# London Petrophysical Society One Day Seminar

## "Do you want more pay?" 17th June 2014

| | | | Name | Company | Talk Title |
|---|---|---|---|---|---|
| | 09:00-09:25 | | **Registration** | | |
| | 09:25-09:30 | 5 | **Iain Whyte** | LPS | Welcome & Introduction |
| 1 | 09:30- 10:05 | 35 | **Mike Lovell** | Leicester University | Gross, Net and Pay; a petrophysical guide through the maze |
| 2 | 10:05 - 10:40 | 35 | **Iain Whyte** | Tullow Oil | A practical approach to use of cut offs and their sensitivities |
| | 10:40 - 11:05 | 25 | **Break** | | |
| 3 | 11:05 - 11:40 | 35 | **Roddy Irwin** | Gaffney Cline | Net and Upscaling |
| 4 | 11:40 - 12:15 | 35 | **Tim Pritchard** | BG | Issues to consider when defining net pay criteria |
| | 12:15 - 13:15 | 60 | **Lunch** | | |
| 5 | 13:15 - 13:50 | 35 | **Michel Claverie** | Schlumberger | More Accurate Net Pay – a Review of Static and Dynamic Evaluation Methods |
| 6 | 13:50 - 14:25 | 35 | **John Bennett** | Cairn Energy | Sw Cutoffs & Averages, frequently misleading |
| 7 | 14:25 - 15:00 | 35 | **Ben Lowden** | RPS Group | Integrating the CBIL and MREX to get net sand properties in thin beds |
| | 15:00 - 15:30 | 30 | **Break** | | |
| 8 | 15:30 - 16:05 | 35 | **Prince Abangwu** | Schlumberger | Workflows for Thin Bed Analysis from Resistivity Anisotropy and Borehole Images" |
| 9 | 15:05 - 16:40 | 35 | **Craig Buchan** | Task Fronterra | Net sand from borehole image logs and core – basics and pitfalls of thin bed pay |
| | 16:40 onwards | | **Refreshments** | | |

**Gross Net and Pay: a petrophysical guide through the maze**

**Mike Lovell; University of Leicester**

Petrophysics is interesting, not least because of the lack of a standard vocabulary, and the tendency to use words to mean different things.

Three petrophysical terms, average porosity, average porosity-weighted water saturation, and pay to gross are constituents in the hydrocarbon in place equation, and determination of each falls to the petrophysicist. Porosity and water saturation can, in principle, be accurately measured at any point in reservoir. Pay to Gross is more difficult because it does not refer to a single point but to the entire thickness of the reservoir. At a basic level, Pay to Gross is probably best thought of as the fraction of the total thickness of the reservoir that is capable of contributing to production

The whole discussion of net and pay is complicated by the use of different terms for the same concepts, and it is imperative we understand what is meant by any terminology or vocabulary.

At a basic level we could define Gross as the total thickness of the reservoir; Net as the total thickness of reservoir quality rock; and Pay as the total thickness of reservoir quality rock that could contribute to production. Net to Gross is then the ratio of Net thickness to Gross thickness, and Pay to Gross is the ratio of Pay Thickness to Gross thickness. But really this set of terms is incomplete in that it lacks the hierarchy that is embedded in the underlying concept.

A better approach may be to define*: Gross rock as the total thickness of the reservoir; Net sand as the total thickness of the potential reservoir rock (i.e. net potential reservoir); Net reservoir as the total thickness of reservoir quality rock (i.e. capabiity to store and allow fluids to flow into the well); and Net Pay as the total thickness of reservoir quality rock that could contribute to production (i.e. net hydrocarbons). Cut offs, or limiting values, allow segregation on the basis of formation petrophysical properties. Thus we can use a Vshale value to define Net Sand, and a porosity value, applied to Net Sand, to define Net Reservoir; we can use an Sw value, applied to Net Reservoir, to define Net Pay. Sometimes additional Cut-offs are used to eliminate thin un-connected sand packages and non-reservoir lithologies.

Convention suggests we use 1 millidarcy for oil reservoirs and 0.1millidarcy for gas reservoirs. For a conventional reservoir these may approximate to the lowest permeability that will yield hydrocarbons in favourable conditions within a field's lifetime. These traditional cut offs, or rules of thumb, provide a fall back position but we should choose values based on data, and dynamic conditioning of data using an iterative approach is possible. Changing cut-offs will affect outputs and we can model how these changes compensate..

Lastly, establishing an agreed, simple vocabulary would make this task easier.

*Reference:

Paul F. Worthington, 2010. Net Pay--What Is It? What Does It Do? How Do We Quantify It? How Do We Use It? SPE Reservoir Evaluation & Engineering, Volume 13, Issue05, Pages 812 – 822. DOI http://dx.doi.org/10.2118/123561-PAISSN

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**A practical approach to use of cut offs and their sensitivities**

**Iain Whyte; Tullow Oil**

A common comment is if you give three petrophysicists one series of logs, you are likely to get three different answers on Petrophysical estimations! This presentation will examine some of those differences and give some experience based insights on things to consider.

Furthermore, we will look at considerations when sharing evaluations and determinations to co-ventures and other work groups who will use the data. The most important thing being that regardless of different approaches it is mission critical to understand and document how the determination has come about and to avoid "double dipping" on cut offs.

