Constrained-Forward Stratigraphic Modelling– Integrating geology, seismic, and production for reservoir modelling

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Summary

Modelling sedimentary geology is a complex task that has not fundamentally changed in the last thirty years. Furthermore, it has often been shown that reservoir models do not reproduce realistic geological features and tend to overestimate connected volumes due to a lack of lateral heterogeneity and a loss of thin flow barriers.

To solve these three problems, we propose a novel constrained-forward-stratigraphic modelling method for easily building realistic sedimentary geological and reservoir models. Instead of creating a facies model using geostatistical tools, we construct deposition bodies using process-based techniques constrained by different data. Traditional process-based methods can create realistic models but cannot be constrained and used directly in the reservoir model.

We construct a stratigraphic volume and then, inside this volume, a reservoir grid, resolving the issue of thin layers, which information is maintained in the grid.

Method / Workflow

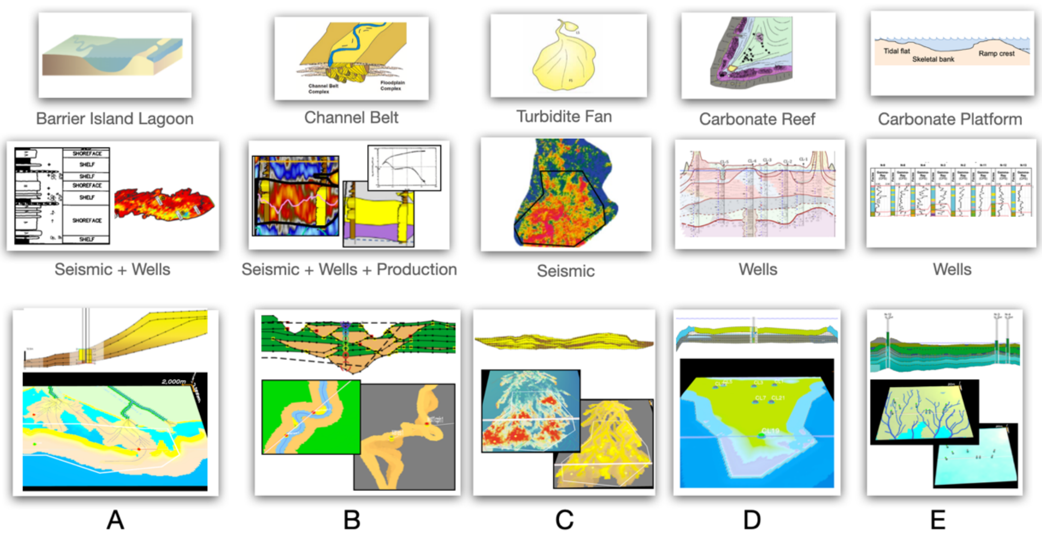
We model the stratigraphy iteratively. First, we create a stochastic topography using the depositional environment's parameters, seismic information, and the well’s lithofacies. As in Leflon (2004), lithofacies information defines the local deposition environment expected at this location, informing bathymetry range constraints. We constrain the terrain stochastic geometry by these ranges. Seismic information provides additional constraints about the topography (valleys, fault-induced deformations, deposit basins, etc.).

Then, using process-based algorithms (diffusion, erosion, migration, etc.), we model layers with their sedimentary objects (rivers/channels, lobes, splay, carbonate reefs, etc.), constraining each body by the lithofacies intervals and constraining the process parameters to the observed lithofacies for this simulation step.

In the traditional workflow, users correlate horizons, create a grid and build a facies model inside the grid. Then, in each facies, porosity and permeability are simulated. With our method, we change the workflow slightly. First, we need lithofacies information and not simply facies indicators. Second, we model the stratigraphy, which creates stochastic correlations, and then the grid. Thin layers, not represented in the grid geometry, are maintained in the grid topology. In each grid cell, we also provide information from the deposition processes, such as granulometry, which can be used as an external drift to simulate porosity and permeability.

Results

In the figure below, we highlight the results of five case studies. The case studies are built from publications by Bryant et al. (Case A), Ainsworth et al. (Case B), Ma et al. (Case C), Nolting et al. (case D), and Eltom et al. (Case E). For each case study, we show the conceptual geological model, the input data and the output geological models in cross-section and 3D. Case A is a wave-dominated delta environment with a lagoon. Case B is a channel belt model constrained by a seismic section between two wells and connectivity information from production. Case C is a turbidite fan environment constrained by seismic proportions and a basin boundary. Case D is a rimmed carbonate platform environment controlled by seven wells. Case E is a carbonate platform's back and tidal flat model controlled by eight wells.



Conclusions

We propose a new method for integrating seismic, geologic, and production interpretation to construct reservoir grids that better represent geological heterogeneity and create more representative flow models. By optimising the use of geological data and moving the modelling difficulty inside rules, we greatly simplify the modelling task.

References

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