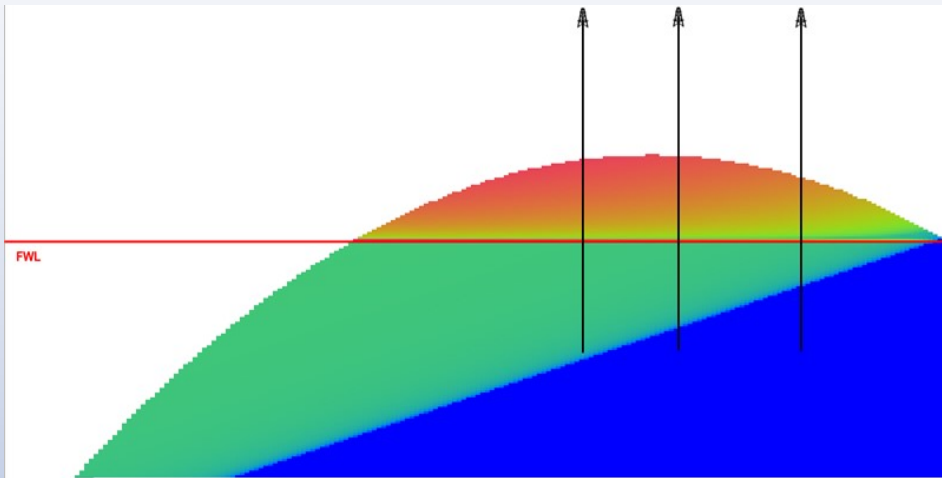


Capillary Pressure & Saturation-Height



presented by

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WATER SATURATION IN THE RESERVOIR & IN STATIC & DYNAMIC MODELS

Water saturations (S_w) in oil & gas reservoirs are controlled by capillary pressure and related forces in most cases. Wireline logs can approximate what these water saturations may be, but do not actually measure S_w directly. Hence, when it comes to building reservoir models and estimating volumes in-place, capillary pressure based saturation-height models are used to describe S_w .

COURSE OBJECTIVES

Proper understanding of the processes controlling hydrocarbon distribution in reservoir rocks is vital; the reasons for varying oil-water contacts in reservoirs with the same Free Water Level are one example. Others include understanding what fluids are present, their volumes, and locations, how hydrocarbons were emplaced and how best to recover them.

As saturation modelling involves careful planning and quality control of both data acquisition & interpretation, understanding how samples are prepared, characterised & screened prior to testing are addressed. The advantages and disadvantages of capillary pressure tests are clearly explained and the main quality control issues are highlighted.

This course will progress to a step-by-step guide to deciding which capillary pressure measurements to acquire, how to rigorously QC the data, and how to interpret those measurements to yield formulae for use in estimating S_w independently from wireline log derived water saturations.

Having these formulae for reservoir description provides the foundation for additional investigations that can be carried out using the combination of saturation-height functions, log evaluations, for-

mation pressures and geological configuration. Suitable investigations will be detailed in the latter part of this course, and 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, saturation-height 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 5 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, world-wide. 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 than dedicated Petrophysics software so that the participants understand which algorithms they should use and why. Attendees will be encouraged to take their spreadsheets with them to use in the future.

COURSE SYNOPSIS

Introduction - Capillarity in Rocks: lithology, total and effective porosity concepts, clay bound water and Q_v , permeability, capillary pressure basic forces, relative permeability, fluid contacts, drainage and imbibition, basic formulae.

Saturation-height Planning: Sample preparation and selection, principal test methods, outline of QC concepts, saturation-height function selection, workflow.

Phase 1 – Experiment & Sample Selection

Sample Screening, Preparation and Selection: Core samples, wettability & wettability conditioning, sample screening, test fluid preparation and characterization, sample preparation, wettability tests, overburden stress estimation.

Sample Characterisation and Base Measurements: Porosity measurement, brine saturation porosity, gas permeability & Klinkenberg correction, Q_v and CEC measurement methods and quality control, SEM, XRD.

Porosity and Permeability at Stress: Porosity data sources, porosity stress compaction factor calculation, permeability data sources, permeability stress correction factor calculation.

Phase 2 – Measurement Interpretation and Quality Control

Mercury Injection: Low pressure & high pressure systems, procedures for primary drainage, saturation determination & calculations, pros and cons, understanding lab data & reports, quality control issues and diagnostics, system and conformance corrections, pore throat size distribution calculations, spontaneous Imbibition.

Centrifuge: Equipment & set up, fluid selection, test procedures, capillary pressure calculation & selection, saturation calculations, understanding lab data & reports, pros and cons, quality control issues & diagnostics, imbibition tests, forced imbibition.

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

Representative Data: Testing for representative sampling, correcting for unrepresentative sampling, determining weighting factors for model fitting.

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

Corrections & Conversions: Closure or conformance (Mercury Injection), clay-bound water (Mercury Injection), stress, impact of corrections, converting fluid systems, pressure to height conversion, combined fluid and pressure to height conversion.

Phase 3 – Saturation-Height Model building

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

Irreducible Water Saturation: S_w vs. porosity, S_w vs. permeability, uncertainty quantification.

Saturation-Height Model Creation & Quality Control: Which models to choose & why, 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 S_w , column previously in transition zone and/or Irreducible S_w , examples of imbibition modelling, volumetric Impact of Imbibition vs Drainage.

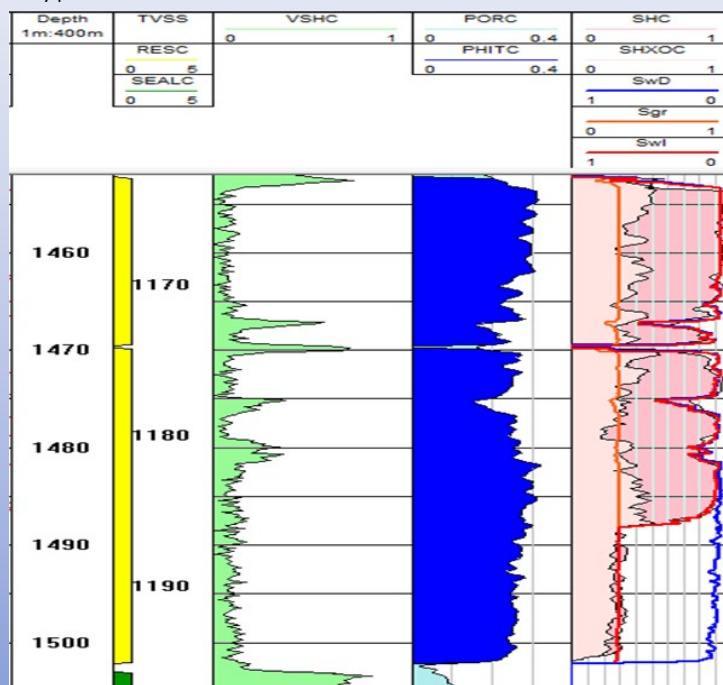
Phase 4 – Saturation-Height Model Implementation & Reconciliation

Reconciliation with Log Data: The importance of permeability, reconciliation with log evaluation, what is an acceptable match, example matches & comments, saturation-height functions from logs.

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

Implementation in Reservoir Modelling: Practical Implementation, the Effect of Scale on Saturation-Height, Porosity-to-Permeability Transforms, water saturation averaging, implementation in Petrophysical Modelling, implementation in Static Models, implementation in Dynamic Models.

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



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.

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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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