P02

Reduce Facies Uncertainties Distribution at Reservoir Scale: Insight from High-Resolution 4D Stratigraphical model

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SUMMARY

Reducing uncertainties at appraisal stage of a reservoir is a key challenge to tackle, due to the limited number of exploration wells. The prediction of the facies architecture inside complex reservoirs is another challenging task, that cannot be assessed using classical geostatistics methods.

The facies are used as the main guideline to populate the properties of static model, reducing error in facies assignation and propagation in the mesh is mandatory. In such a composite context, a tool able to constrain physically and geologically the sediments spatial distribution is a serious advantage.

In this framework, 4D Forward Stratigraphic Modeling can be a useful tool to assess facies distribution. For the last 15 years this tool has been applied, commonly to exploration studies, and is now applied to reservoir scale studies.

4D Forward stratigraphic modelling is a powerful tool to populate with an inner logic a three dimension geological model. The rules of physics, sedimentology and stratigraphy are honored and allowed the building of predictive environment of deposition and lithologies. At fine scale, Forward Stratigraphic Models could be used as a new method suitable for representing geologically reservoir heterogeneities in the static reservoir modelling, during the very challenging well-poor appraisal phase

Introduction

Reducing uncertainties at appraisal stage of a reservoir is a key challenge to tackle, due to the limited number of exploration wells. The prediction of the facies architecture inside complex reservoirs is another challenging task that cannot be assessed using classical geostatistics methods.

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Theory

Forward Stratigraphic Modeling is based on the principle of sequence stratigraphy, coupled with physical laws of diffusion of sediments. Accommodation is controlled by sea level variations, plus basin deformation induced vertical uplift and subsidence.

Supply of sediment may correspond either to boundary condition (inflow / outflow of water and sediment into / out of the simulated area), basement erosion, carbonate production or evaporite precipitation.

Sedimentation and erosion at each point of the basin is defined from the mass conservation equation and these transport equations. Sedimentation occurs at a point of the basin if the transport capacity becomes too low for a type of grain.

Figure 1 Example of Hi-Resolution 4D Forward Stratigraphic Model at Reservoir scale, in complex mixt environment.

Method

Strong geological integration is requested to work at Appraisal and Reservoir Scales. This implies to work in close collaboration with a multi-disciplinary team. A seismic based approach is carried on, with detailed mapping of key horizons and close up look at the internal structures of the target area. Then a phase of detailed geological review is mandatory to enhance the key parameters to be modelled. Sedimentological and Stratigraphical conceptual model to be tested has to be converted into numerical values

To ensure the correct representativeness of modeling parameters, a first set of simulation along 2D sections of typical depositional profile of the studied area are performed. This step is critical to constrain in a geometrically simple environment the correct match between modeling and conceptual depositional model.

Then, first 4D simulations are run at Exploration scale to catch the big picture of the infilling of the basin, and understand the impact of main geological and geodynamical events. These simulations are extended in time to previous and past stage of the targeted reservoir deposition.

Once this first set of simulation is conveniently completed, a second set of simulation at appraisal scale is run, focused, on the target reservoir layer. This step is very important to fine tune the model with an acceptable ratio of simulation time Vs precision of the simulation.

Once a good match is obtained at Appraisal scale between simulation results and hard data (Thickness maps, Well data, internal structures...) final simulations are run at reservoir scale. The outputs allow to dramatically reduce facies uncertainties, based on realistic and geological parameters, respecting the principles and concept of sequence stratigraphy.

Figure 2 Four steps Workflow for geologically relevant 4D stratigraphic models at Reservoir Scale.

Conclusions

4D Forward stratigraphic modelling is a powerful tool to populate with an inner logic a three dimension geological model. The rules of physics, sedimentology and stratigraphy are honored and allowed the building of predictive environment of deposition and lithologies. At fine scale, Forward Stratigraphic Models could be used as a new method suitable for representing geologically reservoir heterogeneities in the static reservoir modelling, during the very challenging well-poor appraisal phase.