Characterizing the Geochemistry of the CO_2-Fluid-Shale Interface

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Abstract Key Points

- Traditionally, shale formations studied as seals
- Recent research focused on:
  - Storage of CO_2 in shale
  - Use of CO_2 as a fracturing fluid in shale
- Injected CO_2 will interact with shale components (i.e. clays, organic matter) and affect rock properties through chemical alteration, matrix swelling/shrinkage, and related geomechanical effects
- Rock property changes will impact effectiveness of CO_2 storage and hydraulic fracturing using CO_2
- In-situ Fourier Transform infrared (FT-IR) spectroscopy
  - Examine the interaction for CO_2 at molecular scale
  - Characterize vibrational changes of sorption bands sensitive to gas-fluid-solid environment
- Surface Feature Relocation via Scanning Electron Microscopy (FE-SEM)
  - Analyze chemical and physical changes before and after dry CO_2 and wet CO_2 exposure

Samples

Utica Shale: Stream Outcrop

Marcellus Shale: Stream Outcrop

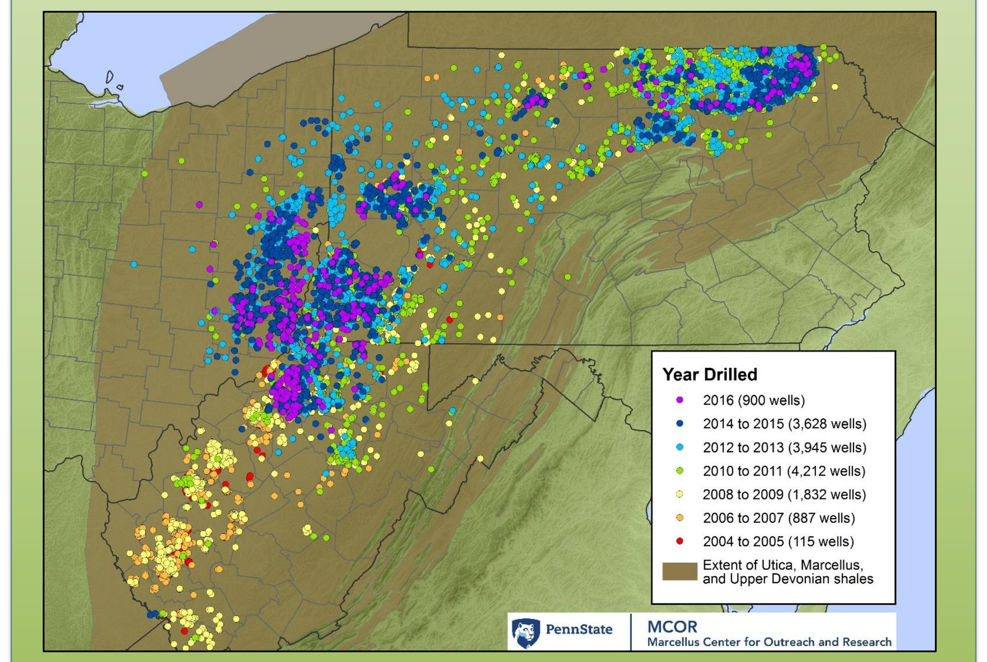
Marcellus Shale: Quarry Exposure

Clays
- Kaolinite
- Illite
- Illite-Smectite
- Chlorite

Kerogen
- Extracted from the New Albany Shale

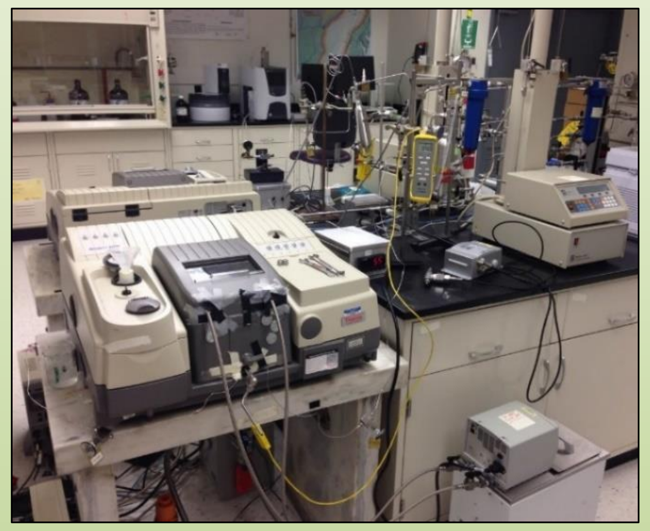
Research Approach

CO_2-(Fluid)-Shale Interface
- Fourier Transform Infrared Spectroscopy
- Feature Relocation-Scanning Electron Microscopy
- Surface Area and Pore Size Analysis
- Sorption Analysis

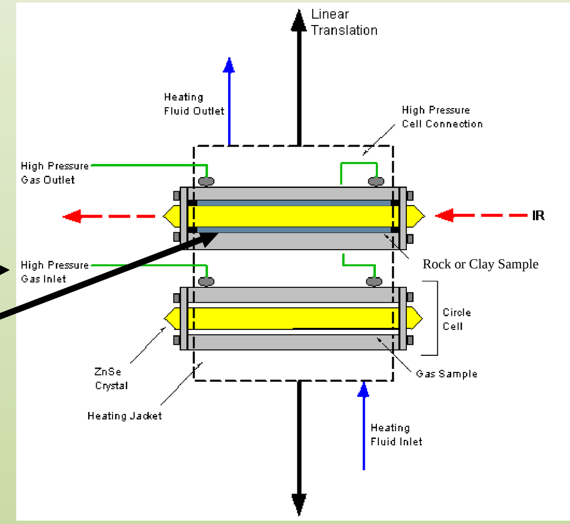


Unconventional Wells Drilled by Year

Analytical Instruments



Left. FT-IR Spectrometer used to conduct In-situ high temperature and pressure experiments.

