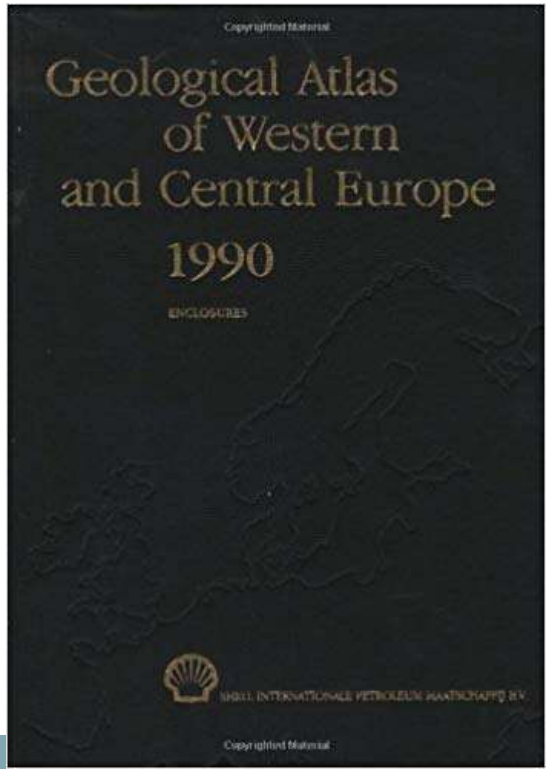
The Ziegler prospect:
Exploration in the Dutch L10 block after more than 40 years of production

Dutch Exploration Day November 21st 2018

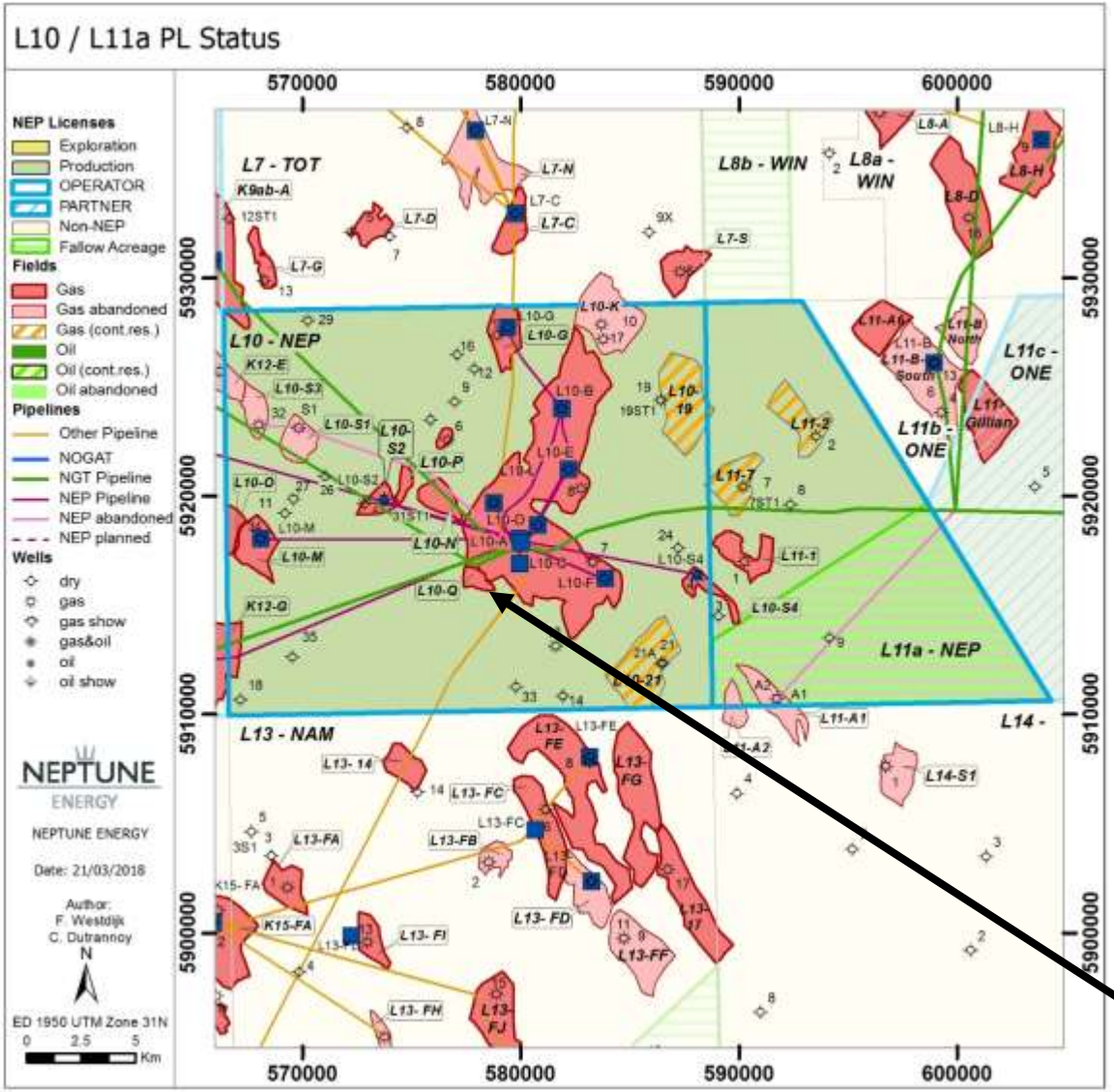
NEPTUNE ENERGY

L10-Ziegler

- Neptune prospects in K9/K12/L10 named after famous scientists (or gems) with some relationship to earth science (Fresnel, Hubral, Escher, Wegener, Planck, Meinesz, Dirac)
- Ziegler: Swiss exploration geologist Peter Ziegler (1928-2013), paleo geographic reconstructions in the Geological atlas of Western and Central Europe.
- Structurally complex prospect
- Drilled from the “senior” L10-A complex (3km distance)



L10/ L11a Production License



L10/L11a Production License (596 km²)

ENGIE	**38.571**	**%**
Rosewood	11.345	%
XTO	10.084	%
EBN	40.000	%

Effective Date: 13-01-1971
End of License: 01-01-2025

L10-Ziegler

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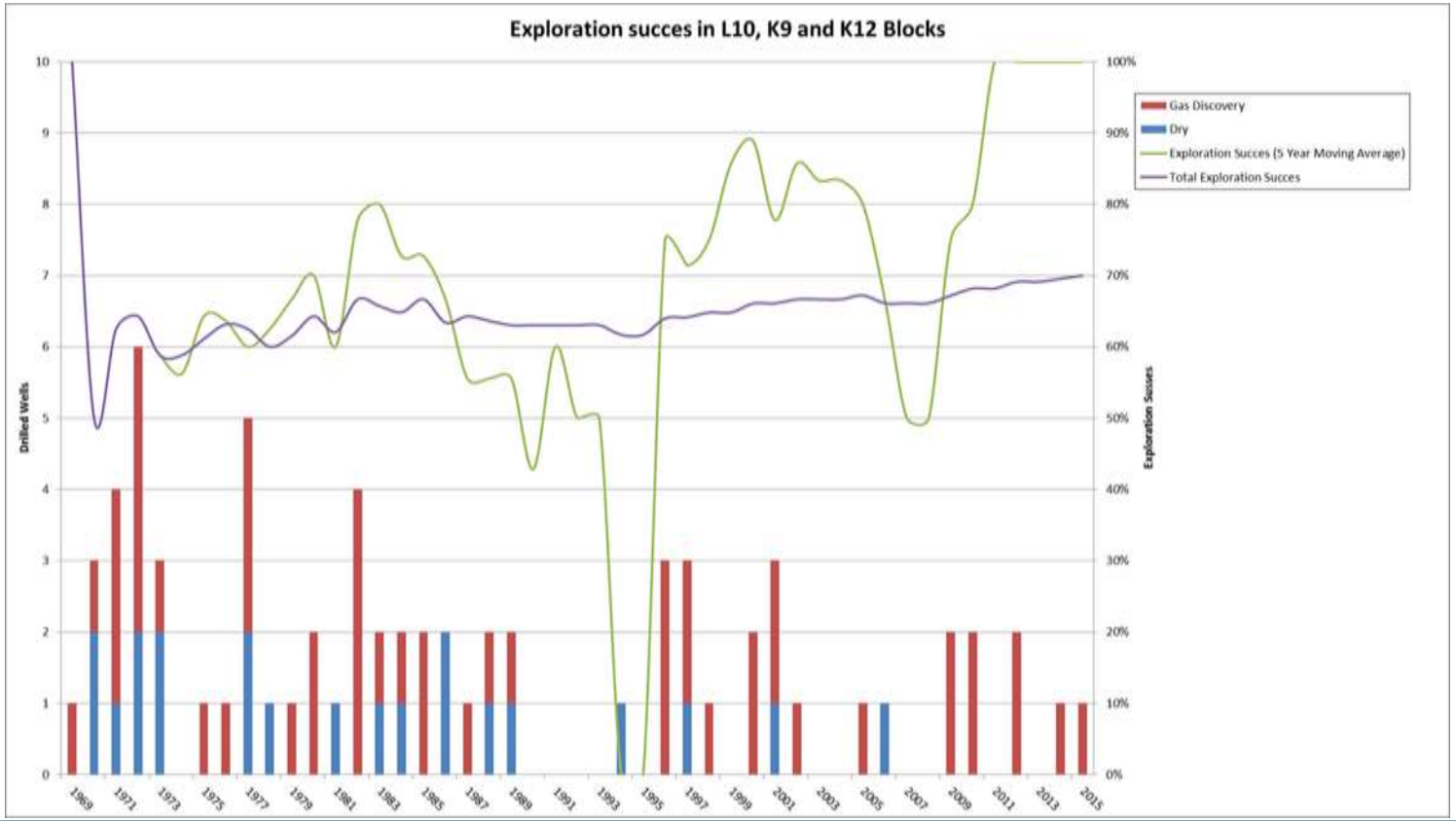
Exploration success in Neptune assets K&L blocks

