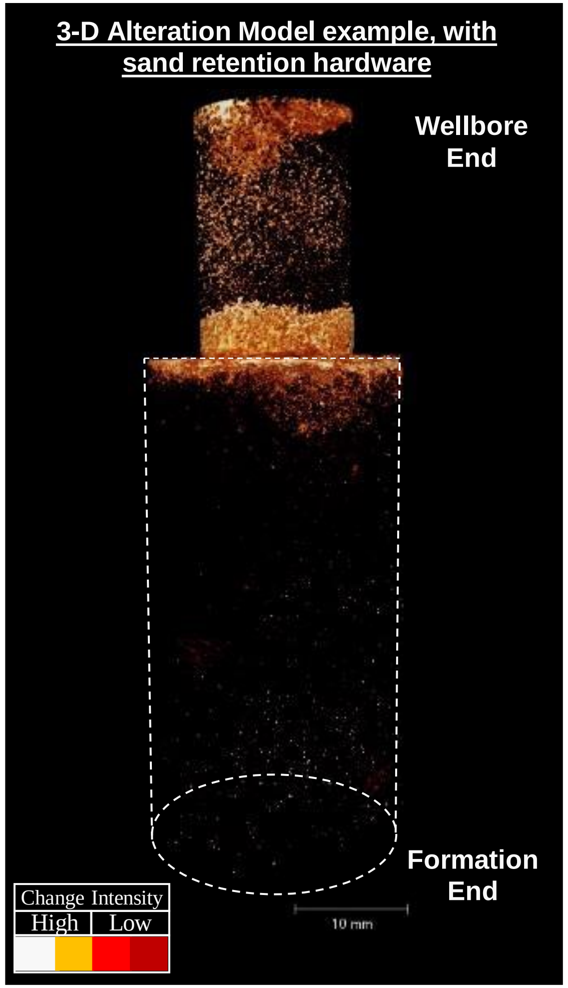
Espinoza, et al., 2018; UT, BEG, Sandia

Reservoir-condition core floods



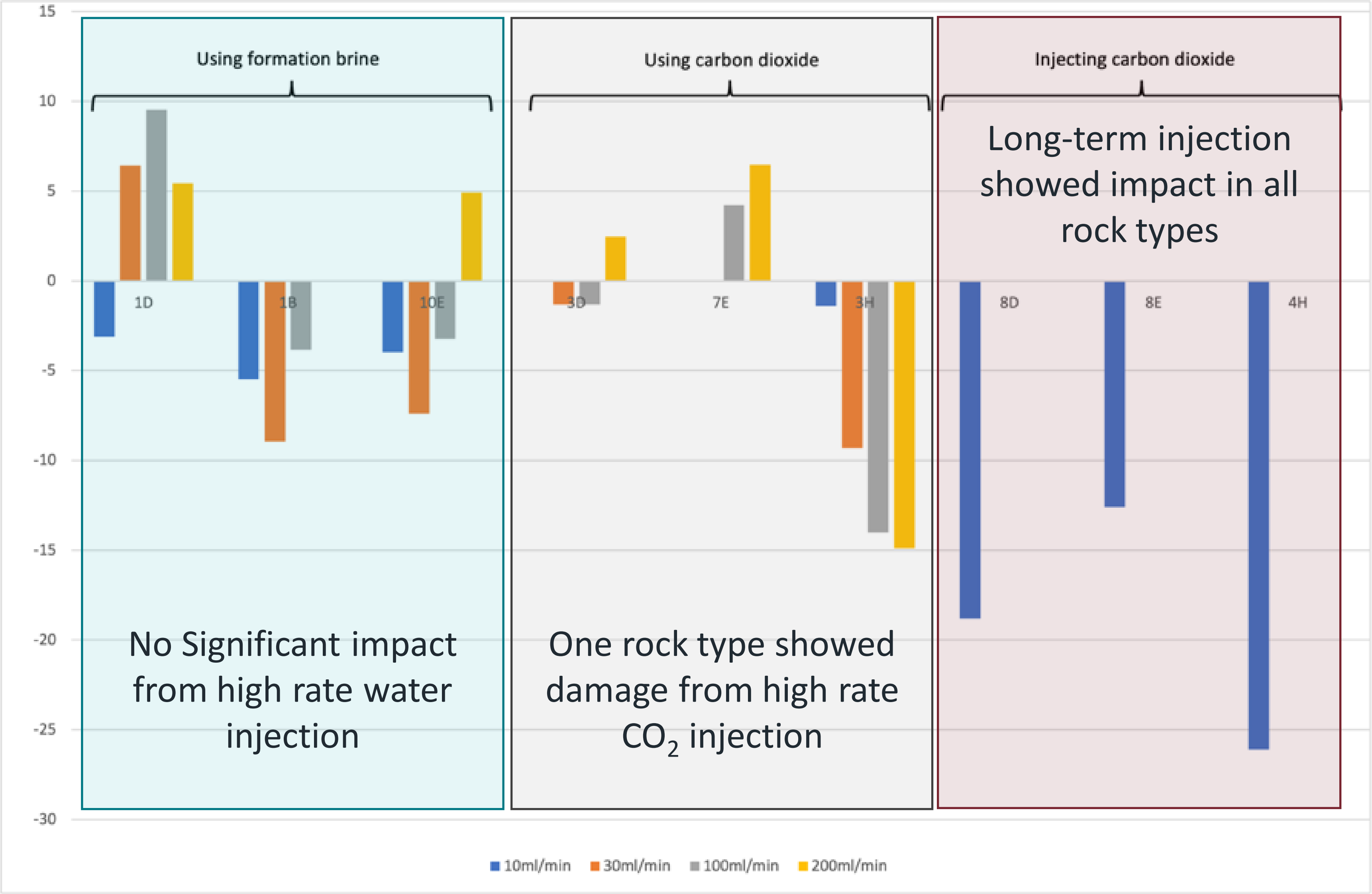




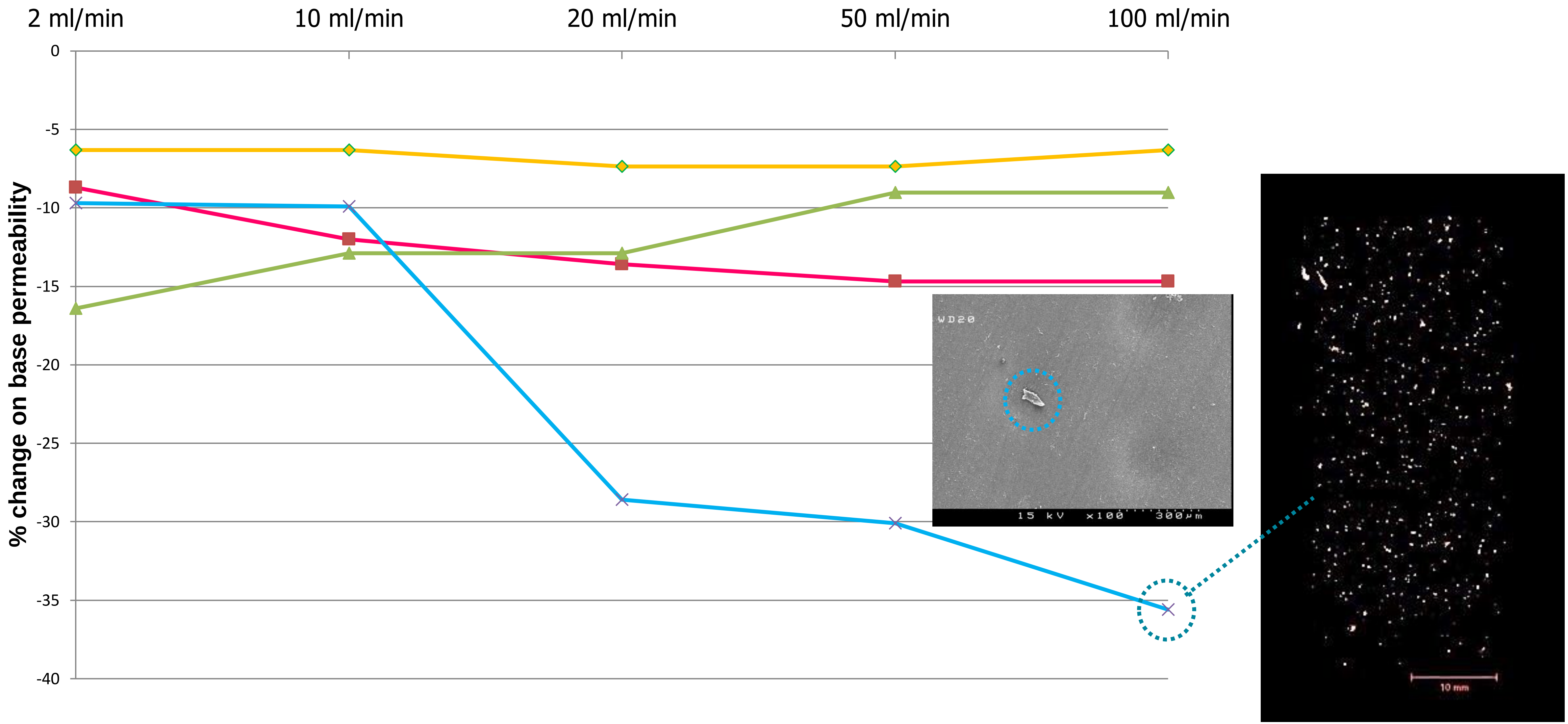


