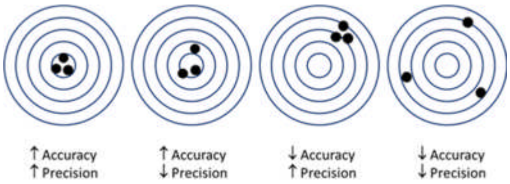


LPS One-day Seminar

"Petrophysical Uncertainty:

Why it matters and what to do about it"

On Wednesday 2nd December 2015 the London Petrophysical Society will be holding a one-day seminar entitled "Petrophysical Uncertainty: Why it matters and what to do about it" at the Geological Society, Burlington House, London.

Agenda

	Time	Speaker	Company	Talk Title
	09:00 - 09:25	**Registration**		
	09:25 - 09:30	Iain Whyte	LPS	Welcome & Introduction
1	09:30 - 10:00	Ashley Francis	Earthworks	***Managing Uncertainty in the Reservoir model***
2	10:00 - 10:35	Olivier Dubrule	Imperial College	***Evaluating Uncertainties***
	10:35 - 11:00	***Tea/Coffee***		
3	11:00 - 11:30	Brian Moss	Independent	***Uncertainty in a petrophysical context - an explanatory discussion of concepts and their implications***
4	11:30 - 12:00	Matthew Brown	E.On E&P UK	***Conceptual Uncertainty in Geoscience***
	12:00 - 13:00	***Lunch***		
5	13:00 - 13:30	Ingrid Demaerschalk	Tullow Oil	***Petrophysical Uncertainty in Geomodelling***
6	13:30 - 14:00	Heikki Jutila	Baker Hughes	***Petrophysical Uncertainties and incorporating them in Dynamic models***
7	14:00 - 14:30	Jean-Etienne Jacolin	Schlumberger	***Uncertainty analysis applied to a simultaneous volumetric solver***
	14:30 - 15:00	**Tea/Coffee**		
8	15:00 - 15:30	Bart Willigers	BG Group	***Maximising the value of Unconventional Reservoirs by choosing the optimal appraisal strategy***
9	15:30 - 16:00	Richard Arnold	Baker Hughes	***Uncertainty in core analysis data***
10	16.00 - 16:30	Mike Millar	BG Group	***A review of some of the uncertainties surrounding the use of electric logs***
11	16.30 - 17:00	Craig Lindsay	Core Specialist Services	***Continuous core data = less uncertainty ?***
	17:00 - 17:15	**Discussion & Closing Remarks**		
	17:15 onwards	**President's Evening - Christmas drinks & savouries at the King's Head, 10 Stafford Street, Mayfair W1S 4RX**		

The following pages contain the Abstracts

Managing Uncertainty in the Reservoir Model

Ashley Francis (Earthworks)

The last fifteen years has seen the role of geostatistics grow from an unused technology to a key application for estimating uncertainty in the volume of oil and gas reserves. Early work began with estimates of uncertainty in the reservoir envelope and this has now developed into the complex geostatistical reservoir models routinely used to determine static volumes and provide input to dynamic fluid-flow simulation. Despite significant advances current geostatistical reservoir modelling still has areas where the technology and user understanding is weak and this presentation will highlight a number of areas including:

- Impact on volumes of scale-up from well logs to model cells and seismic
- Volumetric bias introduced by inappropriate application of cutoffs
- Poro-perm transform strategies resulting in permeability smoothing
- Gross rock volume uncertainty ignored by use of fixed deterministic horizons and fault positions

In addition some significant problems still remain before we are able to fully integrate the wealth of seismic property information available from 3D seismic data volumes. Recent advances in our understanding of rock physics and greater use of pre-stack seismic inversion suggests one possible future of reservoir modelling lies in a direct coupling of the static model to the full 3D seismic response. A partial solution is stochastic seismic inversion. This will be used to illustrate both recent advances and remaining challenges to generating static reservoir models conditioned, via forward modelling, to the pre-stack seismic response in addition to the current conditioning to well and seismic horizon data.

Biography

Ashley Francis is Managing Director of Earthworks, a geoscience service and consultancy company. Ashley is a geophysicist and geostatistician with over 20 years world-wide oil industry experience in exploration, development and production. He has worked in service companies, consultancies and oil companies assisting and advising asset teams worldwide on geophysics, geostatistics, risk and uncertainty. He lectures in geostatistics to MSc Petroleum Geoscience students at Imperial College, London and has been running industry training courses in geophysics, geostatistics and prospect evaluation since 1996. A regular attendee to the SEG Development and Production Forum, he was chairman in 2000 and 2003. Ashley is a member of SPE, SEG, EAGE, IAMG, BSSS, IPSS and PESGB and a Fellow of the Royal Astronomical Society.

