

Case Study

RMS™ helps PEMEX Get The Right Modelling Result on Geologically Complex Kutz Field

Case Study Summary

Customer

Petroleos Mexicanos (PEMEX)

The Field

The Kutz offshore field, Cantarell Asset, Gulf of Mexico

Challenge

With the Cantarell Asset, one of the world's largest oil & gas fields, in general production decline, PEMEX wished to create a detailed 3D reservoir model of the Kutz field - a field which comes with significant reservoir heterogeneities including a symmetrical anticlinal, complex compressional faulting and a diversity of sedimentary environments. There was a need for a 3D model which tackles the field's geological complexities, leads to a greater understanding of the asset and its reserves, and helps support updated field development plans based around its 12 existing wells. The reservoir model will also provide input to further simulations and decisions around the adoption of future enhanced oil recovery techniques.

Solution

Roxar RMS, Emerson Process Management's industry leading reservoir modelling solution, has been designed to integrate the most challenging geological complexities within its model building. With its ability to enable direct reference between the model and the 3D seismic, its corner-point geometry, fault, fracture and object-based facies modelling capabilities, simulation friendly grids, and uncertainty analysis tools, Roxar RMS was the ideal solution for PEMEX in generating a robust and accurate model of the Kutz field which copes with all geological complexities.



Results

Roxar RMS developed the first full-field geostatistical and detailed model of the Kutz field which honours reservoir heterogeneity and upon which PEMEX will base future production strategies. The model will be used in the further development of the field, in future simulation processes, and in maximising oil recovery through water, gas, CO2 and Nitrogen injection processes.

Abstract

As operators are faced with deeper and more challenging geological settings, any reservoir model that oversimplifies geological complexities is not going to deliver the vital information operators require for well planning and reservoir management today. That's why Roxar RMS from Emerson Process Management (www.emerson-process.com) has been designed to cope with whatever structural or modelling complexity is thrown its way with no model compromises or simplifications.

The Kutz field, offshore Mexico, is an example of such a field. Here the geological complexities and reservoir heterogeneities require the very latest in fracture, fault, petrophysics, and object-based facies modelling tools, simulation friendly grids, and uncertainty analysis features to create a robust and reliable reservoir model on which future production decisions can be made.

PEMEX and the Kutz Field

Petroleos Mexicanos (PEMEX) is the largest company in Mexico and one of the largest companies in Latin America with, as of 2010, total assets worth over US\$415 billion. It is also one of the few oil companies in the world that covers the whole oil & gas lifecycle from upstream exploration and production through to downstream activities and final product commercialisation.

The Kutz offshore field lies within PEMEX's Gulf of Mexico Cantarell Asset, one of the largest fields ever discovered, in the Marine Region, Campeche State, next to the giant Akal field (see figure 1).

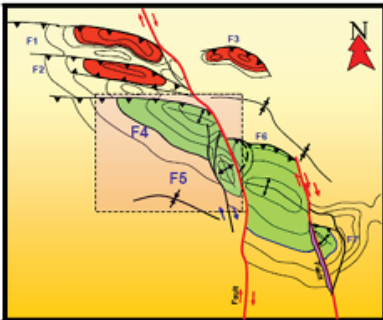


Figure 1 - The Kutz Field

The Cantarell field was discovered in 1976, spans 112 square kilometres and had peak production of 2.1 million barrels per day (330,000 m³/d) in 2003. The field was placed on nitrogen injection in 2000. Production has declined since 2003, however, falling to 464,000 barrels per day (73,800 m³/d) by the end of 2010.

With declining production rates, it was necessary to look at means of increasing production from Kutz – a field which was also geologically complex. The field has a symmetrical anticlinal and a high level of heterogeneity. This was due to a combination of geological events, including complex compressional faulting and a diversity of sedimentary environments linked to the generation of carbonates and severe transportation processes. The reservoirs within the field are also diverse and include Eocene and Paleocene Turbidite reservoirs and Upper, Middle and Lower Cretaceous reservoirs.

It was against this backdrop that PEMEX wished to create stochastic 3D carbonate reservoir models that could support drilling and production forecasts in the field.

Data already available for the study included lithology and petrophysical well logs, 3D seismic, core analysis, and production history for both Eocene-Paleocene and Upper, Middle and Lower Cretaceous reservoirs. In addition (as illustrated in figure 2) structural seismic interpretation and depth conversion data was also available based on the 12 current wells.

