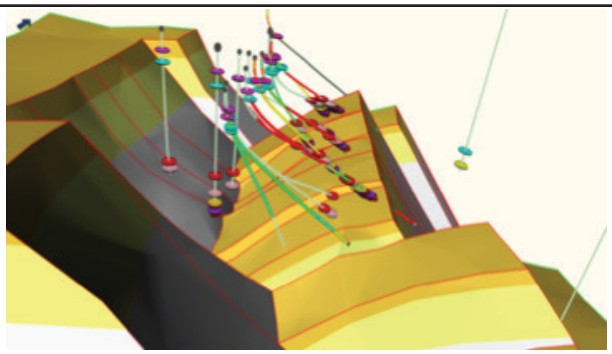
Evaluating the Upside Potential of the Mature Ras El Ush Field

RESULTS

- An integrated uncertainty management workflow provided crucial input into future field development decisions through building a structural model of the field and evaluating several scenarios.
- Gas injection was chosen as the most effective way to increase production, and a future block was identified for appraisal drilling.
- As a result of the reservoir modeling and history matching workflow, the user was able to provide specific input as to how production could be increased in the field.



RMS and Tempest were successfully used in a reservoir modeling and history matching workflow

APPLICATIONS

RMS™ and Tempest™ ENABLE

CUSTOMER

Petrozeit

CHALLENGE

There was a need to evaluate and explore the upside potential of a mature field in a highly tectonically active area of the Gulf of Suez, in order to guide future development decisions. Challenges included complex geology and tectonics with a highly titled and dipping structure. The reservoir was also characterized by the presence of Tarmat acting as a barrier between it and the aquifer, leading to no aquifer pressure support. Reservoir management was therefore a key issue as the field had shown a steep reservoir pressure decline over the previous four years. Maximizing production through the use of secondary recovery and appraisal drilling was highly challenging at such low pressures, as was communication between the different blocks.

SOLUTION

Emerson offered its RMS reservoir management software suite, which included seismic interpretation, structural and property modeling, calculation of total uncertainty from Gross Rock Volume to reserves in-place, and reservoir simulation and history matching.

RMS and its suite of structural modeling and seismic interpretation tools were first deployed to generate a conceptual model of the field and quantify the fault location uncertainties. Conceptual data was taken alongside well data to generate an accurate structural model. This was followed by the creation of a 3D unified grid and then the calculation of Gross Rock Volume (GRV) uncertainty.

'The integrated uncertainty management workflow - from seismic interpretation to the use of dynamic parameters - calculated the upside potential of the Ras El Ush field and optimized investment returns for Petrozeit'.

