DRILLING & EXPLORATION WORLD

DEW

THE COMPLETE ENERGY JOURNAL

IN PUBLICATION SINCE 1989

INTERNATIONAL EDITION

Volume 23 Number 01

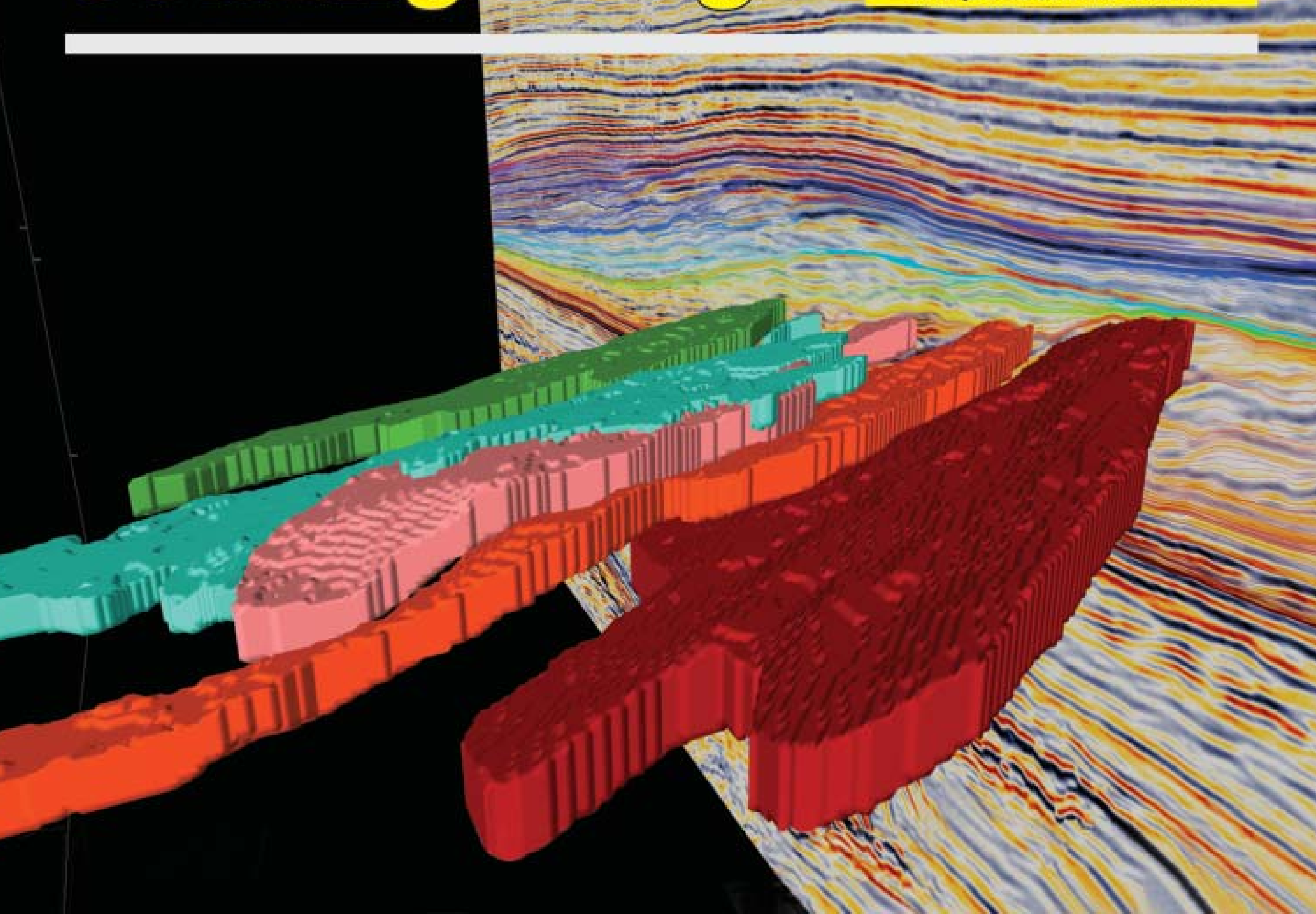
ISSN - 0971 - 7242

dewjournal.com

November 2013

Global seismic interpretation techniques are coming of age

The advances in seismic technology over the last few years have been phenomenal, particularly in the areas of seismic acquisition, processing and interpretation. Global seismic interpretation include a variety of different methods, such as 'Age Volumes', 'PaleoScan', 'Volumetric Flattening' and 'HorizonCube'. Such techniques share a number of algorithms in common with their aim being to correlate seismic positions along geologic time lines to arrive at fully interpreted seismic volumes



