Petrophysics of Unconventional Reservoirs

Jack Breig, Senior Petrophysical Consultant, The Discovery Group
Instructor name, Title, The Discovery Group

The Discovery Group offers courses in petrophysics for your people, at your location, at a date convenient to your needs and internal schedules. The courses will benefit geologists, engineers, geophysicists, and geotechs, and can be of benefit to other specialists who routinely work with those geotechnical specialists. The best class size is from about 10 to 25 people from a variety of specialties who can share their professional experiences in the context of a greater understanding of petrophysics.

Synopsis: The course assumes a basic understanding of common openhole logging measurements and their interpretation and uses that knowledge to expand upon the interpretation into environments and petrophysical situations for which the measurements were not originally designed or intended.
While there are often commonly used methods for evaluating key petrophysical properties, such as porosity and fluid saturation, the class will explore their utility and application to unconventional reservoirs, including those of interest to the client's exploration and production focus.
Exercises which take advantage of client data sets are developed and worked to reinforce best practices, teach adaptability and creativity where interpretations become challenging.

The course follows a workflow which is in wide use for organic rich mudstones and shales, and includes:

- Characterization of the amount and thermal maturity of organic matter, using core and log analysis
- Determination of the nature of mineral constituents, including clays, from core and log analysis.
- Assessment of formation porosity with approaches based on bulk and grain density, advanced spectral geochemical logs, and NMR relaxation times.
- Assessment of formation fluid saturations using traditional Archie's method and shaly sand techniques with various electrical resistivity logs, NMR and dielectric logs.
- Exploration of the use of methane storage capacity experiments derived from shale gas core analysis to estimate adsorbed and free gas volumes.
- Exploration of techniques developed from NMR studies to assess oil viscosity and identify immobile oil.
- Development of a custom Reservoir Quality indicator to rank exploration and development target drilling targets.

Length: Two days

Equipment needed:

Exercises are developed in Excel worksheets. A laptop computer or other device which can run Excel is recommended.

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Agenda: No specific times are listed, as the times to cover material will depend on the questions and comments of the class. Questions and comments based on the experience of participants are welcomed and encouraged, and often provide insights to local conditions and methods that would otherwise not be presented.

Short breaks will be taken throughout the course, as needed.

Based on clients' needs and preferences, the topics below can be individually emphasized or eliminated.

Characterizing organic carbon in unconventional reservoirs

- Concepts applicable to source rocks; Organic matter types (I, II, III); Levels of maturation; Phases (gas, liquid, solid) and viscosity
- Core evaluation techniques:
  - RockEval pyrolysis; LECO, Kerogen density measurement
- Well log analysis:
  - Density (Schmoker, date); DeltaLogR (Passey, date); Spectral GR; Total GR; Neutron spectroscopy.
- Other useful techniques

Porosity

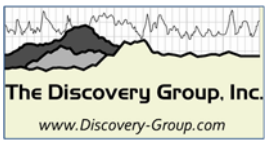
- Concepts of Total and Effective porosity; Shale porosity and clay-bound water (CBW); Organic porosity.
- Core evaluation techniques.
- Well log analysis
  - Shaly sand models; NMR T1/T2 techniques.

Fluid typing and saturation evaluation in unconventional reservoirs

- Fluid compositional properties
  - SARA for oils; Salinity for waters.
- Fluid properties (viscosity, density).
  - Water, gas, oil (including heavy oils)
- Core evaluation for liquid saturations
  - Dean-Stark distillation (CoreLab, Weatherford); Other methods (Schlumberger, TerraTek)
- Core evaluation for adsorbed and free gas content
  - Storage capacity models; Lost gas analysis.
- Well log analysis
  - Porosity/resistivity techniques:
    - Archie's equation; Shaly sand models
  - Dielectric logging techniques; NMR (T1/T2) techniques.
- The bitumen problem
  - Core analysis for bitumen; Log analysis for bitumen:
    - Moveable oil plot; NMR T1/T2 techniques.

Petrophysics of permeability assessment

- Concepts of rock/fluid dynamics
- Properties which affect fluid flow
  - Fluid properties
  - Fluid-rock interactions



Wettability, Capillary pressure
Core evaluation for fluid dynamics
Steady state permeability; Unsteady state permeability (including the GRI method); Lattice Boltzman modeling of pore networks

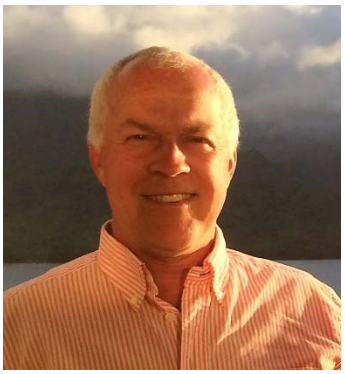
Rocks and minerals
Concepts of rock and mineral classification
Core evaluation for mineralogy and lithology
XRD; XRF; FTIR
Well log analysis
Neutron/Density/Sonic/GR techniques; Neutron spectroscopy techniques; Multimineral solvers.

Tight gas sand petrophysics
Concepts of low permeability sands
Geological origin of TGS; Sand and clay;
Fluid-Rock interactions
Capillary pressure
Core evaluation
Stress sensitivity of porosity and permeability; Capillary pressure measurements.
Well log analysis
Triple combo with shaly sand models; NMR logging.

Geomechanical inputs to wellbore stability and stimulation planning
Concepts of rock mechanics
Material strength.
Mohr diagram; Stress and critical strength
Fracture characterization
Core evaluation
Geomechanical core tests
Triaxial rock strength; Elastic rebound test; Scratch test
Well log analysis
Dynamic elastic moduli
Poisson's ratio; Young's modulus
Stress profile
Fracture characterization using image logs
Electrical; Acoustic
(Other, from azimuthal LWD measurements?)

Time for hands-on exercises, which the class can do individually or in small groups, is included in the above schedule.

About the instructor: Jack Breig



Jack Breig is a Senior Petrophysical Consultant with The Discovery Group, specializing in Unconventional Reservoirs. He was formerly the Chief Petrophysicist with Whiting Oil and Gas, Senior Petrophysical Consultant with Newfield Exploration in the Midcontinent region, and a Senior Development Geologist with Tenneco Oil and Exxon Production Research. He also spent several years working with Schlumberger in Houston on Petrophysics and Petroleum Software development.

Jack received his B.S. degree in Geology from Brown University and an M.S. in Earth and Space Science from the State University of New York at Stony Brook (now Stony Brook University).

Jack is active in several professional societies, including the American Association of Petroleum Geologists (AAPG), Society of Petroleum Engineers (SPE), and the Society of Petroleum Well Log Analysts (SPWLA) and the Denver Well Log Society (former VP of Technology).

When not doing this, Jack plays ice hockey with the University of Denver 'Old Guys' team, snow skis, when possible, and is raising an "awesome rose garden" (his words).

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