Back to Basics Workshop:

An introduction to Formation Evaluation

Thursday 22nd February 2018

The Geological Society, Burlington House, London

	Start Time	End Time	Presenter	Affiliation	Formation Evaluation Topic
	09:00	***09:20***	***Registration***		
	09:20	*09.30*	*Mike Millar*	*LPS President*	*Welcome*
1	09:30	10:10	Mike Lovell	Uni. Of Leicester	Fundamentals of Petrophysics
2	10:10	10:45	Adrian Leech	Gaia-Earth	Data Acquisition & LQC
	10:45	***11:00***	***Coffee Break***		
3	11:00	12:00	Mike Millar	Ind.	Lithology and Shale Volume
4	12:00	13:00	Geoff Page	BHGE	Porosity
	13:00	***13:45***	***Lunch***		
5	13:45	14:45	Roddy Irwin	Rockflow Resources	Water Saturation and Fluid Contacts
	14:45	***15:00***	***Tea Break***		
6	15:00	16:00	Adam Moss	AKM Geoconsulting	Core – Log Integration
7	16:00	17:00	John Bennett	Bennett Petrophysics Ltd.	Net, Pay & Permeability
	17:00	*17:05*	*Mike Millar*	*LPS President*	*Closing Remarks*
	17:05	***18:30***	***Wine & Snacks***	***17:05***	***18:30***

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The aim of these presentations is to provide reasonable and balanced discourse on the titled subjects. Consequently it cannot consider in detail all possible scenarios likely to be encountered and caution is encouraged in apply these principles. Neither the LPS nor the authors can be held responsible for consequences arising from the application of the approaches detailed here.

The following pages contain the Abstracts

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Fundamentals of Petrophysics

Mike Lovell, University of Leicester

Tiab and Donaldson (1996) summarise petrophysics as the study of rock properties and their interactions with fluids (gases, liquid hydrocarbons, and aqueous solutions).

We are interested in how fluids are distributed in subsurface formations, how we can estimate any hydrocarbons present, and whether ultimately, they will flow. Our interest centres on petrophysical properties such as porosity - the fluid storage volume of our reservoir; the water saturation that defines how much hydrocarbon there is; the net, pay and gross that allow us to better define quality reservoir; and last but not least the permeability that determines how these fluids may flow.

To this end we use a variety of downhole and laboratory (core) measurements to either estimate these petrophysical properties or to measure some parameter that these may be related to. We use a variety of equations to relate different measurements to the petrophysical properties; some are theoretical, some heuristic, others empirical.

Underpinning all this we need to consider the processes that determine the fluid distribution in the reservoir; how capillary pressure and wettability control the migration of hydrocarbons; and how laboratory measurements complement downhole measurements to provide an integrated and holistic understanding of fluid distribution in the reservoir.

Over the course of the day with some leading industry experts we will explore aspects of:

- Data acquisition and LQC
- Lithology & Shale volume
- Porosity
- Saturation and Fluid Type
- Core – Log integration
- Net, Pay & Permeability

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Data Acquisition & LQC: *Rubbish in, Rubbish Out or No Rubbish at All!*

Adrian Leech, Gaia-Earth

An introduction to logging:

- What is logging?
- Why we log
- Logging operation setup

What we really measure:

- The Physics of Measurement:
    - A tool only sees what it "sees" - formation properties can only be inferred by logging tools from secondary or even tertiary measurements.
- Drilling and borehole effects on measurements
- Depth of investigation and vertical resolution

Log Quality Control (LQC):

- The importance of Pre-job LQC!
    - Starts at the planning stage
    - Understanding tool limitations and equipment choice
- LQC during logging operations
- Real-time QC aids:
    - The caliper log – washout example
    - The tension log – tool sticking example
    - The repeat section – log response confirmation
    - Density Correction – a hint for other curves
    - Tool Function Flags
    - An example of a good log looks like and how to tell that it is
- The importance of the Post-Job Debrief!
    - The Log QC Report – the starting point for the post job debrief.
    - Lessons Learnt, Solutions and Recommendations - Developing Best Practices.
- The Groningen Effect

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Lithology & Shale Volume from Borehole Data

Mike Millar, Independent

Why do we bother to identify Lithology and calculate Shale Volume?

