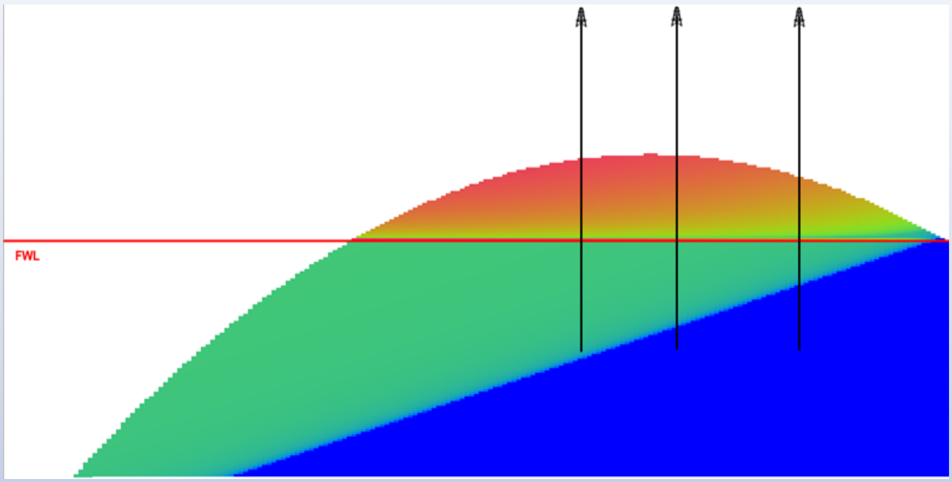
Short Course 2.30
Customised Petrophysics

Incorporating Best Practices in Petrophysical Inputs for Static & Dynamic Modelling with Capillary Pressure & Saturation-Height



presented by

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&
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RESERVOIR PROPERTIES AND IMPLEMENTATION IN MODELS

The course describes best practice approaches to use Routine (RCA) and Special Core Analyses (SCAL) to derive reservoir properties and fluid saturations. How to implement these properties in static & dynamic modelling will also be addressed.

COURSE OBJECTIVES

Proper Reservoir Description is critical to understanding our assets , quantifying their value and how best to produce them. This course provides a guide to deciding which core measurements to acquire, how to QC the data, and how to interpret those measurements to yield formulae for use in reservoir property definition.

Proper reservoir description provides the foundation for additional investigations, that will be detailed in the latter part of this course. These approaches provide a significant opportunity for participants to improve their understanding of their own Fields and how their hydrocarbon systems may actually be working.

AUDIENCE

Geologists, Geophysicists, Reservoir & Production Engineers and others involved in formation evaluation and/or reservoir modelling are the target audience. People who work with selection and application of core test data for analyses and/or use hydrocarbon saturations in their models will find this course of considerable benefit.

VALUE PROPOSITION

Participants will save hours to days of time in experiment selection, interpretation, reservoir property modelling and implementation at the very least. Likely they will also get better definition of in-place volumes and reserves ranges potentially resulting in millions to billions of dollars in increased project value.

COURSE PROGRAMME

The following programme outline describes an intensive 4 day course covering theory and hands-on interpretation skills. The course will cover the subject by alternating between lecturing and exercises with real data from clastic and carbonate oil and gas reservoirs, worldwide. A training manual will be provided to facilitate learning and use of the techniques. The exercises are intended to reinforce the methodologies discussed. MS-Excel will be used for the exercises rather so that the participants understand which algorithms they should use and why.

COURSE SYNPOSIS

Phase 1 – Overview

Introduction & Definitions: Quality controlled logs, net, porosity, permeability, Sw, Sor, Krh, Krw, saturation-height, fluids, contacts, uncertainty, summations, documentation, flow diagrams.

Phase 2 – Core Data

Routine and Special Core Analysis: Value of core data for in-place and reserves calcs. Inputs for static and dynamic models. Test methods & RCA/SCAL workflow.

Coring and Core Damage: Coring methods, sidewall cores, core damage & wettability alteration.

Sample Preparation: Cleaning & drying methods & effects on properties. Core conditioning for total porosity. Conditioning for wettability restoration.

Fluid Saturations: Dean-Stark calculations & corrections. QC diagnostics

Porosity: Total & "effective" porosity. Helium grain volume, helium pore volume & bulk volume methods. Porosity error sources and QC diagnostics.

Permeability: Gas & Klinkenberg permeability. Methods & analysis. Permeability error sources & QC diagnostics.

Porosity and Permeability at Stress: Effective stress concepts and stress calculations for labs. Compaction factors. Absolute-effective permeability & stress corrections to reservoir conditions. QC diagnostics.

Preparation for SCAL: Sample selection, provenance and type, CT scanning, selection criteria for static and dynamic SCAL tests. IFT measurements.

Wettability: Wettability restoration and conditioning protocols. Test methods pros and cons. Wettability tests QC.

Electrical Properties: Formation factor & resistivity index measurements. Archie parameters. Excess conductivity: clays and Waxman-Smits parameters, wet chemistry & multiple salinity CEC and Qv methods and QC diagnostics.

Relative Permeability: In simulation models, test states and wettability. Test methods and analyses: steady state, unsteady state, centrifuge; Why analytical solutions are invalid! How to get reliable and representative rel. perm. data.

Capillary Pressure: Introduction to principal methods: MICP, Porous Plate, Centrifuge etc. Relationship with porosity and permeability (pore throat size).

Overview of Digital Core Analysis: methods. Micro-CT scanning, determination of properties from pore network maps. Comparison with "real" core data.

