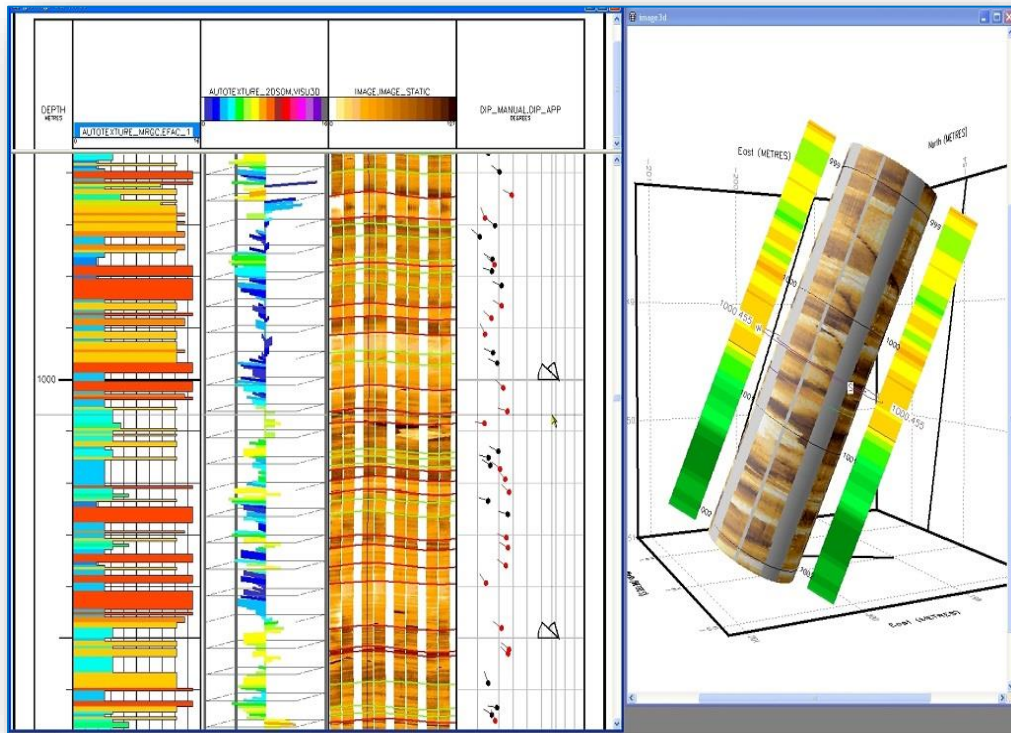




DE146

Modern Petrophysical Well Log Interpretation

Course Introduction:

This five-day course presents the principles and methods associated with the petrophysical interpretation of open- and cased-hole wireline and LWD well logs. Open-hole topics covered include the use of log data to determine porosity, mineralogy, hydrocarbon saturation and lithology, as well as interpretation of facies, stratigraphic and structural features, especially the use of imaging logs. Thru-casing topics include measurements for fluid movement monitoring, cement-bond quality, and a discussion of "best-practice" perforation issues.

Lectures on each topic are supported and illustrated by exercises, and participants build their own interpretations of at least two sets of wireline logs, and are expected to complete several "homework" exercises including a simple interpretation of a third set of (LWD) logs. Participants should bring laptop and scientific calculators with them. This is a challenging course which covers a great deal of ground in only 5 days.

Course Objectives:

Upon successful completion of this course, the delegates will be able to:

a) For Log Quality Control, to:

- ✓ Understand the differences between wireline and LWD/driller's depth and deviation measurements and identify likely sources of error and discrepancies, and the consequent uncertainties in hole navigation
- ✓ Recognize the importance of the verification of log data before attempting interpretation and how to check log quality by crossplots and quick-look overlays
- ✓ Understand that large errors are likely to be encountered by using modern iterative interpretation software without preliminary "eyeball" assessment of data inputs, comparison with other data sources such as bit-samples, cores and mud-logs, as well as step-by-step evaluation of intermediate results

(b) For Open-Hole Measurements, to:

- ✓ Understand and use basic petrophysical and geological models in "clean" formation interpretation
- ✓ Identify zones of potential interest using SP, GR, Resistivity and Porosity measurements.
- ✓ Use wireline and LWD resistivity measurements to calculate R_t , R_{xo} and invasion profiles and use density, neutron and sonic measurements to determine porosity and lithology
- ✓ Apply the basic physical principles of PhotoElectric, Spectral GR and Elemental Capture Spectroscopy measurements and how they can be used to enhance mineralogy determination in complex lithology
- ✓ Appreciate the concept and shortcomings of Formation Factor as the key link between resistivity and porosity/mineralogy measurements

- ✓ Use the empirical logic leading to the Archie Water Saturation Equation and be able to determine water saturation in both virgin and flushed zones
- ✓ Understand the basic functions of Formation Tester hardware and use the resulting pressure measurements to discern formation pressure profiles, fluid contacts and densities and to derive "drawdown" and "buildup" permeabilities
- ✓ Apply the basic physical principles and tool technologies of NMR measurements to distinguish between electrostatically- and capillary-bound water and free fluids, to derive permeability and water-cut, and to identify hydrocarbon-bearing zones, especially in complex or shaly reservoirs
- ✓ Interpret dipmeters and imaging logs to assist geological interpretation, together with typical depositional "signatures" gained from porosity and resistivity logs
- ✓ Use logs, crossplots and overlays to identify probable immature and mature source rocks, and to estimate Total Organic Carbon

(c) For Cased-Hole Measurements to:

- ✓ Evaluate the relative worth of various methods of cement-bond evaluation for zone isolation
- ✓ Use thermal neutron decay and GR spectral measurements, especially in time-lapse overlays, to identify changes in hydrocarbon/water contacts due to production during the life of a reservoir
- ✓ Appreciate issues related to skin effect and perforator performance, such as near borehole damage due to poor perforation methods and inadequate charge penetration

(d). For Advanced Measurements and Interpretation Methods (time permitting, and depending upon participants preferences), to:

- ✓ Use multipole sonic measurements for rock-strength, azimuthal and radial stress evaluations
- ✓ Apply dielectric measurements to determination of saturations in freshwater environments, to texture constants in complex carbonates and to kerogen identification in oil/gas-shales.
- ✓ Acquire a general understanding of the issues and methods involved in advanced log interpretation in thin-beds, shaly-sands, complex carbonates and shale-oil/gas environments

Who Should Attend?

