EC014: Petrophysical Tools

Format and Duration
Self-Paced - 10 Hours

Summary

This course builds a working understanding of the common open-hole logging tools and measurements used in the traditional petrophysical analysis; the measurement principles and the main qualitative and quantitative aspects of their analysis are considered for each individual log type. In combination with the Foundation course, the overarching objective is to increase familiarity with the language, concepts, and tools used in the field of petrophysics.

Learning Outcomes

Participants will learn to:

1. Understand the principles and operation of common openhole logging tools used in petrophysical analysis.
2. Explain the fundamentals of gamma-ray logging and its application in identifying lithology variations and shale volume.
3. Understand neutron and sonic logging principles and learn how to calculate porosity from these logs considering lithology and fluid effects.
4. Gain knowledge of density logging concepts including gamma-ray scattering and the density-porosity relationship.
5. Understand the theory behind resistivity logs, including tool types and the impact of invasion on measurements.
6. Develop skills to derive and apply Archie's equations for fluid resistivity, saturation, and water saturation estimation.
7. Recognize formations that deviate from Archie's law and learn alternative methods for estimating water saturation in complex formations.

Training Method

This is a self-paced e-learning course. Learning materials are structured into short sections, each including interactive text and image content, animations, video and audio. An end of course quiz is scored to provide the learner with their learning progress. Approximately 10 - 12 hours learning time.

Who Should Attend

This course is designed for geoscientists and engineers with a foundational knowledge of petrophysics involved in the exploration, evaluation and production of subsurface reservoirs. EC013 (Foundation Petrophysics) is a recommended prerequisite for this course, introducing the principles and concepts that underpin petrophysical analysis.

Course Content

Gamma-Ray Fundamentals

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In this module, you will learn the principles behind the gamma ray tool, which detects natural gamma radiation emitted by rocks to help identify lithology variations. Additionally, you will understand how gamma ray logs are used to quantify shale volume in the subsurface which is is essential for accurately interpreting well data and making informed decisions in exploration and production.

Gamma-Ray Advanced, Spectral GR, and SP

In this module we will explore the fundamentals and applications of the Spontaneous Potential (SP) and Gamma Ray (GR) logs. You will learn the measurement principles behind the SP log and how it helps identify formation properties through natural electrical potentials. We will also cover the spectral GR log, understanding its underlying principles and how it differentiates rock types based on natural radioactivity. Through visual interpretation of SP and GR log patterns downhole, you will gain practical skills to recognise key formation characteristics. Finally, you will integrate this knowledge to effectively apply both logs in formation evaluation and decision-making.

Density Logs

This module will cover key concepts in density logging, including the principles of gamma-ray scattering for density estimation, the definition and significance of the tool's volume of investigation, and the identification of poor-quality density logs. Additionally, learners will develop the skills to derive and apply the density-porosity equation for accurate formation evaluation.

Neutron Logs

In this module, you will learn how high-energy neutrons interact with formation materials, including the scattering and absorption processes that enable porosity estimation. We will explore the volume of investigation of neutron tools, highlighting how deep and wide their measurements extend into the formation. Finally, you will understand the standard displays of neutron logs and how they are effectively used alongside density logs to improve petrophysical interpretation and accurately determine reservoir properties.

Neutron Porosity

In this module, we look at how to calculate porosity from neutron logs. We will explore how variations in lithology, fluid content, including hydrocarbons, and the presence of heavy elements influence the measurements from these logs.

Sonic Logs

In this module, you will gain a clear understanding of how a simple sonic tool is constructed and operates to measure formation properties. The module looks at key applications of the sonic log in formation evaluation and reservoir characterisation. How to calculate porosity using the Wyllie Time Average equation and perform conversions between velocity and slowness is also covered. Additionally, we will examine the effects of gas presence on sonic log responses, enabling you to interpret data accurately in complex reservoir conditions.

Nuclear Magnetic Resonance (NMR) Logs

This module provides an overview of Nuclear Magnetic Resonance (NMR) logging technology, focusing on its fundamental principles and practical applications. Learners will gain an understanding of the underlying physics of the NMR tool, develop skills to interpret typical T2 distributions, and learn how to evaluate NMR logs to assess potential reservoir quality and fluid systems.

Resistivity Logs

In this module, you will gain a comprehensive understanding of resistivity theory and its application in formation evaluation. You will learn to distinguish between the main types of resistivity tools, specifically the laterolog and induction devices, and understand their operational differences. The module will also cover the invasion process and its influence on resistivity log measurements.

Resistivity and Fluids

In this module, you will develop a clear understanding of fluid resistivity and the methods used to measure it. You will learn to derive Archie's equations and gain insight into the significance of the Archie parameters, m and a.

Resistivity and Saturation

This module looks at how to derive Archie's saturation equation and defines the Archie parameter "n," explaining how it quantifies the relationship between fluid saturation and resistivity changes in the rock's pore space. You will explore examples of rocks, such as shaly or clay-rich formations, that do not conform to Archie's law due to their complex mineralogy and conductive minerals. Practical exercises will guide you through using Archie's equation to estimate water saturation from resistivity data accurately. Finally, the module will introduce alternative methods for estimating water saturation without relying solely on resistivity logs.