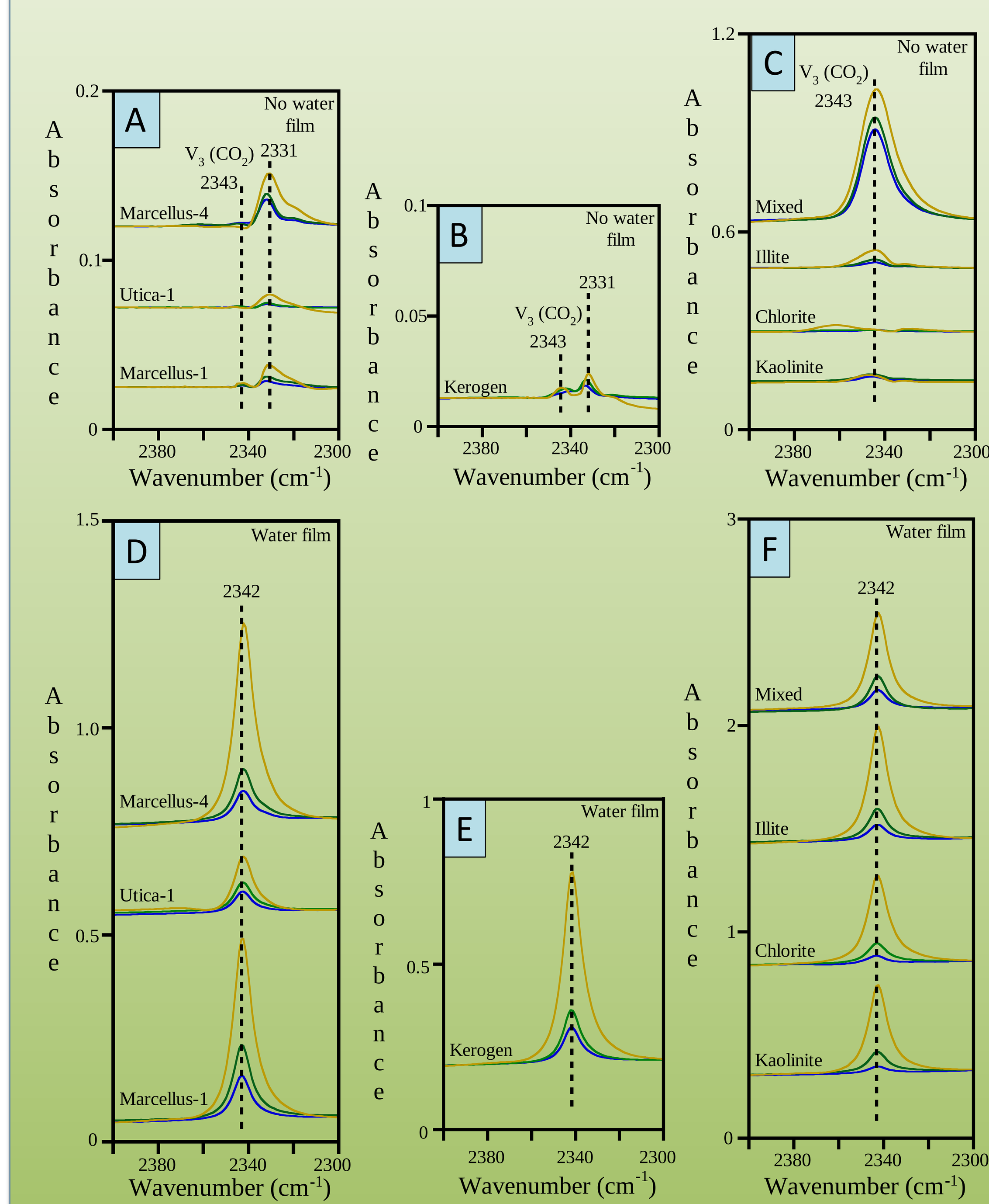


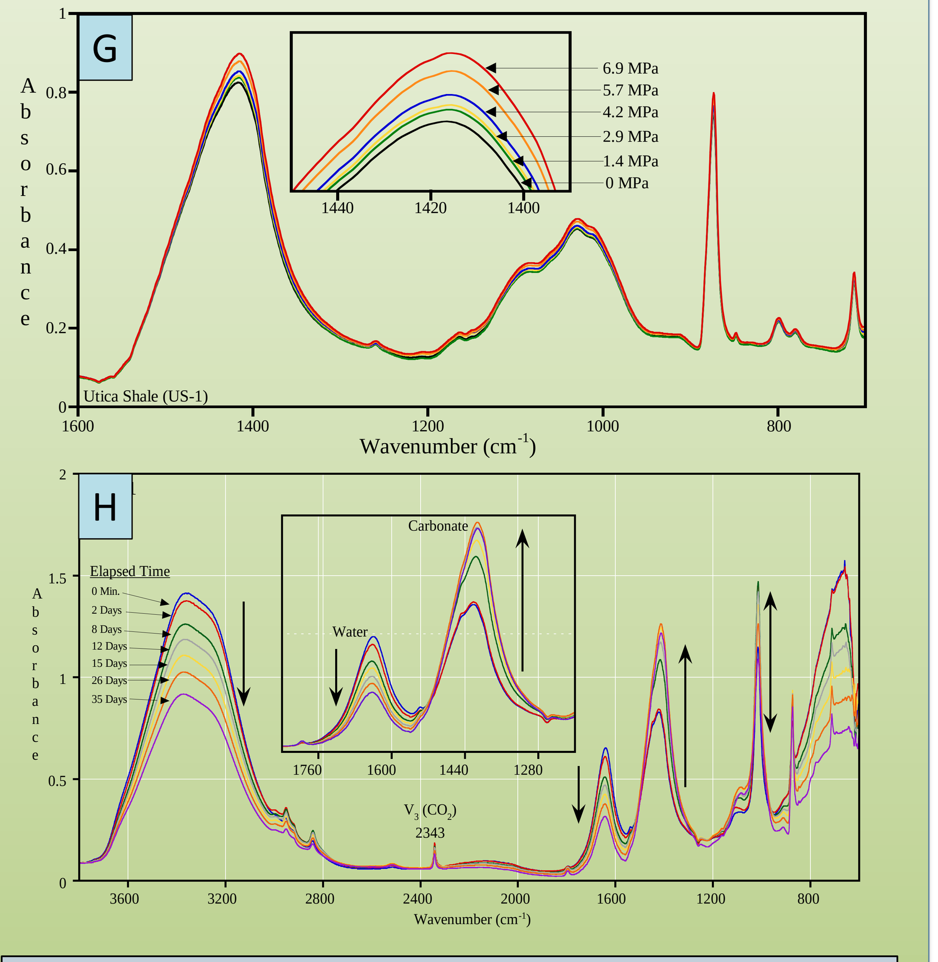
Right. Sample holder set up for FT-IR. Note the addition of a water film.

