

GEO 371T (27564) /391 (27688): CO₂ Injection and Storage in Geological Formations

Spring 2022

Tuesday and Thursday, 9:30-11 am

Zoom (January 18-27), via Canvas
EPS 2.136 (Feb 1-May 5)

Capturing and storing carbon dioxide (CO₂) underground is an important means of mitigating climate change, and geoscientists play a key role in this aspect of the energy transition. In this project-based course, you will go through the same process that practicing geologists and geophysicists do when taking a geologic carbon sequestration project from siting to planning to permitting. You will work with data from real-world projects and learn how to make the predictions, analyses and economic argument necessary for a project to come to fruition. This course is taught by a team comprised mostly of experienced researchers of the Gulf Coast Carbon Center at the Bureau of Economic Geology. There are no prerequisites for this course and upper-level undergraduates and graduate students from a variety of majors are welcome, though a background knowledge in Earth science is desired.

Course Instructors		
Dana Thomas (Instructor of Record)	dthomas@jsg.utexas.edu	DLT
Sahar Bakhshian	sahar.bakhshian@beg.utexas.edu	SB
Alex Bump	alex.bump@beg.utexas.edu	APB
Susan Hovorka	susan.hovorka@beg.utexas.edu	SDH
Hailun Ni	hailun.ni@beg.utexas.edu	HN

Office hours will be held by Zoom on Wednesdays from 1-2 pm. Occasional changes may need to occur. If you send an email after 6 PM, please do not expect a response until the following day.

This class is managed on Canvas. All lecture notes and assignments will be made available on the site.

Learning Outcomes

By the end of the course, students will be able to

1. Interpret geologic data (e.g. maps, logs, seismic, chemical data) to evaluate the physical and geochemical suitability of a reservoir for CO₂ injection and storage.
2. Outline the requirements for a U.S. Environmental Protection Agency (EPA) Class VI injection well.
3. Develop and defend a proposal for a geologic CO₂ storage site.
4. Evaluate risk, public acceptance and financial feasibility of CO₂ storage projects.

Reading Materials

There is no textbook for this course. Readings or other other media will be assigned throughout the course from various sources. The following is a resource we are likely to refer you to.

National Petroleum Council (2019) *Meeting the Dual Challenge: A Roadmap to At-Scale Deployment of Carbon Capture, Use, and Storage*. <https://dualchallenge.npc.org/>

Grading Basis

- Group project: 50%
- Homework assignments, labs and in-class activities: 40%
- Mid-term examination: 10%

The second half of this course is mostly dedicated to a group project, which will include a written proposal for a storage site and a group presentation of your findings. A final report for the group project is due on May 14. You will receive more details about the project after spring break.

In general, assignments will be assigned on Thursdays and due the following Thursday. Assignments build on the work we do in class and are to prepare you for your group project tasks. Unless prior arrangements have been made, late submissions will receive a 10% deduction each day it is late. After more than one week past the due date, late submissions will not be received. Participation in class is also factored into your grade.

Grade boundaries will be based on a statistical distribution around the course mean and determined by the instructors. Final grades will involve the plus/minus system. There is no final exam.

Accessibility and Inclusion

The instructors are dedicated to fostering a fulfilling and inclusive learning environment, where everyone's backgrounds, perspectives and viewpoints are respected. We expect each and every one of you to exemplify this collective goal.

We aim to make learning accessible for everyone. Please let us know if you experience any barriers to learning so we can work with you to ensure you have equal opportunity to participate fully in this course. If you are a student with a disability, or think you may have a disability, and need accommodations please contact Services for Students with Disabilities (SSD). Please refer to SSD's website for contact and more information: <http://diversity.utexas.edu/disability/>. If you are already registered with SSD, please deliver your Accommodation Letter to us as early as possible in the semester so we can discuss your approved accommodations and needs in this course.

Academic Integrity

Teamwork and learning from each other is highly valued in this course. You are encouraged to work together on homework assignments and on the group project. However, the work you turn in must be your own and will be graded individually. We will provide more details on the group project grading mid-semester.