Status pre L10-39

- Average exploration success (since start of exploration, pre-L10-39) 0.71 (51 out of 72)
- Since block wide 3D (1991) only 4 dry wells out of 20 were drilled, this is a success rate of 80% (16 out of 20). Since PreSDM data (2009) success rate is 100% (8 exploration wells)



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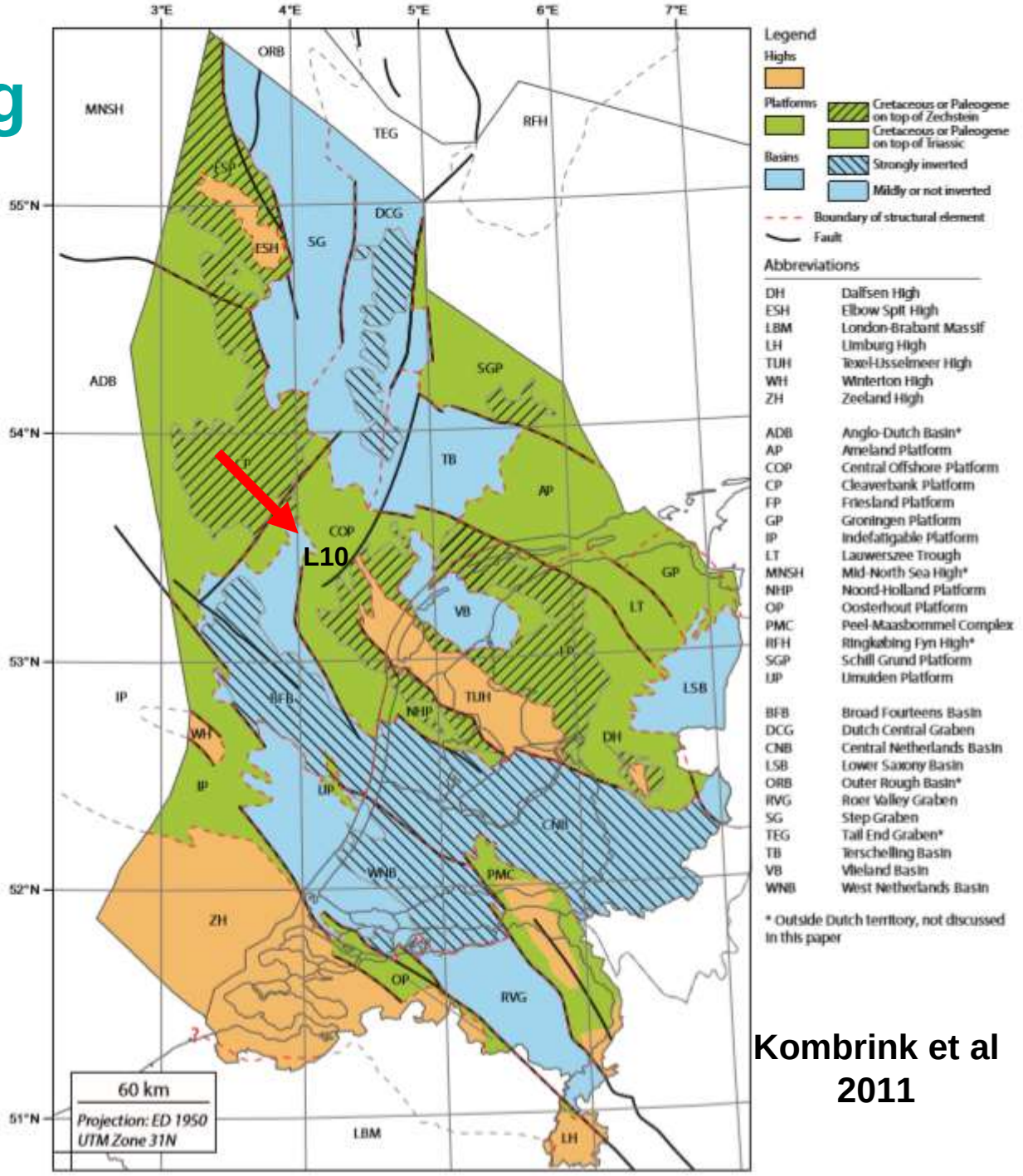
Tectonic setting

- L10 situated on Central offshore platform
- Severe saltdoming present in western part block flanking the linking zone of Central Graben and Broad Fourteens Basin
- In L11 (to the east) the NW extension of the Texel Ijsselmeer High present