Reaction vessels used to expose samples to dry and wet CO_2 at 40°C and 1500 PSI.

Scanning Electron Microscope used for feature relocation before and after dry/wet CO_2 exposure.

Infrared Spectroscopy: Results





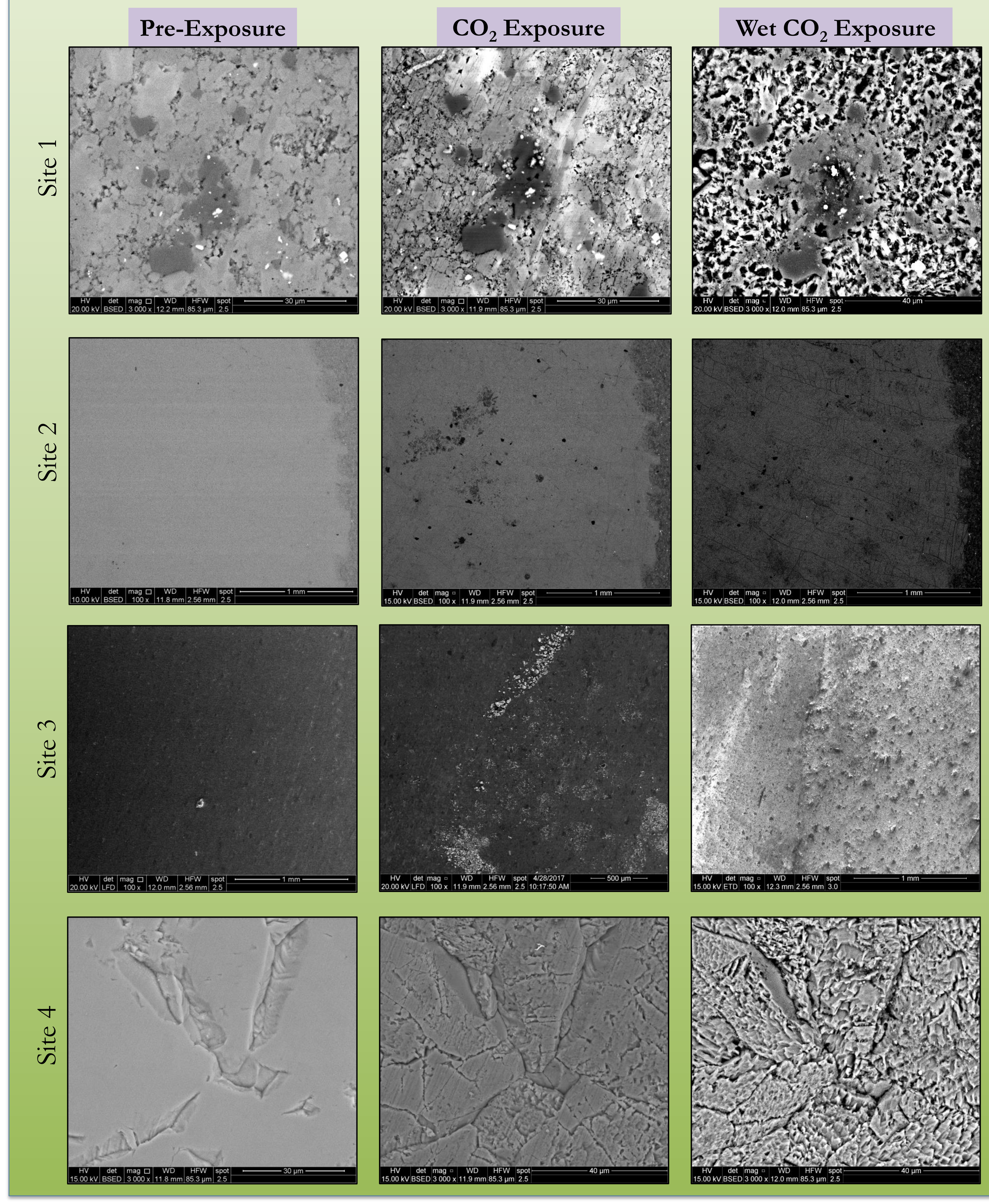
Dry CO_2 Exposure (A-C)
- 2343 cm^{-1} = inorganic interactions
- 2331 cm^{-1} = organic interactions

