Geologic Carbon Storage at Outcrop: Lessons for Subsurface Characterization, Modeling, Risk and Monitoring, Utah (G579)

Tutor(s)

Alex Bump: Research Science Associate, University of Texas at Austin.

Michael Sweet: Co-Director and Research Scientist, University of Texas at Austin.

Overview

Using outcrops from the Cretaceous and Jurassic of Utah, this course will analyze some of the major subsurface challenges facing the storage of CO2 in subsurface formations, with particular reference to the planned Oligo-Miocene carbon stores on the Gulf Coast. It is intended to give participants the opportunity to consider the key factors of injectivity, capacity and confinement, and the range of storage play concepts available to match project needs with practically accessible storage sites. The course will explore the impact of multi-scale reservoir heterogeneity on migration and trapping of CO2, the propagation and dissipation of pressure, and the risks of unintended lateral or vertical migration of CO2 and/or displaced brine. We will also look specifically at boundary conditions and potential leakage paths, including faults and wells, using a variety of outcrops as a natural laboratory to facilitate the learning points.

Duration and Logistics

A 6-day field course comprising a mix of field activities with classroom lecture sessions and discussions. Transport will be by minivan or bus.

Level and Audience

Intermediate. This course is intended for geoscience and engineering professionals working in, or soon to transfer to, CCS projects.

Exertion Level

This class requires a **MODERATE** exertion level. There will be some short hikes to outcrops with some of these over uneven and rocky ground. The climate in southern Utah during the spring and fall is variable, with temperatures from 50°F (10°C) to 100°F (38°C). The elevation is between 4,000 and 5,000 feet (1200 and 1500 meters).

Objectives

You will learn to:

1. Describe the subsurface requirements for a successful storage project, including similarities and differences with oil and gas exploration.
2. Illustrate the CCS reservoir details of proposed Gulf Coast carbon stores and the state-of-play of these projects.
3. Characterize the main depositional features that influence reservoir properties and CCS reservoir development, as well as likely performance, with special reference to clastic coastal/shallow marine

depositional systems.

4. Gauge fluid transport parameters, including the impact of geological heterogeneity and permeability on CO2 injection and plume migration.
5. Evaluate sustainable injection rates for different carbon stores, including pressure propagation and interference, and factors such as loss of injectivity and pressure build-up.
6. Manage containment risks with respect to both structural and depositional heterogeneities.
7. Validate models for plume migration and integrate the key uncertainties.

Course Content

Course Details

The Cretaceous Book Cliffs offer the opportunity to study a variety of clastic coastal/shallow marine deposits, including those interpreted as fluvial, wave- and fluvial-influenced deltaic and shelfal. The course will focus on the proposed carbon stores in the Oligo-Miocene of the Gulf Coast (e.g. Greta Sandstone, Frio Formation) but use outcrops with analogous deposits from the Book Cliffs to consider key carbon storage factors including:

- Injectivity into heterogeneous reservoirs
- Pressure communication
- Pressure barriers
- Sustainable injection rates
- Formation capacity estimation
- Porosity and permeability factors
- Compartmentalization risk
- Seal lithologies and containment risk
- Faults and fractures

The course will be framed around the six major subsurface challenges facing the long-term geologic storage of CO2:

1. Legacy wells
2. Faults and leakage
3. Pressure propagation and interference
4. Unintended migration
5. Induced seismicity
6. Loss of injectivity and pressure build-up

Day 1: Arrive in Salt Lake City

Classroom:

- Early evening course introduction and safety brief

Overnight in Salt Lake City

Day 2: Subsurface characterization for CCS

Classroom:

- CCUS Play Types (depleted fields vs flat-lying aquifers)
  CCUS examples (North Sea, reusing existing fields, North America – injection into saline reservoirs
  Sand tank models of CO2 flow
- Regional geology of the Blook Cliffs and Paradox Basin

Fieldwork:

- We will use outcrops of the Panther Tongue and Spring Canyon Members of the Blackhawk Formation near Helper and in Spring Canyon, Utah to gain insights into reservoir and seal continuity in deltaic and shallow marine, wave-dominated, shoreline deposits. We will also consider the impact of changes in grain size and permeability on CO2 trapping and lateral migration. Core photographs and wireline logs from a series of research cores, cut by Exxon Research and recently made public, will be used to help put what we see in outcrop into a subsurface context.

Overnight in Price

Day 3: Gulf Coast Carbon Stores

Classroom:

- Sandbody connectivity ‘rules’
- CO2 flow pressure, buoyancy, and permeability effects
- CO2 Trapping – residual buoyancy, unsaturated sands and local capillary traps
- Two-phase vs single-phase flow in CO2 reservoirs
- Seals and composite confinement
- Pressure dissipation
- Induced seismicity

Fieldwork:

- The Gentile Wash section of the Blackhawk Formation near Price, goes through multiple parasequences in a wave-dominated shoreline deposit culminating in terrestrial fluvial and overbank deposits. The objectives here will be to better understand vertical stacking of these deposits and how their grain size and finer scale sedimentary structure may control the lateral and vertical migration of CO2.

Overnight in Green River

Day 4: Risk and monitoring

Classroom:

- Deltas – facies, geometry and sandbody connectivity
- Effective Kv/Kh
- What is a barrier for CO2?
- Fault transmissibility – is a fault a pathway or barrier to CO2 flow?
- Deformation bands
- Vertical pathways to flow (faults and well bores)
- Well and completion design

Fieldwork:

- The Ferron Sandstone is a classic and extremely well-exposed, deltaic deposit. Multiple road cuts near Emery along I-70 allow for incredible 3-D exposures of pro-delta, delta front clinoforms, distributary channels and other deltaic facies. The fluvial and coastal plain deposits that overlie these deltaic parasequences are also well exposed. The Ferron system is similar in scale to the deltaic deposits of the Wilcox, Frio and Miocene that are seen as targets for carbon storage in the northern Gulf of Mexico.

Overnight in Green River

Day 5: Subsurface summary

Fieldwork:

- Little Grand Wash Fault is a well-exposed, large-scale normal fault that was activated by movement of the underlying Paradox Salt. It provides an opportunity to discuss the impact of faults as both barriers and pathways to fluid flow. Crystal Geyser, which is actually an abandoned well bore, is a cold geyser driven by migration of CO2 along faults from the underlying Paradox Formation.
- Navajo Sandstone, Canyonlands National Park: the objective of these stops is to look at an exhumed oil reservoir in order to better understand controls on trap and seal.

Overnight in Green River

Day 6: Course summary

Classroom:

- Course summary and wrap up

Return to Grand Junction and travel home