Kombrink et al 2011

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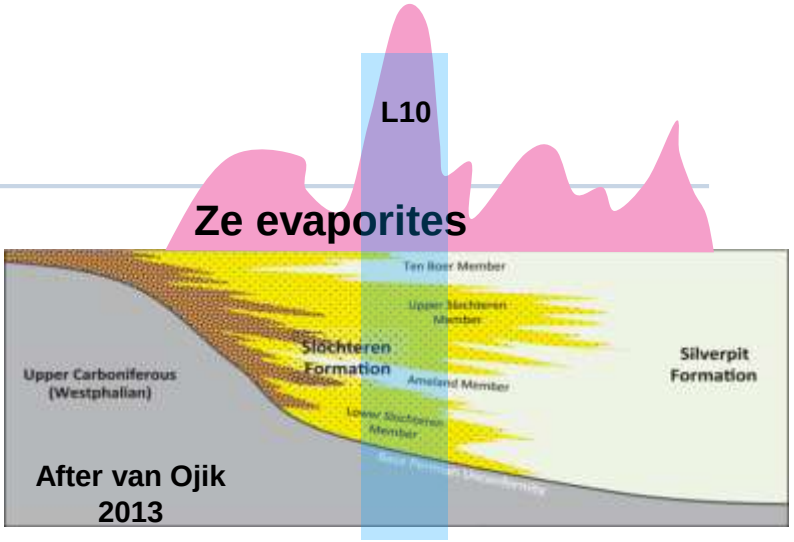
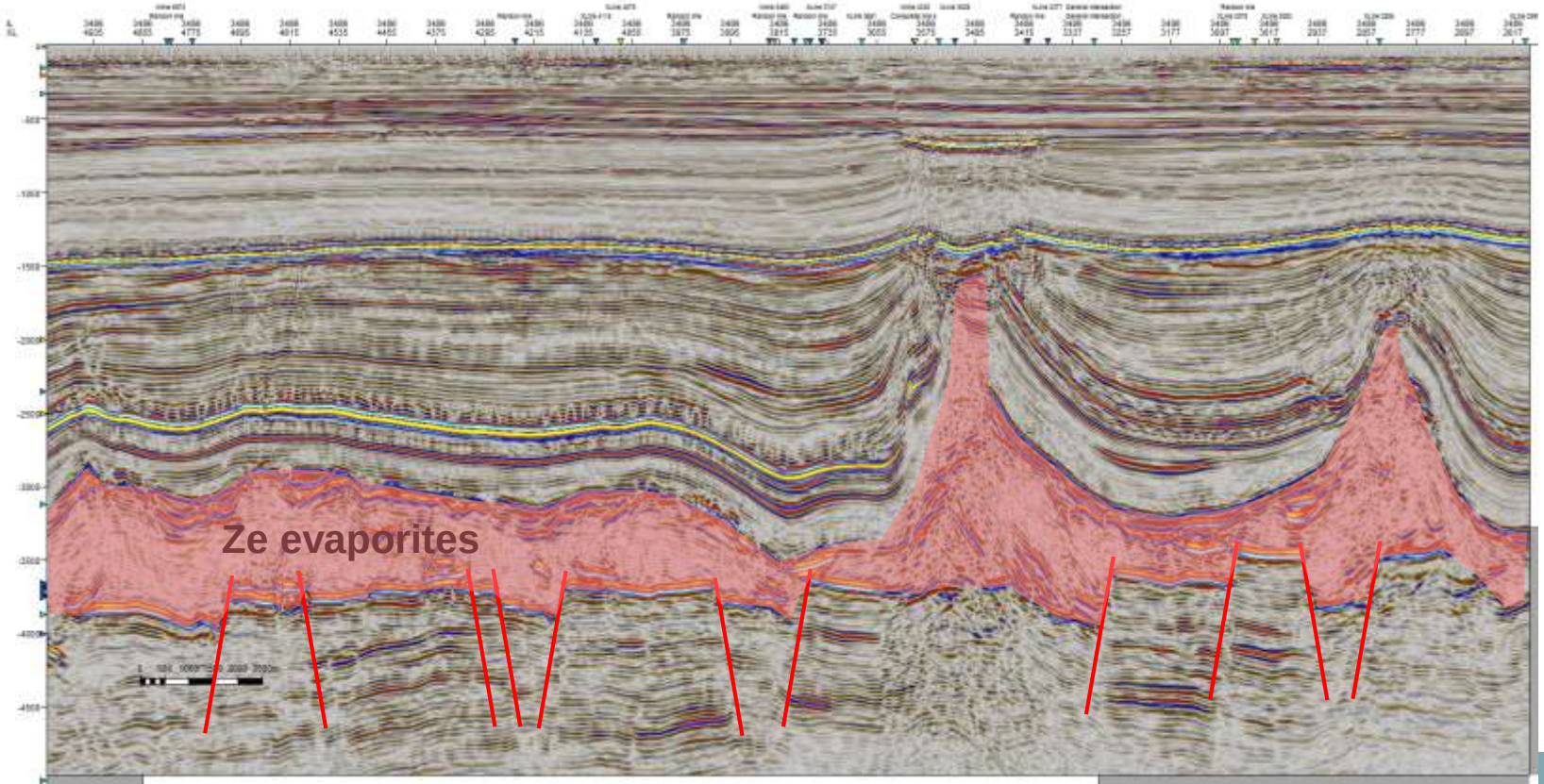
Rotliegend Play in L10

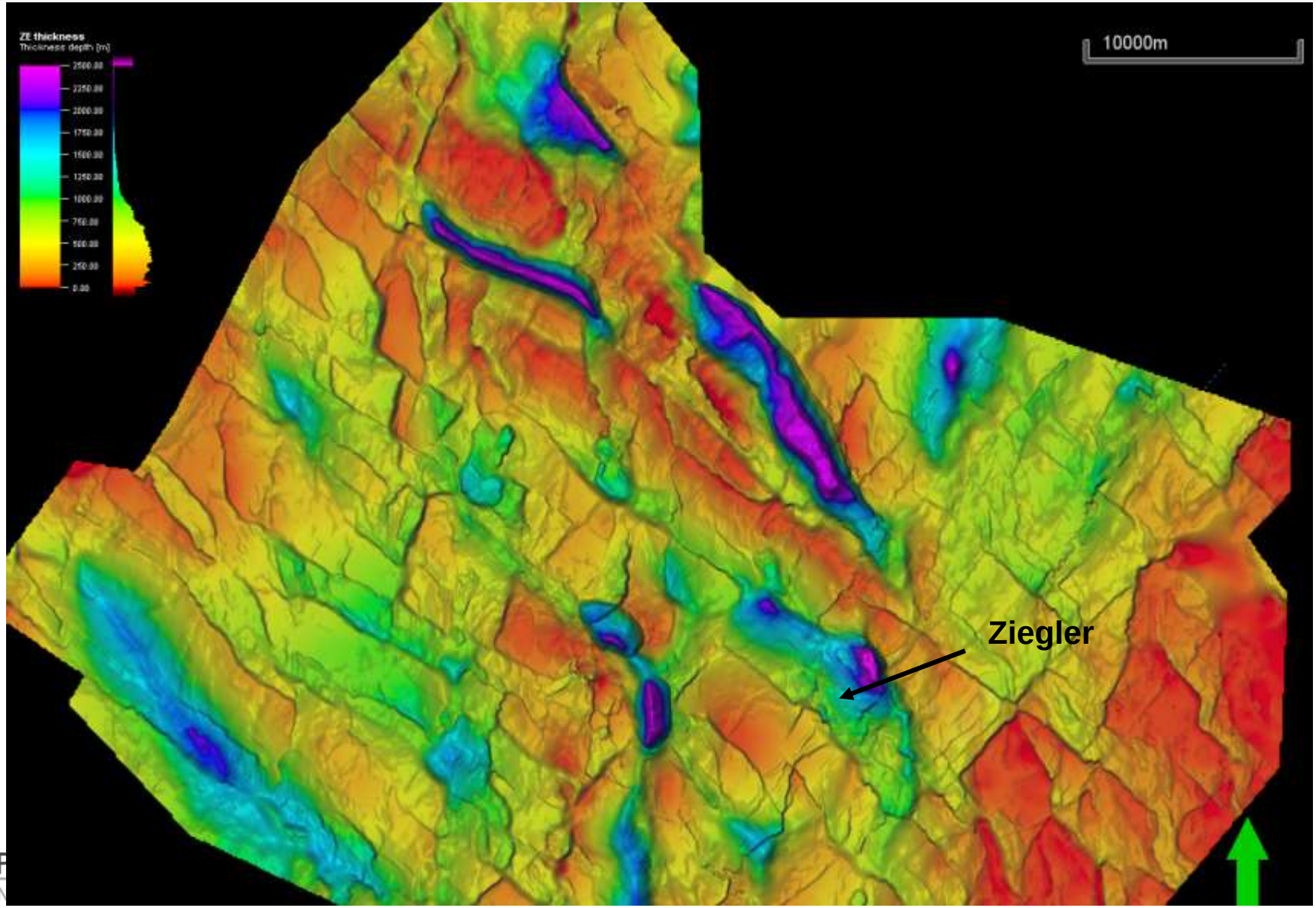
- Upper Slochteren reservoir
- Zechstein evaporites seal
- Traps: tilted extensional fault blocks