Creating the perfect reservoir model

Garrett Leahy, Technical Product Manager, Emerson Process Management

With global oil and gas recovery rates averaging only about 35% (Rigzone, August 2012), reservoir modelling remains one of the most important tools available to the oil & gas industry today in securing its long-term future and delivering improved investment and asset returns.

Model driven interpretation is leading the way enabling operators to squeeze maximum value from their models and heralding a true coming of age. Perhaps the perfect reservoir model is not that far off after all! This article looks at how we can get closer to generating that perfect reservoir model.

Mapping, understanding, and predicting the behaviour of oil and gas reservoirs is critical to profitable business – and the best operators know that having the best 3D reservoir model is the key.

From seismic acquisition and interpretation through to the structural model, fault and fracture modelling, history matching and simulation, reservoir modelling has become the place to integrate subsurface data and guide-decision making.

With the right reservoir model, an operator obtains a spatially accurate analysis of the field, tools to explore reservoir management, and the best available information to estimate reserves and future performance.

Reservoir modelling is also a crucial tool in the industry's goal to increase reservoir recovery rates. Statoil, for example, has a target recovery factor of 65% for platform operated fields and 55% for subsea-operated fields. To obtain maximum reservoir performance, Statoil uses Emerson's reservoir modelling software, Roxar RMS (*Fayemendy et al, EAGE First Break v30, October 2012).

Yet, given the importance and the high regard in which reservoir modelling is held today, are current reservoir modelling software workflows delivering? How close are we to delivering that perfect reservoir model?

Current Limitations

While current modelling challenges such as the unpredictable nature of reservoirs, more complex geological settings and economically marginal prospects, might make the perfect reservoir model a distant reality, there are a number of very specific limitations to reservoir modelling today that need to be addressed.

There remains an increased reliance on a single reservoir model for the subsurface structure, despite the data often supporting many different interpretations. This represents a lost opportunity: many hypotheses and scenarios are

> Given these pre-requisites for the perfect reservoir model, how can we bolster the effectiveness of reservoir modelling workflows today? Emerson is achieving this through a new model driven interpretation workflow based around its latest reservoir modelling software, Roxar RMS 2013. With a variety of new tools, Roxar RMS 2013 gives interpreters the ability to capture uncertainty during the interpretation process to levels and at speeds not previously seen; undergo quicker and more agile modelling with limited data; and access innovative new fault, uncertainty management and up-scaling modules

discarded, even though they may satisfy the data.

For example, current limitations in seismic acquisition technology often lead to only a portion of the earth response being captured in a seismic image and uncertain estimates of horizon or fault locations. This ambiguity also increases markedly as the interpreter moves away from higher certainty data points (such as well logs or cores) resulting in many configurations or scenarios (fault configurations, for example) supported by the data but unable to be distinguished based on the data alone.

Another limitation is that uncertainties in static reservoir properties – depth conversion, fault model, or facies distributions – are often difficult to quantify in reservoir models, particularly in frontier areas where there is little well control. Factors, such as these, are crucial in determining the commercial viability of a prospect and yet are not being explored and analysed to their full potential.

The interpreter might, for example, be relatively sure of the position of a horizon if it has been observed in a number of wells but less sure it the position was derived from seismic data imaged through a salt dome in a region which has never been drilled.Questions need to be addressed, such as: How effective is a given measurement of the real earth? For known features, what variability in measurement is tolerated by the data?And how accurate is the estimate of a peak of a seismic event?As the oil industry moves into more challenging territories, quantified risk assessment will become a key priority.

