3D Reservoir Geomodelling of the Rotliegend Reservoir in the Northern Netherlands

Chaker Raddadi
Vermilion Energy

Summary

Late Permian Rotliegend sandstones deposited in the Southern Permian Basin represent the main gas-bearing reservoir in the Netherlands. These clastic sediments were deposited in continental alluvial and aeolian changing northwards to playa lake depositional settings.

Since 2004, Vermilion Energy Netherlands operates many Rotliegend fields onshore the Netherlands and is actively looking at further developing the existing fields and exploring for new opportunities.

In the study area, the lower part of the Rotliegend group is dominantly aeolian (Slochteren: ROSL) and has by far the best reservoir properties while the upper part (Ten Boer: ROCLT) is composed of interbedded sandstones, silty-sandstones and claystones. Several fields have been discovered decades ago and recent seismic acquisition show considerable remaining potential in the ROSL, but also and sometime mainly within the ROCLT reservoirs when the lower ROSL was drained

The ROCLT sands are difficult to map as the cleaner and most porous sandstone layers are only few meters thick and can have relatively limited lateral extent. One other challenge is the very complex structural setting which creates various juxtaposition configurations across the faults where the lateral sealing capacity of these faults is uncertain and adds difficulty in assessing gas volumes in the existing pools and more risk to the identified prospects and leads.
Analyzing the possible gas migration pathways and faults juxtaposition together with a detailed mapping of the lateral facies change of the Ten Boer reservoir are crucial to better assess the initial and remaining potential within the existing pools (attic gas and undrained reservoir layers) and better constrain the estimated gas volumes within the exploration prospects and leads.

This project builds on the existing data and aims to improve Vermilion's understanding and prediction of reservoir distribution, gas migration pathways, existing and remaining gas reserves, key elements to developing exploration and development opportunity portfolio.

Workflow

A regional 3D reservoir model covering an area of about 2000 sq.km was built using Petrel (Figure-1). This area of interest is fully covered with a 3D seismic survey which was recently reprocessed and was used to pick the key seismic horizons and faults (over 440 faults). The structural model was initially built using Petrel's Structural Framework process due to the large number of faults and very complex structures then converted to corner point grid. This large model is composed of over 730 million cells (100*100m) with thin layering (0.5m) of the main reservoir sections.

101 wells with good quality logs and petrophysical analyses were used in the model. This sizeable dataset provides meaningful geostatistical power to control facies distribution and generate alternative distribution models for uncertainty management.