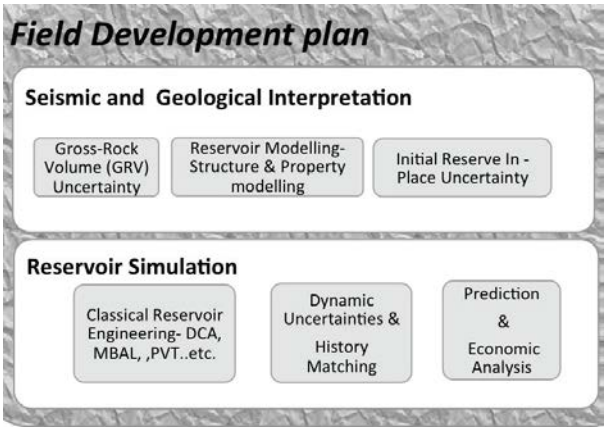


Figure 1. Field development plan

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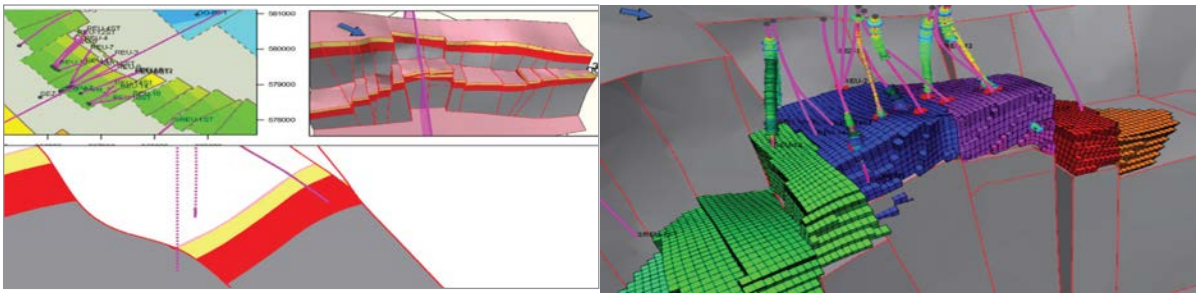

Figure 2: Structural model and 3D unified grid

The structural model generated (Figure 2) was bound by clysmic faults (dip slip faults) and cross faults, which are strike slip in nature and have a dip component along with rotation. The average dip in the clysmic faults is ~40-55 degrees. Cross faults are almost vertical.

Using Emerson's model-driven interpretation (MDI) capabilities that enable users to capture uncertainty during the interpretation process, a grid was created from the structural model to calculate GRV uncertainty - information that could play a key role in the future development of the reservoir.

Due to the poor seismic quality, there were positional uncertainties relating to the clysmic faults and horizon interpretation away from the wells. GRV uncertainty was therefore calculated using MDI based on the conceptual model and lateral fault movements within the estimated uncertainty. Figure 3 illustrates how uncertainty was introduced and calculated for both horizons and faults. Figure 4 shows three out of several multi-realization results and displays the lateral positions of the clysmic fault and horizons within the range of defined uncertainties. Figure 5 shows the GRV volume range due to poor seismic data quality.

The user also carried out a property modeling workflow. This included pixel-based facies modeling of sand, shale and silt using a combination of a Vertical Proportion Curve (VPC) and a lateral trend in the upper most heterogeneous region (Matula and its subdivisions).

The petrophysical parameters (porosity, permeability and water saturation) were populated based on distributions from well and core data. Figure 6 shows a property modeling uncertainty workflow that outlines the Oil Water Contacts (OWC) and the variogram range of uncertainties. Figure 7 displays the histogram; the tornado plot shows the range of reserves in-place and effect of each parameter in calculation.

Following the GRV calculation and structural and property modeling, reservoir simulation and history matching tools from Tempest MORE and Tempest ENABLE were used to history match the results. In the uncertainty analysis and history matching process, the main parameters used were the rock permeability, the communication between reservoir blocks, and the saturation functions. The result was an acceptable history match based on the model (Figure 8, where the solid line is the prediction and the dotted line the history).

