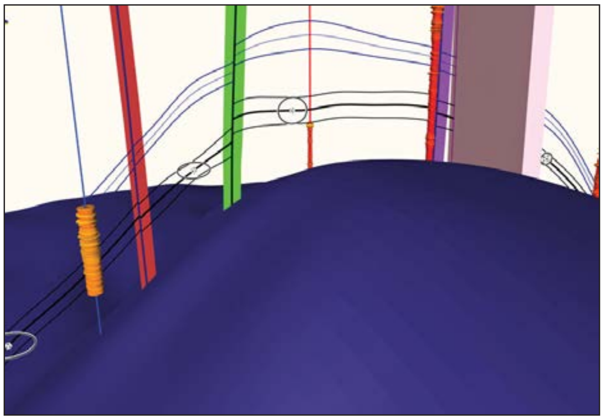
Emerson Helps Abu Dhabi Marine Operating Company Quantify Gross Rock Volume (GRV) Uncertainty through Model-driven Interpretation (MDI)

RESULTS

- ADMA's geomodelers were able to create hundreds of models through estimating uncertainty based on seismic data.
- ADMA gained 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.



Uncertainty in seismic interpretation is used as an integrated part of geological modeling

APPLICATIONS

RMS

CUSTOMER

Abu Dhabi Marine Operating Company (ADMA-OPCO).

CHALLENGE

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 was established in 1977 and is a major producer of oil and gas from the offshore areas of Abu Dhabi.

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

Against this background, there was a need to quantify uncertainty within the reservoir model, 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.

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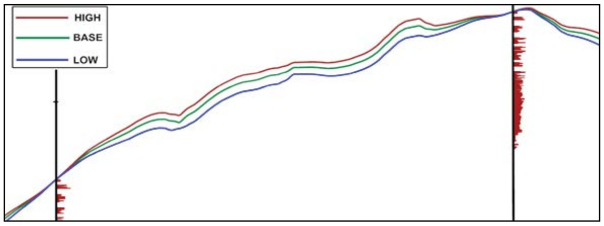


Figure 1 - With the conventional approach, uncertainty is quantified using a simple scalar option (-15 to +15) where the surface points (high, base and low) are positioned up or down.

The conventional workflow for quantifying uncertainty in the reservoir model consists of: 1) importing seismic surfaces and faults; 2) developing a reference structural model and then a full field structural model through the integration of subsurface data; 3) building a 3D grid; and 4) 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 e.g. -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). In addition, faults are kept constant in all realizations and the constant uncertainty ranges have a corresponding impact on the standard deviation maps.

Whereas the conventional workflow approach comes with constraints, in the new workflow 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.

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.

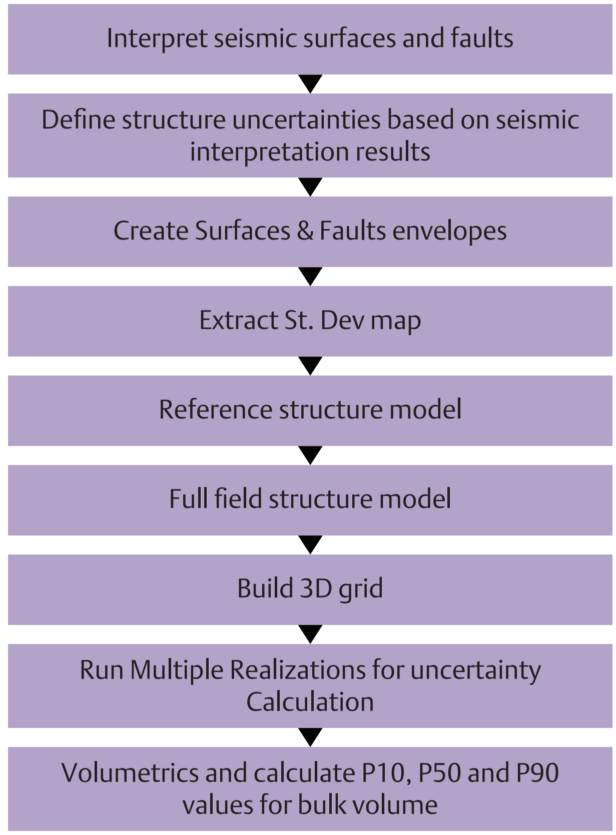
There is therefore a need to increase operator confidence in GRV uncertainty calculations through a more complete representation of the seismic data, where the uncertainty is guided by the data and where the capturing of uncertainty can take place for each single point during the interpretation process.

