N083: Petrophysics and Formation Evaluation: Principles and Practice

Tutor(s): Mike Lovell or David Eickhoff and Jeff Kelley

5 Days	Competence Level: Basic Application
Classroom Course	

Summary

The course examines the fundamental concepts, vocabulary, and techniques used in petrophysics, exploring the physical properties of rock formations and their pore fluids, and demonstrating how these properties are estimated both in the laboratory and the wellbore. It focuses on the key petrophysical ideas that underpin petrophysical analysis and how downhole logs and core measurements enable quantitative estimates of hydrocarbons in place.

Learning Outcomes

Participants will learn to:

1. Illustrate the geophysical parameters, petrophysical core analysis, capillary pressure, and fluid distribution data required for reservoir evaluation.
2. Appraise the nature of the borehole environment.
3. Illustrate how data from the main logging tools is acquired and undertake petrophysical analysis using these data.
4. Establish lithology and calculate porosity from open hole wireline log and core data.
5. Calculate water saturation from open hole wireline log and core data.
6. Establish the key petrophysical parameters from wireline logs.
7. Understand the principles of fluid sampling and borehole pressure measurements as a complementary approach to petrophysical analysis.
8. Define gross, net and pay, and understand how these petrophysical concepts may be applied.
9. Demonstrate how shale content in a clastic reservoir can be estimated and consider the effects of shale on the petrophysical analysis.
10. Illustrate the principle petrophysical differences between conventional reservoirs and unconventional shale reservoirs.

Duration and Training Method

A five-day classroom course comprised of lectures interspersed with practical exercises. The only equipment needed is a scientific calculator and graph paper.

Who Should Attend

Newly graduated scientists and petrophysicists are the main target audience, together with geologists, geophysicists and engineers who communicate with petrophysicists in regional evaluations, prospect generation and development studies.

Prerequisites and Linking Courses

There are no formal prerequisites for this class, due to its introductory nature. Some knowledge of petrophysics maybe advantageous, but not essential.

There are a number of supplimentary and/or follow on classes directly related to the learning from N083. For more on Well Logs, there is N003 (Geological Interpretation of Well Logs) or N121 (Modern Petrophysical Well Log Interpretation). For more detail on working with core, N095 (Integrating Core and Log Data for Reservoir Characterisation) deals with core from drilling to interpretation.

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For increased knowledge of Petrophysics, N030 (Rocks and Fluids: Practical Petrophysics, Isle of Wight UK), is a direct follow on for this class and assumes knowledge of this class before attendance. Follow on classes at Skilled Application Level include N054 (Petrophysics in Reservoir Evaluation), N187 (Low Resistivity, Low Contrast Pay), N267 (Petrophysics for Shale Gas Reservoirs) and N105 (Carbonate Petrophysics). All of these classes do assume a knowledge of Petrophysics, that this class can provide.

Course Content

This petrophysics course focuses on the main petrophysical attributes of porosity and saturation and how these parameters can be estimated in the laboratory from core, and downhole in the reservoir from logs. Topics covered include: the borehole environment, petrophysical properties, geophysical parameters, core analysis and special core analysis, wettability, capillary pressure and fluid distribution, and log measurements and interpretation. Particular emphasis is given to explaining principles underpinning the different measurements and the limitations of petrophysical data. Each lecture is typically associated with a short practical exercise to demonstrate specific points and to enable the student to apply their knowledge and develop their skills.

The main emphasis of the course is on evaluating the hydrocarbons in place (porosity and saturation) in conventional reservoirs; permeability and the concepts of gross, net and pay are also introduced and discussed. In addition the course considers the important effects of wettability and capillary pressure on the fluid distribution in the reservoir.

The course also briefly introduces the petrophysical analysis of unconventional hydrocarbon reservoirs and considers the estimation of the adsorbed and free gas components, and the role of organic content and kerogen, introducing the concepts of Langmuir isotherms, and Langmuir pressure and volume.

Both core analysis and log analysis are considered throughout this course. The integration of these core and log data is key to estimating the hydrocarbons in place in both conventional and unconventional hydrocarbon reservoirs.

Day 1

Introduction to N083
Petrophysical Properties: definitions and controls

- Exercise: porosity discussion

Geophysical Parameters

- Exercise: porosity from density and sonic measurements
- Exercise: Archie's equation: porosity and saturation from resistivity measurements

Conventional Core Analysis: porosity, saturation and permeability

- Exercise: porosity-permeability measurement

Day 2

Special Core Analysis (SCAL): Wettability, Capillary Pressure and Relative Permeability

- Exercise: capillary pressure curves

SCAL: Resistivity Measurements

- Exercise: Archie a, m and n parameters from core

SCAL: Overburden Effects

- Exercise: core porosity measurement

Borehole Environment and Downhole Logging Principles

Day 3

Downhole Logs and Log Interpretation Techniques

Gamma Ray and Spontaneous Potential Logs

- Exercise: bed boundaries, lithology and permeability indicators

Density, Neutron, Pe, Sonic and NMR Logs

- Exercise: lithology and porosity from logs

Resistivity Logs

- Exercise: clean formations – estimating Rw and fluid salinity

Imaging Logs

Day 4

Fluid distribution in the Reservoir

- Exercise: pressure measurements and fluid distribution

Petrophysical evaluation of a conventional reservoir

- Exercise: lithology, porosity and saturation

Gross, Net & Pay: definitions and applications

- Exercise: estimating net and pay

Introduction to petrophysical analysis of shaly sands and effective porosity

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Day 5

Shale Reservoirs

- Shale Reservoirs Introduction
- Petrophysical models & TOC
- Free gas: Porosity & Saturation
- Permeability
- Geomechanics

Concluding discussions

Summary