Reservoir-condition core floods

Fines Migration

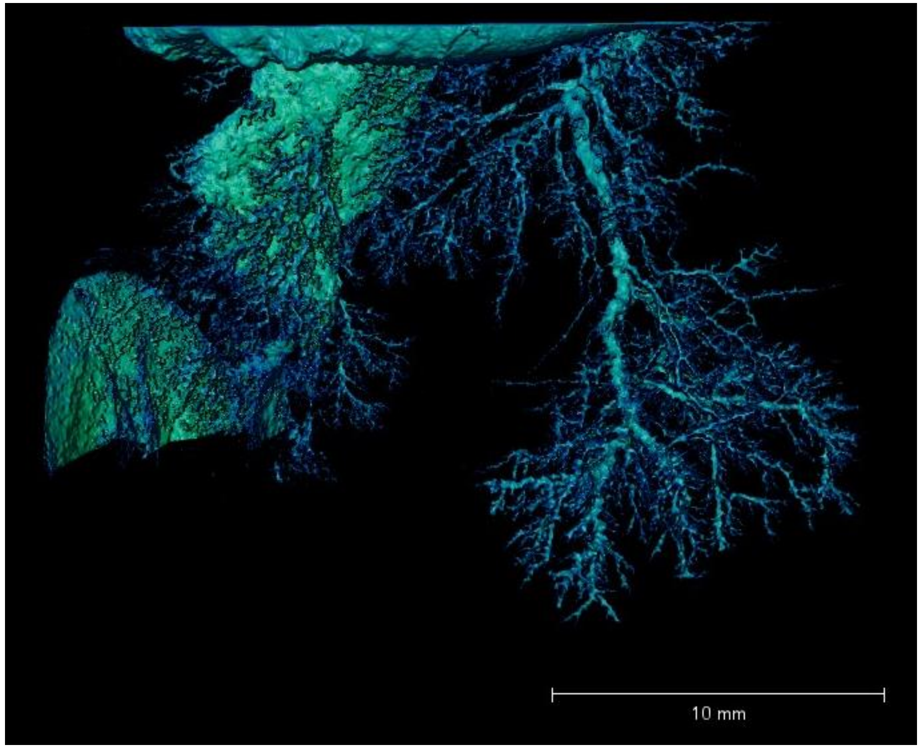


Reservoir-condition core floods



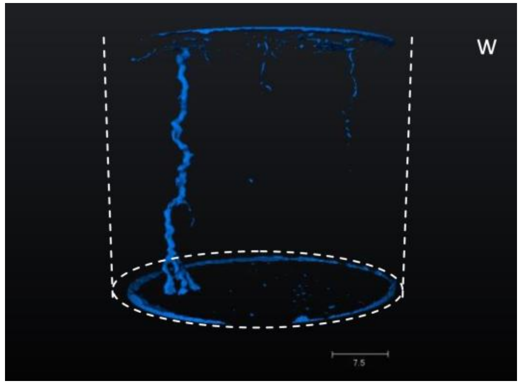
Permeability vs injection rate

