Modelling for comfort or comfort from modelling?

By David Gardiner

Basin & Petroleum Systems Modelling (BPSM) has been utilized within petroleum exploration since the 1970's, helping to underpin several aspects of a successful prospect appraisal by allowing the quantification of risk on key elements affecting prospectivity, e.g. source maturity, charge timing & reservoir temperature history.

In today's low-cost environment, utilizing BPSM is more important than ever, with several outputs which contribute towards a prospect's *Probability of Success* (PoS). Companies who integrate rigorous BPSM into their exploration workflows are typically better able to constrain a prospect's PoS, allowing a more informed/balanced opinion of the prospectivity prior to drilling. Whether this ultimately leads to an increase in successful discoveries is less clear and is ultimately dependent on the modelling approach, quality of data and the understanding of uncertainty in any interpretation.

All models contain inherent biases from the user, both in terms of deciding inputs and interpreting results, no matter how objective we intend our models to be (Grandy, 2003). Subjective decisions are required throughout the workflow to prioritize and quantify inputs to best replicate a natural system.

It is therefore easy for models to be built to support decisions that have already been made, either wholly of partially. This has been referred to as "*modelling for comfort"* (Bentley, 2015). In many cases, we are primarily modelling for the comfort of decision-makers (e.g. exploration managers), and overly fixed review processes tend to encourage this. It can be far easier to provide technical support for a project to move ahead, especially as most teams may promote projects to progress after a significant amount of budget and/or personal effort has been invested. Ultimately, however, it is asserted that the power of modelling is greatest when it is used to improve or change a decision, even if this causes discomfort in the process.

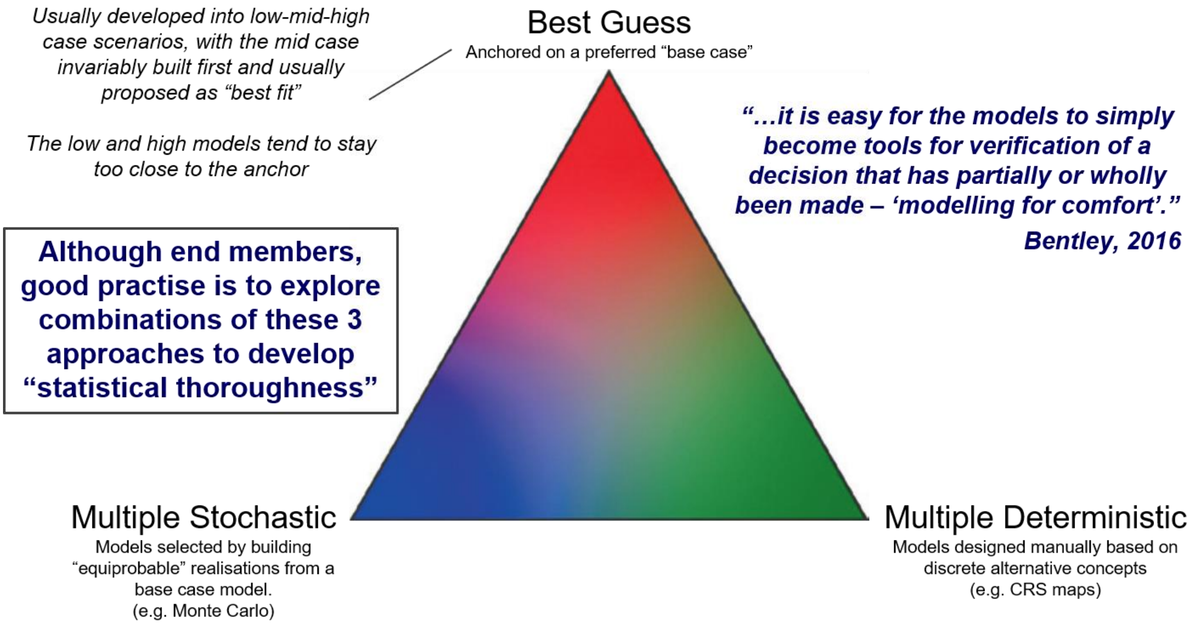

Figure 1: There are multiple approaches to basin modelling, each with inherent advantages and disadvantages with respect to user bias, time cost and ease of results integration to determine a prospect's Probability of Success (PoS) (modified from Bentley, 2015).

Perhaps a best practice workflow may be to utilize a range of modelling approaches, compensating for the inherent biases we invoke if relying on one modelling concept (e.g. stochastic *vs.* deterministic). In Figure 1 we demonstrate how a best-practice workflow should integrate at least 2 (or more) modelling approaches to compensate for these biases.

For example, within BPSM a prospect's PoS may require information on charge phase and volumes, which can be explored using a multivariate stochastic approach (e.g. Monte Carlo simulation) to test the impact of distributed ranges of key inputs (e.g. TOC, kerogen kinetics, geothermal gradients). We should combine these results with a deterministic approach, creating multiple Ultimate Expulsion Potential (UEP) maps by assuming variables which together comprise what the modeler would term low-case, base-case and high-case scenarios. The outputs from deterministic models can be combined into Common Risk Segment Maps (CRSM) on which, like in reservoir play fairway analysis, discrete components can be "stacked" to produce composite maps that highlight areas of greatest probability of any number of factors (e.g. mature source rock).

The outputs from these modelling approaches may either correlate or dissociate, but either way, digging deeper into the data to understand the results may yield important information which can help better constrain the next iteration of the model, and ultimately affect the PoS. Communicating this uncertainty to decision makers who want concise summaries and simplified PoS values is another issue…!

When "modelling for comfort" it is easy to achieve the results you want/need by tailoring the inputs and refining scenarios until the desired outcome is achieved. This is of course bad practice with little scientific merit, which ultimately risks significantly overestimating the PoS.

However, a related approach can be useful, particularly in speculative/data-poor areas, when used to define scenarios based on "what do I need to make the system work?", and critically assessing how likely the required inputs are. If any parameters are deemed unrealistic then this should lower the PoS proportionally, potentially below the company's risk threshold for approval (which is of course still a valid modelling outcome).

Perhaps the most informed approach is to acknowledge the inherent uncertainty and limitations of each modelling approach and use a multi-faceted approach which integrates different techniques (deterministic & stochastic approaches), aiming to keep the model as objective and predictive as possible. By doing this, we can perhaps take "comfort from modelling" when making critical decisions.

References

BENTLEY, M. 2015. Modelling for comfort? Petroleum Geoscience, 2014-089.

GRANDY, R. 2003. What Are Models and Why Do We Need Them? Science & Education, 12, 773-777.