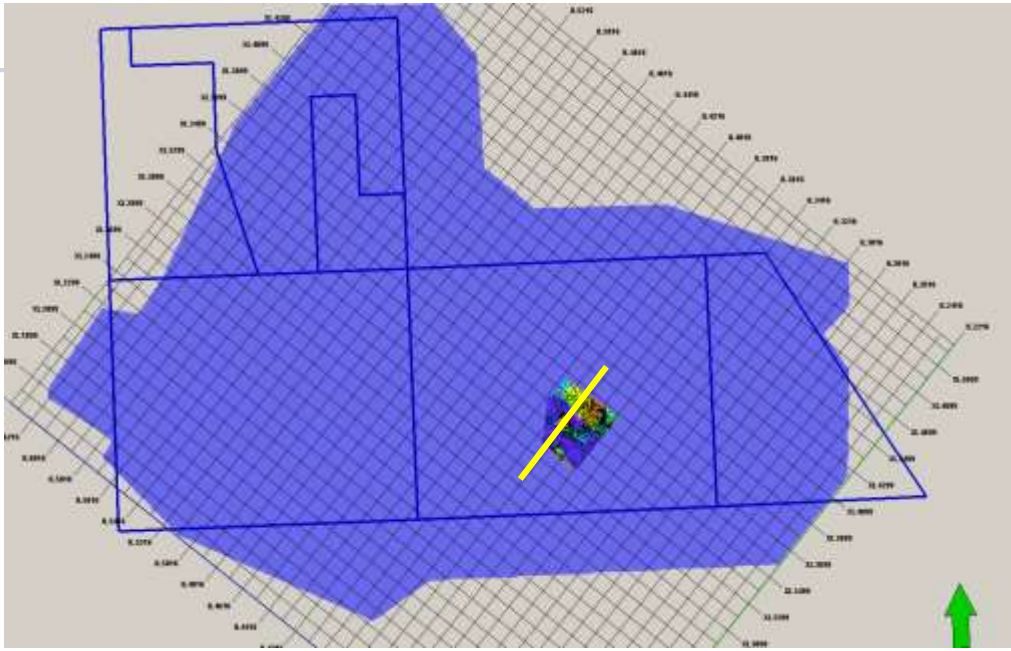
Seal: Zechstein Thickness

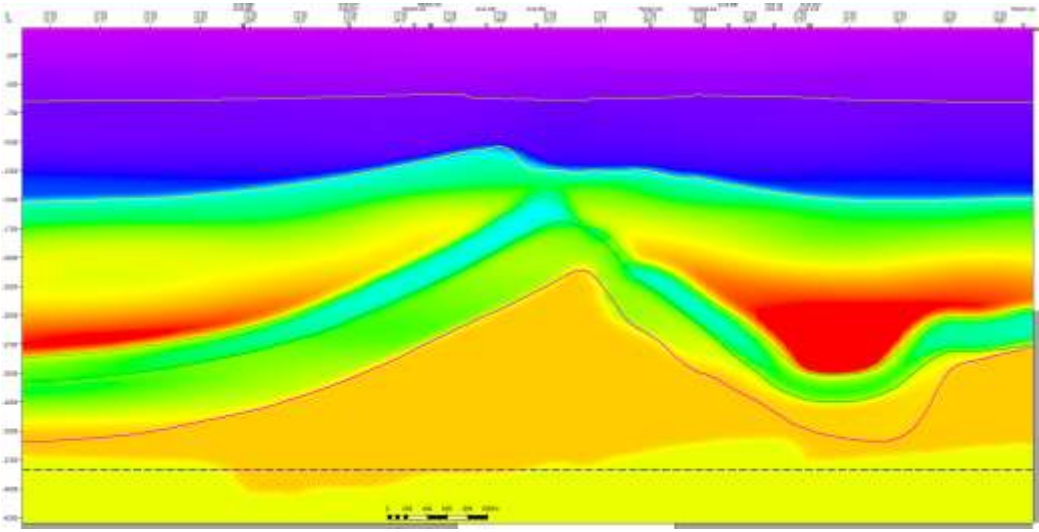
Domes and leak windows



Seismic data

- L10-Ziegler is covered by the KL08 PreSDM acquired in 2008 processed by CGG
- Kirchhoff and Beam migration algorithms applied.
- PreSDM velocity for this survey has been calibrated by 100+ wells
- Seismic quality good except underneath salt domes and stacks of floaters





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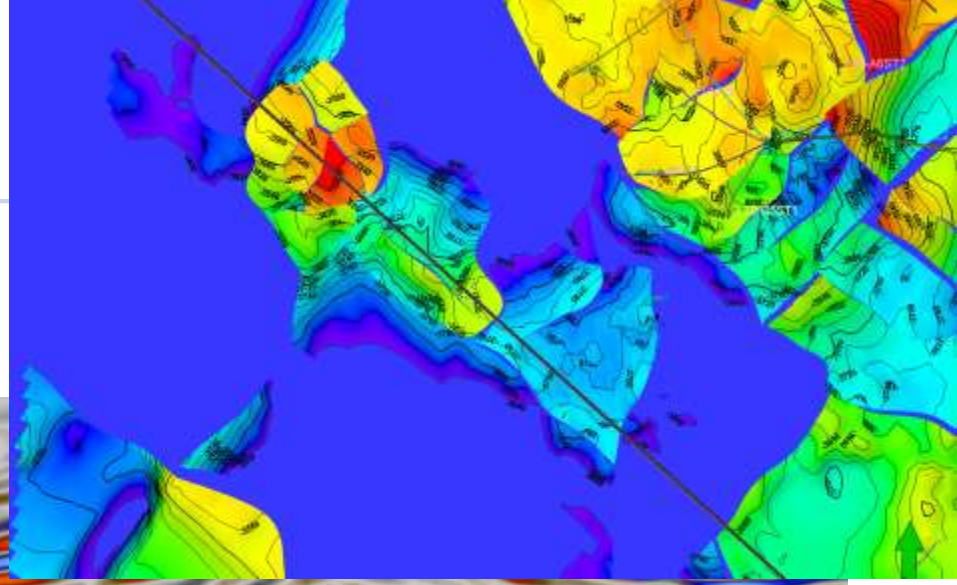
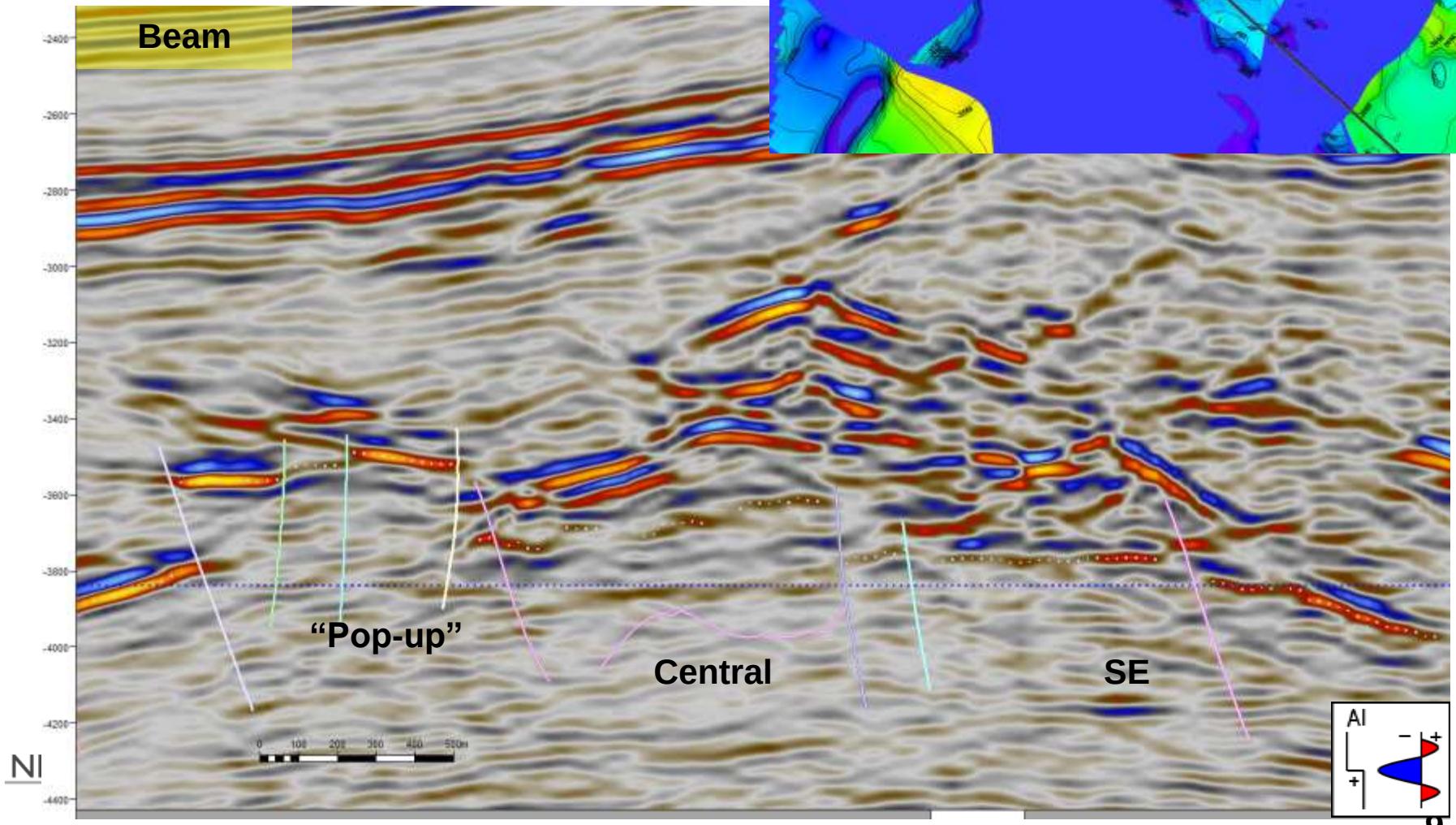
Strike-line showing Ziegler's areas