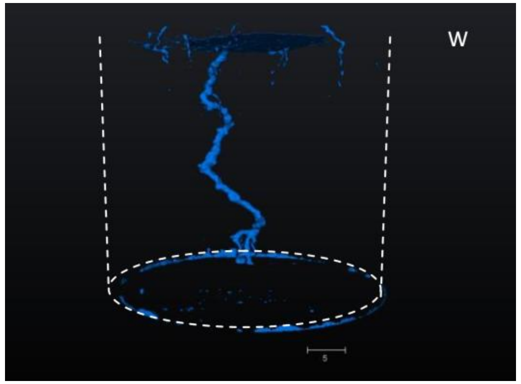
Reservoir-condition core floods

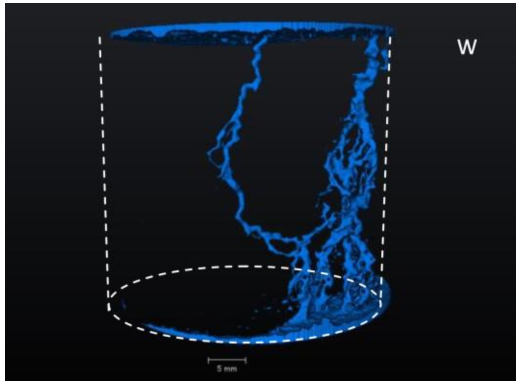


Understand the geology!

- Carbonates as an example
- CO2 reactions and worm-holing have been seen
- Controlled by things like mineralogy, pore shape and size, temperature, residence time, concentration
- Studies need to take this into account, including long-term exposure and looking at dissolution and precipitation







