TETRA TECH RPS ENERGY | TRAINING

N030: Rocks and Fluids: Understanding Petrophysics through Outcrop Studies *(Isle of Wight, UK)*

Instructor(s): Martin Kennedy and Mike Lovell

Format and Duration

Field - 5 Days
Low Physical Demand

Summary

The course is a field-based introduction to the fundamentals of petrophysics and in particular the way reservoir fluids interact with reservoir rocks. The emphasis is on understanding the fundamentals of petrophysics rather than on using the mostly empirical equations that are used in everyday work. Consequently, most of the course uses simple descriptive models to explain what controls petrophysical properties, the distribution of fluids in reservoirs and the scale dependence of these properties.This course deliberately changes the emphasis from simply calculating the value of a petrophysical property, to considering how the value of a property depends on the scale under consideration and how precisely it is defined (which can vary between individuals and operators). At the end of the course, participants should appreciate what a particular petrophysical property refers to and the complications that can result from particular geological environments. They should be well equipped to appreciate exactly what a petrophysical model is describing and be able to communicate with petrophysicists, geoscientists, and engineers what they need from it.

Business Impact: Petrophysical properties are too often taken for granted, although a closer look shows they are not quite as simple as supposed. This course is designed to give participants a deeper understanding of the principal petrophysical properties that can be applied to regional evaluations, prospect generation, and appraisal and development studies.

Learning Outcomes

Participants will learn to:

1. Define the basic petrophysical properties of Porosity, Water Saturation, Shale Volume and Permeability. Be aware of alternative definitions and understand their significance when describing the components of a reservoir.
2. Understand how these properties can be measured or estimated and the limitations and inherent uncertainty of the different methods.
3. Describe the interactions between water and the minerals that make up sedimentary rocks. Understand how these interactions control the distribution of fluids in the sub-surface and complicate the definitions of the basic properties.
4. Explain the basic principles used by logging tools and how these determine their volumes of investigation and what precisely they measure. Understand the significance of this for the estimation of petrophysical properties using logs.
5. Appreciate how core measurements complement downhole measurements to provide an integrated petrophysical interpretation of the reservoir.
6. Realise the importance of scale and heterogeneity in petrophysical interpretation.

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Training Method

A field course on the Isle of Wight, which combines classroom work and exercises in the field at a ratio of about 30:70. Weather permitting, classroom work is limited to introducing the material that is essential to the fieldwork, discussion of completed field based exercises, and wrap-ups.

Calculations can all be performed using a scientific calculator (or smart phone) and graph paper, and do not require any mathematical techniques beyond simple arithmetic.

Physical Demand

The physical demands for this course are LOW according to the Tetra Tech RPS field course grading system; the course requires basic fitness levels. The majority of stops are beach side locations. The longest walk is just over 2 km (1.25 miles), but is along a sandy beach section. All transport during the class is by coach.

Who Should Attend

This course is designed for the end users of petrophysical models, although log analysts and petrophysicists will also benefit from attending. The course is suited to all geologists, geophysicists, and engineers who communicate with petrophysicists and use petrophysical properties in their workflows, as well as managers who need to acquire a broader understanding of petrophysical data.

Course Content

The heart of the course is a series of structured group exercises carried out on carefully selected outcrops in the field. These exercises are specifically designed to emphasise the problems that arise when dealing with real rocks with pores that are at least partially saturated with water.

The course covers the fundamentals of petrophysical properties, the interaction of fluids and minerals from the microscopic to the reservoir scale, and how these are quantified. Specifically, it covers definitions, controls, measurement and scale dependence of the basic properties such as porosity, permeability and saturation as well as the more artificial quantities that have been developed to rank and categorise reservoirs (e.g. net thickness and heterogeneity).

Some of the key topics discussed throughout the week include:

Introduction to petrophysics

Petrophysical processes and properties

- Definition of petrophysical properties and controls
- Porosity, permeability and saturation; Gross, net and pay

In situ petrophysical measurements (logs)

- Measurement principles, advantages and limitations of logging measurements
- Interpretation principles using logs and core; porosity and saturation estimation in real rocks

Fluid distribution

- Wettability, capillary pressure, fluid contacts, and free water level
- Measurement, scale dependence, and heterogeneity
- Fundamentals of petrophysical properties and the interaction of fluids and minerals from the microscopic to the reservoir scale

Because the course revolves around fieldwork on coastal outcrops, the detailed timetable is highly dependent on tides; the following is intended as a guide only:

Day 0

Travel to the Isle of Wight. That evening there is a short introduction, safety briefing, and group dinner.

Day 1

Technical overview of how different petrophysical properties are defined and their controls at the pore scale are discussed. During the day we make an excursion to examine the sandstones that make up Knock Cliff, a short walk from the hotel. We discuss their suitability as reservoir rocks by examining them at small scale and then consider lateral and vertical variability at large scale. This is also a good opportunity to revise field skills. Conditions permitting, the day finishes with a drive to a viewpoint from which the geology of the island can be appreciated.

Day 2

The field component is spent at Whitecliff Bay on the NE side of the island. The outcrop consists of several hundred metres of alternating sand and shale beds with nearly vertical dips. This allows well scale bedding to be studied by simply walking along the beach. The exercise consists of producing a detailed lithological log of the section. Depending on tides and weather, classroom work comprises of an introduction to downhole log measurements, their depth of investigation and resolution, and an introduction to the effects of shale/mudstone on logs and log analysis.

Day 3

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We look in the field at (i) how we estimate effective porosity in shaly sandstones and (ii) at reservoir scale issues. We visit some fluvial sandstones on the south coast of the island to look at the distribution of clay/shale and we examine the geometry of the sand bodies and their interconnections. We then attempt to predict what their average properties are at the reservoir scale and how hydrocarbons would distribute themselves in such a system. The supporting classroom work introduces capillary pressure and shows how it controls fluid distribution.

Day 4

This day focuses on downhole well logs. We return to Whitecliff Bay to consider how well logs would respond to the different rock types identified on day 2. We also look at the effects of dipping beds and vuggy limestones on core measurements and log responses. Classroom work completes our study of core and downhole logs.

Day 5

This day is spent interpreting a fractured chalk outcrop near the western tip of the island, before returning to the hotel and having a wrap up session, before participants are free to leave.