Finally, the disjointed and time consuming nature of many reservoir modelling workflows today provides one of the biggest barriers to adding uncertainty to a reservoir model: time. With geophysicists interpreting thousands of points at seismic scale, and geo-modellers doing the best they can to fit the model to the interpretation, it's perhaps inevitable that many iterations may be required before the model converges to a fit-for-purpose solution.

In summary, while reservoir modelling has advanced hugely over the last few years, the perfect reservoir model is still some way off. The rest of this article will look at how we can get closer to generating that perfect reservoir model.

The Perfect Reservoir Model – Key Characteristics

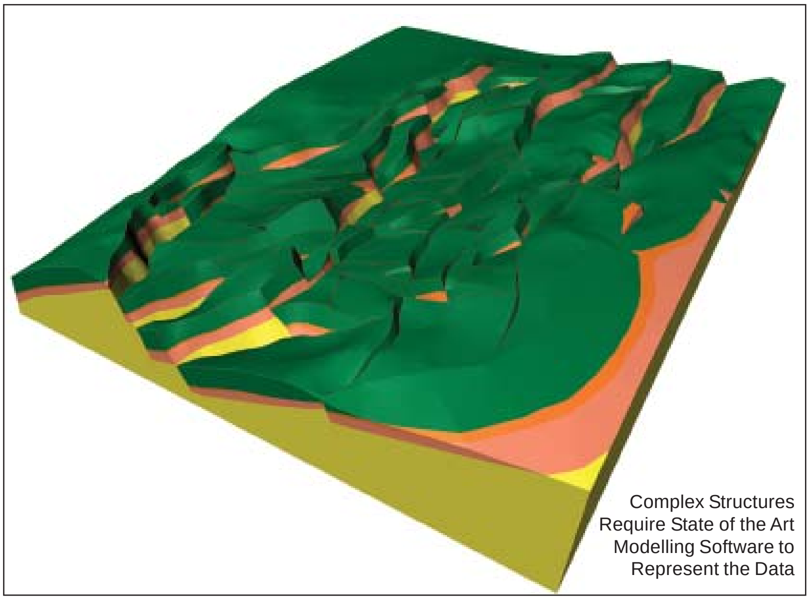
So what are the essential elements of the perfect,fit-for-purposereservoir model? In my opinion, there are four key benefits reservoir models must deliver for the operator.

Firstly, reservoir models need to represent the data – whether from seismic images, property logs, regional geology or even production data – accurately and comprehensively. Such models need to generate a realistic depiction of the geometry and properties that impact fluid flow and volumes, and an accurate representation of the structural framework. This includes faults, geologic horizons in the reservoir and all heterogeneities in the reservoir.

Secondly, reservoir models need to be able to operate effectively in all environments and deal with whatever structural or modelling complexities are thrown their way. Whatever the reservoir's geological complexities, operators need to be able to generatepredictive reservoir models that realistically represent the underlying seismic data.

Thirdly, reservoir models need to pose the right questions and generate information that can be used directly as input into decision-making. With the gigabytes of data that can potentially be generated, this requires a tight integration of the data and an understanding of the various roles of interpreters, modellers, reservoir engineers, and drillers and the data they need throughout the process.

Finally, reservoir models need to get better at quantifying uncertainties and accurately depicting the inherent risks throughout the reservoir lifecycle. Whether it be bid valuations, new field development and operational plans, or production estimates or divestments, operators need to quantify uncertainty within



Complex Structures Require State of the Art Modelling Software to Represent the Data