This course is intended for entry-level geoscientists and engineers, as well as for more experienced staff and technical assistants needing a better understanding of the principles of log interpretation and/or to update themselves on the range of log measurements and techniques now available to them.

Course Outline:

Day 1:

INTRODUCTION; RESISTIVITY MEASUREMENTS

- Introductions: Lecturer, Course Participants
- What is required of Wireline and LWD Measurements?
- Basic Petrophysical Models and Relationships Used in "Clean" formation interpretation:
- Basic Geological Models and Signatures obtainable from well logs
- Basic Reservoir Engineering data obtainable from well logs
- Depth Measurements and Control
- Conductivity in Electrolytes and Derivation of R_{mf} at Formation Temperature
- Use of SP for Geological Interpretation and to determine R_w
- Resistivity Measurements to Determine R_t , R_{xo} and invasion profile
- Simple Gamma Ray Measurements
- Caliper Measurements
- Identification of Potential Zones of Interest using SP, GR and Resistivity

Day 2:

POROSITY AND MINERALOGY/LITHOLOGY MEASUREMENTS

- Density, Neutron and Sonic Measurements for Determination of Porosity and Mineralogy/Lithology
- Gamma Ray Spectrometry and Core Sampling for Enhanced Mineralogy Determination
- Other Geological Applications of Porosity and GR Spectrum Measurements, including source rock identification and evaluation

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Day 3:

LINKING RESISTIVITY WITH POROSITY/MINERALOGY MEASUREMENTS

- Linking Porosity, Formation Factor and Water Saturation
- Determination of Water Saturations in Virgin and Flushed Zones
- Completion and review of first example set of logs which the participants have been working on over the first 3 days

Day 4:

NMR AND TOPICS FOR GEOLOGICAL AND PETROLEUM ENGINEERING APPLICATIONS

- Nuclear Magnetic Resonance T1 and T2 measurements to determine total, bound-water and free-fluid porosities, fluid types, kerogen identification
- Formation Testers for Pressure Measurements, Fluid Sampling and Analysis
- Permeability Determination from Logs and Pressure Measurements

- Geological Interpretation topics, including:
 - Dipmeters, Imaging Logs and Paleomagnetic Logs
 - Using logs for inter-well correlation
- Petroleum- and Reservoir-Engineering topics, including:
 - Cement-bond logs (CBL/VDL, CET, Segmented-bond, Isolation Scanner, Temperature and Noise)
- Thru-casing measurements to determine porosity, water saturation and changes in fluid levels during production by time-lapse monitoring:
 - Porosity logs
 - TDT logs
 - Carbon/Oxygen and GR spectroscopy logs
 - Borehole gravity for gas-cap monitoring
 - Thru-casing resistivity
- Skin-effect and Perforation issues
 - Overview of skin-effect, damaged zone
 - Implications for perforator performance and API RP19 sections 1-4 criteria
 - Perforation design alternatives and recommended procedures to enhance productivity index

Day 5:

LOG QUALITY CONTROL, INTERPRETATION OF FINAL EXAMPLE

- Overview of Some Important Log Quality Control Issues
- Recap of Uncertainties and Assumptions in Log Measurements, and Suggested Procedures to "Eye-ball" Data for Problem Identification and Preliminary Interpretation
- Overview of Computer Log Interpretation Methods
- Participants work on second example set of logs, preferably from general area of course
- Review of interpretation of second set of logs, final summary and prize-giving, award of certificates

OTHER TOPICS ON SPECIAL REQUEST, OR IF TIME PERMITS:

Advanced Logging Measurements

- Multifrequency acoustic logging for investigation of azimuthal and radial changes in rock-strength properties
- Modern dielectric log measurements and interpretation applications
- Logs for casing-corrosion identification and monitoring
- Production logs for flow analysis in highly deviated holes

Advanced Interpretation Overviews

- Thin-bed problems

- Shaly-sands
- Shale-oil/gas
- Complex carbonates

At the beginning of days 2-5, the previous day's activity and any overnight "homework" will be briefly reviewed.

Course Certificate:

International Center for Training & Development (ICTD) will award an internationally recognized certificate(s) for each delegate on completion of training.

Course Methodology:

A variety of methodologies will be used during the course that includes:

- (30%) Based on Case Studies
- (30%) Techniques
- (30%) Role Play
- (10%) Concepts
- Pre-test and Post-test
- Variety of Learning Methods
- Lectures
- Case Studies and Self Questionnaires
- Group Work
- Discussion
- Presentation

Course Fees:

To be advised as per the course location. This rate includes participant's manual, hand-outs, buffet lunch, coffee/tea on arrival, morning & afternoon of each day.

Course Timings:

Daily Course Timings:

08:00 - 08:20	Morning Coffee / Tea
08:20 - 10:00	First Session
10:00 - 10:20	Coffee / Tea / Snacks
10:20 - 12:20	Second Session
12:20 - 13:30	Lunch Break & Prayer Break
13:30 - 15:00	Last Session