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What you want and what you get – next generation petroleum system analysis technologies

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ABSTRACT

A challenge for the scientific and technology developing community is that goals appear not always to be well aligned with the needs of the Explorationist.

What we – as an exploration company - want is flexible technology which allows us to work efficiently to test geologic scenarios in real-time, but what we see is the increase in computing power being eaten up by ever more complex modelling approaches.

What we want is to spend 95% of the time on understanding and solving the problems, but what we often get are workflows where 95% of the time is spent on data compilation, constructing models and debugging.

We also see the need to dynamically display geologic processes instead of “frame by frame” in “static” post-simulation settings in order to better understand simulation results.

The contributions of petroleum system analysis to exploration today are (1) the identification of prospective acreage by addressing the presence and quality distribution of source rock, (2) empirical and/or numerical prediction of the present day and paleo-temperature field and (3) its impact on petroleum generation and expulsion processes. Fluid migration models (4) are also applied to some extent but may be more relevant for scenario testing rather than allowing for reliable predictions.

We will discuss each of these components, beginning with the prediction of source rock presence. This is still a challenge in many areas, even where source rock has been penetrated by wells, because these observations may not be representative of the source rock in the deeper kitchen areas. To address these questions, we have developed technologies to detect source from seismic (Løseth et al., 2011) as well as explored the possibilities offered by paleo-climate modelling. Here we focus instead on methods for representing organic matter sedimentation and preservation within basin-filling depositional models. We demonstrate an example where we utilise commercial software to predict source rock formation and offer a glimpse of our in-house developments using similar methods.

Once source quality distribution is constrained, the question of its hydrocarbon generation behaviour arises. In numerical simulations we have used kinetic concepts to describe petroleum generation for more than 30 years. Current kinetic approaches have focussed on adding more components or reactions to kinetic schemes to enable PVT predictions. However, it is also suggested that the conventional design of kinetic parameter sets may have flaws (Stainforth, 2009). We addressed this topic and developed a more accurate and physics-based description of hydrocarbon generation. We show an example using the thermal alteration of vitrinite as a starting point, but also highlight the potential of the novel concept for primary generation and secondary cracking simulations.

Since those computations depend on a precise prediction of temperature and temperature history, we show examples of tectonically- and seismically-constrained thermal models, as opposed to classical basin models. Eventually, we aim at moving from such discipline-specific, stand-alone technologies for temperature prediction to models where such computations are integrated in a meaningful way.

Once temperature-constrained generation models are available, the question of when and how petroleum leaves the source rock needs to be addressed. Here we give examples of outcrop-scale observations of expulsion supplemented by experimental observations conducted at the University in Kiel which are used to create stress dependant expulsion models. The experimental data may not easily be scaled to expulsion happening over geologic time in a basin, but the approach allows complementing mechanistic models with organic geochemical parameters.

In the field of petroleum migration we pursue both quick turnover methods as well as heavy stochastic approaches in cooperation with Migris AS (see also Tømmerås presentation). An example from a failed structure in an otherwise prolific basin will show which shortcomings we need to overcome to obtain predictive methods.

While geophysical constraints can be used to improve basin models, the output of basin models can also be used to improve seismic imaging. We will show an example of where “Geophysical Basin Modelling” (Szydlik et al., 2015) helped improve seismic imaging by optimising the velocity field to geologically reasonable scenarios. Common practice in seismic velocity model building is to make simple assumptions in areas where reflectivity is poor. These assumptions are typically smooth and numerically simple, but often geologically implausible. Basin model outputs coupled with rock physics models can vastly improve these velocity models, giving a marked uplift in image quality.

These examples show a wide range of topics which we hope will improve exploration work and may give some suggestions as to which direction PSA technology development could head in the future.