EP002: Petrophysics and Formation Evaluation for Geoscientists

Format and Duration
Self-Paced - 20 Hours

Summary

A package of Petrophysics courses designed to provide geoscientists with a thorough foundation in Petrophysics, the application of key Petrophysical Tools 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.

EC015 - Petrophysical Tools for Geoscience builds a working understanding of the common open-hole 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. This geoscience stream also explores how open-hole logs can be used to interpret facies, depositional environment, and sequence stratigraphy. It concludes by introducing dipmeter and borehole image logs for geological interpretation. 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 and their geological interpretation.

EC018 - Formation Evaluation provides detail on the integration of the various open-hole logs into a robust qualitative and quantitative analysis of the subsurface. In combination with the Foundation and 'Tools' courses, the overarching objective is to increase familiarity with the language, concepts, and tools used in the field of petrophysics and their interpretation.

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.

EC015 - Petrophysical Tools for Geoscience

1. Establish the measurement principles and integration of data obtained from open-hole logging, mudlogging, and core analysis.
2. Illustrate the principles and measurements of traditional open-hole logs; Gamma Ray, Spontaneous

Potential, Bulk Density, Neutron, Sonic, Nuclear Magnetic Resonance, and Resistivity logs.
3. Determine shale volume, porosity, and water saturation from traditional open-hole logs.
4. Examine how open-hole logs can be used to interpret sedimentary facies, depositional environment, and sequence stratigraphy.
5. Interpret the measurement principles and geological interpretation of dipmeter and borehole image logs.

EC018 - Formation Evaluation

1. Describe how petrophysical logs and other data are integrated to complete a robust analysis through formation evaluation.
2. Understand the difference between continuous and discreet properties and how these can be described in the context of the 'Petrophysical Model'.
3. Appreciate how special lithologies such as coal are identified and their importance to the Petrophysical Model.
4. Learn about the density neutron combination and how to read a typical density neutron cross-plot.
5. Consider alternate cross-plots using different log data.
6. Consider the importance of integration and iteration of estimates of shale volume, porosity, and saturation and how these can be used be help define 'NET' and 'PAY'.

Training Method

This is a bundle of self-paced e-learning courses, totalling ~20 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 to provide an understanding of the petrophysical tools used in the geological interpretation of open-hole log data and Formation Evaluation

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.

EC015 - Petrophysical Tools for Geoscience

Gamma-Ray Fundamentals - In this module, we will cover the use of natural radioactivity logging tools for the determination of lithology and mineralogy: gamma-ray. This module starts with the principles, goes through practical issues, like units and vertical resolution, and ends up describing how the tools can be used to estimate how much clay is in the formation and even the interpretation of depositional facies and trends using logs motifs.

Gamma-Ray Advanced, Spectral GR, and SP - This module will cover the use of 'Spontaneous Potential' and Spectral Gamma Ray tools. We start with their measurement principles and practical issues before integrating the SP and GR logs to aid in understanding lithology and estimates of shale volume in the subsurface.

Density Logs - This measurement responds to average porosity within the volume of investigation and is indifferent to its form: e.g., intergranular, fracture, or vuggy. It also depends on what fluid is in the pore space: water, or water and hydrocarbon.

Neutron Logs - This measurement responds to average porosity within the volume of investigation and is indifferent to its form: e.g., intergranular, fracture, or vuggy. Having said that, neutron porosity also responds strongly to clay and the presence of heavy elements. It also depends on what fluid is in the pore space: water, or water and hydrocarbon.

Special Lithologies, Minerals, and Fluids - In this module, we consider how density and neutron logs can be integrated to provide qualitative lithology indicators. We also discuss how clay and the presence of

heavy elements impact these logs.

Sonic Logs - The sonic log is a continuous record of sonic velocity along the wellbore. This has a number of applications besides estimating porosity, but it is the latter that is of interest here. There is no universal relationship between velocity and porosity, as generally the fabric of the rock and the nature of the fluids in the pore space can both have a strong influence. Nevertheless, some equations linking porosity and sonic slowness (the reciprocal of velocity) have been proposed that do sometimes give reliable estimates.

Nuclear Magnetic Resonance (NMR) Logs - In this module, we look at the basic principles underlying the tool and try to understand how to interpret typical T2 distributions. We explore how different fluid systems affect NMR responses and we interpret NMR logs to define their potential reservoir quality.

Resistivity Logs - In this module, we will introduce you to the key principles associated with resistivity measurements and how rocks and fluids in the subsurface interact with electrical currents. We will also introduce the main types of resistivity tools and how their measurements are presented for analysis.

Resistivity & Fluids - In this module, we deepen our understanding of how fluids interact with electrical currents. We then begin to explore Archie's famous equation for calculating water saturation, and how the Archie parameters a and m are related to pore morphology, and how they can be estimated.

Resistivity & Saturation - In this module, we continue to explore Archie's equation and its parameters. We then consider resistivity measurements in non-Archie rocks and other ways of estimating water saturation.

Log Motifs & Patterns - This module looks at log motifs and patterns and how these can be used in a variety of interpretative techniques. It starts with how log motifs and patterns are influenced by changes in sedimentology and depositional environments, with emphasis on understanding the different logging tool responses to sedimentological physical and chemical properties.

Depositional Environments, Sequence Stratigraphy & Dipmeter/Image Logs

Log correlation between wells, the development of cross sections, and the construction of fence diagrams are introduced, together with Dipmeters and Imaging logs as additional key logs for describing subsurface geological changes. The module concludes with the application of log motifs and log responses to the principles of Sequence Stratigraphy.

EC018 - Formation Evaluation

The Petrophysical Model: Lithology and Special Minerals - In this module we introduce the concept of data integration and the generation of a 'Petrophysical Model'. We look at how the identification of special minerals such as coal and halite can help in the understanding of a basin and how these are handled within the context of the model. Finally the learner will be introduced to the density neutron combination and appreciate how this is a powerful tool to use during a petrophysical formation evaluation project.

Density-Neutron Combination Advanced - In this module we deepen our understanding of how the density and neutron logs can be used in combination to estimate shale volume and other properties for the petrophysical model. We examine how to read a typical density-neutron cross-plot and how to interpret shale volume and porosity from them.

Formation Evaluation: Integration & Averaging - In this module we will understand the importance of integrating all log data in deriving the petrophysical model and reflect on the interaction between parameters and a need for an iterative process. We will then consider the concepts of NET, PAY and averaging in petrophysical analysis. Finally we will explore the potential for a downhole measurement of permeability.