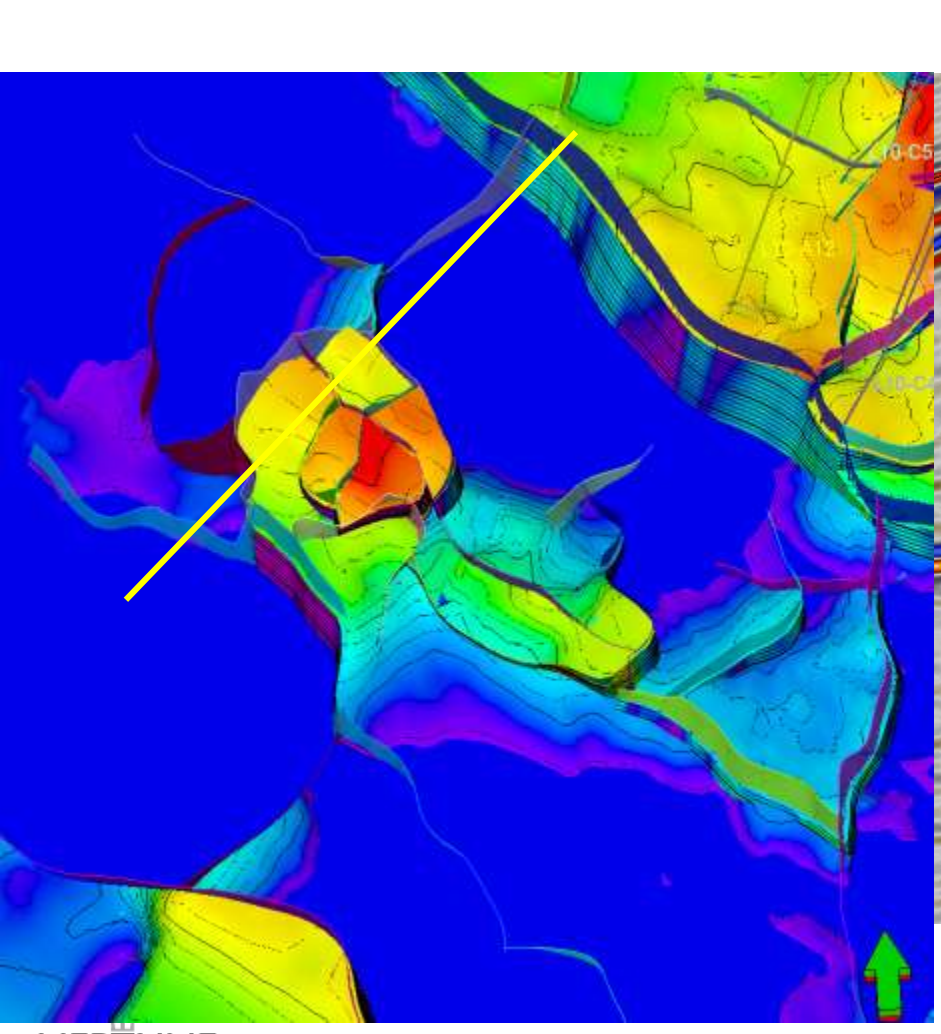
NW

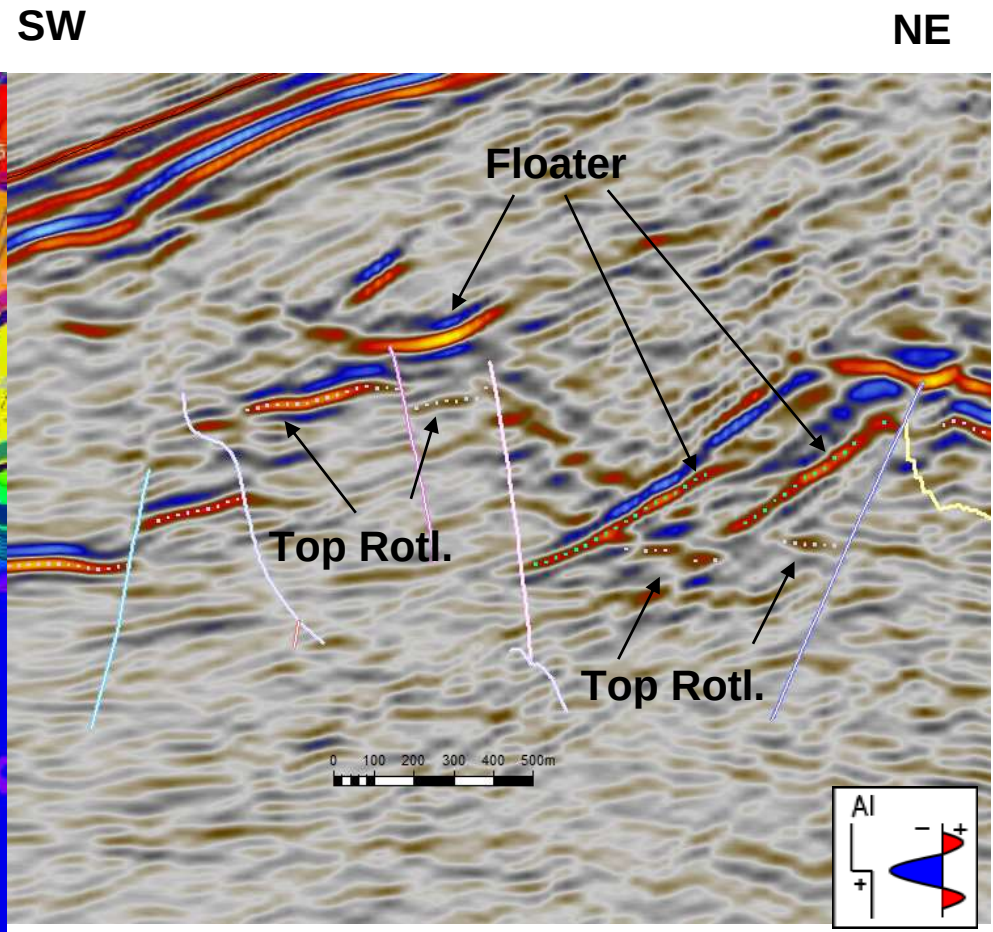
SE→





Line through “pop-up”





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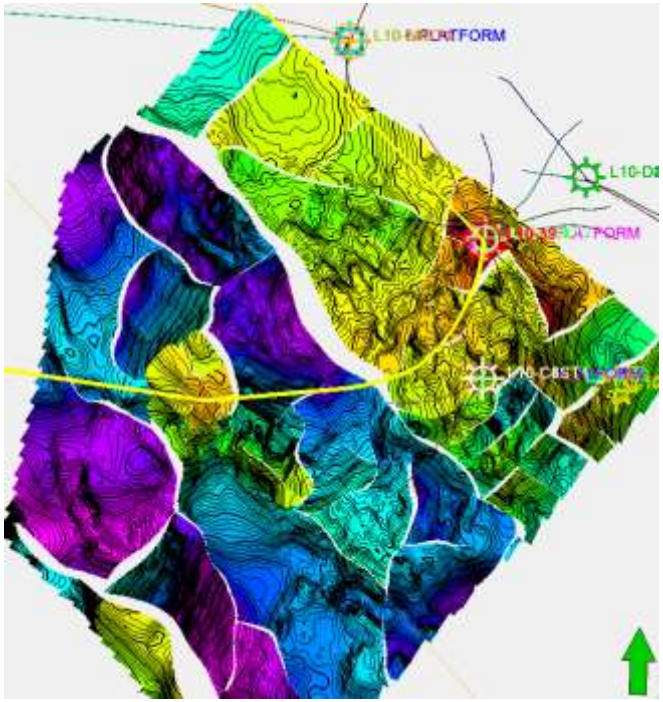
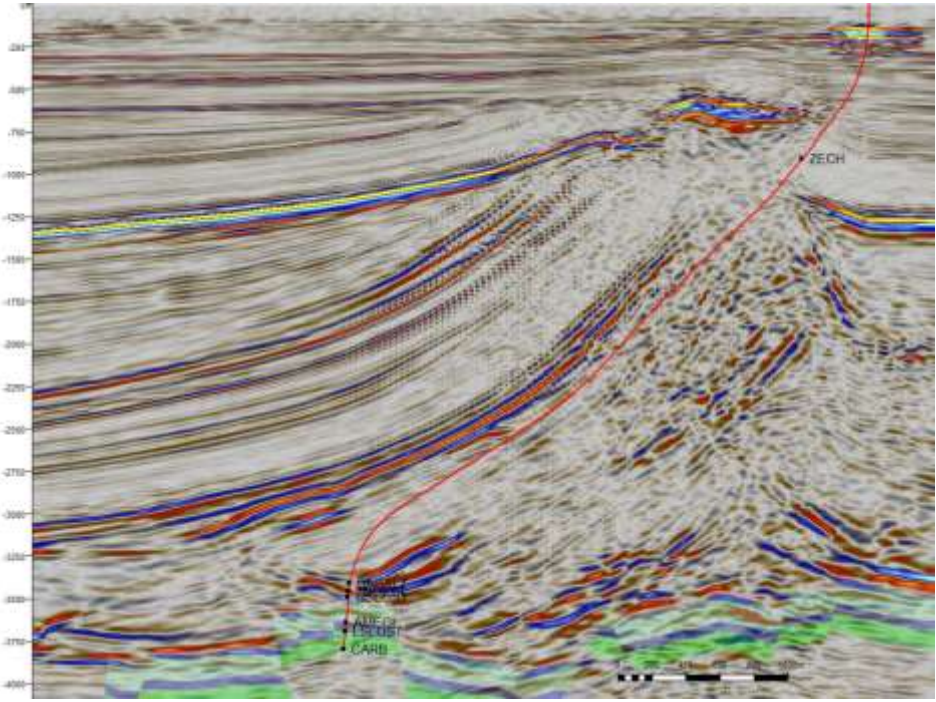
L10-39 exploration well