Other measurements: NMR, SEM & XRD, geomechanics, acoustic properties.

Phase 3 – Dealing With Uncertainty

In Measurements: Properties from interpretation of measurements. So what uncertainties are in measurements?

In Derived Properties: How to derive uncertainties in porosity, permeability, fluid densities, clay conductivity, log-derived Sw and Saturation-Height. What values are typical? And what about the equation/model uncertainty?

Data averaging: And when data are averaged, what happens to uncertainty?

Phase 4 – Workflows & Representative Data

Workflows: How to put the puzzle together. When to check data is valid? Who is responsible? Resolution matching data. Vertical/Horizontal matching workflows.

Data Sources: Cap. Pressures, logs, analogues.

Representative Data: Testing & correcting for representative sampling.

Data Collation and Formatting: Which data to extract from core reports, data formats to facilitate workflows.

Phase 5 – Capillary Pressure for Saturation-Height Modelling

Mercury Injection: Low & high pressure systems, primary drainage, saturation determination & calculations, understanding lab data & reports, quality control issues & diagnostics, pore throat size distributions, spontaneous Imbibition.

Centrifuge: Equipment & set up, fluid selection, test procedures, capillary pressure calculation & selection, understanding lab data & reports, QC issues & diagnostics, forced imbibition tests.

Porous Plate: Equipment & set up, fluid selection, test procedures, capillary pressure selection, saturation determination & calculation, understanding lab data & reports, QC issues & diagnostics, imbibition tests.

Corrections & Conversions: Closure or conformance correction (MICP), stress correction, clay-bound water correction (mercury injection). Converting fluid systems, pressure to height conversion.

Baseline Datasets: Putting all the measurements together.

Phase 6 – Saturation-Height Concepts

Model Input Data Quality Control: Comparing different measurement types, QC of baseline datasets.

Irreducible Sw: Sw vs. porosity, Sw vs. permeability, uncertainty quantification.

Saturation-Height Model: Which models to choose & why.

Saturation-Height Model Creation & Quality Control: Weighting factors to ensure representative, model fitting, individual curve correlation method, all data simultaneously using Excel Solver, problems with parameter selection, recommended initial parameters for the Solver, sub-groupings, uncertainty quantification, checking for "Good Behaviour".

Imbibition Modelling: Column previously at irreducible Sw, column previously in transition zone and/or Irreducible Sw, examples of imbibition modelling, volumetric Impact of Imbibition vs Drainage. IFD model independent of drainage model.

Phase 7 – Saturation-Height Reconciliation with Logs

Reconciliation with Log Data: The importance of perm., reconciliation with log evaluation, what is an acceptable match, example matches & comments, SHF from logs. Using SHF to extract additional information.

Additional Uses: Identifying reservoir & seals, current and original FWLs, thin beds, dodgy or missing resistivity logs, pore throat size distributions, permeability prediction.

Special Situations: Perched Contacts, Dual (or More) Porosity Systems, Oil or Mixed-Wet Systems, Gas-Oil-Water Systems.

Phase 8 – Properties & Saturation-Height Implementation

In Petrophysics: Practical Implementation, the Effect of Scale on Saturation-Height, Porosity-to-Permeability Transforms, water saturation averaging.

Reservoir Properties in Static Modelling: Approach, upscaling, propagated geologically? Do Sws match logs? Other independent checks and QC.

Reservoir Properties in Dynamic Modelling: Approach, saturation-height look-up tables. Rel. perms. using Corey exponents and de-normalisation. Independent checks and QC, kH comparisons with flow data. Two phase perms, what is a valid match? Drainage or Imbibition? How to initialize in latter case? Is reservoir at static equilibrium initially? If not, what is happening and how to model?

Property Checks: Representativeness. Check models match upscaled logs at wells. Do averages by unit /Formation match well averages – if not , why?

Volumetric Checks: Are volumes by unit in static & dynamic models similar to well averages with the same bulk rock volumes. If not, why?

Documentation: Work should be described in sufficient detail to enable it to be reproduced by someone skilled in the areas of expertise required.

Stephen Adams

Steve has been a Petrophysicist since 1987. Following training and an initial 7 years with Shell, he has worked as an independent consultant with clients in Australasia, Asia, the Middle East and elsewhere. He has been providing petrophysically focussed training courses since 2001.

Steve has 19 papers published and is well known in the industry as a Specialist in Saturation-Height Modelling. His 2016 book "Saturation-Height Modelling for Reservoir Description" has been well received by the Industry.

During his career, Steve has had a great deal of exposure to some challenging problems involving capillary pressure in different lithologies. Much of this work has been "leading edge" in that similar cases have not been described in the literature previously. Some of these examples will be referred to in the training where the work has been published or permission has been otherwise received.

Colin McPhee

Colin has over 40 years' experience in petrophysics, core analysis, geomechanics, formation damage and sand management. Before becoming a Director of Mercat Energy Colin was Global Head of Rock Properties with LR Senergy. He previously worked for Helix-RDS, Edinburgh Petroleum Services, Heriot Watt University and Wimpey Laboratories. Colin has worked on over 500 major integrated petrophysics and geomechanics projects in Asia, Middle East, Europe, Africa and elsewhere.

Colin is peer-recognised as an industry expert on rock properties and core analysis testing and interpretation for input to static and dynamic reservoir models .

He is the author or co-author of over 20 technical papers and co-author of the "Core Analysis: Best Practice" textbook.

He has presented over 100 in-house and public training courses on core analysis to about 1500 industry professionals throughout the world.

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