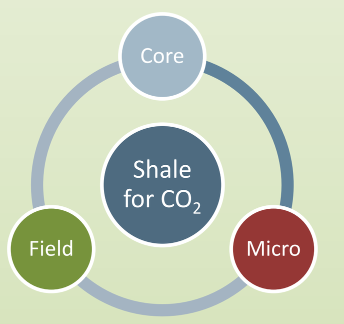
Wet CO_2 Exposure (D-F)
- 2342 cm^{-1} = dissolution of CO_2 in water

Dry Carbonate Analysis (G)
- Carbonate fluctuated but increased overall

Wet Carbonate Analysis (H)
- Water decreased and carbonate increased

Scanning Electron Microscopy: Results





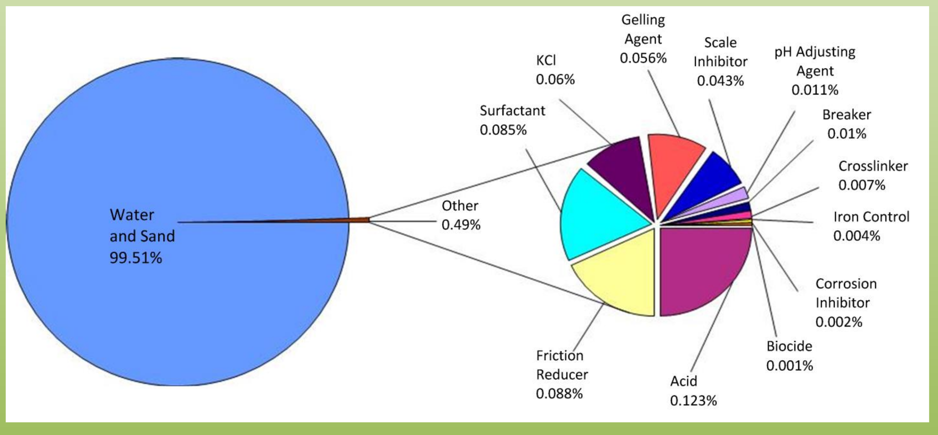
Dry CO_2 Exposure
- Minor etching, dissolution, and precipitation

Wet CO_2 Exposure
- Major etching, dissolution, and precipitation

Conclusions:
- Water contained in the interstitial pore space may interact with supercritical CO_2 in dry reactions
- Dissolution and precipitation occur as the carbonate reactions reach equilibrium upon exposure to CO_2

Future Work

Increase complexity of the fluid
- Various brine compositions
- Fracturing fluid



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