EMENTAS DAS DISCIPLINAS DE TÓPICOS
DO PROGRAMA DE CIÊNCIAS E ENGENHARIA DE PETRÓLEO

1º semestre de 2025

PP390 B – Topics in Reservoir Engineering: Fundamentals of subsurface geology and reservoir engineering

Professors: Rosangela Barros Zanoni Lopes Moreno; Alejandro Escalona; Tina Puntervold; Raoof Gholami; Wiktor Weibull; Pål Ø. Andersen.

Number of hours: 3 hours per week for 15 weeks

Where: Online - Google Meeting

Day and time: Tuesdays and Thursdays 16.30 – 18.00 CET (12.30 – 14.00 Brazil)

Duration: week 9 (Feb 24th) – week 26 (Jun 27th) – need flexibility due to public holidays.

Max 26 students: reservoir + exploitation.

Timeline:

Topic	Duration	Instructor
Introduction	Week 9	Alejandro Escalona
Petroleum and reservoir geology	Week 10-11	Alejandro Escalona
Reservoir engineering	Week 12-14	Tina Puntervold
Formation evaluation	Week 15-17	Raoof Gholami
Reservoir Geophysics	Week 18-20	Wiktor Weibull
Reservoir simulation	Week 21-23	Pål Ø. Andersen

Course description: This course focuses on the fundamental knowledge for understanding and developing reservoirs for hydrocarbons from geology to reservoir simulation. The same knowledge builds the basis towards the energy transition where reservoirs are of importance, particularly with a focus on CO2 and hydrogen storage, and geothermal energy.

Week 9-11

Understanding petroleum reservoirs is one of the key activities of the oil industry to increase and maintain reserves, or to store energy and sequestrate CO2. Definition of reservoir rock and its boundaries is part of the basic knowledge that professionals need to confront on a daily basis in the petroleum industry. This course offers a good understanding of subsurface geological processes and the steps that are taken to characterize a potential reservoir or storage site. Key topics are sedimentology, stratigraphy and structural geology related to petroleum geology.

Week 12-14

The course provides insights into reservoir phase components and properties influencing fluid location and flow in porous media, such as capillary pressure, wettability, relative permeability. Pressure-volume-temperature (PVT) phase behavior will be covered, as well as PVT testing and their results forming basis for material balance calculations for production estimation during reservoir pressure depletion and waterflooding of reservoirs.

Week 15-17

A thorough introduction to formation analysis using wireline logging will be given, covering fundamental concepts and practical applications. Students will learn to interpret subsurface data to evaluate hydrocarbon potential and understand the properties of rocks and fluids in the reservoir. Advanced tools such as repat formation testers and image logs will also be introduced to better characterise reservoirs.

Week 18-20

We will go through seismic signals, including understanding seismic amplitudes, and how to model these. Furthermore, we will also look at reservoir properties estimation using seismic inversion. Finally, we will look into some examples of seismic monitoring of CO2 injection using the Sleipner CO2 injection data.

Week 21-23

In reservoir simulation we present black oil modeling, model inputs and build simple models. Pressure depletion and water injection are investigated with focus on recovery and time scales as well as the interplay of mobility ratio, thief zones, gravity segregation and cross flow.

Recommended books:

Gluyas, J. and R. Swarbrick, 2013, Petroleum Geosciences, John Wiley & Sons, 376 pages
Bateman, R. M. (2020). Formation Evaluation with Pre-digital Well Logs, Elsevier, 266 pages
Dake, L. P. (1978). Fundamentals of reservoir engineering, Elsevier, 443 pages

Ashcroft, W. (2011). A Petroleum Geologist's Guide to Seismic reflection, Wiley-Blackwell, 176 pages.

PP528/A – Tópicos em Geofísica de Reservatórios: Análise de Velocidade em Migração

Docentes: Joerg Schleicher; Maria Amélia Novais Schleicher.

Ementa: Tópicos importantes da literatura recente em Métodos da Análise de Velocidade Sísmica usando métodos de migração.

Bibliografia: Artigos recentes em revistas internacionais da área.

PP528/B – Tópicos em Geofísica de Reservatórios: Elementos de Sísmica 3D

Docente: Emilson Pereira Leite

Ementa: Propriedades gerais de ondas mecânicas. Ondas em fluidos. Eventos sísmicos. Propriedades de fluidos de reservatórios. Ondas em sólidos. Ondas em sólidos porosos. Aquisição sísmica 2D e 3D. Processamento e aspectos computacionais. Criação de conjuntos CMP e empilhamento. Conceitos de migração. Extração de informação geológica a partir dos dados sísmicos.

PP590 C – Tópicos em Geoengenharia de Reservatórios: Sequestro e Armazenamento Geológico do Carbono

Docentes: Alfredo Borges de Campos, Ricardo Perobelli Borba e Wanilson Luiz Silva.

