The Operator, The Reservoir & Gross Rock Volume Uncertainty

The sole owner of the field is the Abu Dhabi National Oil Company (ADNOC) with Abu Dhabi Marine Operating Company (ADMA-OPCO) as the operator. ADMA is a major producer of oil and gas from the offshore areas of the Emirate of Abu Dhabi and was established in 1977.

The reservoir in question is in the appraisal/early development stage with nine wells unevenly distributed across the field and not all of them having penetrated the bottom of the reservoir. The quality of the seismic data is also only fair with limited well and seismic data. There was therefore limited confidence in the velocity model.

Against this background, there was a need to quantify uncertainty within the reservoir model and in particular Gross Rock Volume (GRV) uncertainty. GRV uncertainty is often the most significant uncertainty, especially in the early phases of field appraisal and development with the correct handling of structure and contacts often the key to realistic uncertainty assessment. Through the accurate quantification of GRV uncertainty, operators can reduce risk and improve drilling and reservoir management decisions.

SUMMARY

Customer
Abu Dhabi Marine Operating Company (ADMA-OPCO).

The Field
Abu Dhabi Offshore field.

Challenge
To increase confidence in uncertainty calculations through the integration of geophysical and geological data to generate a multi-realization 3D uncertainty structural model. Such a model would quantify Gross Rock Volume (GRV) uncertainty and play a key role in guiding the early appraisal and development of the reservoir.

Solution
Roxar RMS 2013 and its new model-driven interpretation approach capture the uncertainty during the seismic interpretation process. RMS 2013 enables the interpreter to use seismic data to guide the structural uncertainty and generate multi-realization structural models to calculate the P10/P50/P90 estimation of GRV.

Results
Rather than creating one model and adding constant uncertainties to evaluate structural uncertainties, RMS 2013 has enabled ADMA’s geomodellers to create hundreds of models through estimating uncertainty based on seismic data. As a result of structural uncertainty being guided by the data, vertical and lateral uncertainties can be defined for every interpreted point of the horizon and fault.

SUMMARY CONTINUED

Fault positions, fault throws and the fault dip can all be changed for each realization and the standard deviation maps can be extracted from the seismic interpretation to reflect the seismic data quality confidence level.

RMS 2013 has subsequently enabled ADMA to have greater confidence in its GRV uncertainty, creating P10, P50 and P90 GRV values that will provide valuable input and reduce risk in future field appraisal and development plans.

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Quantifying Uncertainty – Conventional Versus Alternative Workflows

The conventional workflow for quantifying uncertainty in the reservoir model consists of: i) importing seismic surfaces and faults; ii) developing a reference structural model and then a full field structural model through the integration of subsurface data; iii) building a 3D grid; and iv) running multiple realizations to calculate uncertainties. This results in P10, P50 and P90 volumetric calculations that determine the probabilities of the reserves.

With the conventional approach, uncertainty is quantified using a simple scalar option (for example -15 to +15) where the surface points (high, base and low) are either positioned up or down. For example, the reservoir can have a bigger volume or a lower volume. Figure 1 illustrates this. In addition, faults are kept constant in all realizations and the constant uncertainty ranges have a corresponding impact on the standard deviation maps.

There are weaknesses to this approach, however.

There is little flexibility in being able to react to the different data elements in the model (surface points must either be positioned up or down) and there is no clearly defined approach for setting the uncertainty parameters in the structural model that will vary from interpreter to interpreter. The conventional interpretation process is also geared towards producing just a single model or scenario for the configuration of subsurface geobodies, despite the data being able to support many different interpretations.

There is therefore a need to increase operator confidence in GRV uncertainty calculations through a more complete representation of the seismic data where the uncertainty is guided by the data and where the capturing of uncertainty can take place for each single point during the interpretation process.

The Advanced Workflow – Model-Driven Interpretation

Rather than focusing on a single horizon or fault, in the new workflow uncertainties are represented by envelopes that change size based on the interpreter’s estimate of uncertainties on each interpreted location.

The interpretation method measures both a best-estimate interpretation of a geologic feature and an associated uncertainty as can be seen in figure 2. Figure 2 shows that, as the interpreter moves away from the well control - where there are minimum uncertainties - the uncertainty increases. As compared to the conventional workflow, where uncertainty can only be moved vertically by the constant factor, in the new workflow for each point uncertainty is guided by the data.

Following the model-driven interpretation process, a standard deviation map is then extracted which is also used to capture the uncertainty prior to the building of a structural model and is then taken through the remaining elements of the workflow to create multiple realizations.

Figure 2 - As the interpreter moves away from the well control, the uncertainty increases.