The core values of The University of Texas at Austin are learning, discovery, freedom, leadership, individual opportunity, and responsibility. Each member of the University is expected to uphold these values through integrity, honesty, trust, fairness, and respect toward peers and community. As a student of UT Austin, you have agreed to abide by the core values of the University and uphold academic integrity. <https://deanofstudents.utexas.edu/conduct/standardsofconduct.php>

Students who violate University rules on academic dishonesty are subject to disciplinary penalties, including the possibility of failure in the course and / or dismissal from the University. Since such dishonesty harms the individual, all students, and the integrity of the University, policies on academic dishonesty will be strictly enforced. Plagiarism is taken seriously at UT. Therefore, if you use words or ideas that are not your own (or that you have used in a previous class), you must cite your sources. Otherwise you will be guilty of plagiarism and subject to academic disciplinary action, including failure of the course. For further information, please visit the Student Conduct and Academic Integrity website at: <http://deanofstudents.utexas.edu/conduct>.

Sharing of Course Materials Prohibited

No materials used in this class, including, but not limited to, lecture hand-outs, videos, assessments (quizzes, exams, papers, projects, homework assignments), in-class materials, review sheets, and additional problem sets, may be shared online or with anyone outside of the class unless you have the instructor's explicit, written permission. Unauthorized sharing of materials promotes cheating. UT is aware of the sites used for sharing materials, and any materials found online that are associated with you, or any suspected unauthorized sharing of materials, will be reported to Student Conduct and Academic Integrity in the Office of the Dean of Students. These reports can result in sanctions, including failure in the course.

Title IX Disclosure

Title IX is a federal law that protects against sex and gender-based discrimination, sexual harassment, sexual assault, sexual misconduct, dating/domestic violence and stalking at federally funded educational institutions. UT Austin is committed to fostering a learning and working environment free from discrimination in all its forms. When sexual misconduct occurs in our community, the university can:

- Intervene to prevent harmful behavior from continuing or escalating.
- Provide support and remedies to students and employees who have experienced harm or have become involved in a Title IX investigation.
- Investigate and discipline violations of the university's relevant policies (<https://titleix.utexas.edu/relevant-policies/>).

Beginning January 1, 2020, Texas Senate Bill 212 requires all employees of Texas universities, including faculty, report any information to the Title IX Office regarding sexual harassment, sexual assault, dating violence and stalking that is disclosed to them. Texas law requires that all employees who witness or receive any information of this type (including, but not limited to, writing assignments, class discussions, or one-on-one conversations) must be reported. We are Responsible Employees and must report any Title IX related incidents that are disclosed in writing, discussion, or one-on-one. Before talking with any of your instructors, or with any faculty or staff member about a Title IX related incident, be sure to ask whether they are a responsible employee (or in other words, a Mandatory

Reporter). If you would like to speak with someone who can provide support or remedies without making an official report to the university, please email advocate@austin.utexas.edu. For more information about reporting options and resources, visit <http://www.titleix.utexas.edu/>, contact the Title IX Office via email at titleix@austin.utexas.edu, or call 512-471-0419.

Religious Holy Days

Religious holy days sometimes conflict with class and examination schedules. If you miss an examination or lab assignment due to the observance of a religious holy day you will be given an opportunity to complete the work missed within a reasonable time after the absence. We request that you must notify your instructors at least fourteen days prior to the classes scheduled on dates you will be absent to observe a religious holy day.

University Resources for Students

Services for Students with Disabilities (SSD): <https://diversity.utexas.edu/disability/>

Counseling and Mental Health Center (CMHC): <https://cmhc.utexas.edu> or call 512-471-3515

University Health Services (UHS): <https://www.healthyhorns.utexas.edu/>

Sanger Learning Center: <https://ugs.utexas.edu/slc>

Student Emergency Services (SES): <https://deanofstudents.utexas.edu/emergency/>

JSG Counselor in Academic Residence (CARE) Counselor: Toby Leblanc, tbleblanc@austin.utexas.edu

Instructors: Alex Bump (APB), Dana Thomas (DLT), Hailun Ni (HN), Sahar Bakhshian (SB), Susan Hovorka (SDH)

Guest Lecturers: Tip Meckel (TM), Katherine Romanak (KDR)

Please note that due to individual schedules, some topics after spring break are subject to modification.