Ementa: Ciclo geológico do carbono. Lei da Ação das Massas e o sistema carbonático. Conceitos e fundamentos do CCS. Captura, transporte e armazenamento geológico do carbono. Monitoramento do armazenamento geológico do carbono. Uso de Modelos Geoquímicos no CCS. Atividades práticas em campo e laboratório.

Objetivos: Apresentar e discutir referencial teórico-conceitual, métodos e técnicas sobre sequestro e armazenamento geológico do carbono. Introduzir os alunos em métodos de investigação de materiais geológicos para o armazenamento do carbono.

Conteúdo programático:

1 - Ciclo geológico do carbono: implicações para o CCS (4hs)

2 - Lei da Ação das Massas e o sistema carbonático (8hs)
- Reatividade do CO2 com minerais e rochas
- CO2 supercrítico

3 - Conceitos e fundamentos do CCS (4hs)
- Tecnologias de CCS

4 - Captura, transporte e armazenamento geológico do carbono (12hs)
- Métodos e técnicas de captura e transporte do carbono
- Armazenamento onshore e offshore
- Estabilidade do armazenamento geológico
- Mecanismos de aprisionamento do carbono

5 - Monitoramento do armazenamento geológico do carbono (8hs)
- Balanço de massa
- Monitoramento espacial e temporal
- Riscos do armazenamento

6 - Uso de Modelos Geoquímicos no CCS (8hs)
- Fundamentos teóricos da modelagem geoquímica e uso do PHREEQC

- Previsão de cenários e armazenamento geológico do carbono (exercício prático)

7 - Projetos de CCS no Brasil e no Mundo (4hs)

8 - Atividades práticas em campo e laboratório (12hs)
- Perfis geológicos, visitas a instalações experimentais
- Termometria do sistema carbonático

9 - Apresentação de seminários (4hs)

Critérios de avaliação: O curso será avaliado por meio de: 1) elaboração e apresentação de seminários individuais sobre temas relacionados ao sequestro e armazenamento geológico do carbono (70%); 2) exercícios e elaboração de relatórios sobre atividades desenvolvidas em laboratório e campo (30%).

Bibliografia:

Aghajanloo, M.; Yan, L.; Berg, S.; Voskov, D.; & Farajzadeh, R. (2024). Impact of CO2 hydrates on injectivity during CO2 storage in depleted gas fields: A literature review. Gas Science and Engineering, 205250.

Ajayi, T.; Gomes, J. S.; & Bera, A. (2019). A review of CO2 storage in geological formations emphasizing modeling, monitoring and capacity estimation approaches. Petroleum Science, 16, 1028-1063.

Akindipe, D.; Saraji, S.; & Piri, M. (2022). Pore matrix dissolution in carbonates: An in-situ experimental investigation of carbonated water injection. Applied Geochemistry, 147, 105483.

Ali, F.; Negash, B. M.; Ridha, S.; & Abdulelah, H. (2023). A review on the interfacial properties of caprock/CO2/brine system-implications for structural integrity of deep saline aquifers during geological carbon storage. Earth-Science Reviews, 247, 104600.

Bashir, A.; Ali, M.; Patil, S.; Aljawad, M. S.; Mahmoud, M.; Al-Shehri, D.; ... & Kamal, M. S. (2024). Comprehensive review of CO2 geological storage: Exploring principles, mechanisms, and prospects. Earth-Science Reviews, 104672.

CCS Brasil (2024). 1º Relatório Anual de CCS no Brasil 2022/2023 de Paulo Ferreira, L.; Surmas, R.; Tonietto, S. N.; da Silva, M. A. P.; & Peçanha, R. P. (2020). Modeling reactive flow on carbonates with realistic porosity and permeability fields. Advances in water resources, 139, 103564.

Do, H. K.; Yu, S.; Ryuh, Y. G.; Ju, Y.; Kang, H. J.; Ha, S. W.; & Yun, S. T. (2022). Tracing CO2 leakage and migration using the hydrogeochemical tracers during a controlled CO2 release field test. Applied Geochemistry, 143, 105390.

Gholami, R.; Raza, A.; & Iglauer, S. (2021). Leakage risk assessment of a CO2 storage site: A review. Earth-Science Reviews, 223, 103849.

Gupta, P. K.; & Yadav, B. (2020). Leakage of CO2 from geological storage and its impacts on fresh soil–water systems: a review. Environmental Science and Pollution Research, 27(12), 12995-13018.

Iyer, J.; Lackey, G.; Edvardsen, L.; Bean, A.; Carroll, S. A.; Huerta, N.; ... & Cerasi, P. (2022). A review of well integrity based on field experience at carbon utilization and storage sites. International Journal of Greenhouse Gas Control, 113, 103533.

Mwenketishi, G. T.; Benkreira, H.; & Rahmanian, N. (2023). A Comprehensive Review on Carbon Dioxide Sequestration Methods. Energies, 16(24), 7971.

