Updating structural models under uncertainty

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The last few years have seen significant advances in reservoir modeling technology, aiming at removing some of the critical bottlenecks in underlying work processes.

Given the large uncertainties and limited data available, it is easy to recognize the value of using all available data to its maximum potential while simultaneously managing uncertainties. Unfortunately, however, both data and knowledge tend to get lost when transferred between disciplines, and more importantly, so do the associated uncertainties.

This leads to incomplete and maybe inconsistent information being passed through the modeling chain that ultimately ends up forming the basis of decisions made on field development and planning. Hence, a focus on getting it right from the beginning of the reservoir modeling workflow should be of key importance.

Against the context of relatively low oil prices and a declining trend in investment returns, it’s our belief that it is time to revisit some of the classical reservoir modeling approaches and demonstrate alternative solutions. This article will look at how we meet these requirements and accommodate and support alternative approaches for reservoir improvement.

A seamless integration of geophysics in characterizing reservoir structure

It’s essential that geoscientists and geophysicists are given control over the uncertainties in the definition of the reservoir structure.

It is well known that the assumptions made during seismic processing and the ambiguity inherent in the data leads to a fairly large uncertainty on predicting the true depth of reflectors and faults.

The source of these errors can - to a large degree - be attributed to the lack of data for estimating anisotropy or directional dependencies of seismic velocity. Therefore in fields with limited well control and/or low quality seismic, uncertainties in the velocity model and seismic interpretation are generally agreed to be of primary importance.

However, even though the industry is well aware of the uncertainties linked to depth conversion and the risks involved, the uncertainties are more often than not ignored. At the stage where the reservoir grid is made, there is usually no going back to revisit these early and highly important assumptions.

This practice can (depending on company policy) be extended to involve a hand-picked selection
of alternative velocity models, or simulated horizons in a random-field (i.e. adding noise).

The technology for the seamless and automated incorporation of multiple structural realizations based on uncertainties in both the velocity model and seismic interpretation has recently been made available within Emerson’s reservoir modeling software, Roxar RMS. We believe that this will lead to an improved practice of combining a statistically most likely case with an ensemble of models capturing the uncertainty estimates.

**Uncertainty in the interpretation of a seismic reflector**

Determining exactly the position of a seismic reflector during interpretation can also be a time-consuming and challenging task, due to the low resolution inherent in the seismic signals.

Our solution is to simultaneously interpret and define an envelope of probable and alternative positions of the horizons or faults in a model driven interpretation approach. This allows for an interpretation at the level of detail that can be justified by the quality in the seismic signals.

The efficiency of the interpretation is secured through a flexible combination of new snap-to-seismic technology useful in areas of good signals, and dynamic interpolation where the seismic signal is disrupted or too noisy to position the reflector accurately.

A key advantage of this approach is that the geophysicists and geoscientists are given the means to propagate their knowledge of interpretation uncertainty into the modeling workflow. Furthermore, because the knowledge of uncertainty is captured, the model driven interpretation allows the flexibility to switch between deterministic and stochastic simulation approaches in modeling the reservoir structure.

**An automated workflow with multiple realizations of reservoir structure**

Multiple realizations of structural models and the automatic creation of 3D grids are, according to many practitioners, a long way from reality in the industry today.

We can only speculate as to what the true reasons are for the lack of incorporating structural uncertainties as a standard modeling step, but one explanation might be that there have been limited possibilities for integrating the velocity modeling as a stochastic process in the workflow.

Another reason might be that few gridding solutions today can handle varying input data of faults and horizons and still produce consistent, sensible 3D grids of the changing structures – grids that are ready for simulation without heavy, manual-based QC steps.

Robust and flexible 3D gridding fully integrated with the structural model has been the backbone of Roxar software technology for many years (e.g. Hoffman et al. 2008).

The real step-change can be seen in the implementation of the new technologies as described above, i.e. model driven interpretation and geostatistical depth conversion, Together, these enable the estimating of the impact of realistic structural uncertainties on key outcomes, such as
volumes in place and simulated reserves, or its impact on well performance and net present value.

![Figure 1: Fault uncertainty envelopes](image)

**Calculating GRV uncertainty in an offshore Middle East field**

In one offshore Middle East example, the operator used Emerson’s model driven interpretation approach to quantify Gross Rock Volume (GRV) uncertainty.

The sole owner of the field in question is the Abu Dhabi National Oil Company (ADNOC) with Abu Dhabi Marine Operating Company (ADMA-OPCO) the operator.

The reservoir in question is in the appraisal/early development stage. It has nine wells unevenly distributed across the field, not all of which have penetrated the bottom of the reservoir. The quality of the seismic data is only fair, with limited well and seismic data and limited confidence in the velocity model. Against this background, there was a need to quantify uncertainty within the reservoir model and in particular calculate Gross Rock Volume (GRV) uncertainty.

Figure 1 illustrates the fault uncertainty envelopes generated. The uncertainty along the faults can be provided during interpretation for each point or can be kept constant and defined manually on both the hanging wall and the footwall side during the structural modeling workflow.

Based on the geological knowledge of the reservoir and seismic signal quality, the ranges of fault parameters such as lateral position, dip, strike and throw can also be now incorporated within a defined range to run multiple realizations.

The next stage of the workflow was the creation of a 3D grid out of which multiple realizations were generated to quantify GRV ranges (see figure 2). This generated the P10, P50 and P90 GRV values as well as indicating which horizons, velocity models or fluid contacts are affecting the GRV calculation.

The results for ADMA OPCO will be improved GRV uncertainty, valuable input into field appraisal and development plans, and reduced risk.
Final Thoughts

This article has described new technology integration and workflow steps that helps the asset teams towards closer integration of the reservoir modeling workflow between the geophysics and geomodeling domains.

By investing resources to set up the workflow from interpretation to gridding and classical reservoir characterization, the benefit is that you will make the foundation for an evergreen model that can be refined, updated, or even dismissed as we move through the different reservoir modeling domains.

It is not enough for an integrated software platform to only be able to perform the operations of each domain. The key is that all the information, including uncertainties, is part of a broader knowledge transfer. Only then can a workflow be said to be truly integrated.

References


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