N526: Sequence Stratigraphic Controls on Deep-Water Reservoirs Architecture: Brushy Canyon Formation, Permian Basin *(West Texas and New Mexico, USA)*

Instructor(s): Vitor Abreu

Format and Duration

Field - 5 Days
Moderate Physical Demand

Summary

Business Impact: Unlike continental and shallow-marine depositional environments, **deep-water depositional systems** develop in remote, difficult to access locations that prevent more direct observations of **sedimentary processes** and resulting **depositional architecture**. Therefore, **outcrop analogues** are even more important to observe and learn from, in order to support **de-risking costly exploration projects**, for example by assessing **reservoir presence risk**, **net-to-gross predictions** and **reservoir connectivity.**

Also, vertical scales of 10 to 20 meters are often below **seismic resolution**, making it difficult to predict in that **scale facies variations** occurring in distances of 1 to 2 kilometers, which are common **well-spacings** in **production deep-water projects**. Seismic-scale outcrops like the ones from the Brushy Canyon Formation help fill this gap in showing **lateral and vertical variations in facies** in scales that are not represented by data using conventional, industry seismic and wells.

This field course is designed for geoscientists and engineers exploring for and producing deep-water (DW) reservoirs globally, and particularly in the Permian Basin. At the end of this course, participants should have improved abilities to recognize deep-water depositional facies and reservoir architecture, as well as how to use sequence stratigraphy to identify and map key surfaces for DW exploration. The Guadalupe and Delaware mountains in west Texas and New Mexico show unique, world-class exposures of shelfal to slope and basinal settings with seismic-scale, continuous exposures. These exceptional outcrops are ideal to learn about depositional systems, lateral and vertical variations in facies and sequence stratigraphic architecture and surfaces. Coeval shelfal to deep-water environments are exposed both downdip and along strike, with clear stratigraphic relationships from a carbonate shelf margin incised by canyons, feeding confined to weakly confined channel systems, connected to distributive lobe complexes and distal fan fringe sandstones that thin and pinch out onto a basin margin far removed from siliciclastic sediment sources.

Learning Outcomes

Participants will learn to:

1. Recognize main archetypes of deep-water-reservoirs, relating them to exploration strategies and production behavior
2. How to interpret key stratigraphic surfaces based on changes in lithofacies stacking and associations.
3. How to interpret DW EoD's based on lithofacies associations, stacking and diversity
4. How to use outcrop analogues and depositional models to better understand 3-D distribution of reservoir facies.
5. Analyze exposures of carbonate shelf and ramp to siliciclastic basinal systems in order to relate depositional facies to seismic scale geometries and sequence stratigraphy.
6. Examine seismic scale outcrop geometries, document outcrop facies, and demonstrate similarities to productive intervals in the Permian Basin.

7. Apply Walter's Law and chronostratigraphic principles in core, well-log and seismic interpretation, and relate to prediction of play elements and best productive intervals for unconventional resources.
8. Analyze sequence stratigraphy for carbonates and mixed carbonate-clastic depositional systems.

Training Method

This is a field course, supported by classroom lectures. Almost every field stop includes exercises that illustrate and reinforce the key concepts and methods discussed in lectures and documented in the course notes.

Physical Demand

The physical demands for this class are moderate according to the Nautilus Training Alliance field course grading system. Participants should anticipate field days with an average of 8-10 hours away from lodging facilities. The field area is at an elevation of approximately 1500 m (5000 ft). This fairly high elevation in combination with hot temperatures and dusty conditions may lead to unexpected fatigue or shortness of breath for some participants. In order to gain the full benefit of this class, participants should be fit enough to complete these hikes under these conditions.

Transport on the course will be by SUVs. Most of the driving is on black-top roads, with some driving on graded dirt roads. Two days include long 17-mile off-road track driving on rough, rocky trails.

Who Should Attend

The course is relevant to all subsurface geoscientists who wish to broaden and deepen their knowledge of deep marine clastic plays.

Prerequisites and Linking Courses

Participants are expected to have a working knowledge of fundamental geological concepts, such as presented in Foundation Application courses N155 (Introduction to Clastic Depositional Systems: a Petroleum Perspective), D073 (Integration of Sedimentology, Petrophysics, and Seismic Interpretation, for Exploration and Production of Carbonate Systems), and D080 (Geophysics for Subsurface Professionals).

Suitable follow-on courses at Skilled Application level include N349 (Practical Methods for Sequence Stratigraphic Prediction) and field courses such as N011 (High Resolution Sequence Stratigraphy: Reservoir Applications (Utah, USA)), N042 (Reservoir Sedimentology and Stratigraphy of Coastal and Shelfal Successions: Deltas, Shorelines and Origins of Isolated Sandstones (NW Colorado, USA)), N451 (Practical Oil-Finders Guide to Siliciclastic Sequence Stratigraphy (Wyoming, USA)), D517 (Well Log Sequence Stratigraphy for Exploration and Production), D518 (Seismic Sequence Stratigraphy for Exploration and Production), and N442 (Reservoir Architecture of Deep Water Systems (California)).

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Course Content

Day 0:

- Arrive in El Paso, Texas.

Day 1:

- Morning: Introductory lecture and safety briefing.
- Depart El Paso - 2-hour drive to Salt Flat Graben, Texas.
    - Stop 1.1: Salt Flat Graben – Regional Geology and Stratigraphy of the Permian Basin. Geology of the Guadalupe and Delaware Mountains.
    - Stop 1.2: Rest Area – front of El Capitan + Lunch. Architectural Elements of Channel Systems.
    - Stop 1.3: Road Cut. Channel fills – facies, stacking and erosional features
- Evening overview lecture and dinner.
- Overnight: Van Horn

Day 2:

- Reservoir Architecture of Distributive Deep-Water Systems.
- Delaware Mountain Ranch - 2 hour drive from hotel.
    - Stop 2.1: Overview of Brushy Canyon Formation in outcrops along the Southern Basin Margin, Southern Delaware Mountains
    - Stop 2.2: Terminator Canyon - Establish Stratigraphic Framework and Hierarchy for Sandstone-rich Succession from Vertical Profiles, Upper Brushy Canyon
    - Stop 2.3: Carol Canyon. Facies and facies stacking.
- Overnight: Van Horn

Day 3:

- Submarine Canyon and Upper Slope Systems: Slope Discordances and Canyon Fills. Brushy Canyon Formation. Guadalupe Mountains National Park.
- Drive to Guadalupe Mountains National Park (3 hours)
    - Stop 3.1: Slope Facies and Architecture, Rest Area Gully
    - Stop 3.2: Mass Transport Deposits of the Lower Brushy Canyon Formation, Rest Area Gully
    - Stop 3.3: Thin-bedded sandstone architecture, Lower Brushy Canyon, Rest Area Gully
- Overnight: Carlsbad, New Mexico.

Day 4:

- Sequence Stratigraphic Controls on Deep-Water Systems. Shelfal by-pass during lowstand. Facies, facies stacking and stratal geometries during transgression and highstand.

    - Stop 4.1: Last Chance Canyon. Transgressive and highstand systems tracts on the shelf, by-pass surfaces and sequence boundaries. Full-day in the field.
- Overnight: Carlsbad, New Mexico.

Day 5:

- Sequence Sets and Composite Sequences. Shoreline Trajectories and recognition criteria for Composite Sequence Boundaries
    - Stop 5.1: Slaughter Canyon. Shoreline trajectory and progradational patterns – lowstand x highstand.
    - Stop 5.2: West Face. Final exercise and school wrap-up
- Fly home from El Paso.