Carbonate Depositional Systems: Reservoir Sedimentology and Diagenesis (G105)

Tutor(s)

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Overview

This course is aimed at those with little or no previous experience with carbonate rocks as reservoirs or aquifers. A broad introduction to carbonate systems is presented, with multiple case examples interspersed throughout the course, in order to illustrate the different types of carbonate deposition, stratigraphy and diagenesis. Besides reviewing the essential components and origins of such rocks, it also illustrates how key characteristics are identified from seismic data and the issues relating to flow behaviour. Participants will attain a broad understanding of carbonate rocks – their components, depositional models and diagenetic variation – to better assist in the prediction of carbonate reservoirs from seismic to pore scale.

Duration and Logistics

Classroom: A 4.5-day in-person classroom course. Digital course notes and exercise materials will be distributed to participants before the course.

Virtual version: Nine 3.5-hour interactive online sessions. Digital course notes and exercise materials will be distributed to participants before the course.

Level and Audience

Fundamental. The course is intended for geoscientists (geologists and geophysicists) and petroleum engineers with little or no experience of carbonate reservoirs.

Objectives

You will learn to:

1. Understand and describe the principal carbonate sediment components and systems of carbonate classification.
2. Describe the primary controls on carbonate deposition temporally and spatially, and discuss the contrasts between the controls on siliciclastic deposition.
3. Describe the main types of carbonate platform, their variability, scale, main seismic features and distribution of likely reservoir units.
4. Demonstrate sequence stratigraphic aspects of carbonate build-ups, their differing response to SL change compared to clastic sediments and discuss their seismic characters.
5. Review principal types of likely reservoir facies (platform interior, carbonate sands, reefs, slope systems and chalks), their recognition, architecture, sequence stratigraphy and porosity types.
6. Identify the diverse pore types in carbonates and how these relate to reservoir quality.
7. Understand how the development of primary and secondary porosity has varied through geological time and how these changes impact reservoir quality.
8. Explain how the variety of diagenetic environments affects primary and secondary porosity in

carbonate rocks and understand the implications for reservoir quality.
9. Understand the uses of the main techniques for deciphering diagenetic sequences in carbonates.
10. Discuss the principal modes of formation of dolomites and the predictive uses of different dolomite models.
11. Understand the diverse origins of palaeokarstic macroporosity, its subsurface recognition, and different strategies for developing palaeokarstic systems for geothermal energy and hydrocarbon reservoirs.

Course Content

Course Details

The 4.5-day course is divided into five sections – introduction; basin-seismic scale (platform models); facies (reservoir) scale; and pore scale (diagenesis and porosity) and generic reservoir types. The course includes multiple exercises.

Introduction

1. Comparison of carbonates and siliciclastics as reservoirs; advice on further reading.
2. Principles of carbonate sedimentology, where they form, how they form, sediment producers (practical), concept of the factory (factories) and how these relate to seismic expressions and gross facies architectures.
3. Describing carbonate rocks – grain types and textures.

Exercise

Basin-seismic scale

1. Carbonate platforms and isolated platforms: for each covering oceanographic factors, environments, sediment types, architecture, seismic recognition, identification of zones of increased porosity and permeability potential. Examples include the Great Bahama Bank; Turks & Caicos Islands, Triassic Dolomites, PreCaspian of Kazakhstan.
    - *Extended exercise using seismic facies to differentiate carbonate buildups from other features*
2. Carbonate shelves; Florida Bay (oceanographic factors, environments, sediment types, architecture, seismic recognition, identification of zones of increased porosity and permeability potential). Examples include Canning Basin, Sierra del Cuera, Capitan Reef complex.
3. Ramps (oceanographic factors, environments, sediment types, architecture, seismic recognition, identification of zones of increased porosity and permeability potential). Examples include southern Arabian Gulf, Lower Carboniferous of South Wales, Huqf of Oman; seismic stratigraphic issues.
4. Epeiric and intraplatformal basins; Cretaceous on Middle East, including Shuiba and Natih.
5. Sequence and cyclostratigraphy of high-rise platforms.

Facies scale

1. Platform interior deposystems 1: processes, products and recognition; ice-house and green-house architectures; plays and strat traps.
2. Platform interior deposystems 2: ice-house systems and porosity-permeability relationships and cycle types.
3. Carbonate sands 1: tidal sandbodies and reservoir examples.
4. Carbonate sands 2: wave-dominated sandbodies,
   Well log exercise on Cretaceous sandbodies
5. Reefs 1: processes and types.
6. Reefs 2: morphologies and facies, reservoir issues.
7. Reefs 3: sequence stratigraphy, case studies of relevant types for class (e.g. rudist build-ups, phylloid mounds, microbialites)
8. Slope carbonates and related near slope systems.
   - Exercise on seismic facies
9. Chalk reservoirs (optional).

Pore scale and generic reservoir types

1. Porosity 1: introduction and types.
   Exercises on thief zones and their origins
2. Porosity 2: approaches to porosity classification 1.
3. Porosity 3: approaches to porosity classification 2.
4. Marine diagenesis: processes, role in producing permeability barriers; diagenetic bedding and marine dissolution effects.
5. Meteoric diagenesis: hydrogeology and impact of porosity and permeability.
6. Burial diagenesis, including burial corrosion.
7. Introduction to techniques including staining, CL, UV, stable C & O, and clumped isotopes, Sr isotopes.
8. Dolomites 1: types, petrophysical aspects.
9. Dolomites 2: models for dolomitization including HTD.
10. Palaeokarstic reservoirs: processes and types.
11. Palaeokarstic reservoirs: subsurface recognition and case studies.