TETRA TECH RPS ENERGY | TRAINING

EP002: Petrophysics and Formation Evaluation

Format and Duration
Self-Paced - 22 Hours

Summary

A package of Petrophysics courses designed to provide geoscientists and engineers with a thorough foundation in Petrophysics, the application of key Petrophysical Tools, advanced Petrophysical Interpretation skills and the processes of Formation Evaluation.

EC013 - Foundation Petrophysics introduces the fundamental principles and concepts of traditional petrophysical analysis. The objective is to familiarize learners with the dominant language and concepts used in the field of petrophysics. Topics covered include the use of complementary data from mudlogging and core analysis, the influence of rock characteristics on fluid distribution in the subsurface, and an introduction to total and effective porosity concepts.

EC014 - Petrophysical Tools builds a working understanding of the common openhole logging tools and measurements used in 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.

EC042 - Advanced Petrophysical Interpretation and Formation Evaluation focuses on integrating all available data into a comprehensive petrophysical model of the formation. It emphasises the use of well logs for correlation, mapping, and basin history analysis, while also introducing advanced logging tools such as dipmeter and image logs, dielectric logs, and geochemical logs to enhance formation characterisation.

Learning Outcomes

EC013 - Foundation Petrophysics

1. Describe the main concepts underpinning the field of petrophysics and open hole logging.
2. Explain how mudlogging and core analysis complement open-hole logging in petrophysical analysis.
3. Identify the role of downhole pressure measurements in the downhole data suite and their contribution to petrophysical analysis.
4. Interpret the factors that influence fluid distribution in a porous and permeable rock.
5. Describe the processes involved in the formation and evolution of porosity in rocks.
6. Recognise the significance of the concepts of Total and Effective porosity, and their role in the petrophysical analysis.

EC014 - Petrophysical Tools

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.

EC042 - Advanced Petrophysical Interpretation and Formation Evaluation

1. Integrate diverse data sources including well logs, drilling data, and core information into a comprehensive petrophysical model of the formation.
2. Differentiate between continuous petrophysical properties and discrete categorical flags within formation evaluation.
3. Identify and appropriately handle special lithologies such as coal in petrophysical modeling.
4. Utilize well logs for correlation, mapping, and basin history analysis to improve geological interpretations.
5. Interpret log motifs and patterns related to sedimentary facies and understand the relationship between gamma ray readings and grain size.
6. Apply advanced logging tools including dipmeter and image logs, dielectric logs, and geochemical logs to enhance formation characterization.
7. Understand and apply sequence stratigraphy concepts using well log data for subsurface correlation.
8. Calculate geomechanical properties and interpret permeability directly from well log data.
9. Read and interpret density-neutron crossplots and other advanced log crossplots for shale volume and porosity evaluation.
10. Integrate and iterate estimates of shale volume, porosity, and saturation to improve accuracy and consistency in reservoir evaluation.

Training Method

This is a bundle of self-paced e-learning courses, totalling 22 hours learning time. Learning materials are structured into short sections, each including interactive text and image content, animations, video, and audio. End of course quizzes are scored to provide the learner with their learning progress.

Who Should Attend

This course is designed for geoscientists and engineers wanting to develop a foundational knowledge of petrophysics, understand petrophysical tools and to advance their expertise in petrophysical interpretation and formation evaluation.

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Course Content

EC013 - Foundation Petrophysics

Introduction to Petrophysics - In this module, we will explore the basics of petrophysics and delve into open-hole logging and the subsurface borehole environment. We will start with an in-depth look at the hydrocarbon initially in place equation and discuss the use of petrophysical models to describe a formation or reservoir.

Open-Hole Logs - This module provides additional background information on typical open-hole logs and how they can be influenced by rock properties.