Solution

The advanced workflow introduced in this case study is based on Emerson's RMS reservoir modeling software. RMS offers MDI capabilities that enable users to not only create the geological model while conducting seismic interpretation, but also to capture uncertainty during the interpretation process.

In this workflow, once the seismic surfaces and faults have been imported or interpreted, the interpreter is able to defi ne structural uncertainties based on the seismic interpretation results and create standard deviation surfaces and fault envelopes. It is then possible to create a reference structural model and full field structural model based on the interpreter's requirements.

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.



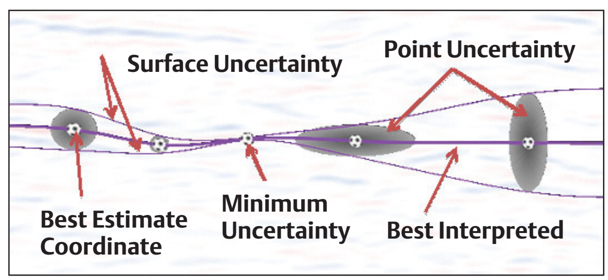


Figure 2 - As the interpreter moves away from the well control, uncertainty increases.

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

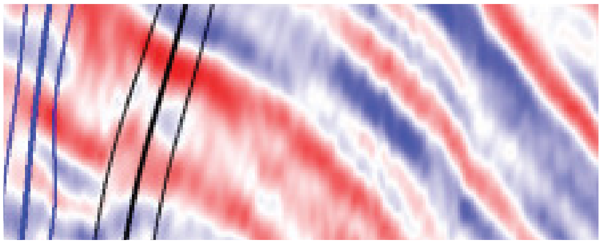


Figure 3 - Real data from the field using conventional seismic lines. As part of the advanced workflow, the interpreter created an uncertainty range in all the faults and all the horizons.

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

In the field, Emerson's RMS workflow allowed ADMA's geomodelers to define lateral and vertical uncertainty at every pick based on the seismic interpretation workflow alongside velocity models and fluid contacts (Figure 3). This approach enables users to define uncertainties at all stages of the workflow, from seismic interpretation to structural modeling (Figures 4 and 5).

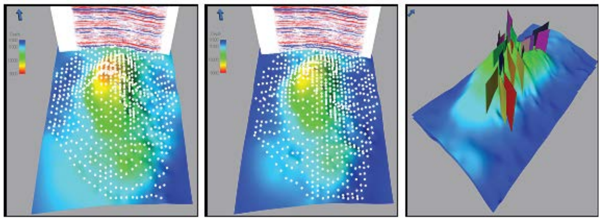


Figure 4 - The control points that were used for the two surfaces.

Figure 4 illustrates the control points that were used for the two surfaces – upper, lower, and base case surfaces with the fault network. Each point represents a best estimate coordinate with different uncertainty ranges applied to 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.

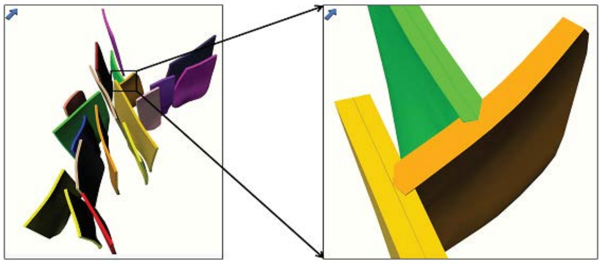


Figure 5 - Fault uncertainty envelopes.

