Geochemical effects of CO2 on Reservoir, Seals and Engineered Environments during CCS (G544)

Tutor(s)

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Overview

The geochemistry of saline aquifers, depleted oil/gas fields in the context of CO2, and other waste gas, injection is considered. The reactions of CO2 with different reservoir rocks and top-seals, and their constituent minerals, and the cement and metal work used in the construction of wells are central to this course. The course includes reference to numerous CCS and CO2-EOR case studies, CCS-pilot sites, experiments, geochemical modelling, reaction-transport modelling, monitoring of CCS sites, microbiological processes in CCS systems, and the risk of halite scale formation.

Duration and Logistics

Classroom version: A 3-day course comprising a mix of lectures, case studies and exercises. The manual will be provided in digital format, and participants will be required to bring a laptop or tablet computer to follow the lectures and exercises.

Virtual version: Five 3.5-hour interactive online sessions presented over 5 days. Digital course notes and exercise materials will be distributed to participants before the course. Exercises will be used throughout the course; these will include calculations, largely based on spreadsheets. Quizzes will be used to test knowledge development.

Level and Audience

Advanced. The course is largely aimed at specialist geoscientists, but petroleum engineers and petrophysicists who are working on, or plan to work on, CCS projects will also find the course instructive. A foundation knowledge of geochemistry is assumed.

Objectives

You will learn to:

1. Appraise the types and sources of information needed to define geochemical aspects of CCS sites.
2. Evaluate the role of CO2 pressure in influencing reactions at CCS sites.
3. Assess the information that can be gathered from natural analogues of CCS projects.
4. Evaluate the role of composition of the injected gas (role of contaminants) in influencing reactions at CCS sites.
5. Gauge the role of water composition in influencing reactions at CCS sites.
6. Characterize the role of mineral composition (rock type) in influencing reactions at CCS sites.
7. Manage examples of mineral dissolution in CCS systems.
8. Predict possible examples of mineral precipitation in CCS systems.
9. Gauge CO2 interaction with cements and pipes used in well completions.

10. Assess how experimental simulation, geochemical reaction modelling and reaction transport modelling can help predict if dissolution or precipitation will occur.
11. Validate the links between geochemical processes and geomechanical and petrophysical properties in CCS systems.
12. Use geochemical tracers to track process in CCS systems.
13. Characterize the microbiological processes that may occur at CCS sites.
14. Predict the geochemical formation damage in CCS.
15. Quantify the role of CCS in basalt hosts in comparison to sedimentary hosts.

Course Content

1. Definitions, sources of geochemical information and injected gas compositions

- Defining the geochemistry of CCS
- The sources of information that inform us about geochemical processes involved in CCS
- What gases will be injected into the subsurface during CCS

2. Forms of CO2 in the subsurface and dissolution of CO2

- CO2 phase behavior
- Forms of CO2 in the subsurface
- Solubility and dissolution of CO2

3. Mineral dissolution and precipitation processes during CCS

- Under what circumstances and how mineral dissolution occurs following the injection of CO2 and contaminant gases
- Under what circumstances and how mineral precipitation occurs following the injection of CO2 and contaminant gases
- The driving force behind dissolution and precipitation due to CO2 injection
- Reaction kinetics of dissolution and precipitation reactions due to CO2 injection

4. Sandstone reservoirs and CCS geochemistry

- Introduction to sandstone mineralogy and texture
- Evidence that sandstones can undergo dissolution during CCS
- Evidence that minerals may precipitate during sandstone CCS
- The role of acid gas contamination on sandstone geochemical processes
- Review and summary of the effects of dissolution and precipitation on sandstone rock properties

5. Carbonate reservoirs and CCS geochemistry

- Introduction to carbonate mineralogy and texture
- Evidence that carbonates can undergo dissolution during CCS
- Evidence that minerals may precipitate during carbonate CCS
- The role of acid gas contamination on carbonate geochemical processes
- Review and summary of the effects of dissolution and precipitation on carbonate rock properties

6. Low permeability rocks and CCS geochemistry

- Introduction to the mineralogy and texture of low-permeability top-seals and fault-seals
- Evidence that top-seals may undergo reaction during CCS
- Effects of CCS reactions on top-seal properties
- Evidence that fault-seals may undergo reaction during CCS
- Effects of CCS reactions on fault-seal properties

7. The well environment, corrosion leakage and CCS geochemistry

- Leakage risks associated with cement and pipe corrosion
- Metal-CO2 (and contaminant gases) corrosion processes
- Cement-CO2 (and contaminant gases) corrosion processes

8. CCS monitoring using geochemical tracers and the effect of CCS on microbial processes

- Geochemical tracers for CCS (natural and synthetic)
- Potential use of geochemical tracers in CO2 storage sites
- Microbial processes in CO2 storage sites

9. Halite and other geochemical formation damage and basalt-hosted CCS

- Summary of types of formation damage in CCS projects
- Halite growth in saline aquifers and reduced CO2 injectivity
- CO2 storage in basalt: summary of the CarbFix project
- Why solid sequestration of CO2 occurs in basalt and contrast to geochemical processes sedimentary hosts for CO2
- Summary of the topics covered in the geochemistry of CCS