Ziegler prospect

- Drilled from L10-A platform to Ziegler prospect. Plug and abandon L10-A8, slot recovery.
- Target: Upper Slochteren Sst Formation
- Spud November 2017





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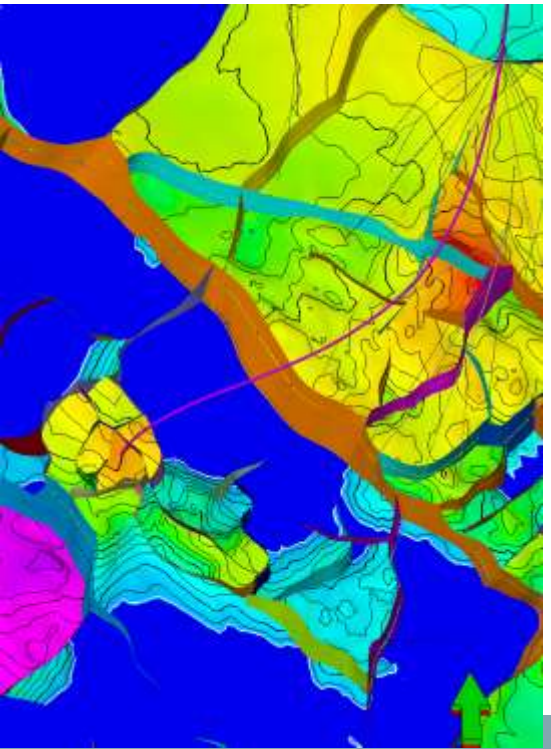
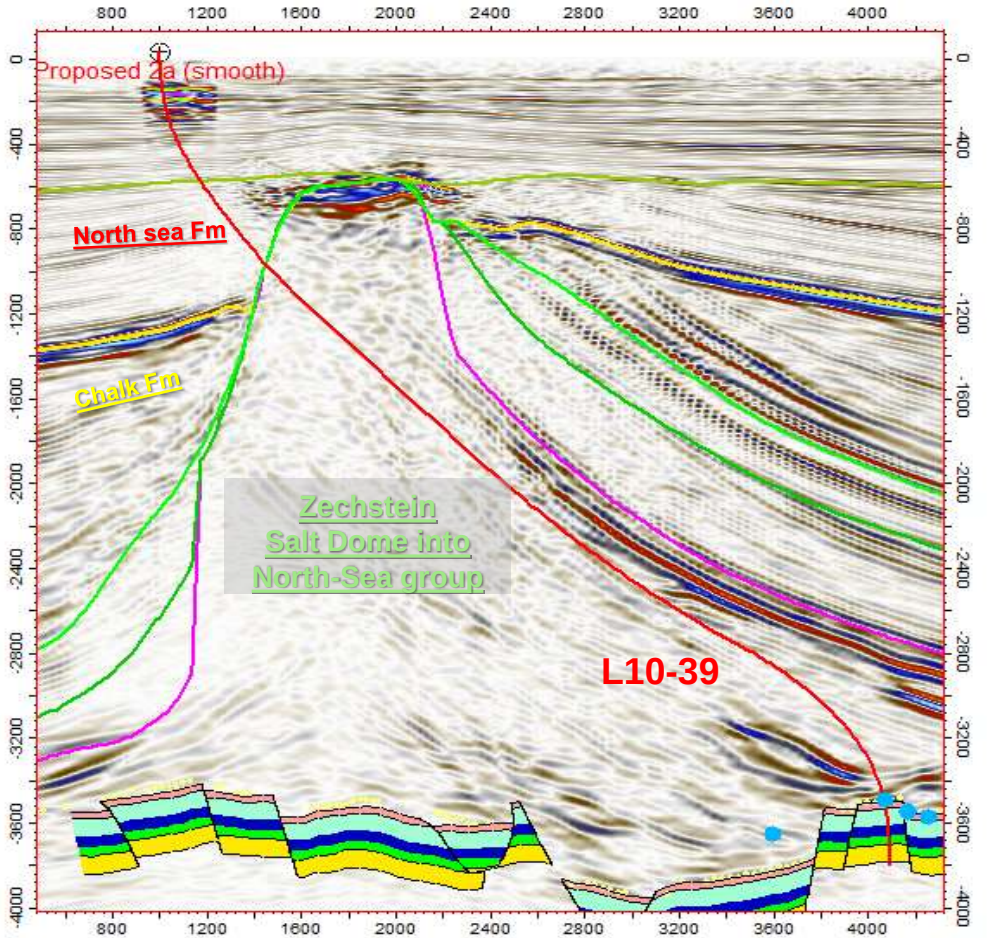
L10-39 Well path

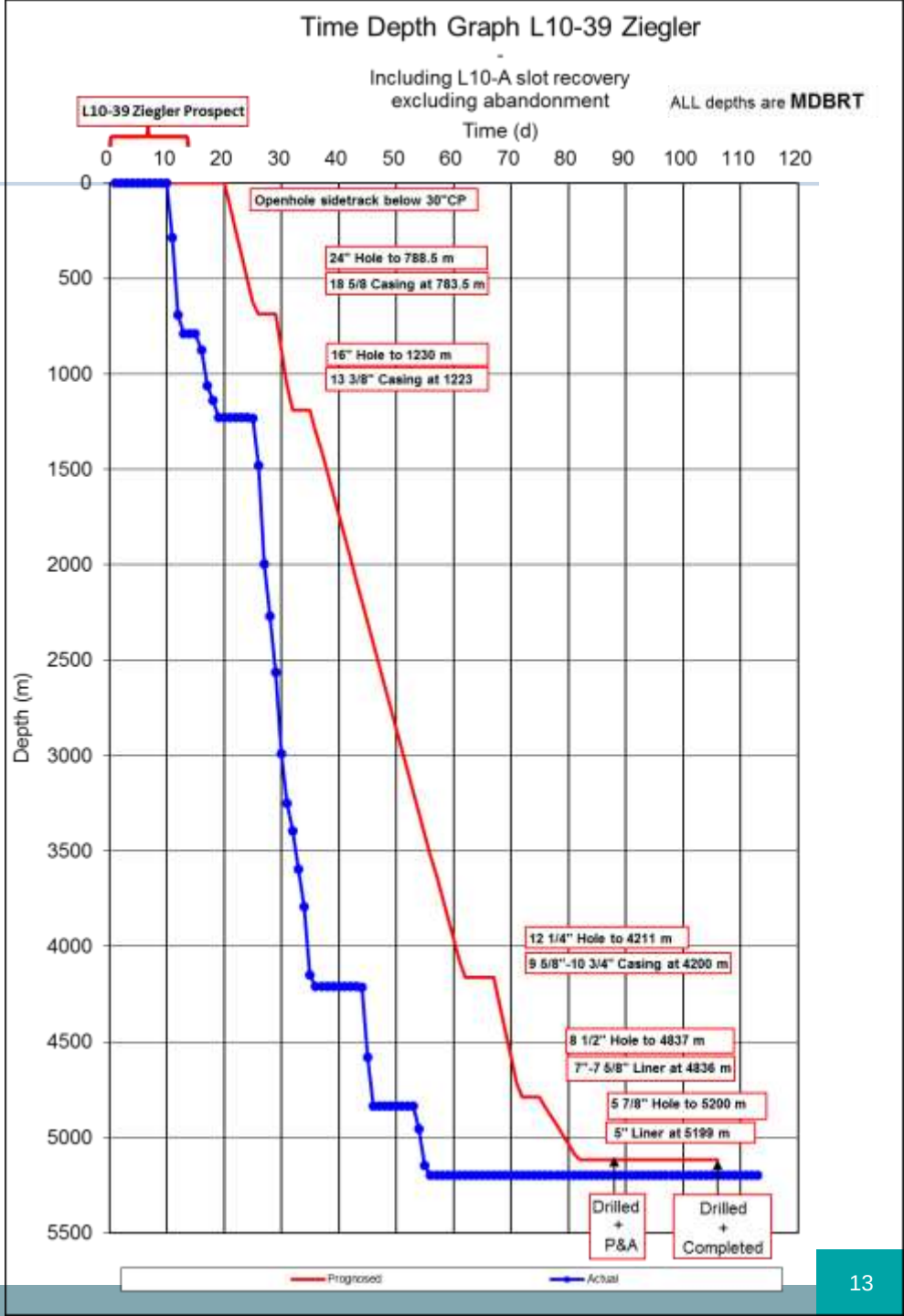
- Trajectory length ~ 5100 m with step-out of ~ 2.7 km
- Target Depth of 3500 m (Top Rotliegend)
- Trajectory planned to penetrate the salt dome in a position where no Chalk is expected
- Trajectory avoids squeezing Zechstein salts and Floaters seen on seismic