Mud Logging and Core - This module will focus on some important complementary measurements and observations to downhole logs, as well as the factors supporting the migration of hydrocarbons into the reservoir. Mudlogging forms a critical part of drilling an exploration well, while core data from routine and special core analysis provide important constraints on our interpretation of downhole logs. Wettability and capillary pressure control the distribution of fluids in the reservoir and the process by which hydrocarbon accumulates, while downhole pressure measurements complement the integration of core and log data in providing a complete petrophysical picture.

Rock Properties - This module will explore the petrophysical model and how rock characteristics influence the distribution of fluids in the subsurface.

Porosity Fundamentals - This module will start by defining porosity and will discuss two alternative models (Total and Effective) that are used in petrophysics. These alternatives arise because of the strong interaction of water with many of the solid minerals that make up sedimentary rocks, and we will deviate slightly to discuss the reasons and consequences of these interactions. It will then move on to discuss how porosity is initially formed and how it subsequently evolves as sediments are buried in the subsurface. The final part of this module will look at how porosity can be measured on core plugs (and other samples) and the generalities of using logs to estimate it in situ.

EC014 - Petrophysical Tools

Gamma-Ray Fundamentals - 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 & 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.

EC042 - Advanced Petrophysical Interpretation and Formation Evaluation

The Petrophysical Model: Lithology and Special Minerals - In this module, you will explore the concept of the petrophysical model, including its typical outputs and their applications in reservoir evaluation. You will learn the distinction between continuous properties like porosity and discrete flags that categorise features at specific depths. The module also covers identification and treatment of special lithologies, such as coal, within the model. Additionally, the module considers how combining density and neutron log curves provides a powerful qualitative tool for lithology interpretation.

Density Neutron Combination Advanced - This module covers how to read a typical density-neutron crossplot, enabling you to analyse the relationship between formation density and neutron porosity logs. You will learn to interpret shale volume and porosity directly from the crossplot, helping to distinguish between shale and reservoir zones. Additionally, the module introduces alternate interpretive crossplots using different log data, expanding your ability to evaluate formation properties under varying conditions and data availability.

Formation Evaluation: Integration and Averaging - This module focuses on three key learning points essential for reservoir evaluation. First, it emphasizes the importance of integrating and iterating estimates of shale volume, porosity, and saturation to improve accuracy and consistency in petrophysical analysis. Second, it introduces the concepts of NET and PAY zones as defined in this course, highlighting their relationship to interval average properties and acknowledging that definitions may vary among operators and professionals. Finally, the module provides a general understanding of how continuous permeability curves are generated and their role in modeling reservoir flow characteristics. Together, these topics lay a foundation for effective reservoir characterisation and decision-making.

Log Motifs and Patterns - This module looks at key concepts in well log interpretation for sedimentary facies analysis. It looks at log motifs and patterns characteristic of different sedimentary environments and the relationship between gamma ray (GR) readings and grain size, including their limitations. The module also covers how to integrate additional data and measurements to enhance geological interpretations from well logs. Finally, methods for correlating well logs to improve subsurface geological understanding and decision-making are reviewed.

Depositional Environments, Dipmeter/Image Logs & Sequence Stratigraphy - This module considers how to interpret geological signatures and log shapes, identify common challenges and pitfalls in correlating logs between wells, and understand the principles behind electrical imaging tools. Additionally, the module will introduce key concepts of sequence stratigraphy as applied to well log data, enhancing

your ability to analyse and correlate subsurface geological features effectively.

Geomechanics and Permeability - This module considers how to calculate key geomechanical parameters using well log data, enabling a better understanding of subsurface rock behaviour under stress. Also covered is the interpretation of permeability directly from downhole logs, in addition to the traditional Nuclear Magnetic Resonance (NMR) models looked at in previous modules.

Dielectric and Geochemical Logs - This module looks at the measurement principles behind dielectric logs and how they can be applied to accurately estimate water saturation in various geological environments. Fundamental concepts of geochemical logging and its diverse applications in reservoir characterisation, formation evaluation, and environmental studies are also covered.