Reservoir-condition core floods

Worm-holing in carbonate sample due to alternating CO2-brine flow

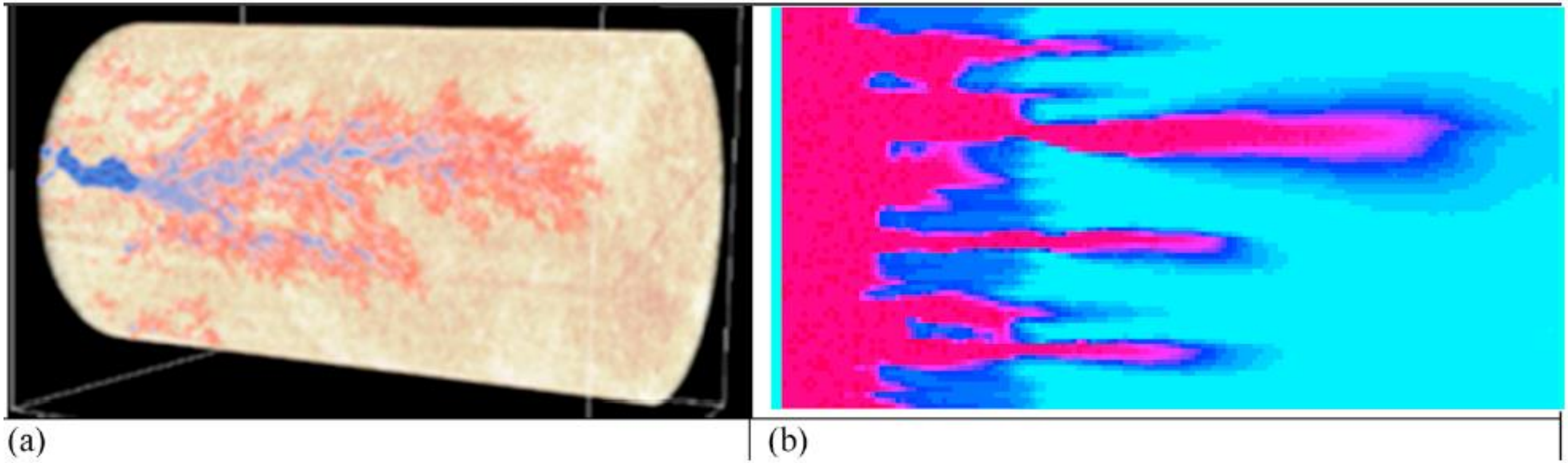
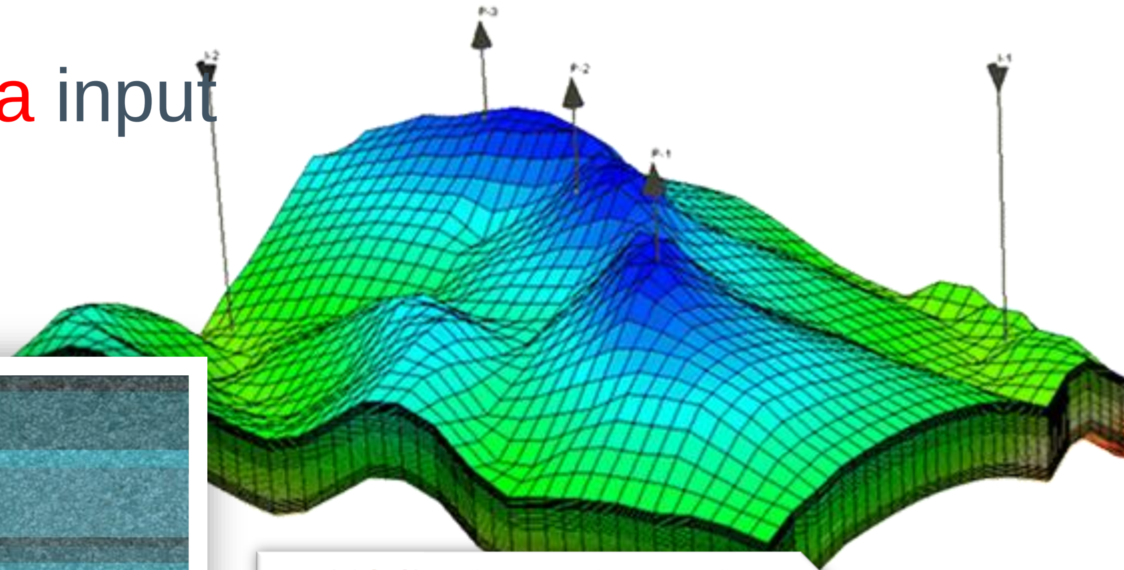


