TETRA TECH RPS ENERGY | TRAINING

N505: Applications of Time-Lapse Seismic Data to Reservoir Management and Carbon Storage

Instructor(s): David H. Johnston

Format and Duration

Classroom - 2 Days
Virtual - 4 Sessions

Summary

Changes in these reservoir properties that occur during hydrocarbon production are identified and quantified by 4D analysis and used to identify areas of bypassed and undrained pay and to improve geological and engineering models. The purpose of this course is to provide an overview of the fundamentals of 4D seismic technology, starting from its role in field lifecycle planning and then through seismic acquisition, processing, and analysis. However, a primary focus of the course is interpretation and data integration. Case study examples and exercises will be used to demonstrate key concepts and will be drawn upon to demonstrate the range of interpretation methods currently employed by the industry and the diversity of geological settings and production scenarios where 4D is making a difference.

Business Impact: Time-lapse (4D) seismic technology is a key enabler for improved hydrocarbon recovery and more cost-effective field operations. By analyzing differences of multiple seismic surveys acquired over a producing reservoir and by integrating with conventional reservoir monitoring data, 4D seismic data provides valuable insight on dynamic reservoir properties such as fluid saturation, pressure and temperature.

Learning Outcomes

At the end of this course, the student should be able to discuss the fundamental principles of time-lapse 4D seismic monitoring applied to reservoir surveillance of saturation and pressure changes and to carbon storage.

Participants will learn to:

1. Recognize the geological settings, reservoir and fluid property conditions, and production scenarios where 4D monitoring can be effectively applied.
2. Explain the influence of seismic acquisition and processing techniques on the detection of reservoir changes and the methods employed to measure and optimize repeatability.
3. Identify the basic concepts and workflows for time-lapse seismic interpretation and integration with geological and production data.
4. Indicate how 4D seismic data can be used to impact reservoir management and monitor carbon storage.
5. Examine the practical application of 4D seismic data through the examination of various case studies.
6. Discuss recent advances in time-lapse geophysical technology.

Training Method

This is a classroom or virtual classroom course that includes presentations, case studies, exercises and discussion sessions. The presentations will focus on fundamental principles and applications, emphasizing case studies and minimizing mathematics.

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Who Should Attend

4D seismic interpretation is inherently integrative, drawing upon geophysical, geological, and reservoir engineering data and concepts. As a result, this course is appropriate for individuals from all subsurface disciplines. Attendees do not need a theoretical background in either geophysics or engineering. For those who would like to explore 4D seismic technology in more detail, the course book and notes provide additional material and references.

Course Content

The following topics will be addressed in the course:

Session 1

Introduction to 4D seismic technology: A review of reservoir management concepts and the incentives for seismic reservoir monitoring, key 4D concepts, technical issues, success factors, and the role of 4D in field lifecycle planning.

Reservoir engineering fundamentals: Describes how different reservoir depletion mechanisms influence fluid and pressure distributions in hydrocarbon reservoirs and how 4D seismic might be used to monitor them. Hydrocarbon fluid systems and conventional reservoir surveillance tools are also discussed.

Session 2

The petrophysical basis for 4D: Understanding the rock physics link between the geological and engineering properties of a reservoir and the elastic properties is essential to 4D interpretation. This section presents a review of the acoustic properties of fluids and how seismic velocities and density depend on rock properties, stress, temperature, and fluid saturation.

4D seismic modeling and feasibility studies: Where and when can 4D seismic methods be successfully applied? Time lapse seismic modeling is taken from simple spreadsheet approaches to well-log fluid substitution and then to seismic models derived from reservoir flow simulation. Approaches to estimate the business impact of 4D data are also discussed.

Session 3

Seismic acquisition and repeatability: The reliability of 4D seismic data is determined in large part by the similarity of repeated seismic surveys. Measures of repeatability and causes of non-repeatability are discussed along with strategies for acquiring repeatable seismic data in both marine and land settings.

4D seismic processing, data analysis and QC: The objectives of 4D processing are to maximize repeatability, preserve and resolve differences associated with production, and retain true relative

amplitudes. Critical factors in 4D processing are discussed along with cross-equalization and data QC methodologies.

Session 4

Qualitative 4D interpretation and data integration: Basic interpretations workflows and how to interpret simple 4D amplitude differences and time shifts are described using model and case study data. Other case studies are used to help address the following issues: Which time-lapse seismic attributes are most effective for interpretation? How is production data used to validate 4D interpretation? When can map-based or volume-based interpretation methods be used? What are the pitfalls in 4D interpretation?

Quantitative 4D interpretation and model updates: The ability to distinguish saturation from pressure changes is discussed along with quantitative interpretation methods such as 4D elastic inversion. In addition, machine learning techniques are being applied to quantitative 4D analysis. More advanced topics such as the application of time-lapse attenuation, interpretation for compacting reservoirs, and updates of geological and reservoir flow simulation models are discussed in the context of case studies.

Session 5

The future for geophysical monitoring: Enabled in part by permanent monitoring systems and the instrumented oil field, many fields have multiple and sometimes closely-spaced repeat surveys which have advantages for time-lapse interpretation. Recent efforts to apply seismic monitoring to unconventional reservoirs are described and the course concludes with a discussion of 4D seismic success factors.

Exercises Included

This course integrates practical exercises to complement theoretical learning. You will complete exercises on:

- Using reservoir data to estimate saturation changes and sweep efficiency
- Analyzing the results of three rock physics modeling studies to determine the chance of success for 4D data to monitor various production scenarios.
- Using 4D modeling results to assist interpretation of gas expansion and oil-water contact (OWC) movement in 4D amplitude difference data.

These exercises are designed to refine your skills and enhance your ability to tackle complex challenges.