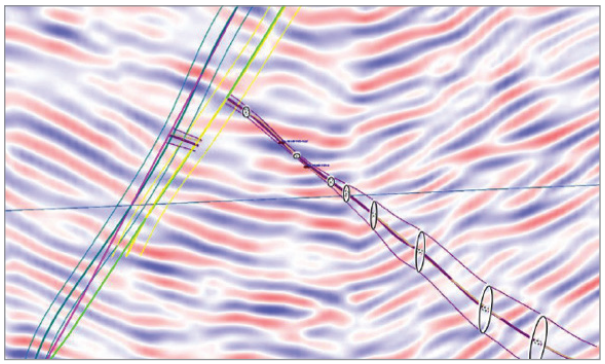

Figure 3: Horizon and fault uncertainties

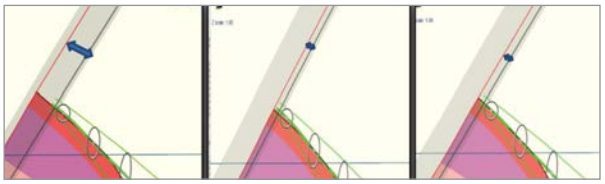

Figure 4: Fault positions and horizons in different realizations

Figure 5: GRV range

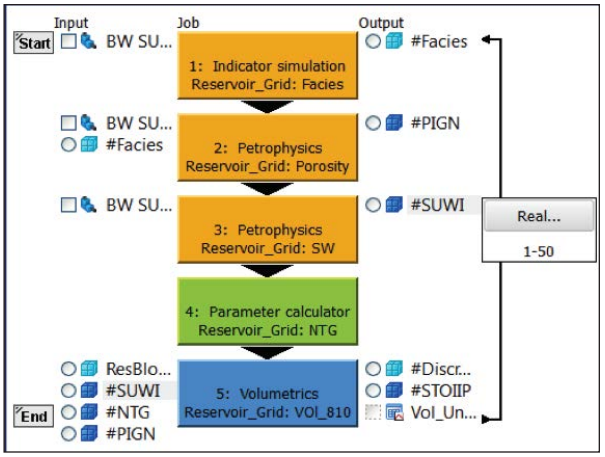

Figure 6: The uncertainty workflow – petrophysical and OWC uncertainties

Nubia and Matulla reservoir pressure performances indicate that both reservoirs are in good communication, acting as a single material balance (MBAL) tank with the developed blocks communicating well.

As a result of the reservoir modeling and history matching workflow, the user was able to provide specific input as to how production could be increased in the field.

Figure 9 illustrates three production scenarios with different water injection (blue line) and gas injection (red line) rates and the scenario of no further action (NFA) (green line). With the highest water injection rate requiring at least 8 to 10 years to yield just small production increases, gas injection - that delivered increased production faster - was selected as the best secondary recovery method for the developed blocks.

RESULTS - Exploring the Upside Potential of the Field

The newly identified blocks are located in the Southeast part of the field. The blocks have the pre-rift reservoirs as a primary target and are separated from the producing field by cross faults (Figure 10).

Structural uncertainty played a major role in testing the adjacent blocks against the main producing field. The seismic data quality was poor with the high formation dip leading to large structural uncertainty.

Using the data collected from the wells in the developed blocks (production cumulatives and pressure), the operator was able to identify the oil in place in the Ras El Ush field as a tank model and compare it with in-place volumes from the static and history matched dynamic model.

From the comparison, it was clear that the appraisal block was not communicating with the main developed blocks. This brings with it considerable upside potential. If the appraisal block was communicating with the existing blocks, high gas saturation and pressures of +/-220 psia would be expected, resulting in few oil and gas reserves being added through the drilling of appraisal wells.

Economic evaluation was performed for different field development plans using different combinations of strategies in development and appraisal blocks. This helped the operator select and design the Final Development Plan (FDP) and was crucial for assessing the incremental costs and benefits of the project and ranking the development plans based on the net present value or internal rate of return.

Through combining structural uncertainty quantification and OWC and stochastic parameter uncertainties, the Ras El Ush field was found to have an upside potential of 0.36 times existing production. This was due to an extra block being identified.