Evaluating Uncertainties

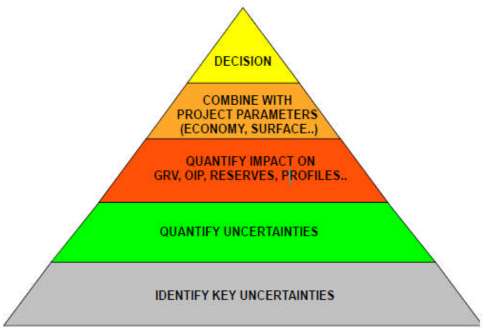
Olivier Dubrule (Imperial College/Total)

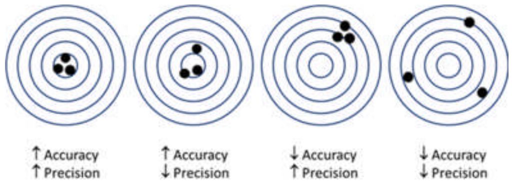
Most oil and gas companies are keen to evaluate subsurface uncertainties likely to affect a new development, especially in the current oil price climate. Different companies use different approaches, from so-called “deterministic” scenario-based approaches to fully stochastic ones.

However, whatever the approach used, experience shows that the industry does not have a good track-record of evaluating uncertainties. The presentation will provide a discussion of the existing approaches, and of why they can be challenging to implement. The following points will be stressed:

- Evaluating uncertainties means anticipating all possible subsurface outcomes, which is simply impossible. All we can do is imagine a number of outcomes and quantify their economic impact.
- Most uncertainties evaluations must be performed with the goal of providing support to decision-making. It is important to be aware of which decision is at stake (Figure below).
- Different companies have different cultures as far as uncertainty evaluations are concerned.

Some are more reluctant to use stochastic techniques, arguing that “deterministic” approaches are more reliable. This dichotomy of view will be discussed.
- Subsurface uncertainty quantification may be a waste of time if it focuses on parameters that have no impact on the final criterion that will be used for the decision-making. This means that we should not just simply evaluate parameters uncertainty but also the impact of this uncertainty. The Bayes formalism nicely clarifies this association between uncertainty and impact.
- Some petrophysical uncertainties are easier to incorporate than others in subsurface uncertainty studies. However there are numerous associated challenges, such as the impact of upscaling, or of interrelationship between geological, elastic and dynamic parameters.





Uncertainty in a petrophysical context - an explanatory discussion of concepts and their implications

Brian Moss (Independent)

A degree of uncertainty is a fundamental attribute of any measurement activity and the business of making predictions from those measurements. In the guise of "Error Analysis", capturing uncertainty and using this information to qualify predictions is a fundamental underpinning of the science of inferential statistics. We see a distinction drawn between random errors and systematic errors and discuss the way in which each type of uncertainty (error) can be observed and used in making predictions. This part of the presentation touches on Bayes' method for capturing prior knowledge in the form of observed uncertainty to improve predictions. Moving into the geoscience world, we see the importance of data partitioning - not mixing populations - in providing summary statistics with the potential for reduced uncertainty. This has implications for upscaling. Clever engineering, careful calibration and operating within design limits helps us understand and quantify the uncertainty attendant in our petrophysical measurements. Recognizing the potential for systematic errors in our choice of model and the parameterization of those models is a very important part of understanding the strength of our petrophysical predictions. Those predictions frequently carry significant economic consequences.

The presentation will visit the world of statistical inference to cover fundamental explanatory concepts and illustrate the implications drawn from that understanding when conducting geoscientific and petrophysical analyses.

Conceptual Uncertainty in Geoscience

Matthew Brown (E.On E&P UK Ltd.)

In 2007 a paper by Bond *et al.* described the results of a study on how geoscientists deal with conceptual uncertainty in incomplete datasets. This study asked respondents to interpret a seismic section (Fig. 1) and determine the structural regime it represents. Respondents were also asked to complete a questionnaire detailing aspects such as their length and area of expertise and educational background.

Bond *et al* (2007) concluded that experience and education level did not have a significant impact on the number of correct responses. Instead the number of different techniques used to interpret the section was the key determining factor. Use of particular interpretation techniques encourages “Geological Evolutionary Thought” and this increases the likelihood of a correct interpretation. This leads to the concept of an “effective expert”; someone who uses several techniques to achieve a good result regardless of their experience level.

