Reservoir characterization using electrofacies analysis: application to the Norne Field (Norway)
Gil Correia

Introduction
The Norne pilot project is a benchmark case based on real field data established between the IO Center, NTNU, and Norne Field Operations (StatOil, ENI & Petoro). The main goal is to provide a real dataset to different research groups in order to evaluate and compare different methods for history matching and ultimately closed-loop reservoir management. It was necessary to generate new models because the deterministic model provided in the Norne Field benchmark case was not adequate to be used in current probabilistic history matching procedures and to improve the geological characterization of the Norne Field reservoir. The major steps are (Figure 1):
1. Data preparation involves: (1) gathering all the available geological information regarding the reservoir or analogues; (2) a common suite of logs in all the wells used as input data; (3) rigorous quality control of those datasets; (4) depth matching of various logs; (5) creation of a diff curve for each well:
   \[ \text{diff} = \rho_{\text{phi}} - \rho_{\text{phif}} \]
where \( \rho_{\text{phi}} \) is the neutron porosity and \( \rho_{\text{phif}} \) the density porosity.
2. Electrofacies classification based on the artificial neural networks algorithm (ANN). The unsupervised ANN was used because no core data was available to train the neural network. For quality control purposes, the obtained electrofacies were compared with the simplified lithological column that was available in some of the geological well reports. The ANN should be used with caution when constructing 3D models, due to over an under-training problems, being more useful when integrated with statistical methods;
3. Simulation grid refinement in order to maintain as much as possible the fine scale heterogeneities seen in the well logs, namely the thin carbonate and the shale layers that could act as vertical stratigraphic barriers due to their low permeability;
4. Upscale well logs and the created electrofacies to the high resolution geomodel grid to be able to generate 3D facies and petrophysical models through geostatistical methods. This high resolution grid should maintain as much as possible the fine scale heterogeneities seen in the well logs;
5. Generation of 3D facies and petrophysical models (porosity, permeability and NtG) using stochastic methods able to generate multiple realizations under certain uncertainty ranges. The 3D models of each petrophysical property were restricted by the 3D facies distribution and by correlation factors between each property obtained from the data analysis process.

Application
The methods were applied in the real dataset, the Norne Field benchmark case, which includes: a reservoir simulation model with grid cell sizes of 60 x 60 x 8 m, 44927 active cells, subdivided in 22 reservoir zones; 47 wells most of all including gamma-ray (gr), bulk density (rhob) and neutron porosity (nphi) logs and density porosity (phif), permeability and Vshale calculations, with a sampling rate of 0.125 m3 production data and 4D seismic data.

Specials interests:
- UNISIM
- UNISIM Publications
- Reservoir Simulation and Management Portal
- Previous Issues

Links:
- UNICAMP
- Cepetro
- Petroleum Engineering Division
- School of Mechanical Engineering
- Petroleum Sciences and Engineering

Graduate:
Petroleum Sciences and Engineering: interested in Masters and PhD in the Simulation and Oil Reservoir Management area click here.
tion through the NtG becomes directly related to the electrofacies by defining specific ranges of uncertainty to each electrofacies instead of using the frequently problematic permeability cut-offs and Vshale curves. To the sandstones (facies 3, 4 and 5) was assigned a NtG = 1, to the shaly-sandstones (facies 2) an intermediate NtG (mean 0.5) and for the carbonate and shale horizons it was assumed that the grid cells were practically disconnected (NtG < 0.2).

Finally, 200 facies and petrophysical models were generated using different petrophysical ranges to each electrofacies (in each of the 22 reservoir zones), different NtG values attached to each facies, and the variograms. Stochastic methods were used for this purpose. The pore volumes of each realization were analyzed, being in agreement with the deterministic pore volume informed in the Norne Field benchmark case (673x10^6 m^3) however, with a wider range.

Final Remarks

Besides the absence of a geological model, the Norne database provided only a deterministic solution based on kriging methods applied into a low resolution grid. The electrofacies scheme and the high resolution models obtained in this study allow a refined comprehension of the geological framework. Also help to identify and characterize small variations in the reservoir quality and are essential in recognizing the location, thickness, extent and frequency of decimeter shale/cemented layers that could act as vertical barriers to fluid flow displacement. These high resolution models give also a better control on the upscaling methods to the coarser simulation grid, allowing us to understand, quantify and minimize the information that is lost due to the smoothing effect. The stochastic methods used in the modelling stages allow us to work with uncertainties, forming the working basis in the integration with a probabilistic and multi-objective history matching approach using both production and 4D seismic data, and assisted by geostatistical parameterization techniques.

References


About the author:

Gil Correia graduated in Geology and M.Sc. in Petroleum Geology from the University of Coimbra. Since 2012, is a researcher at UNISIM Group and Ph.D. student in Petroleum Science and Engineering at Uni- camp.

For further information, please visit http://www.unisim.cepetro.unicamp.br