Figure 5 shows the fault uncertainty envelopes. 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.

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; the one on the right comes from the new 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 input by the interpreter.

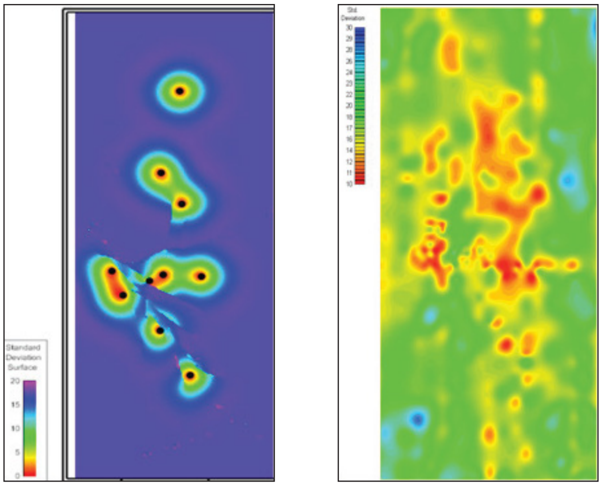


Figure 6 - Standard deviation maps generated from the conventional (left) and advanced (right) workflows. Red shades indicate where uncertainty is low and green where it is high.

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.

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 (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

Results

The technology led to improved GRV uncertainty, enabling valuable input into field appraisal and development plans, and reduced risk. Furthermore, quantifying GRV uncertainty on the reservoir in the field was so successful 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 RMS will be used to generate P10, P50 and P90 calculations across the whole field development.

Benefits

RMS and its MDI approach capture uncertainty during the seismic interpretation process. RMS 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. It provides a more complete representation of the data and ensures that MDI and uncertainty management remain at the heart of the asset team's work, leading to reduced risk and greater investment returns.

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.

"Emerson and RMS place model-driven interpretation and uncertainty management at the heart of the asset team, resulting in improved quantifying of uncertainty and risk, and better decision-making – whether applied to bid valuations, new field development plans or other reservoir management scenarios."

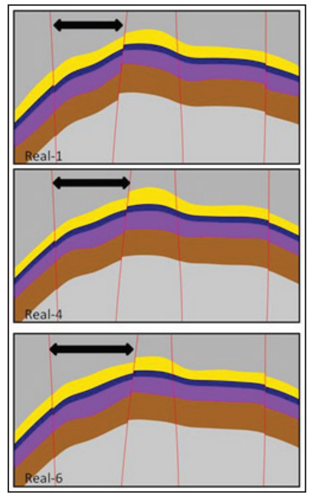


Figure 7 - Fault displacement in three different realizations.

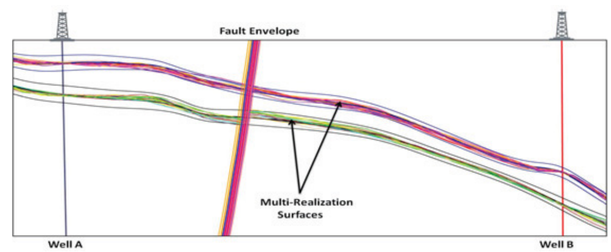


Figure 8 - Multiple realization surfaces where the surface can go up or down in between the fault envelopes. The faults are also changed for each realization with fault uncertainty being measured as well.

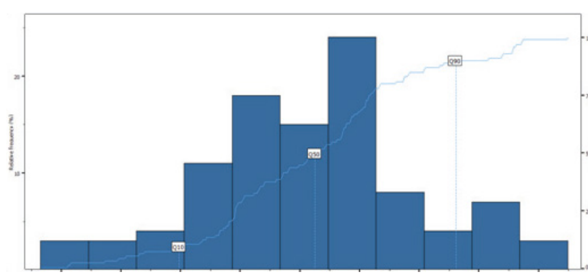


Figure 9 - Multiple realizations and Gross Rock Volume.

Emerson thanks ADMA for permission to publish this case study.

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