This talk introduces the Bond *et al* (2007) paper and describes the results of running the same experiment within E.ON E&P. It will highlight some of the biases that we are subject to using examples from these experiments. I will develop these ideas in the context of seismic interpretation in a standard industry environment; highlighting pitfalls of workstation based interpretation. The presentation will conclude by suggesting some ways in which we may improve our interpretation with the aim of understanding and reducing conceptual uncertainty.

Bond, C.E., Gibbs, A.D., Shipton, Z.K. and Jones, S.; 2007, What do you think this is? “Conceptual Uncertainty” in geoscience interpretation. GSA Today, V. 17, no. 11, p4-10.

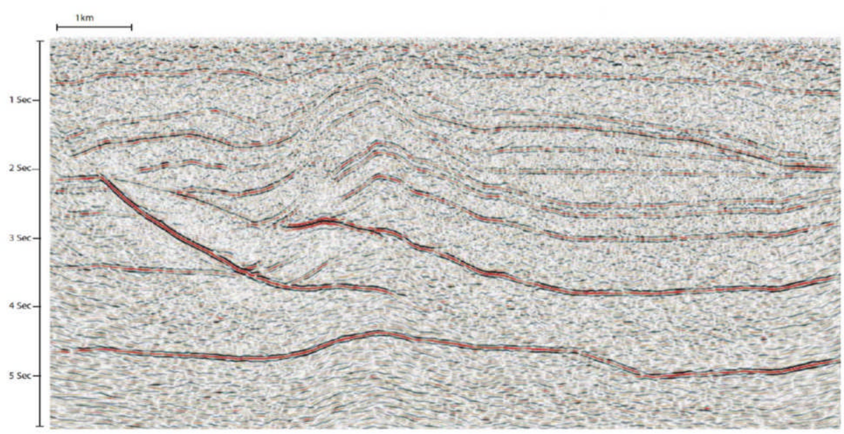


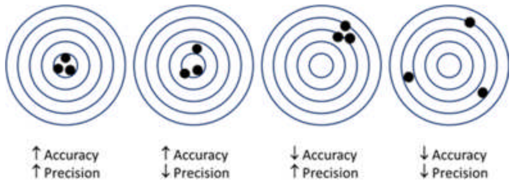
Figure 1. What do you think this is? (Please feel free to have a go before I tell you !)

Petrophysical Uncertainty in Geomodelling

Ingrid Demaerschalk (Tullow Oil)

When considering any uncertainties it is important to remind ourselves why we are building models in the first place. After a quick overview of the modelling workflow we will have a look at potential petrophysical uncertainties to include and look at a few things to consider when assessing what to include and what matters.

Alternative workflows will be explained including some principles and tools which help the geomodeller and their team to practically include the uncertainties.



Petrophysical Uncertainties and Incorporating Them in Dynamic Models

Heikki Jutila (Baker Hughes)

The petrophysical uncertainties tend to be forgotten sometimes while building and running dynamic (simulation) models. This may because they seem to be hidden in the ‘bowels’ of the earth models. The dependencies between, for instance, permeability and water saturation are not always well communicated between the disciplines and might have a significant impact on the hydrocarbons in situ estimations.

The main petrophysical inputs into dynamic models are usually a permeability-porosity relationship, relative permeabilities, capillary pressures and some estimate of initial water saturation. These tend to be currently modelled in integrated packages and they are rarely changed during the dynamic calibration phase (history matching).

The petrophysical relationships are represented as equations where porosity and sometimes facies are the independent variables. Permeability, saturation, and so on are dependent. Current dynamic modelling packages have the facility to do calculations internally using various arithmetic operations; conditional statements can also be affected. This gives the opportunity to fully incorporate these relationships into dynamic modelling. They can be sensitised and refined manually or using modern Assisted History Matching tools.

Biography

Heikki Jutila is Regional Discipline Lead for Reservoir Engineering at Baker Hughes Reservoir Consulting, based in Aberdeen.

He has 34 years’ experience in petroleum and reservoir engineering gained with Shell, Neste Oy, Halliburton, PGL (now LR-Senergy), ingen-ideas and as independent consultant before joining Baker RDS 4 years ago.

