N349: Practical Methods for Sequence Stratigraphic Prediction

Tutor(s): John Snedden

5 Days	Competence Level: Skilled Application
Classroom Course	

Summary

Sequence stratigraphy has proven useful in the identification of critical elements of the petroleum system: reservoir, seal and source. This course avoids the academic debate on nomenclature and eustasy and focuses upon time-tested methods for hydrocarbon identification and exploitation using well logs, cores and seismic. Using a large number of real world examples, participants learn methods applicable to compartments, fields, prospects, plays and basins. Conventional and unconventional reservoirs are considered.

Learning Outcomes

Participants will learn to:

1. Discriminate between lithostratigraphy and chronostratigraphy and understand how sequence stratigraphy improves exploration, development and production success.
2. Assemble data for seismic stratigraphic analysis and contribute to planning and implementation of seismic stratigraphic projects to address play element uncertainty.
3. Discuss methods for creating seismic facies maps using workstation seismic interpretation software.
4. Evaluate well logs for characteristic patterns indicating system tracts, sequences and sequence sets and understand differences between low- to high-order.
5. Assess stratal terminations to identify and correlate key surfaces (sequence boundaries, maximum flooding surfaces) on various types and vintage of reflection seismic data.
6. Integrate biostratigraphic and physical stratigraphic observations from well data to establish local/global chronostratigraphic designations of depositional sequences.
7. Evaluate and map non-amplitude based seismic facies and combine with isochore and amplitude maps to predict reservoir distribution.
8. Assess other key elements of petroleum systems (seal, source, and stratigraphic trap) from integration of seismic and well data.
9. Understand how source to sink analysis (advanced provenance work, empirical scaling relationships) supplement and enhance the sequence stratigraphic approach to basin analysis.

Duration and Training Method

A five-day classroom course comprising of well-illustrated classroom lectures set up 20 hours of practical seismic interpretation and well log correlation exercises. Special media (.avi movies) of experimental and numerical models support concepts and theory.

Who Should Attend

This course has been designed for working geoscientists who wish to learn practical methods that can be used in the workroom and on the workstation.

Prerequisites and Linking Courses

A familiarity with structural and stratigraphic concepts, basic seismic interpretation and basic well log evaluation is assumed, such as offered in Basic Application level courses N005 (Tectonic Controls on Basin Development and Petroleum Systems), N085 (Introduction to Seismic Interpretation) and N003 (Geological Interpretation of Well Logs).

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A comprehensive introduction to sequence stratigraphy is offered in N007 (Seismic and Sequence Stratigraphy for Play Prediction and Basin Analysis). A number of Nautilus courses explore sequence stratigraphy in the field and would be suitable before or after attending this course.

Course Content

Introduction

1. Principles: lithostratigraphy (rock), biostratigraphy (faunal abundance, ranges, datums), chronostratigraphy (time-rock)
2. Why chronostratigraphic correlation is better than lithostratigraphic correlation
3. Defining surfaces: sequence boundary, flooding surface, transgressive surface, maximum flooding surface and systems tracts (highstand, transgressive, and lowstand)
4. Hierarchy of sequence stratigraphy: from supersequences to parasequences (to bedset, bed, laminaset, etc.)
5. Sequence stratigraphy from non-marine to deep marine; sandstones, carbonates and shale reservoirs
   Exercise: ACCOMMODATION EXERCISE (Wheeler Diagram)

Supersequences and Sequences: basin and play scale (emphasis on seismic stratigraphy)

1. Basics of seismic interpretation
2. Why seismic reflections follow chronostratigraphic boundaries instead of lithostratigraphy
3. Stratal terminations:
   - Angular truncation, toplap, onlap, downlap: discrimination and prioritization
   - Relationship of surfaces and terminations to systems tracts: identification on seismic:
   Exercise: STRATAL TERMINATIONS (forward seismic model)
4. Mapping seismic sequences (methodology and data preparation)
5. Seismic facies analysis from shallow to deepwater: geometry, amplitude, frequency and continuity of seismic reflections
6. Source to sink correlation: hinterland to abyssal plain seismic examples
7. Exploration play analysis from a sequence stratigraphic perspective
   Exercise: CLINOFORM SEISMIC CORRELATION EXERCISE (Main Pass, Louisiana)

Chronostratigraphy

1. Seismic facies stratigraphic observations with biostratigraphy and other age-constraining information
   Exercise: CHRONOSTRATIGRAPHIC DESIGNATION (Ferron Group, Utah)

Systems Tracts and Parasequences: regional and field scale (emphasis on logs and cores)

1. Reservoir content, continuity, and quality by systems tract
2. Stacking patterns in logs, cores, and outcrops; relationship to key surfaces
   Exercise: PARASEQUENCE LOG CORRELATION (South Louisiana Miocene)
3. Recognition of sequence boundaries, flooding surfaces, and maximum flooding surfaces in cores and logs
4. Log motifs from alluvial to deep marine paleoenvironments; shale continuity by paleoenvironment

and sequence stratigraphy
5. Alluvial channel, channel belt, and valley-fill
6. Lobes, lobe complexes and storeys in deltaic and deepwater distributive systems

Combining Seismic and Log Correlations

1. Data Preparation, analysis and interpretation: seismic displays (wiggle trace vs. variable density displays) and loop-tying horizons
   Exercise: DIFFERIENTIATING STRUCTURE AND STRATIGRAPHY (Orange Basin, South Africa, North Slope Alaska)
2. The art of well ties (synthetic seismograms), and understanding seismic amplitude maps
   Exercise: WELL-TIE EXERCISE, WILLISTON BASIN, NORTH DAKOTA (Bakken Shale)
3. Seismic facies classification: amplitude-dependent and –associated; non-amplitude class
4. Combining A-B/C seismic facies maps with amplitude maps
5. Seismic facies on the workstation: pseudo-fault and pseudo-horizon techniques
   Exercise: MIOCENE SHELF-SLOPE-BASIN CORRELATION AND SEISMIC FACIES MAPPING EXERCISE
   - correlation of well logs from shelf to slope; identification of sequence boundaries and maximum flooding surfaces
   - tie wells to 2D seismic lines with synthetic seismograms; interpret seismic lines and loop tie correlations;
   - identify and map seismic facies; map shelf margins; relate both maps to seismic amplitude map pattern. Pick development well and near-field wildcat locations. Report-out as teams.

Source to Sink Analysis

1. Predictive capability of the sequence stratigraphic approach is enhanced by identification of large, well-integrated drainage systems which often feed large submarine fans
2. Point bar size is a reliable proxy for river catchment size within a climatic regime
3. Role of advanced provenance analytical approaches like Detrital Zircon geothermometry in source to sink reconstructions
   Exercise: *SOURCE TO SINK ANALYSIS, LOWER MIOCENE WATER EXPLORATION*
4. Use empirical scaling relationships for fluvial systems to predict submarine run-out length