N187: Low Resistivity Low Contrast Pay

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3 Days	Competence Level: Skilled Application
Classroom Course	

Summary

This course will provide a proven methodology to identify and evaluate Low Resistivity Low Contrast (LRLC) pays as seen in modern wells or as depositional bypassed pays in old wells. Worldwide examples from productive LRLC reservoirs will be discussed. The guest lecture, filling the morning of Day 3, will cover the applicability of some of the latest logging tools.

Learning Outcomes

Participants will learn to:

1. Assess possible low resistivity low contrast pay from modern logs in new wells, or as potential bypassed pay from older logs in old wells.
2. Propose the causes of low resistivity low contrast pay.
3. Evaluate the role of clays and conductive minerals, grain size variations and associated capillary properties and their impact on log response.
4. Perform thin bed interpretations in low resistivity low contrast pay intervals.
5. Judge the appropriate cementation exponents, saturation exponents and water saturation models to use in petrophysical evaluation of these pay sections.
6. Select appropriate logging tools to evaluate low resistivity low contrast pays.
7. Assess core data (conventional whole core, sidewall cores and drill cuttings) as a component of a LRLC pay evaluation.
8. Judge the effectiveness of logging and coring programs designed to evaluate LRLC pay intervals.

Duration and Training Method

A three day course comprising of classroom lectures with examples and hands-on exercises. Participants are encouraged to bring their own non-proprietary examples for end-of-the-day group discussion / evaluation.

Who Should Attend

The course is intended for exploration and development professionals who are working in environments where LRLC sands may be present and for those who are evaluating these difficult sands.

Prerequisites and Linking Courses

A basic familiarity with petrophysical evaluation is assumed, as presented in N083 (Petrophysics: Basic Principles and Practices) or N121 (Modern Petrophysical Well Log Interpretation). The topics covered by the Guest Lecture are more fully developed in N314 (Advanced Petrophysics for Conventional Reservoirs).

Course Content

Although low contrast (LRLC) sands in the Gulf of Mexico Basin (GOM) were commonly considered wet, misidentified as shale or completely overlooked due to logging tool resolution, they have yielded significant volumes of hydrocarbons over the past 50 years. Low-resistivity pay has been typically defined at or below the 1.0 ohm-meter resistivity level, yet many productive reservoirs are found in the 0.3 to 0.5

ohm-m resistivity range. The interpretation of seismic response, the analysis of drill cuttings, sidewall and conventional cores, the interpretation of log response with the application of appropriate petrophysical models, along with wireline and production testing, can all contribute to an integrated LRLC evaluation.

Geological causes of LRLC pay include: laminated clean sands with shales; silts or shaly sands; clay-coated sands; glauconitic sands; sands with interstitial dispersed clay; sands with disseminated pyrite or other conductive minerals; clay-lined burrows; clay clasts; altered volcanic/feldspathic framework grains; very fine-grained sands; microporosity; or sands with very saline formation water. LRLC depositional systems include deepwater fans, with levee-channel complexes, delta front and toe deposits, shingle turbidites and alluvial and deltaic channel fills. The lack of high-resolution logging tools across intervals with reservoir sands below the tool resolution is frequently the "cause" of the LRLC.

Geological and petrophysical models developed in the GOM for the evaluation of LRLC pay are applicable in other world basins. A conventional Archie clean sand or Waxman-Smits shaly sand model are commonly used to evaluate LRLC log anomalies. Often, shaly sand models are not necessarily suited for LRLC evaluation. The Archie lithology exponent (m) and saturation exponent (n) for many LRLC reservoirs can range from 1.4 to 1.85, and from 1.2 to 1.8, respectively. In thinly laminated LRLC reservoirs, net sand distribution is identified with high resolution logging tools, the examination of rock samples and interval testing. Recent application of nuclear magnetic resonance logging has provided a better identification of fluid type, pore size distribution and hydrocarbon saturation in LRLC sands. Resistivity forward modeling can also aid in establishing the "true" resistivity in laminated sands. This course will provide a proven methodology to identify and evaluate LRLC pays as seen in modern wells or as potential bypassed pays in old wells.

The guest lecture on the morning of Day 3 examines recent developments in low resistivity pay and shaly sand analysis, including Multicomponent Induction Resistivity for identification of thin beds, Elemental Capture Spectroscopy for mineral and clay volumes and Nuclear Magnetic Resonance for pore size distribution.

1. Introduction
2. Clays and Clay Minerals (and their shale counterparts): The Biggest Culprits behind LRLC
3. Rock Properties: Their Impact on the Saturation Calculation
4. Analog Studies and Literature Bibliographies: Keys to Understanding the Causes of LRLC Pays
5. Methodology
6. Guest lecture: Some "Recent Advances: What's Beyond the "Triple-Combo"?
7. Selected Case Histories