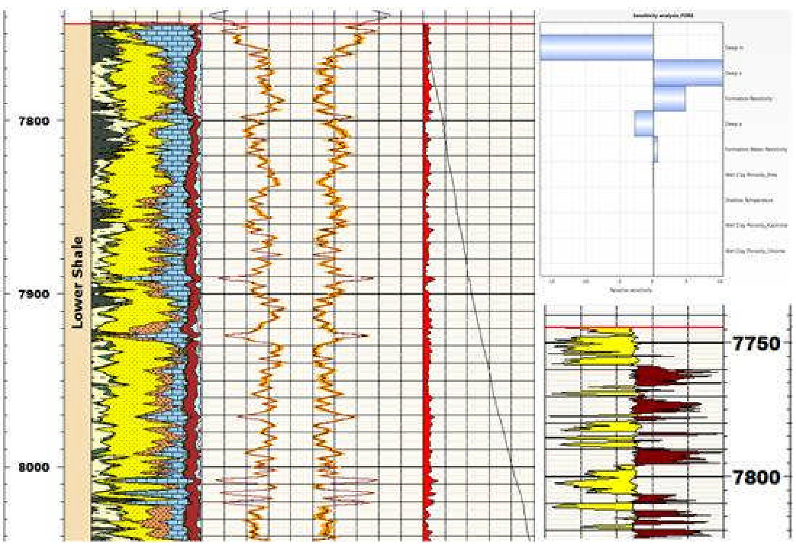
Uncertainty analysis applied to a simultaneous volumetric solver

Jean-Etienne Jacolin (Schlumberger)

The mineralogical volumetric inversion technique that can be used for quantitative formation evaluation consists in optimizing simultaneous equations describing one or more interpretation models. By doing so, and as opposed to classical sequential evaluation, all inputs are considered simultaneously, and more importantly, the effects of the reservoir components on all of the inputs (gas, heavy minerals, etc.) are being accounted for. Depending on the complexity of the reservoir, the volumetric inversion model can become complex, and can use as inputs non-conventional logs such as NMR or spectroscopy.

Assessing the relevancy of the model and the quality of the results is key in the process, and it becomes important to evaluate in which extent the outputs become dependent on slight variations in the model parameters and settings. In other words how robust the model is.

This presentation details several techniques that can be used for that purpose. First one is aimed to review the complexity of the system, in the light of the set of inputs that is used. With one key question that is raised, should the model be over-determined. Then, the influence of the model inputs and parameters will be assessed through both Monte-Carlo and Sensitivity analysis. Finally, the notion of scenario will also be examined together with the criteria that can be applied to select one of the scenarios.



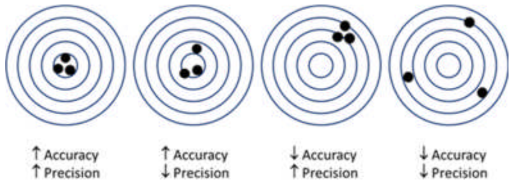
Maximising the Value of Unconventional Reservoirs by Choosing the Optimal Appraisal Strategy

Bart Willigers (BG Group)

The decision whether or not to develop a reservoir is largely determined by the outcome of the appraisal programme. The choice of appraisal strategy largely determines the amount of remaining uncertainty around reservoir performance that is carried forward to the development and execution phase of the project. Hence, the selection of an appraisal strategy is a crucial decision that has a large impact on the ultimate value generation potential of a hydrocarbon accumulation. Reservoirs are appraised by drilling and producing wells. In unconventional reservoirs these wells sample an underlying population of possible wells that could be monetised if the decision is made to develop the reservoir.

This study explores how an optimal appraisal strategy can be designed in terms of the number of appraisal phases, the number of wells to be drilled in each appraisal stage, and how long to produce the appraisal wells before deciding whether to abandon the project or whether to progress the project to the next stage. It is demonstrated how the view on the average expected ultimate recovery of a well in an unconventional reservoir can be repeatedly revised as new information arises during appraisal.

Production data from a large well set from the Montney Formation, that straddles British Columbia and Alberta, Canada has been used to assess the predictive power of initial production on the expected ultimate recovery of a well.



Uncertainty in Core Analysis Data

Richard Arnold (Baker Hughes)

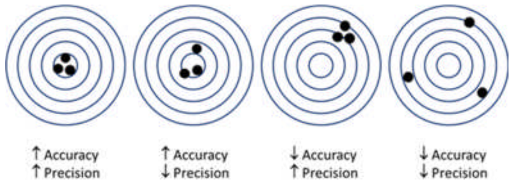
Data used to calculate hydrocarbons in place and recovery come from a variety of sources and is often used without calibration. Reliable and representative core analysis data are essential to calibrate and validate the other, remotely-sensed, data in order to reduce uncertainty in the calculations. No remote data source can be viewed in isolation from core analysis data. Core provides a direct sample of the reservoir and so should be the standard against which other data can be compared and validated.