Prasad, S. K.; Sangwai, J. S.; & Byun, H. S. (2023). A review of the supercritical CO2 fluid applications for improved oil and gas production and associated carbon storage. Journal of CO2 Utilization, 72, 102479.

Wang, X.; Li, S.; Tong, B.; Jiang, L.; Lv, P.; Zhang, Y., ... & Song, Y. (2024). Multiscale wettability characterization under CO2 geological storage conditions: A review. Renewable and Sustainable Energy Reviews, 189, 113956.

Wei, B.; Wang, B.; Li, X.; Aishan, M.; & Ju, Y. (2023). CO2 storage in depleted oil and gas reservoirs: A review. Advances in Geo-Energy Research, 9(2), 76-93.

Yekeen, N.; Padmanabhan, E.; Thenesh, A.; Sevoo, L.; Kamalarasan, A.; Kanesen, L.; & Okunade, O. A. (2020). Wettability of rock/CO2/brine systems: A critical review of influencing parameters and recent advances. Journal of Industrial and Engineering Chemistry, 88, 1-28.

Zheng, L.; Nico, P.; Spycher, N.; Domen, J.; & Credoz, A. (2021). Potential impacts of CO2 leakage on groundwater quality of overlying aquifer at geological carbon sequestration sites: A review and a proposed assessment procedure. Greenhouse Gases: Science and Technology, 11(5), 1134-1166.

Zhong, H.; Wang, Z.; Zhang, Y.; Suo, S.; Hong, Y.; Wang, L.; & Gan, Y. (2024). Gas storage in geological formations: A comparative review on carbon dioxide and hydrogen storage. Materials Today Sustainability, 100720.

Zhu, H.; Xu, T.; Tian, H.; Feng, G.; Yang, Z.; & Zhou, B. (2019). Understanding of Long-Term CO 2-Brine-Rock Geochemical Reactions Using Numerical Modeling and Natural Analogue Study. Geofluids, 2019.

Livros:

Asian Development Bank (2019). Carbon Dioxide-Enhanced Oil Recovery in Indonesia: An Assessment of its Role in a Carbon Capture and Storage Pathway. Asian Development Bank.

Ballerat-Busserolles, K. (2018). Cutting-Edge Technology for Carbon Capture, Utilization, and Storage. Wiley.

Birdi, K. S. (2021). Surface Chemistry of Carbon Capture. CRC Press

Bui, M.; & Dowell, N. M. (Eds.) (2019). Carbon Capture and Storage. Royal Society of Chemistry.

Cook, P. J. (2014). Geologically Storing Carbon: Learning from the Otway Project Experience. Wiley.

Costa, H. K. M.; & Musarra, R. M. L. M. (2019). Sustainable Development Goals And Legal Aspects of CCS in Brazil. LAP LAMBERT Academic Publishing.

International Organization for Standardization (2019). ISO 27916:2019, First Edition: Carbon dioxide capture, transportation and geological storage - Carbon dioxide storage using enhanced oil recovery (CO2-EOR) Multiple. Distributed through American National Standards Institute (ANSI).

Jones, A. C. (2020). Injection and Geologic Sequestration of Carbon Dioxide: Federal Role and Issues for Congress. Independently published.

Khosrokhavar, R. (2015). Mechanisms for CO2 sequestration in geological formations and enhanced gas recovery. Springer.

Koukouzas, N.; Tyrologou, P.; & Koutsovitis, P. (Eds.) (2020). Climate Change, Carbon Capture, Storage and CO2 Mineralisation Technologies. Mdpi AG.

Mohaghegh, S. (2018). Data-Driven Analytics for the Geological Storage of CO2. CRC Press.

Rackley, S. A. (2017). Carbon Capture and Storage. Butterworth-Heinemann.

Ringrose, P. (2020). How to Store CO2 Underground: Insights from early-mover CCS Projects (SpringerBriefs in Earth Sciences). Springer.

Shah, Y. T. (2021). CO2 Capture, Utilization, and Sequestration Strategies (Sustainable Energy Strategies). CRC Press.

Smit, B.; Reimer, J. A.; Oldenburg, C. M.; & Bourg, I. C. (2014). Introduction To Carbon

Capture And Sequestration (Berkeley Lectures On Energy). Imperial College Press.

Surdam, R. C. (2013). Geological CO2 Storage Characterization: The Key to Deploying Clean Fossil Energy Technology. Springer.

Tajnik, T. (2014). Carbon Capture and Storage - theoretical knowledge and experiments: Analysis of CO2 adsorption in different geological materials and water samples. LAP LAMBERT Academic Publishing.

Vishal, V.; & Singh, T. N. (Eds.) (2016). Geologic Carbon Sequestration: Understanding Reservoir Behavior. Springer.

Wilcox, J. (2014). Carbon Capture. Springer.