- We need to know where we are in the well.
- We need to know how this well compares to nearby wells.
- We need to know how good our reservoir is.

What do we mean by Lithology?

- Physical characteristics of a rock.
- Rocks are igneous, sedimentary or metamorphic.
- Hydrocarbons are found in sedimentary rocks (mostly).

Lithology from borehole data:

- Indications and interpretation of lithology from mud logs, including a worked example.
- Cores - SWC and conventional
- Lithology from open-hole logs
- General Log responses to Lithology and Fluids and generalised elemental compositions
- Lithology from cross-plots, including worked examples.
- Short introduction to Geochemical logs (Flex, ECS type)

Shale Volume

- What does Shale Volume really mean?
- What is Shale or Claystone?
- Calculating Shale Volume from a single tool response, including a worked example.
- Calculating Shale Volume from cross-plots.

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Porosity

Geoff Page, Baker Hughes a GE Company

What is "Porosity" and does everyone mean the same thing? We will look at the different definitions of porosity and how they can be calculated. There have been previous heated debates (in this very room at the Geological Society) on which is best!!

There are many sources for porosity information:

- Core
- Standard logs:
    - Density
    - Neutron
    - Acoustic
- Advanced services, e.g.:
    - NMR
    - Dielectric.

In this section we ask:

- Do they all measure the same thing?
- Do many even measure porosity??
- How accurate are they, and what are the relative uncertainties?

We will also look at variations due to mineralogy, fluids and pore structure and how the various measurements can be compared, calibrated, and what else can they tell us?

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Water Saturation & Fluid Contacts

Roddy Irwin, Rockflow Resources

Fluids in the Reservoir:

- Hydrocarbon fluid distribution in reservoirs
- Capillarity and buoyancy controls on fluid levels and saturation

Fluid Type:

- Identification of fluid types - Gas/Oil/Water
    - From logs, samples, core and pressure data
- Identification of fluid contacts:
    - From logs, core and pressure data

Petrophysics of Water Saturation:

- Evaluation of Water Saturation
    - Resistivity logs
    - Archie's equation and principles
    - Water Resistivity
    - Shaly sand effects
    - Porosity systems and implications

Saturation-Height Modelling:

- From core capillary pressure data
- From log data (e.g. FOIL Function)

Some Worked Examples

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Core – Log integration

Adam Moss, AKM Geoconsulting

Core Acquisition & Handling

Scales of Measurement:

- Log scale
- Core scale

Heterogeneity

- Not every inch of rock is identical!

Core to Log Shifting

- The importance of getting it right!

Special Core Analysis (SCAL) Data to Calibrate Log Interpretation Models:

- Archie Saturation Model
- Shaly Sand Saturation Models
- Density Porosity
- NMR Saturation & Permeability Models

Overburden Stress Corrections to Core Data

Dean-Stark Water Saturation from Core

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Net, Pay & Permeability

John Bennett, Bennett Petrophysics Ltd.

What do we mean by "Net"?

How and where is it used?

- Volumetric calculations
- Input to Geocellular models
- Cut-off vs non cut-off curves input to geocellular models

Porosity & V-shale cut-offs:

- Proxies for (usually uncertain) Permeability

Net indicators:

- Other than V-shale, Effective Porosity & Sw

Bed resolution, thin beds & edge effects

- Is a 100% N:G, 55% V-shale, 12pu rock
- The same as a 50% N:G, 10% V-shale, 24pu rock?
- Illustrated with numerically modelled example

Water Saturation

- The perils of "average" Sw
- Do you need additional layers for Sw averaging?
- The advantages of Sw height functions

Permeability

- Definitions of
- Selecting the correct cut-off