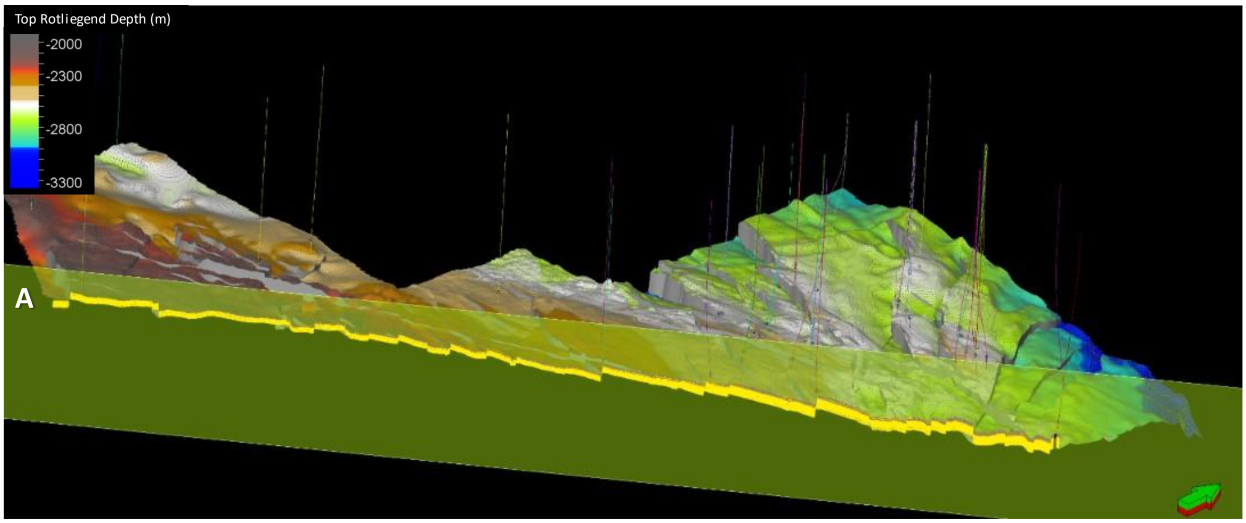

Figure 1 : 3D block diagram showing the Top Rotliegend depth structure map and a North-South cross-section (A) of the Rotliegend Reservoir.

Results, Observations, Conclusions

It has been established through public 3D basin modeling that the study area is charged from long distance gas migration from a northern kitchen. It can be confirmed that the Rotliegend fields are organized in a structural fill spill chain model from the north towards the south of the area of interest, demonstrated by a good match between observed FWL and structural spill/ leak points. Gas has initially filled all the traps to structural spill points (none of the studied traps was underfilled). A favorable active fault seal between the ROSL and ROCLT reservoirs was needed to maintain a gas column in few of the traps (Figure-2). The mechanisms behind the sealing capacity of these faults will be investigated further (SGR, cataclasis,…).
The difference between the original and the current FWL in successive development wells can often be explained with production volumes offtake in all pools. In one instance however, there is a large discrepancy between the initial, current FWL, pool size and volume produced. It is currently assumed that the large gas volume which filled the trap initially was partly lost during geological time most likely due to faults reactivation post migration resulting in unfavorable juxtaposition.

The 3D geological model is a very precious tool to integrate and synthesize all available data (seismic, wells logs, petrophysics, production volumes, pressure,…) and helps to demonstrate and prove or invalidate some of the previous assumptions and interpretations. The model is used to calculate the initial and remaining gas volumes in existing gas discoveries and to better define the range of volumes in the identified prospects and Leads. It also helps getting a much better idea about the possible gas migration pathways and the fill-and-spill history of the different pools.

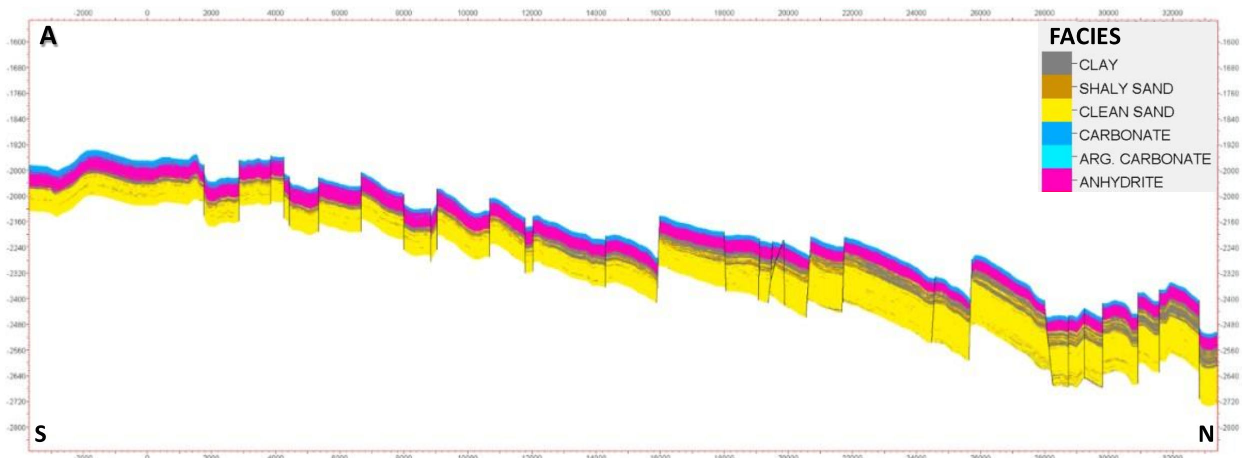

Figure 2 : A detailed view of the North-South cross-section (A) showing the Zechstein 2 carbonate and the Rotliegend sandstone reservoirs