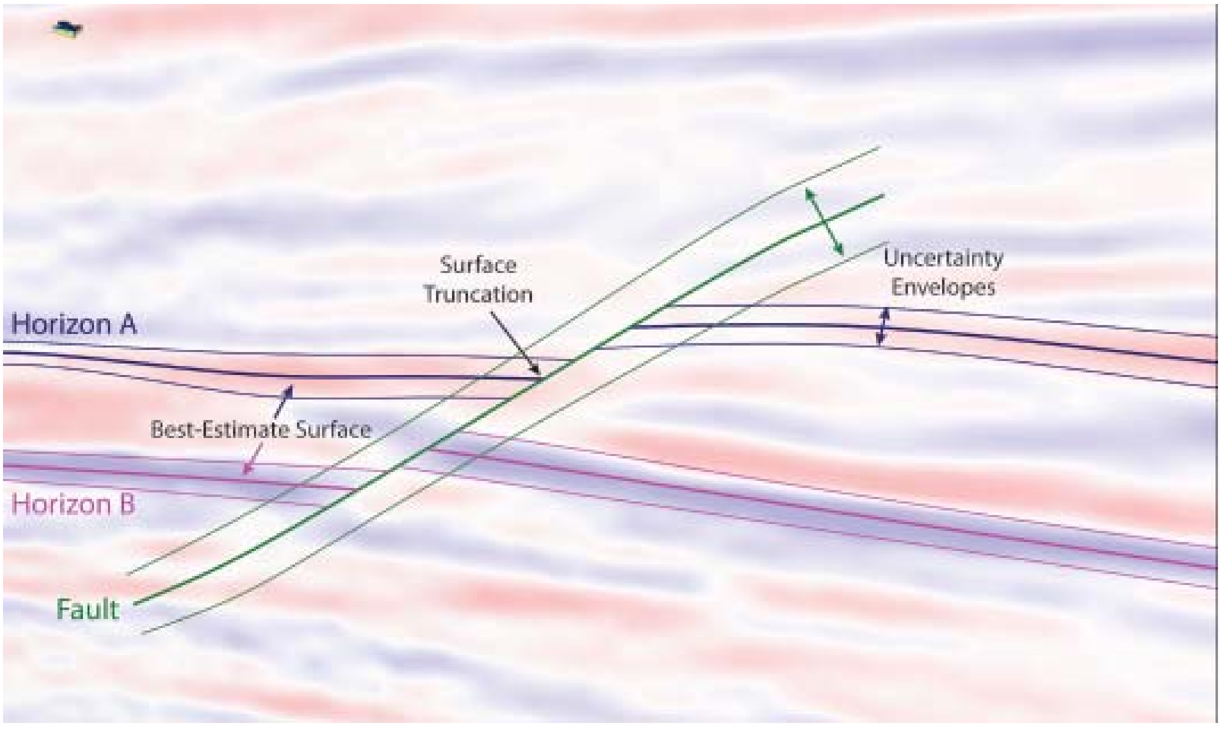


Fig.1 Illustrates how measurement uncertainty is applied to a simple seismic section. The interpreter measures a best estimate surface and an associated uncertainty envelope. These envelopes can be used to generate multiple realizations of structural models, resulting in a statistically robust ensemble of reservoir models. Uncertainty may also vary laterally due to data quality and frequency content.

their reservoir models.

So, given these pre-requisites for the perfect reservoir model, how can we bolster the effectiveness of reservoir modelling workflows today?

Emerson is achieving this through a new model driven interpretation workflow based around its latest reservoir modelling software, Roxar RMS 2013.

Model Driven Interpretation

Model driven interpretation is exactly what it says – building a reservoir model directly from the geophysical data. The interpreter uses the data to map geologic features like faults and horizons, while the engine under the hood constructs and constantly updates reservoir models that obeys geological rules.

Based on Emerson's belief that it is the interpreter who is best placed to integrate uncertainties into the interpretation, Roxar RMS 2013 comes with a variety of new tools which enable just that. Roxar RMS 2013 gives interpreters the ability to capture uncertainty during the interpretation process to levels and at speeds not previously seen; undergo quicker and more agile modelling with limited data; and access innovative new fault, uncertainty management and up-scaling modules.

Central to this model driven interpretation are software tools where uncertainty information is collected and paired with an interpreted geologic feature, such as a horizon, fault, or contact. In this way, the interpreter can see what parts of the model are most uncertain, where more detailed analyses is needed and where new data needs to be acquired.

Rather than creating one model with thousands of individual measurements as took place previously, the new model driven interpretation workflow creates thousands of models via the estimated uncertainty in their measurements. The software can then generate statistically significant ensembles of models based on these probability distributions, providing a range of different outcomes and immediate value to geoscientists.