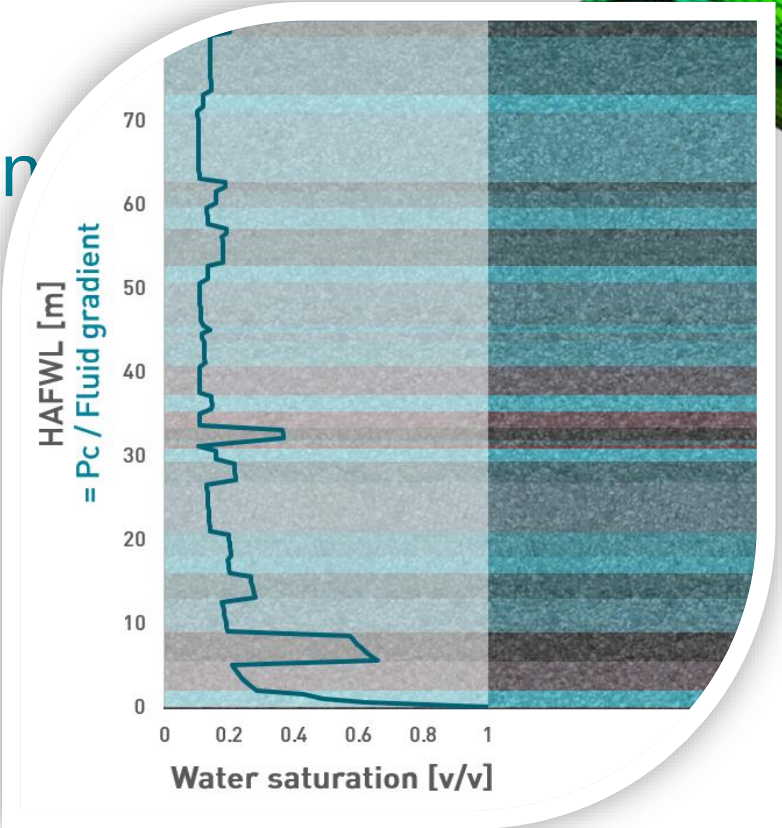
Fig. 14. WAG results - dissolution pattern from (a) experiment and (b) fine-scale model.

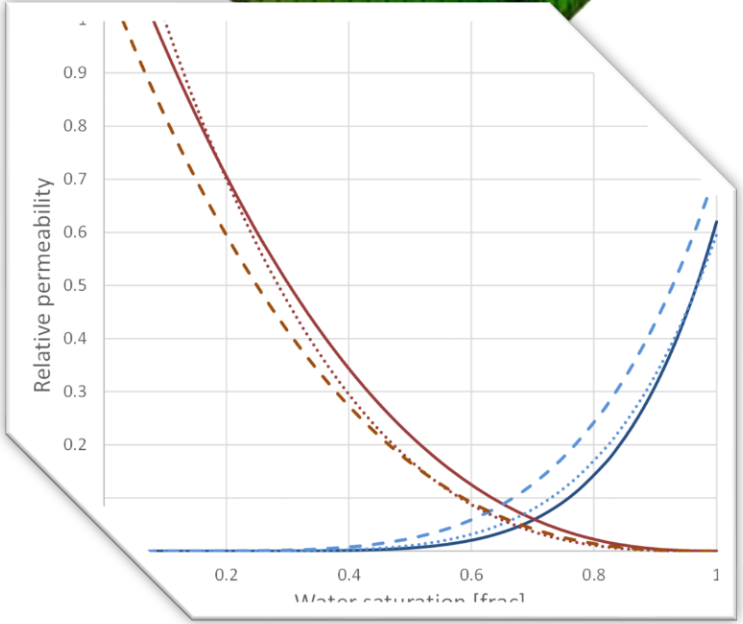
Jeroen Snippe, et al., 2020, Intl. J Greenhouse Gas Control

What all this can tell us

- Modeling CO_2 injection needs quality data input
  - Fluid properties
  - Mineralogy, lithology
  - Storage capacity
  - Saturation vs injection
  - Saturation vs height
  - Reservoir integrity
  - Wellbore stability
  - Exposure impact







Final thoughts

- Reservoir characteristics and human interventions define CO_2 injectivity
- Understanding behavior at every process stage reduces uncertainty to reduce risk and add value
- Industry standard best practices are needed for lab testing of CCS reservoir and seal rock.
- EPA Class VI well characterization guidelines are helpful, but they don’t clearly address changes in reservoir properties with CO_2 exposure.
- Effects of CO_2 injection on reservoir and seal formations should be incorporated into AOR and reservoir integrity models.
- As always: there is no substitute for quality lab data using representative materials at in-situ conditions.

Any Questions?

Contact details:
Jules Reed
Global Technical Manager
jules.reed@premiercorex.com

Joel Walls
Geoscience Advisor
joel.walls@premiercorex.com

www. premiercorex.com/ccus

PREMIER COREX