Iran section

SPE-Iran Section Technical Workshop

Basic Well Log Analysis and Petrophysics

Course Objectives

Cover the fundamentals of log analysis for interpreting open-hole and LWD logs.

- Present basic log analysis principles, petrophysical calculations, and interpretation techniques which can be applied to routine wireline and LWD logs.
- Present practical methods in estimating porosity, permeability, lithology/rock type, shale volume, rock strength, Poisson's Ratio, friction, fluid content, and water saturation.
- Describe how to integrate core data, drill-cuttings reports, DST results, and production information into log analysis.
- Discuss standard log quality control and normalization.
- Require exercises using Excel to implement log analysis and calculation of petrophysical parameters.
- Include publication references for important equations and concepts.

Course Outcome

At the end of the course, each participant should be able to:

- Confidently assemble and assess the quality of a basic log suite for interpretation of Overburden (Sv), Pore Pressure using NCT's, Porosity, Rock Properties.
- Identify the effects of Gas, Oil, Salinity on the basic log suite measurements.
- Identify presence of mud cake and fluid invasion from analysis of appropriate logs.
- Identify borehole failure effects on the basic log suite measurements.
- Understand the effect of water based and oil based muds on basic log suite.
- Analyze a basic log suite for Overburden (Sv), Porosity, Rock Properties using common petrophysical equations.

Course Content

1. Overview and Definitions

- Open Hole vs. Cased Hole logs
  - MD – TVD
  - Wireline – driller's depth vs. loggers' depth
  - LWD – measurements in time, convert to depth
- Tools** – sources
  - mechanical – caliper
  - electrical – SP, resistivity
  - nuclear – gamma ray, density, neutron
  - acoustic – sonic, caliper (LWD)
  - nuclear magnetic resonance
- Borehole Environment
  - bit size
  - hole diameter
  - borehole wall
  - mudcake
  - flushed zone
  - invaded zone
  - uninvaded zone
- Drilling muds
- Formation Temperature
- Core
- Well Tests
- Physical properties
  - Lithology – mineralogy
  - Shale Volume
  - Pore Geometry
  - Porosity – total, effective, relative
  - Permeability – absolute, effective, relative
  - Resistivity
  - Formation Fluids – Identification, gradients – water, oil, gas
  - Fluid Saturations – water, oil, gas
    - Irreducible water
    - Water cut
- Log Interpretation Chartbooks

** Detail for each wireline and LWD log measurements:

- Advantages/disadvantages of wireline and LWD logging tools
- Interpretation value of the log measurement

- Physics of the log measurement, include volume of investigation and vertical resolution
- Operational conditions that affect the measurement and ideal conditions
- Assumptions which affect the measurement and its interpretation
- Environmental corrections
- Quality control
- Mnemonics with tool and curve names from different vendors
- Example of log and headers
- Detailed interpretation example
- Exercise that requires using the log for estimating petrophysical parameter

2. Evaluate Log Quality and Pre-analysis Strategies

Headers and Mud Logs
Preparation for Analysis
    Depth
        MD – TVD
        Depth shifts or stretch/compress
    Hole Conditions – identify and eliminate “bad data” zones
    Repair logs and fill gaps – practical methods
        parameter and log regression
        interpolation
        data from offset well
    Normalization and calibration process
        Standard scales
        Expected range of log values
    Gas effect

3. Log Analysis for Petrophysical Parameters

Overburden – vertical stress
Shale content – Vshale calculations
    Shale indicators – gamma ray, neutron porosity, bulk density/neutron porosity separation, magnetic resonance
    Linear and non-linear equations
    Histograms and analysis of different shales
    Use of SP log to distinguish clean sands from shaly sands
    Carbonates
Interpretation of Porosity and Lithology
    Analysis of standard log combinations
    Gas effect, detection
    Analysis of neutron-density-sonic cross plots for porosity
    Analysis of matrix identification crossplots
    Determining matrix constants
    Synthetic Porosity logs – regression analysis

Effect of mud invasion on porosity interpretation
Crystalline rocks – fractured reservoirs

Fluid Saturation

Archie

Archie-Pickett crossplots

R_w and salinity

Waxman-Smits and other models

Low resistivity shale effects

Sw influence on porosity calculation

Permeability

Overview of modern seismic petrophysics

Applying rock physics theory to the interpretation of seismic data

Calibrated with laboratory and well measurements

Exercises in Excel Workbook

Prep-logs for analysis:

Plot and assess quality of logs

Decide if/where appropriate to delete spikes or smooth data

Create and apply bad-hole flag based on caliper and drho

Density and Overburden

Fill gap in density curve using regression

Fill gap in density curve using pseudo-density from appropriate log

Calculate overburden (vertical stress) from both and compare

Shale volume

Calculate and plot using gamma ray

Calculate and plot using Induction log and SP

Calculate and plot using bulk density and neutron porosity

Calculate and plot single log porosities – RhoB, Dt, Nphi

Calculate first pass synthetic bulk density, compare to original bulk density

Calculate UCS using Dt and porosity based equations, with various Vshale

Using cross plots for porosity and lithology analysis

Use linear regression to determine transform

Apply transform to calculate and plot better porosity curve, synthetic RhoB, UCS

Compare to previous calculations

Calculate and plot Sw using Archie

Use crossplot to determine a, Rw, m, Rt, water line

Determine Vshale from neutron porosity – density porosity separation

Calculate porosity using Vshale to define the mix of sand and shale.

Determine sand and shale parameters

Use X-plots

Compare density porosity, neutron porosity, and acoustic porosity

Calculate and plot synthetic density and UCS curves

Compare to previous calculations