N565: Carbon Capture and Storage for Geoscientists and Engineers

Instructor(s): Richard Worden

Format and Duration

Classroom - 3 Days
Virtual - 5 Sessions

Summary

The course will establish basics such as how much CCS is needed to make a difference to global warming and explore what types of CO2 injection have already happened including dedicated long-term CCS projects, pilot projects and CO2-enhanced oil recovery projects. The course will address CO2 as a fluid phase and the key question of CO2 storage efficiency, the equivalent of oil recovery factor. The course will address the rate of CO2 injection and the role reservoir permeability. The all-important issue of the geomechanical effects of CO2 injection and feedbacks between induced mineral dissolution and rock strength and other rock properties will be addressed. The range of possible interaction between CO2 and both aquifer and top-seal will be covered as will the range of potential leakage mechanisms that need to be assessed. The course will conclude with detailed consideration of the monitoring strategies available to assure the safety and integrity of the CO storage site.

Business Impact: This course will provide participants with **awareness and understanding** of the **subsurface needs** of **CCS projects** including subsurface CO2 **storage volumetrics**, CO2 **flow in the subsurface** away from injector wells, the objective of **permanent and safe storage** of CO2, and **the key issues** of reservoir depth, well design, reservoir lithology, reservoir quality, and reservoir architecture.

Learning Outcomes

Participants will learn to:

1. Understand the role of CCS in CO2 emissions-reductions.
2. Develop awareness of the role of geoscience and reservoir engineering in CCS.
3. Appreciate the types of CO2 injections projects have occurred so far, and the ones that are planned.
4. Discuss CCS projects that have been a success and those that have had problems.
5. Understand CO2 as a fluid in the subsurface and how it differs from oil, gas and water.
6. Build awareness of the reservoir rocks that store CO2 and the volumetrics of CO2 storage.
7. Appreciate the importance of the storage efficiency factor in controlling how much CO2 can be injected.
8. Gain an appreciation of the question of the injectivity of CO2 and the roles of permeability and aquifer architecture on CO2 flow.

Training Method

This is a classroom or virtual classroom course comprising a mixture of lectures, discussion, case studies, and practical exercises.

Who Should Attend

The course is aimed at geoscientists and engineers, but other sub-surface staff will also find the course useful. Participants are expected to have a working knowledge of petroleum geoscience. However, the subject matter of this course, the geoscience of carbon capture and storage, is covered from basic

principles.

Course Content

Session 01: Background, why we know CCS can work, history of CO2 injection

- Why do we need to reduce CO2 in Earth's atmosphere?
- Where does CO2 in the atmosphere come from?
- Plans to mitigate CO2 release
- What are the key steps involved in allowing/making CCS happen?
- How much CCS has happened so far?
- CCS and CO2-enhanced oil recovery
- Plans for future CCS
- What gas will be injected - CCS and injected gas purity
- Exercise: How many CCS projects are needed to cut a nation's CO2 emissions
- Exercise: How many CCS projects are needed to cut a world's CO2 emissions
- Exercise: Rough estimate of subsurface storage capacity

Session 02: CO2 in the subsurface, CCS reservoirs and CO2 storage volumes

- How CO2 is distributed in the subsurface
- CO2 physical properties
- CO2-brine chemical properties
- CO2 quantities: mass and volume
- The fate of CO2 over time
- Movement and trapping of CO2
- Controls on porosity in aquifers and reservoirs planned for CCS
- Examples of reservoir quality from CCS sites
- Estimation of CO2 storage mass in aquifer (reservoirs)
- Geometry of CO2 plumes and storage efficiency
- Estimation of CO2 storage mass in old oil fields
- Exercise: CO2 mass stored and reservoir depth
- Exercise: CCS reservoir porosity controls
- Exercise: Refined estimate of CO2 storage capacity accounting for storage efficiency

Session 03: CO2 injectivity, formation damage and geomechanical effects of CCS

- CO2 injection rates and injectivity index
- Permeability, its geological and petrophysical controls
- CO2 permeability when water is present: rel perm
- CO2 injection rates and reservoir permeability
- CO2 movement patterns after injection
- Modelling CO2 injection rate in a reservoir

- Formation damage and well injection rates
- CO2 large-scale flow patterns
- Modelling CO2 flow patterns
- Geomechanics and well-bore stability
- Geomechanics and regional uplift due to CCS
- Exercise: Prediction of CO2 injection rates
- Exercise: Effect of formation damage on CO2 injection rates
- Exercise: Risk of failure due to excessive injection rates

Session 04: CO2 - reservoir interaction, CO2 top-seal and fault-seal interaction

- CO2 mixing with formation water
- Minerals and possible processes and reactions in CCS reservoirs
- Stable and unstable minerals in CCS reservoirs: pH buffering
- Where do minerals reactions occur in the CCS reservoir
- Water chemistry evidence of mineral dissolution from EOR and CCS projects
- Rates of reactions: kinetics
- Driving force for reaction; distance from equilibrium
- Reaction-flow modelling of CCS systems
- Downhole evidence of CCS-induced changes to the reservoir
- Top-seal: diffusion and advection of CO2 as escape mechanisms
- Top-seal mineralogy, pore throat size
- Top-seal geomechanical considerations
- Exercise: Prediction of rate for reservoir (mineral) dissolution due to CO2 injection
- Exercise: Effect of water chemistry and mineralogy on CO2-rock interaction
- Exercise: Halite precipitation from saline formation water blocks CO2 injectivity

Session 05: CO2 leakage, monitoring and risk assessment

- Introduction to the need to prevent CO2 leakage to surface
- CO2 loss through top-seals
- Injection well design
- Borehole leakage risk
- Geomechanical problems and CO2 leakage
- Monitoring CCS sites: geophysics, geochemistry, borehole monitoring, etc
- Assessment of risk due to CCS
- Exercise: Risk of loss of CO2 by diffusion through seals
- Exercise: Risk of loss of CO2 by flow through seals
- Exercise: CO2 column height calculation