Drilling performance

- Drilling safely
- Drilled in less than 40 days to a Measured Depth of over 5000m
- No problems encountered in the challenging Zechstein section



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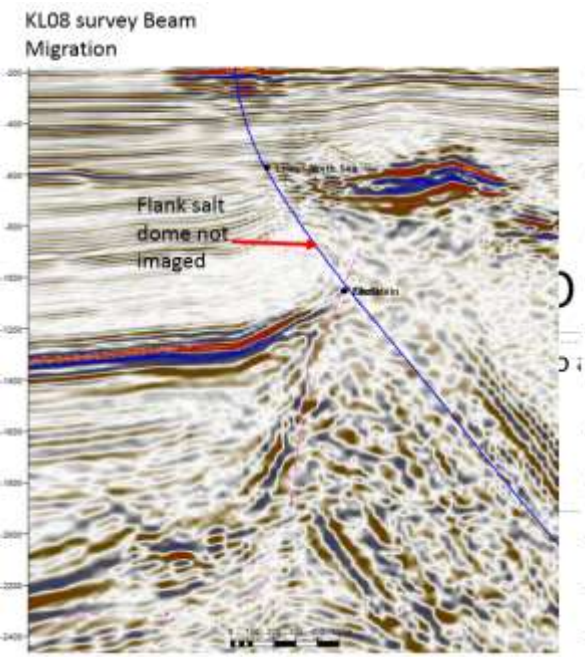
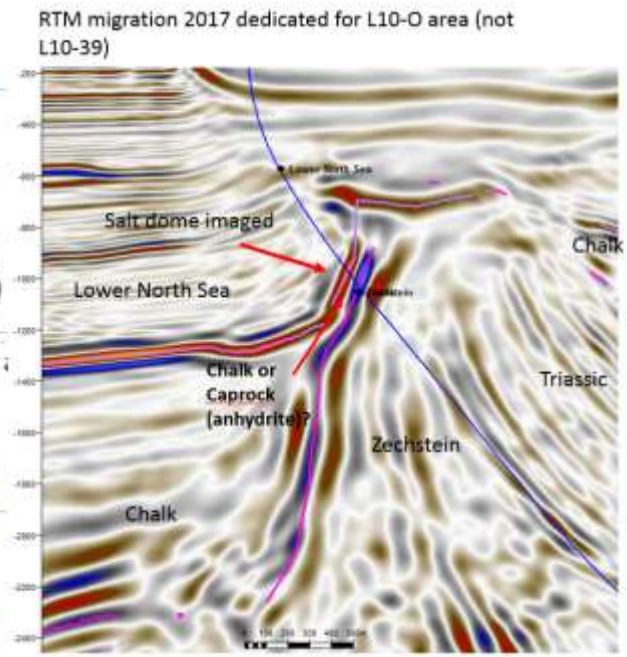
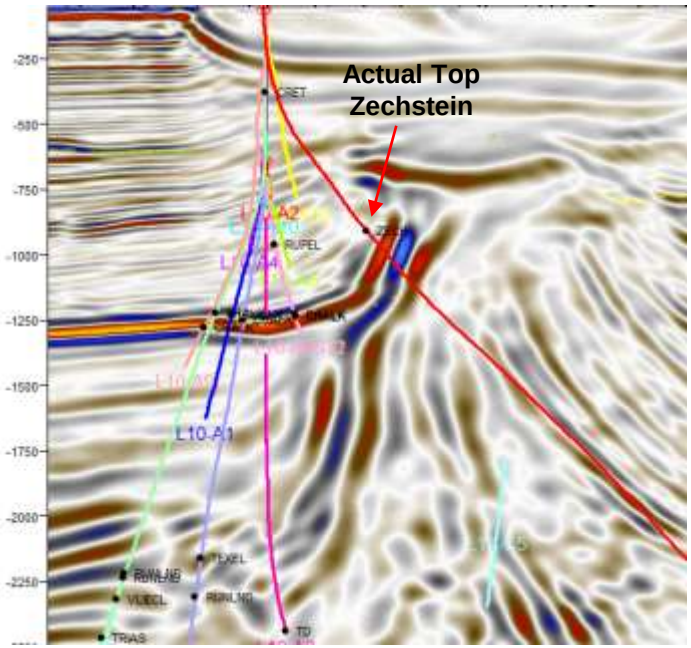
L10-39
Well tops

- No Chalk encountered (no losses)
- Top reservoir about 40 m shallow
- Slightly thicker Rotliegend interval







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Gas!

L10-39
Results

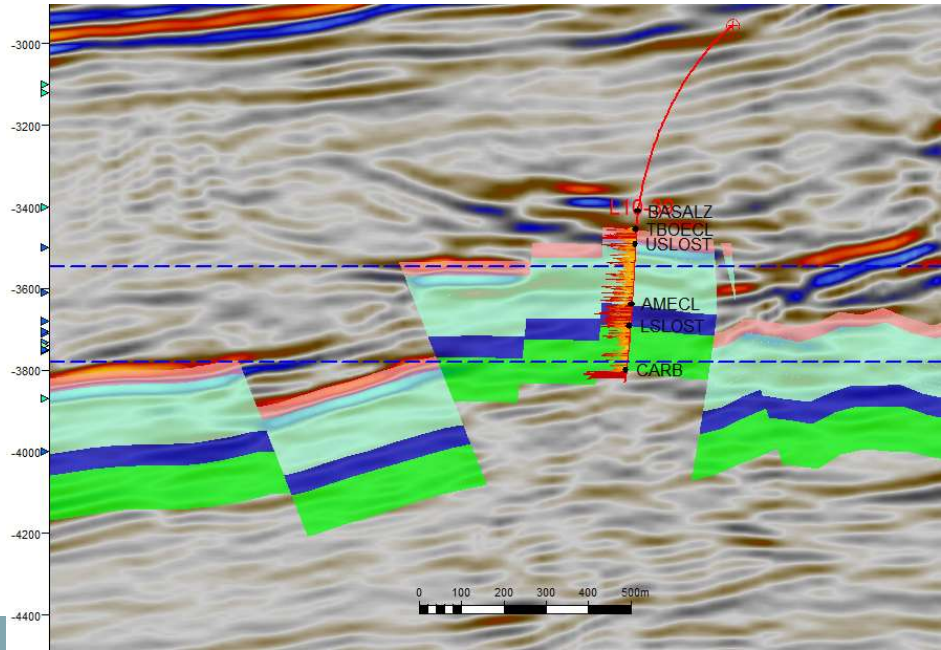
- Rotliegend came in ~40m shallower
- Reservoir slightly thicker than expected, probably some reverse faulting
- N/G and Porosity in line with regional Upper Slochteren properties
- Small depletion due to production neighbouring fields (aquifer)
- FWL shallower than expected, structure not filled to spill
- The well was tested successfully and will be/is turned into a production well

Under-filled structure

Potential reasons

- Insufficient charge (but, almost all structures filled to spill)
- Pop-up structure formed after fill (but, similar structures filled to spill; L10-N (former Ruby prospect), L10-P (former Ruby-west prospect))
- Leakage into floaters (but, limited reservoir potential, limited volume, no connection to overburden)
- Intrusive dykes breaking seal (but, no evidence here, reason L10-S2 under-fill?)
- ……..