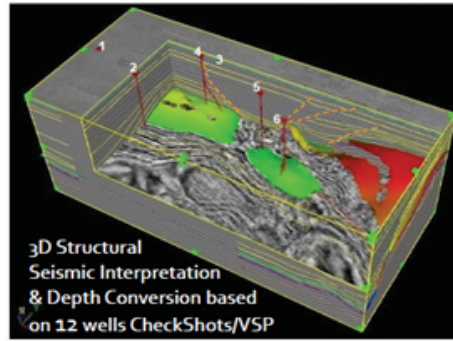


Figure 2 - Structural Seismic Interpretation and Depth Conversion Data from the Kutz Field.

Roxar RMS

PEMEX looked to Emerson Process Management's Roxar RMS solution to build the reservoir model. Roxar RMS is Emerson's flagship reservoir modelling solution and comprises xx fully integrated software modules, including mapping, reservoir modelling, well planning, reservoir simulation and uncertainty modelling tools.

Key features which appealed to PEMEX included a suite of structural modelling tools which can reduce the time required to build a structural framework; RMS's fault and fracture modelling capabilities; its simulation friendly, high resolution modelling grids suitable for accurate production predictions; and uncertainty and probability analysis tools.

The latest version of Roxar RMS – RMS 2011 – also comes with new features to cope with whatever structural or modelling complexity is thrown at it, including enhancements to the seismic architecture to allow direct reference between the reservoir models and 3D and 4D seismic data, geological well correlation improvements, and new fracture modelling capabilities.

Building the Reservoir Model for the Kutz Field

A high resolution modelling grid of 13 millions cells was built within RMS using corner-point geometry and incorporating ten faults. The algorithms within RMS and, in particular, its simulation grid module, RMSsimgrid, are ideal for the complexity of such corner-point geometry with upscaling carried out through direct sampling. Direct sampling eliminates many of the approximations of re-sampling methods in regard to sample cell volume, shape, orientation and location.

RMS's fault modelling tool also allows geologists and reservoir engineers to quickly and easily analyse the fault sealing properties and fluid flow properties across faults in the 3D reservoir model, as in this case.

Reservoir properties in the Kutz field were distributed using RMS's stochastic 3D modelling tools for both the modelling of the facies and in developing a petrophysics model, as illustrated in figure 3.

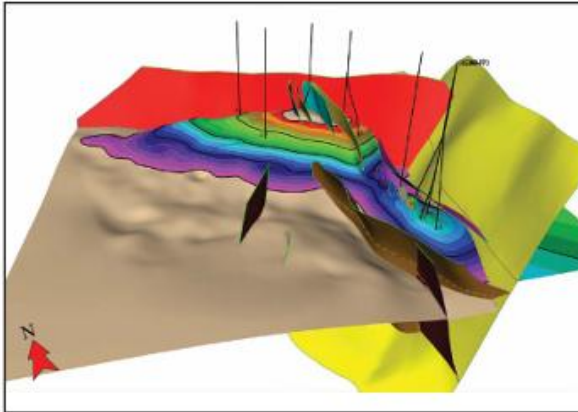


Figure 3 - Structural modelling technique based on 'blocks' was used for building the horizon and creating the 3D geological grid.

Roxar RMS provides a range of object based facies modelling methods which can be refined for a range of different geological environments and which come with the ability to accurately honour well data and multi-well correlation. The facies modelling results can be merged in any sequence allowing for the modelling of hierarchical heterogeneities and more complex facies environments.

To this end, the Kutz field's Eocene and Paleocene Turbidite reservoirs were modelled through RMS's object-based modelling tools, as illustrated in figure 4.

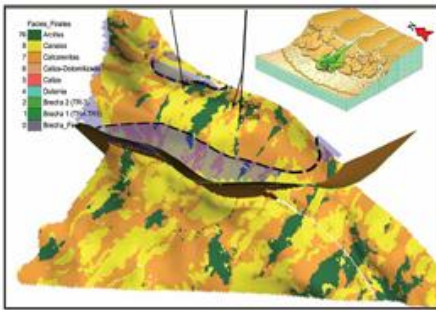


Figure 4 - Modelling of Eocene and Paleocene Turbidite Reservoirs Through RMS's Object Based Modelling Tools.

The Cretaceous reservoir (figure 5) was modelled using a combination of object and pixel-based methods conditioned to 3D seismic attributes. This consists of RMS's own advanced sequential indicator simulation tool, a pixel based modelling method ideal for large reservoirs. With the ability to honour a wide range of trends and seismic attributes, this algorithm is very flexible and also includes accurate volume matching constraints to ensure reliable results.