While core data reduces the uncertainty in other datasets the uncertainty in core data needs to be understood, quantified and where possible, eliminated. This is often dependant on the core being correctly treated and analysed accordingly, with a test programme being designed in such a way as to provide the end user with the data required, rather than the “usual” programme.

Examples of how uncertainty can affect core analysis data and some basic precautions to avoid poor quality data will be discussed.

Biography

Richard is Senior Petrophysics/Core Analysis Consultant at Baker Hughes Reservoir Services, based in Aberdeen.
He has over 35 years of industry experience in formation evaluation and reservoir description through core analysis gained with Core Lab, Corex and Robertson Research before joining Baker RDS 5 years ago.
He is currently President of the Scottish Chapter of the SPWLA – the Aberdeen Formation Evaluation Society (AFES).



Whether we Push or Pull, where does the uncertainty come from ? A review of some of the uncertainties surrounding the use of electric logs

Mike Millar (BG Group)

So what's the problem with electric logs? We have good logging tools and we have good logging engineers who know how to run them. We have computers to analysis the log readings. Logging tools are designed and built by humans, their designs are based on assumptions and simplifications of the real world, and then they are run in very demanding conditions. All of which are subject to error and uncertainty.

This talk will take a brief look at some of the issues and uncertainties surrounding the acquisition and use of open-hole electric log data, whether the well is logged by wireline, LWD or any other conveyancing method. It will try to show why the calibration and quality control of logging tools and log curves is so important. Logs are frequently the only safe and cost effective way of collecting accurate borehole data that can be used to meet well objectives and so they add considerable value to our business.

Each logging tool has a specific range of measurement uncertainty which will result in a definable range of accuracy. Nuclear processes are essentially random, but can be described with Poisson statistics. All tools use man-made instruments to measure the logging responses and are thus subject to accuracy limits. These are the published by the logging companies in their various tool catalogues and QC guides the ranges of accuracy of logging tools should be the concern of all users of logs, especially if you are running probabilistic type evaluations.

Drilling the well changes the rocks and fluids, for example, pressure, temperature and chemical changes. All borehole measurements (logs, cuttings, cores, fluid samples) are affected to some extent by drilling mechanics and the mud. Logging tools are designed to run in specific ways under specific conditions, variations from these will materially affect the reliability and accuracy of the measurement.

Unless we know where the log measurement comes from, it has no value. Depth measurement is just as uncertain as any other measurement. We never have absolute depth accuracy, there is always error. And there are a number of depth references, such as Drill-floor (DFE), Rotary-table (RTE) or Kelly-bushing (KBE) elevations, Mean sea-level, Ground level, Mud line. We need to be very clear which depth reference is being used.

Continuous core data = less uncertainty ?

(Craig Lindsay, Core Specialist Services)

Based upon practicality, cost and practice the majority of core data is acquired from individual core plugs which only sample a small volume of the core raising the question of “how representative is the resultant data and what is the level of uncertainty”? This situation is made worse in the case of advanced studies such as SCAL and geomechanics where due to budgetary and cost constraints a small number of samples are subject to analysis. Selecting representative sampling points particularly in heterogeneous rock can be problematic. Data derived from such studies can have a profound economic and strategic impact on filed development and asset value.

Multi-sensor core scanners can acquire a wide variety of data types in a single pass. The resultant high resolution data can provide a powerful resource for enhancing our knowledge of the rock properties. Most importantly representative intervals can be identified that can be subsequently targeted for sampling for advanced studies, considerably reducing uncertainty.

This presentation provides an overview of the meaning of “continuous” core data and some of the available technologies. Examples are shown of the application of “continuous” core data and it use as an aid in sampling for advanced studies.

These data are not commonly provided by core analysis contractors and yet could be at relatively low cost after initial investment in equipment. The volume of data that can be acquired could readily generate entire new petrophysical workflows to enhance and combine with petrophysical log data for more effective formation evaluation.

Biography

A geologist by background, Craig has 32 years of experience in the core analysis industry. After 18 years working in the lab in a wide variety of roles, Craig joined Helix RDS consultancy in 2002 and went on to found Core Specialist Services in 2010. Core Specialist Services are a consultancy specialising in the planning, design and management of core based studies. Craig served as President of the Society of Core Analysts from 2012-13. Core Specialist Services have a combined total of more than 120 years in the core analysis industry.