Effect of Biogeomechanical Altered Properties on Geologic Carbon Storage in Unconventional Reservoirs

Oladoyin Kolawole[1], Ion Ispas[1], Mallika Kumar[1], and Joachim Weber[1]

[1]Texas Tech University

November 26, 2022

Abstract

Geologic carbon storage (GCS) is part of a process known as carbon capture, utilization, and storage (CCUS); being adopted to mollify extreme weather events (global warming) as a result of CO2 emissions and improve energy production. Previous studies have shown promising potentials of permanent CO2 storage in depleted shale reservoirs. In this study, we experimentally and analytically investigate the impact of microbially-altered mechanical properties on carbon storage in the Niobrara shale reservoir, using a cultured solution and shale samples from Niobrara formation. Firstly, we obtained the properties of the untreated samples. Secondly, we treated and cultivated the samples with the cultured solution at specific conditions. Further, we obtained the new properties of the treated shale rocks. Lastly, we show the impact of the altered properties on CO2 storage integrity in unconventional shale reservoirs. Our results suggest that in shale reservoirs, biogeomechanical alterations can enhance the long-term integrity of geological sequestration of atmospheric CO2, by mitigating any deep subsurface potential leakage to the atmosphere.

EFFECT OF BIOGEOMECHANICAL ALTERED PROPERTIES ON GEOLOGIC CARBON STORAGE IN UNCONVENTIONAL RESERVOIRS

Oladoyin Kolawole, Ion Ispas, Mallika Kumar and Joachim Weber

Texas Tech University, Lubbock, Texas, USA

AGU FALL MEETING

Online Everywhere | 1–17 December 2020

PRESENTED AT:

AGU FALL MEETING

Online Everywhere | 1–17 December 2020

BACKGROUND

- Geologic Carbon Storage (GCS) is the process of injecting CO_2 into deep subsurface formations for long-term storage.
- Previous studies have shown promising potentials of permanent CO_2 storage in depleted shale reservoirs.
- Assessment of geomechanical properties have implications for CO_2 storage in shale reservoirs.

GEOLOGICAL FORMATION

- Core samples utilized are from Niobrara Shale formation.
- Located in Northeastern Colorado and parts of adjacent Wyoming, Nebraska, and Kansas.
- Have a low porosity (ϕ) (<10%), and ultra-low permeability (<1 μD).

RESEARCH APPROACH & METHODOLOGY

- Integrate **geomicrobiology** and **geomechanics**.
- Determine the pre-treatment (0 days) and post-treatment (30 Days) geomechanical and microstructural properties.
- Geomechanical properties were measured using the **Scratch Test method**.
- Microstructural properties were investigated using the **Scanning Electron Microscope (SEM)**.
- Experimentally assess the impact of biogeomechanics on carbon storage in the Niobrara shale reservoir.

RESEARCH APPROACH & METHODOLOGY (CONT.)

- The Scratch Test method provides a continuous strength profile measurement of mechanical properties along a sample.
- The mechanical properties measured are the: unconfined compressive strength, *UCS*; ultrasonic shear and compressional velocities (V_s and V_p), and the corresponding dynamic Poisson's ratio (ν).

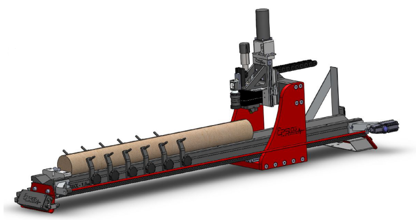

Figure 1: Epslog Wombat scratch machine

- Scanning Electron Microscope (SEM) was used to investigate the microstructural features of the core samples.