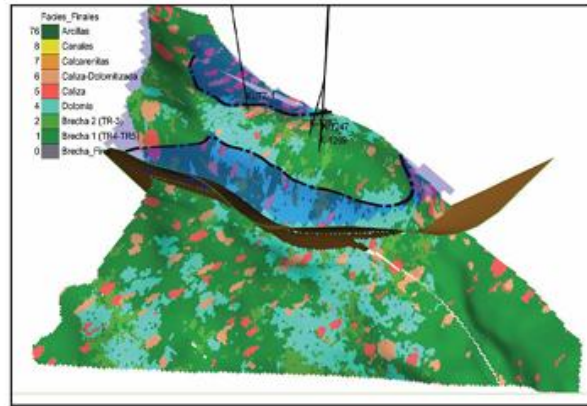


Figure 5 - Modelling the Cretaceous Reservoir

Furthermore, in such situations, RMS's ability to allow direct reference between the reservoir models and the 3D seismic data, that the interpretation and modelling is based on, is particularly important. The resulting realizations in RMS reproduced the conceptual sedimentological model for the Kutz field, illustrated in figure 5.

For petrophysical modelling on the Kutz field, a Sequential Gaussian Simulation algorithm, a procedure for estimating the reservoir characteristics between data points based on refining the model through a reduction of errors, was used within RMS to effectively model the porosity, permeability and rock types for the first and second medium, as illustrated in figure 6.

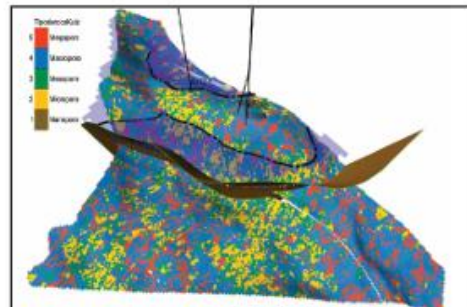


Figure 6 - Petrophysical Modelling Through The Sequential Gaussian Simulation Algorithm.

A simulation of the discrete fracture network was also built to reproduce the natural fractures in 3D within the Kutz field and for estimating the modified permeability, which was both conditioned to seismic attributes and based on the variograms and geomechanical analysis.

With Roxar RMS, fractures are fully integrated through the Discrete Fracture Network model. This enables robust, fractured models to be built faster and provides an important tool in tackling the complex, fracture-prone geologies present in the Kutz field and many others worldwide.

Uncertainty & Probability Analysis

With RMS having built a geostatistical and detailed model of the Kutz field, the final stage was to conduct uncertainty and probability analysis to estimate recovery from the field and future production trends.

To this end, 50 realizations were produced for uncertainty and probability analysis using RMS's uncertainty management tools, including that of recovery factor estimation.

RMS allows subsurface uncertainties across the complete modelling workflow to be investigated with the range of parameter uncertainties including structure, velocity model, facies, net to gross, porosity/ permeability, water saturation, fluid contacts and development scenarios.

A complete range of 2D based data analysis tools (tornado charts, box plots, histograms and scatter plots) are also available to help identify and understand the impact of key uncertainties and an experimental design optimises the number of scenarios and realizations.

In the case of the Kutz field, three realizations (P10, P50 and P90) were re-scaled so that the compositional simulation stage could be started. Following the flow simulation, the realization with the best match to the historical data was then selected as the most representative. Figure 7 outlines this process.

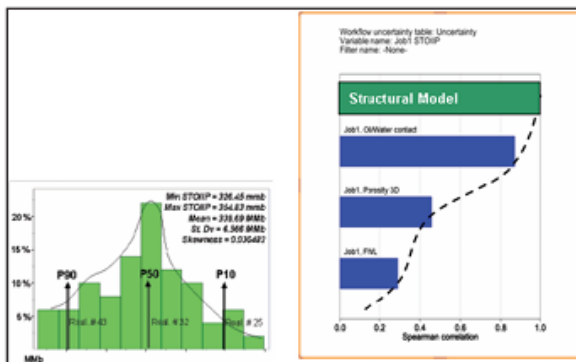


Figure 7 - The Uncertainty and Probability Analysis Process.

Conclusion & Results

The result of the reservoir modelling process was the first full-field geostatistical and detailed reservoir from the field which fully honours the reservoir heterogeneity. The reservoir model, created through RMS, will be used for future production development plans and simulations as well as the maximising of oil recovery through water, gas, CO2 and Nitrogen injection processes.

There can be few better examples of reservoir modelling being pushed to the limit than in the Kutz field.

From the inherent geological complexities and reservoir heterogeneities to the corner-point geometry, fault, fracture, petrophysics and object-based modelling, simulation friendly grids, uncertainty and probability analysis tools, and the need to leverage the 3D seismic, PEMEX needed a complete reservoir modelling solution to tackle all geological complexities. With Roxar RMS, they got that solution.

For further information please email rms@roxar.com or go to our website www.roxarsoftware.com for regional contact information.