Uncertainty maps can also be used to investigate key risks in the prospect, or areas can be quickly identified for more study. The possibilities are wide and varied, but the fact remains that by capturing uncertainty at the beginning of the geoscience workflow, operators gain the best possible picture of their subsurface risks.

The Importance of Structural Models

This model driven interpretation approach can only be successful through accurate and robust structural models that provide 3D representations of the faults and horizons within the reservoir and enable geoscientists to guide and update a 3D, geologically consistent structural model directly from the data.

To this end, Emerson's Roxar

RMS enables structural models to be generated on the fly to guide the user as to where more detail is needed. The software allows modellers to rapidly map the key features of the reservoir using a sparse representation and also comes with structural modelling algorithms that can be applied to interactively construct a geologically consistent model of the static reservoir. Fault uncertainty can also be added to simulate the position and geometry of faults in the model.

Horizon uncertainty workflows also enable users to generate structural model realizations that account for a wide range of uncertainty parameters, including horizon positions, zone logs, or even uncertainty in the velocity model. It is this ability to analyse the full range of structural uncertainties that enables geoscientists to create suites of model realizations that satisfy many external constraints – from well picks through to velocity uncertainty and horizon or fault positional uncertainty.

It is through structural modelling that static bulk volumes of the reservoir can ultimately be computed and using these volumes, interpreters can compute a posterior probability distribution to de-risk the prospect and provide input to future field development planning.

Creating the Perfect Reservoir Model

So how much further have these technology innovations taken us in developing the perfect reservoir model? In order to answer this question, it's necessary to look at the key elements of a reservoir model again.

Firstly, does model driven interpretation improve data representation? The answer is a resounding yes. By capturing uncertainty and building models directly from the data, modeldriven interpretation generates a more complete representation of the data in less time. It also allows interpreters to focus their efforts directly on where the model needs more detail – the complex geometries so common in reservoirs today.

Model driven interpretation also provides an effective forum for cross-disciplinary interactions. Geophysicists, for example, with a strong understanding of the complexities of seismic data can work together with geologists and their understanding of the lithologies and facies to generate a more complete model and data representation.

Secondly, can the reservoir model operate effectively in all environments – no matter how geologically complex? Again, the answer is in the positive with the workflow specifically designed to meet more complex tectonic settings and more commercially complex projects. In addition, Roxar RMS also enables 4D seismic data to be incorporated into the reservoir model alongside existing data types, such as geological, geophysical and simulation data, to ensure that no geological complexities are over-simplified or ignored.

Thirdly, is the reservoir model generating the right information for decision-making? Again, the answer is yes. Model driven interpretation empowers geoscientists to quickly build risked models of static reservoir volumes and generate information that can be directly inputted for commercial decision-making. Histograms and static reservoir volume distributions, for example, can be directly used in financial modelling.

Finally, model driven interpretation can better quantify uncertainties and identify risk. By combining interpretation uncertainty with structural uncertainty modules, operators can make risked predictions of horizon or fault positions. When combined with logging-while-drilling data and precision steering, real-time risked hazard avoidance also becomes a reality.

At at a field-wide level, placing the model and risk analysis at the centre of the decision-making process can also play a key role in deriving reserve estimates and providing key input to bid valuations, new field development and operational plans, drilling programs, or production estimates or divestments.

Reservoir Modelling - Coming of Age

With global oil and gas recovery rates averaging only about 35% (Rigzone, August 2012), reservoir modelling remains one of the most important tools available to the oil & gas industry today in securing its long-term future and delivering improved investment and asset returns.

Model driven interpretation is leading the way enabling operators to squeeze maximum value from their models and heralding a true coming of age. Perhaps the perfect reservoir model is not that far off after all! dewjournal.com

about the author

Garrett Leahy is Technical Product Manager at Roxar Software Solutions, a business unit of Emerson Process Management. Garrett has extensive experience with technology commercialization and R&D spanning acquisition through interpretation. Garrett has a PhD in Geophysics from Yale University.

Emerson has recently published a white paper – 'Five Benefits Operators Expect from Their Reservoir Models and How These Can be Achieved.'