Figure 2: Hitachi S-4300 scanning electron microscope

RESULTS

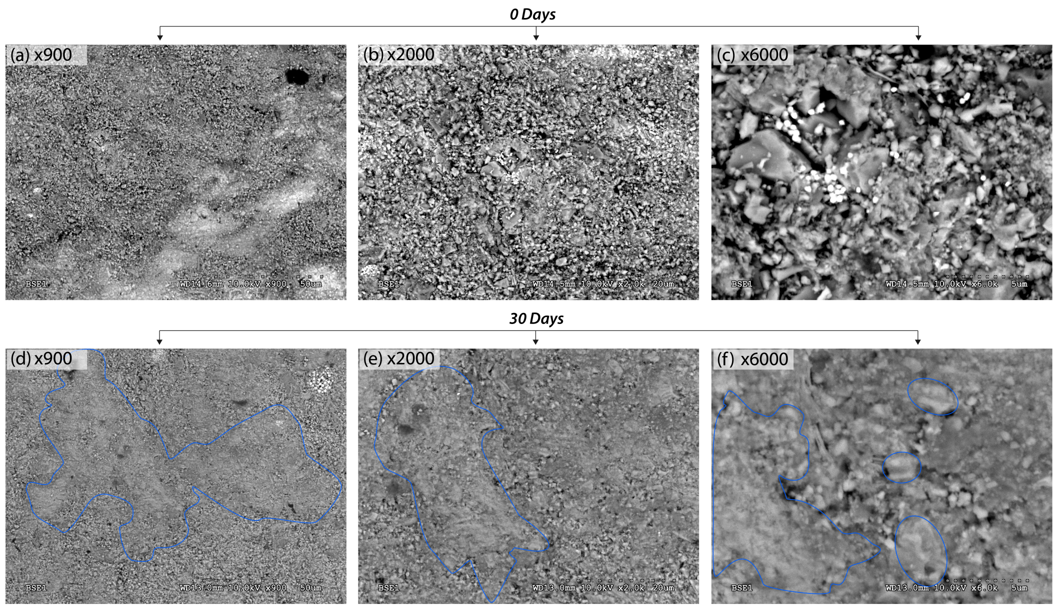

Figure 3: Microscopic investigation of pre- and post-treatment Niobrara shales.

RESULTS (CONT.)

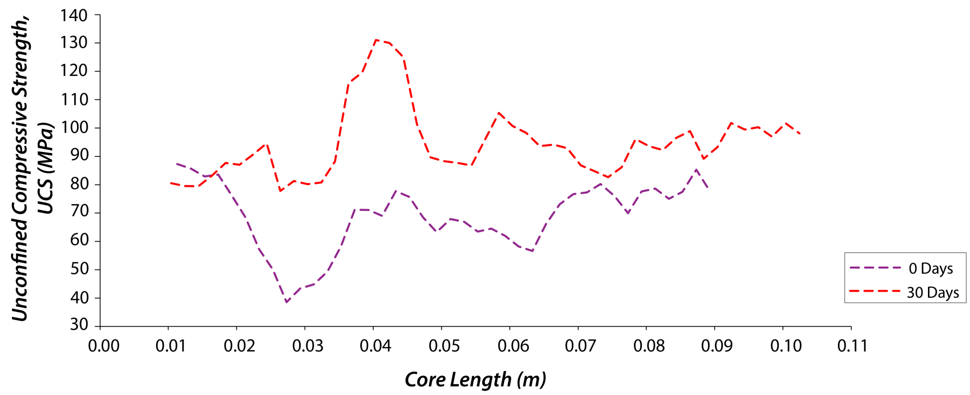

Figure 4: Unconfined compressive strength (*UCS*) for pre- and post-treatment Niobrara shales.