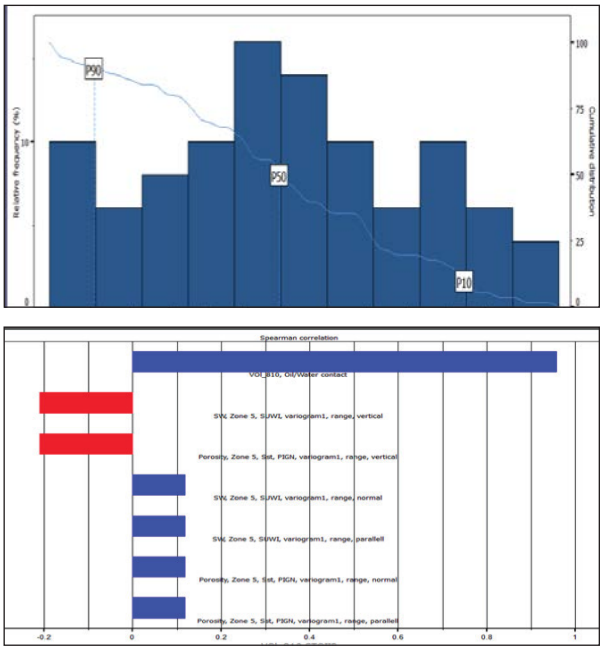

Figure 7: The range of in-place reserves and the effect of OWC and variograms

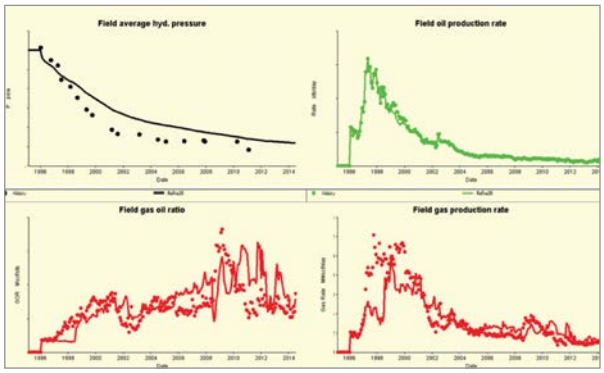

Figure 8: Observed data versus simulation and history matching results

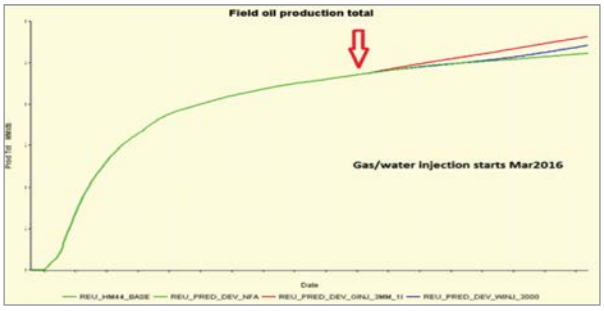

Figure 9: Production scenarios – water injection (blue), gas injection (red) versus no further action (green)

BENEFITS

The integrated reservoir management software workflow provided crucial input into future field development decisions through the building of a structural model of the field and the evaluation of a number of scenarios. The results pointed to gas injection being the most effective way of increasing production and identified a future block for appraisal drilling. With the introduction of the new reservoir block, the field was calculated to have an upside potential of 0.36 times existing production.

The information generated will provide vital input into future production and enhanced recovery decisions, in particular with the identification of a new block for appraisal.

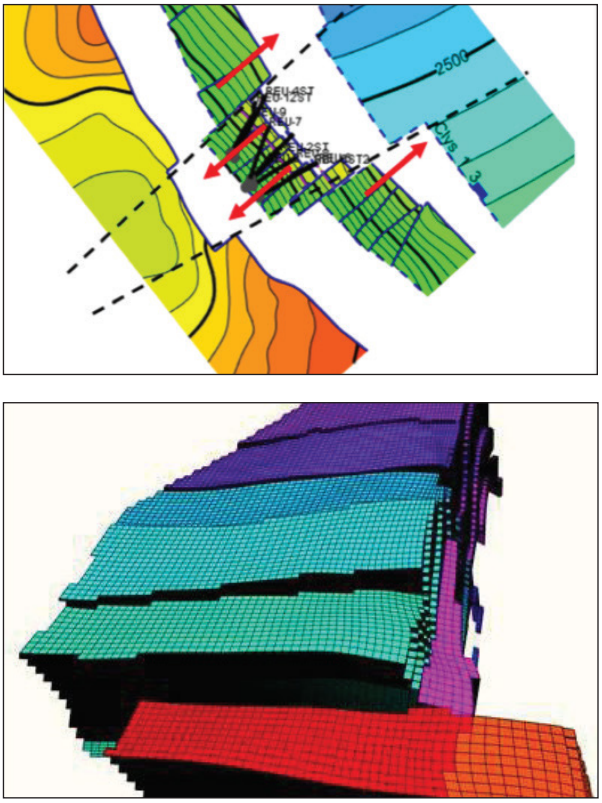

Figure 10: Newly discovered block in the Southeast of the field

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