**Net and Upscaling**

**Roddy Irwin and Sumon Bhattacharyya; Gaffney, Cline and Associates**

Petrophysicists are commonly concerned with the detailed definition of cut-off criteria to define "Net "portions of the reservoir. Depending on the order of cut-offs applied, the "Net Sand", "Net Reservoir" and "Net Pay" portions of the reservoir sequence can be identified at the well log scale. However, these specific terms can be lost in translation between the Petrophysicist, the Geoscientist and the Reservoir Engineer during the upscaling process.

This talk clarifies the definition of the "Net" terms and offers a guide to the upscaling process. Outline workflows for the upscaling of net properties are presented and the determination of Net Pay, and hence volumes, through quality controlled geocellular modelling is described.

**Issues to consider when defining net pay criteria**

**Tim Pritchard**

Investment decisions in the development of oil /gas reservoirs are made on the basis of various investment criteria, net pay being one of them. This presentation reflects on the use of Petrophysical cutoff methods consistent with this application for conventional and unconventional formations, and best practice requirements.

**More Accurate Net Pay – a Review of Static and Dynamic Evaluation Methods**

**Michel Claverie**

We will review static formation evaluation methods focused on reducing the uncertainty of reservoir thickness and volumes of hydrocarbons-in-place. Solutions for thin laminated reservoirs will include applications of NMR free fluid volume, resistivity anisotropy and log resolution enhancement from borehole images. For silty, fresh water and even shale reservoirs, we will examine applications of NMR fluid typing, dielectric dispersion and GR spectroscopy, and will conclude this section with the estimation of static evaluation uncertainties.

The section on dynamic evaluation methods will examine how we may attempt to predict the produced fluids types and rates, either through the use of alternative net pay criteria, or more comprehensive reservoir simulation at the high resolution of the petrophysical logs and borehole images.

*Michel Claverie is a Petrophysics Advisor for Schlumberger, based in London, where he provides technical support to operators in Europe and Africa, on OH and CH petrophysical logging technology and interpretation.*

**Sw Cutoffs & Averages, frequently misleading**

**John Bennett; Cairn Energy**

Net Pay is often defined as Net Reservoir with water saturation > 50%.

Whilst this is an appropriate method on many reservoirs, there are also situations where a more thoughtful approach is required.

This talk will discuss what we really mean by “Net Pay” in day to day usage and consider some specific circumstances where the definition of Net Pay is not straightforward.

**Integrating the CBIL and MREX to get net sand properties in thin beds**

**Ben Lowden; RPS Group**

NMR logs offer a simple way to estimate net sand directly from the amount of free fluid seen in the T2 distributions. However, smoothing across sand/shale boundaries in thin beds causes free fluid to be underestimated in the sands (and bound fluid to be overestimated) as signal from shale is merged with signal from sand. Here, we offer a simple solution to the problem by comparing sand thickness identified from the circumferential borehole image log (CBIL) against the MREX pore volumes, which we use to build a relationship that predicts shale-free answers to free fluid, bound fluid, Swirr and permeability.

**Workflows for Thin Bed Analysis from Resistivity Anisotropy and Borehole Images**

**Prince Abangwu; Schlumberger**

We present an introduction to resistivity anisotropy processing and its applications to the Net Pay evaluation of thin-bedded sandstone reservoirs. We include details of the interpretation workflow and options, illustrate the results with recent examples from offshore Africa exploration wells, and correlate the results to other data types such as NMR fluid typing, Sonic slownesses, and formation testing and sampling.

Prince Abangwu is the Lead Petrophysicist for Schlumberger PetroTechnical Services in Luanda.

**Net sand from borehole image logs and core – basics and pitfalls of thin bed pay**

**Craig Buchan; Task Fronterra**

Dr Craig Buchan VP UK/Africa Task Fronterra Geoscience; Dr Jeremy Prosser and Lawrence Bourke

Conventional open hole log analysis can present a problem for assessing net sand and net pay in sedimentological environments where thin beds are common. The course resolution of these logs, typically 6 inch along hole, can lead to pay being over estimated where sequences are composed of stacked thin beds of sand and shale, or can lead to underestimates of upside potential where small packets of thin beds are not adequately resolved by these logs in for example channel abandonment sequences or overbank deposits. One solution to this problem is to incorporate higher resolution logs into the analysis with a smaller along hole sampling rate which therefore have a better chance of resolving these beds. Borehole image logs are perfect for this application as they generally have much higher along hole sampling rates and smaller measurement buttons, but are all image logs equal in this task, and what pitfalls should we be aware of when applying such 'high' resolution techniques?

In this presentation we will examine what factors need to be considered when selecting an appropriate image log for analysis. Along hole sampling resolution is one factor to consider, but with the wealth of different measurement types available among logging tools from micro-resistivity to sonic and neutron tools; we must also be aware of the positives and negatives of the measurement physics involved and ask ourselves the question of – how thin is thin bedded? In other words what scale do we need to resolve and are my tools up to the job? We will examine how drilling factors can assist in the analysis and how we can use complimentary datasets such as core to gain complimentary and often even higher resolution assessments of thin beds. Finally we will compare automated versus manual techniques of sand analysis and assess the pitfalls and artefacts that may affect the result. It will be shown that although the term 'automated' is often used, in fact a large amount of user input and care is required to remove artefact effects so that in the end we produce the highest confidence estimate. By being aware of the positives and negatives of these techniques we will show that image logs can be a powerful tool for net sand/net pay estimation and greatly improve input to reservoir modelling over more standard OH log methods.