Whereas the conventional workflow approach comes with constraints, in the new workflow the uncertainty is guided by the data. This ability to provide users with unique tools for quantifying geologic risk early in the interpretation process leads to better decision-making and improved investment returns.

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“GRV uncertainty is often the most significant uncertainty, especially in the early phases of field appraisal and development with the correct handling of structures and contacts often the key to realistic uncertainty assessment”
Capturing Uncertainty on the Studied Reservoir

On the field, Emerson introduced the new advanced RMS 2013 workflow that allows ADMA’s geomodellers to define lateral and vertical uncertainty at every pick based on the seismic interpretation (figure 3) workflow alongside velocity models and fluid contacts. This approach enables users to define uncertainties at all stages of the workflow from seismic interpretation through to structural modelling (figures 4 & 5).

Figure 4, for example, illustrates the control points that were used for the two surfaces – the upper surface control points, the lower surface control points, and the base case surfaces with the fault network. In all these illustrations, each point represents a best estimate coordinate with different uncertainty ranges then applied for each point. This uncertainty may be high or low with nearer the well lower uncertainty and away from the well higher uncertainty based on the quality of the seismic.

Figure 5 illustrates the fault uncertainty envelopes. 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 modelling workflow.

The Standard Deviation Maps & Multiple Realizations

The standard deviation maps generated through the advanced workflow to address the uncertainties at every interpreted point varied significantly compared to the conventional workflow.

In figure 6, the map on the left shows the standard deviation map generated from the conventional uncertainty workflow and the one on the right comes from the new advanced workflow. As one can see, the standard deviation map generated through the advanced workflow reflects confidence in the quality of the seismic data rather than the constant uncertainty ranges inputted by the interpreter. The red shades indicate where the uncertainty is low and the green where the uncertainty is high.

Figure 6 illustrates the change in position of faults and surfaces for different realizations. In the conventional method this cannot be done. Based on 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 standard deviation has been used to generate the multiple structural models using multiple realizations. Figure 7 shows the faults displacement in three different realizations, whereas figure 8 shows a section where several realizations result in different horizons and faults. However all the results are confined within the defined uncertainty envelope.

Case Study

“Emerson and Roxar RMS 2013 is placing model driven interpretation and uncertainty management at the heart of the asset team, resulting in an improved quantifying of uncertainty and risk, and better decision-making – whether applied to bid valuations, new field development plans or other reservoir management scenarios.”
Case Study

Figure 7 - The faults displacement in three different realisations.

Figure 8 - The multiple realization surfaces where the surface can go up or down in between the fault envelopes. The faults are also changed for each realization with the uncertainty of the faults being measured as well.

The Results - Gross Rock Volume Ranges

The next stage of the workflow was the creation of a 3D grid. The grid size was 200 by 200 with 214 rows, 191 columns, 20 layers and a corner point gridding format along with pillar gridding for the faults. It is through the grid that multiple realizations were generated and eventually Gross Rock Volume ranges (see figure 9). This generates the P10, P50 and P90 GRV values as well as indicating which horizons, velocity models or fluid contacts are affecting the GRV calculation.

With the conventional workflow, along the wells the uncertainty is very low but as you go out from the well, the uncertainty range is higher before tending to become the same everywhere. With the new workflow, the uncertainty may be lower in other areas depending on data quality and not just based on well control. This will be reflected in the model giving the interpreter better control over the standard deviation maps and the uncertainty envelope and a more accurate distribution of the GRV.

Conclusions

This case study illustrates the benefits of GRV uncertainty quantification through the new model-driven interpretation workflow in RMS 2013.

As opposed to the conventional workflow where uncertainty is quantified using a simple scalar option, faults are kept constant in all realizations, and the standard deviation maps are affected by constant uncertainty ranges, the new workflow allows uncertainty to be guided by the quality of the seismic data. Fault positions are changed for each realization and the standard deviation maps reflect the confidence level of seismic data quality. In short, interpreters are given the flexibility to follow the data and honor the geology.

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

The Benefits to ADMA

- Reduced Risk
- Increased Investment Returns
- Greater Confidence in the Data

Furthermore, such has been the success of quantifying GRV uncertainty on the reservoir in the field that developments are already taking place to address further the impact of structural uncertainties on facies and petrophysical parameters and how such petrophysical parameters can help calculate uncertainty. It is also likely that Roxar RMS 2013 will be asked to generate P10, P50 and P90 calculations across the whole field development.

As the oil & gas industry moves into more complex geological settings and as operators look to greater investment returns from their fields, the improved quantifying of geologic risk and the importance of generating models guided by the data and representative of geology has never been more important.

In the case of ADMA, Emerson and Roxar RMS 2013 are providing geomodellers with a more complete representation of the data and are ensuring that model-driven interpretation and uncertainty management remain at the heart of the asset team.

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