www.oleumkhaos.com chief-petrophysicist@oleumkhaos.com

Jeremy Daines' Technical Expertise & Approach

Introduction

Jeremy's primary technical expertise is Petrophysical interpretation from a geological foundation. This foundation can be significant because, without a good understanding of depositional systems, bed-forms and lithology; understanding what logging tools are providing and what valid information can be gleaned from them, is the first critical step in evaluation.

Jeremy was fortunate to work with Dr Paul F Worthington who sadly died in 2020. One of Dr Worthington's many strong points is the number of high quality papers he's published, particularly relating to pragmatic petrophysical evaluation.

The following papers, published by Dr Worthington, are highly recommended:

- The Evolution of Shaly-Sand Concepts in Reservoir Evaluation, 1985
- Conjunctive Interpretation of Core & Log Data Through Association of the Effective & Total Porosity Models, 1998
- Scale Effects on the Application of Saturation-Height Functions to Reservoir Petro-facies Units, 2001
- Application of Saturation-Height Functions in Integrated Reservoir Description, 2002
- The Effect of Scale on the Petrophysical Estimation of Intergranular Permeability, 2004
- The Role of Cut-Offs in Integrated Reservoir Studies, 2005
- Optimizing the Value of Reservoir Simulation Through Quality-Assured Initialization, 2014

All Petrophysicists plus Geoscientists and Reservoir Engineers can benefit significantly from the topics covered in the papers above.

A Petrophysicist is not defined by the software he or she can use. It doesn't matter whether an Operator uses Techlog™, Interactive Petrophysics™, Geolog™ or any other package. None of these applications will give rise to better results because it is the expertise of the Petrophysicist who undertakes proper data quality assurance and then cerebral, iterative analysis. The software is simply a tool; however, many people now give the software far too much weighting. If you can drive Techlog™ or Petrel™ you are now an experienced Petrophysicist or Geologist / Modeller. I beg to differ.

Uncertainty

Understanding uncertainty is fundamental. Many people consider stochastic methods provide the best way to understand uncertainty. In theory this is the case; however, in practice we consistently under-estimate the range of uncertainty in input parameters, assume probability density functions which may be incorrect, fail to assign, or assign, incorrect dependencies. This leads to a range of results which staff and Management tend to believe is accurate. It generally isn't. Plus, the range of results may not be realistic in terms of what each scenario means. I think Shell started to realise their stochastic reservoir model-derived in-place volume estimates were flawed because many of the reservoir models were simply untenable.

A further nail in the coffin of stochastically derived estimates is the significant difficulty in auditing them. If it can't be audited then really, it shouldn't be used. Don't get me started on auditing 3D reservoir models!

Jeremy's preferred approach to petrophysical uncertainty is not to derive a single set of reservoir properties. In theory the objective of all technical evaluations is to derive the Most Likely properties, not the Mean or P50. In anything other than a uniform clean sand, estimating in isolation, the Most Likely properties, tends to be difficult, if not impossible. However, this is what the majority of Petrophysicists try to do, on a day-to-day basis.

There is a more rigorous way to describe some of the uncertainty. The validated raw data provides low and high values of each input parameter. The key words here are valid data. Thorough data quality assurance is absolutely essential before any evaluation is undertaken, otherwise invalid data gets adopted. Once the valid minima & maxima are known these provide boundaries for uncertainty scenarios. They are unlikely to describe the full range of uncertainty because the data probably doesn't reflect the total population. But they are, at least, auditable data-driven parameters.

Two petrophysical scenarios can easily be constructed using the Low & High input properties of the porosity model. This is easy and very auditable. The same approach can be used for Shale Volume, mineral proportions, permeability and water saturation. Now I hear you say; using all the Low (or High) estimates together is unrealistic; which I agree.

The probability of all the low parameters combining in nature is very low. Which is actually very useful because we can adopt these results as sort of equivalent to a P01 in the stochastic world, suggesting to Management that it's unlikely to be less than this, based on the data we have to work with. So, the Low (nominal P01) and High (nominal P99) reservoir properties can be derived in a straight-forward manner.

How does the Most-Likely estimate get derived? Therein is the problem. If the data does not provide an indication of a unimodal value, then it cannot be derived. In this situation the fall-back is to derive a Mid Case between the Low and High parameters and ensure Management understand this is not the Most-Likely scenario.

There are generally two explanations for inaccurate Petrophysical interpretations; firstly poor data quality assurance and secondly; the lack of partitioning of different petro-facies. In other words the Petrophysicist fails to separate out the different petro-facies and tries to characterise a mixture of log & core responses with one category. The classic core-plug poro-perm cross-plot is a common expression of this. I don't recommend anyone uses such a cross-plot without classifying all of the core plugs first. In fact don't try to derive poro-perm correlations using such cross-plots, at all.

Why do we have to deal with such uncertainty? The root cause is a misunderstanding, by Operators, of the value of information.

Operators perceive that obtaining whole core is too expensive and that it's more cost-effective to use other means such as logs. This is actually a fallacy.

Consider the levels of uncertainty in reservoir & fluid properties when estimated from (particularly uncalibrated) logs versus, for example, whole core. In theory, if the whole core is obtained correctly and the correct core plug handling and analyses are undertaken; then the sedimentological, lithological and reservoir property, plus fluid uncertainty, is minimal or even close to zero.

In other words, we know the answer at the well.

Without whole core of the reservoir, we do not know the answer at the well, we typically make a guess, or with a suitably experienced Petrophysicist; a range of guesses.

The moral of the story is spend the money to get the answer with minimal uncertainty because this allows confident investment or divestment decisions. Get whole core with a minimal suite of logs, perhaps just basic LWD, plus an RFT to confirm free-water levels. More often than not, Value of Information exercises fail to account for the amount of uncertainty inherent in different data types. For example, log-derived permeability has a significantly lower value than core derived; to the extent that the additional cost of acquiring core should be justifiable.

Last But Not Least

Jeremy can provide Operators with the expertise to achieve the lowest uncertainty data, including whole core acquisition, handling and analysis encompassing conventional and special core analysis programmes.

Visit www.oleumkhaos.com to find out more about Jeremy's 30+ years of experience and, if you're interested in a cost estimate for some petrophysical work, you can register and enter your project details in to the world's only online petrophysical project cost estimator.