Date	Lecture number	Topic	Assignment to be assigned	Assignment due	Instructor(s)	Other Notes
Tue, Jan 18	1	Introduction and overview	Bring a news article, podcast, etc. about a climate change-mitigation strategy you have heard of and be prepared to give a 30-second summary Pre-test/questionnaire		All	
Thu, Jan 20	2	Climate change mitigation strategies	Read Chapter 7 - CO2 Geologic Storage in Meeting the Dual Challenge	30-second summary about a climate change-mitigation strategy you have heard of	All	Jan 21 last day of official add/drop period
Tue, Jan 25	3	UTCCS-6 Meeting (virtual link on MS Teams will be provided)	UTCCS-6 related assignment	Questionnaire/pre-test for assessing prior knowledge	All	UT CCS runs 1/25-26 all day, students should attend as much as possible. Capture, storage, policy and petroleum engineering.
Thu, Jan 27	4	Source-sink matching: site selection	Assign assignment 1	UTCCS-6 related assignment due	SDH	
Tue, Feb 1	5	Reservoir characterization: geologic characterization			TAM	Anticipated first day in-person
Thu, Feb 3	6	Reservoir characterization: hydrologic properties	Assign assignment 2	Assignment 1	HN	
Tue, Feb 8	7	Fluid characterization: CO2 phase behavior, physical			HN	

		properties				
Thu, Feb 10	8	Trapping mechanisms: confining systems and traps, dissolution, capillary trapping and mineral trapping	Assign assignment 3	Assignment 2 due	ABP, DLT	
Tue, Feb 15	9	Static capacity: Pore space, monte carlo, storage efficiency			TAM	
Thu, Feb 17	10	Multiphase flow basics: CO2-rock interactions: capillary and relative permeability (efficiency)	Assign assignment 4	Assignment 3 due	SB	
Tue, Feb 22	11	Dynamic Capacity: Pressure build-up, AoR, EasiTool			SB	
Thu, Feb 24	12	Design injection plan	Assign assignment 5	Assignment 4 due	SDH	
Tue, Mar 1	13	Uncertainty and risk (Faults and well penetration)			APB	Ask students about Mar 29 topic
Thu, Mar 3	14	Monitoring a commercial storage site, site closure	Assign assignment 6	Assignment 5 due	SDH, KDR	
Tue, Mar 8	15	Financial analysis			APB	
Thu, Mar 10		Midterm exam	N/A		N/A	
Tue, Mar 15		SPRING BREAK, NO CLASS				
Thu, Mar 17		SPRING BREAK, NO CLASS				
Tue, Mar 22	16	Pore- and Reservoir-scale simulation			SB	
Thu, Mar 24	17	Physical lab experiments	Assign project milestone 1	Assignment 6 due	HN	
Tue, Mar 29	18	Case studies/policy examples			To Be Decided	

		(student-decided)				
Thu, Mar 31	19	Case studies/policy examples (controlled releases)	Assign project milestone 2	Project milestone 1 due	KDR	
Tue, Apr 5	20	How to put a project together (DecisionSpace, Petrel, Seiswork)			Dallas Dunlap	April 4 is last day an undergrad can "Q-drop"
Thu, Apr 7	21	Machine learning in CCS			HN	
Tue, Apr 12	22	Wellbore issues	Assign project milestone 3	Project milestone 2 due	SDH	
Thu, Apr 14	23	Core viewing field trip (Pickle campus)	Assign project milestone 4	Project milestone 3 due	DLT and SDH	
Tue, Apr 19	24	Regulatory issues – Groundwater protection and Environmental Justice tool			SDH on Class VI RGE on EJ	
Thu, Apr 21	25	Public acceptance	Assign project milestone 5	Project milestone 4 due	KDR	
Tue, Apr 26	26	Case studies/policy examples: CarbFix and Wallula			DLT	
Thu, Apr 28	27	Demo of Geochemists Workbench (GWB); Group project work time		Project milestone 5 due	DLT	
Tue, May 3		Group project presentations	Prepare critiques of projects as a project reviewer.		All	
Thu, May 5		Group project presentations; Reflection, assessment and recommendations	Prepare critiques of projects as a project reviewer.		All	Last day of class; May 6 is last day grad students can drop a class
Sat, May 14		Final Report Due				No final exam