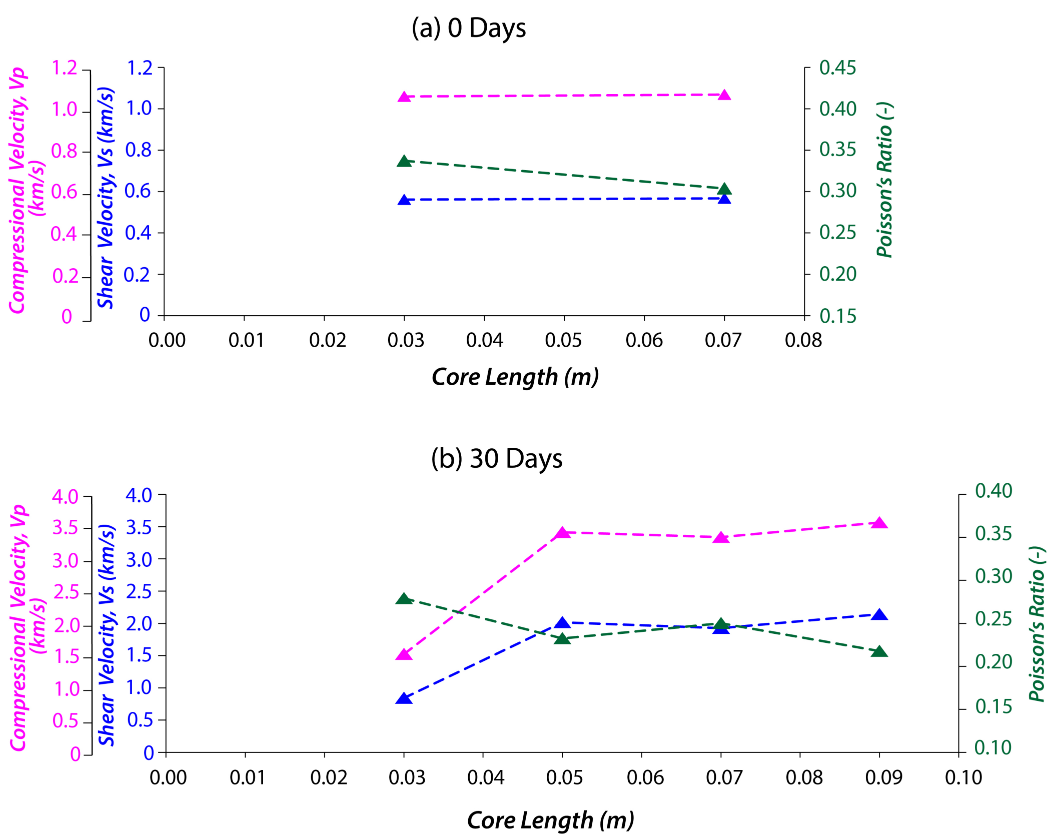

Figure 5: Ultrasonic compressional (V_p) and shear (V_s) velocities, and dynamic Poisson's ratio (ν) for pre- and post-treatment Niobrara shales.

CONCLUSIONS

- Integrated geomicrobiology and geomechanics can alter the microstructure of shales.
- The unconfined compressive strength (*UCS*) values significantly increased along the core length after treatment.
- Post-treatment altered shale samples exhibit higher Ultrasonic shear (V_s) and compressional (V_p) velocities and lower dynamic Poisson's ratio (ν).
- Biogeomechanical altered properties indicate an enhancement in mechanical integrity.
- Biogeomechanical alterations in shales could potentially enhance long-term geologic CO_2 storage integrity.

ABSTRACT

Geologic carbon storage (GCS) is part of a process known as carbon capture, utilization, and storage (CCUS); being adopted to mollify extreme weather events (global warming) as a result of CO_2 emissions and improve energy production. Previous studies have shown promising potentials of permanent CO_2 storage in depleted shale reservoirs. In this study, we experimentally and analytically investigate the impact of microbially-altered mechanical properties on carbon storage in the Niobrara shale reservoir, using a cultured solution and shale samples from Niobrara formation. Firstly, we obtained the properties of the untreated samples. Secondly, we treated and cultivated the samples with the cultured solution at specific conditions. Further, we obtained the new properties of the treated shale rocks. Lastly, we show the impact of the altered properties on CO_2 storage integrity in unconventional shale reservoirs. Our results suggest that in shale reservoirs, biogeomechanical alterations can enhance the long-term integrity of geological sequestration of atmospheric CO_2, by mitigating any deep subsurface potential leakage to the atmosphere.