Neptune fields in L10 area are filled to spill (within depth uncertainty), only 1 (other) exception



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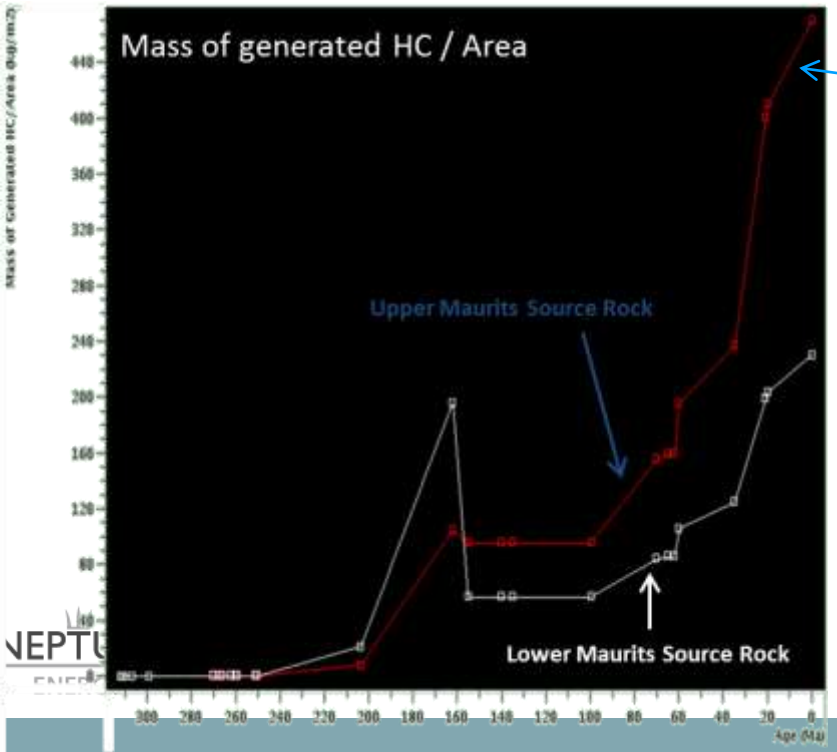
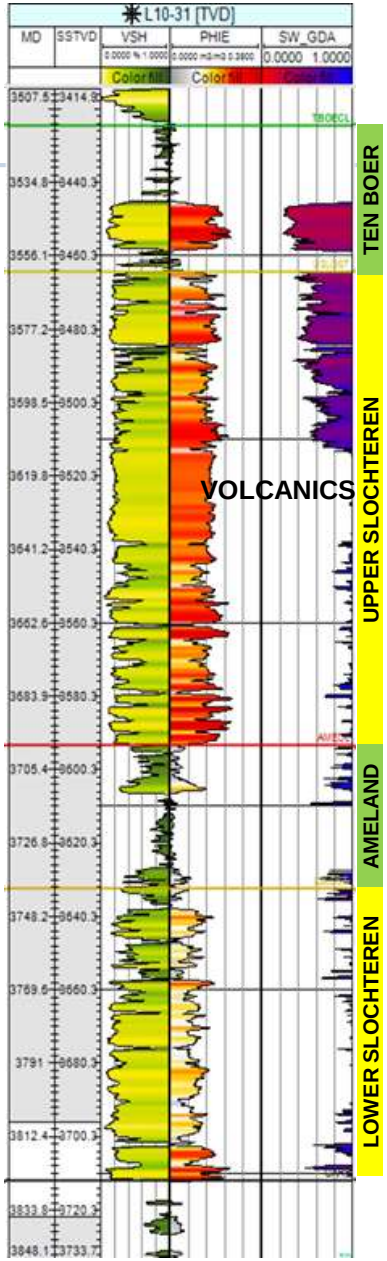
Other structures:
L10-S2 field, not filled to spill

3 possible explanations:

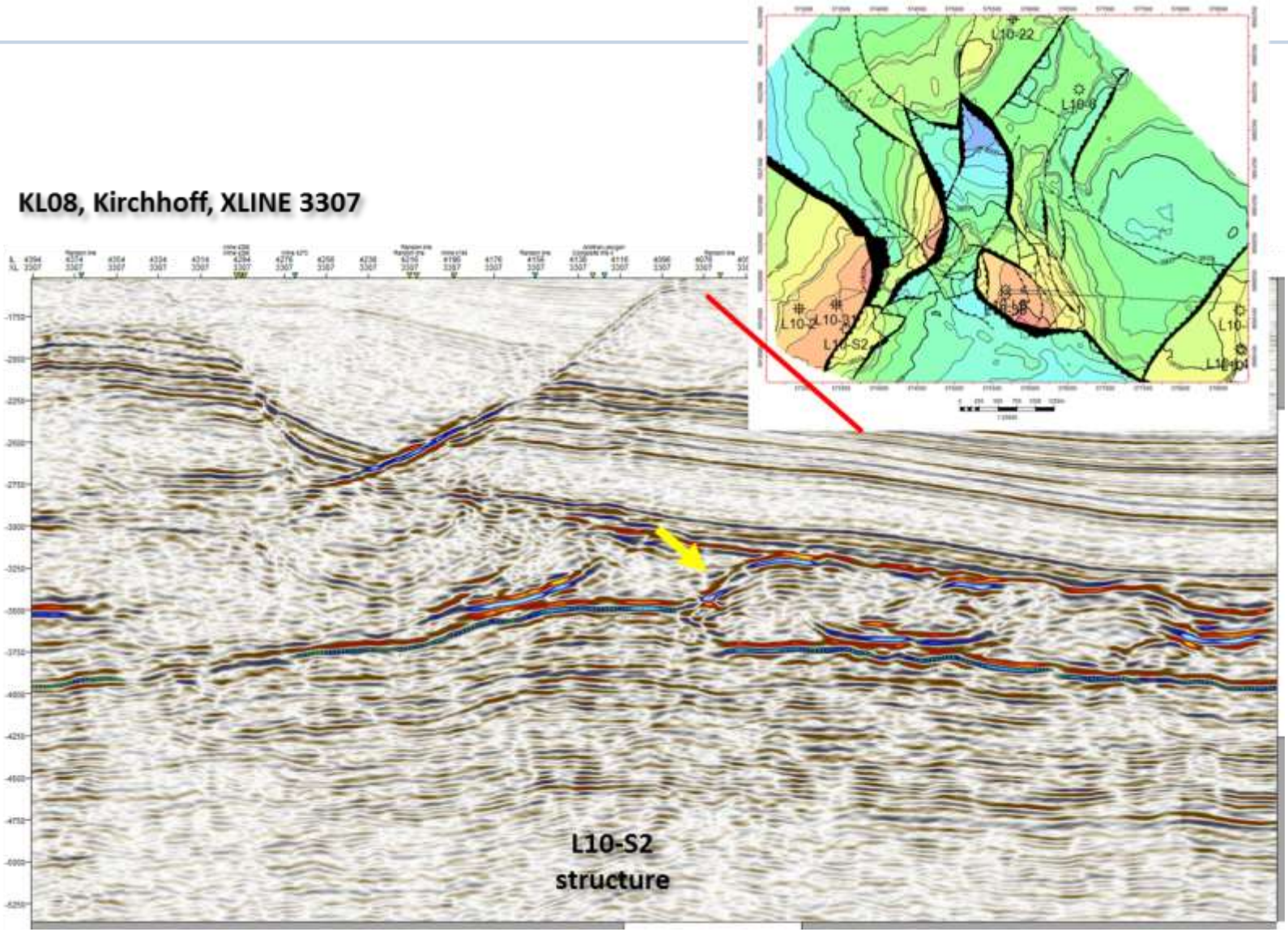
- Late structuration during Savian tectonic phase, after last hydrocarbon generation?
- Leakage due to volcanics emplacements in Jurassic time. Volcanics identified in L10-31 and L10-6 in the Upper Slochteren.
- Leakage through a floater making a bridge to Triassic



Post-Savian Hydrocarbon generation



L10-S2 leakage through floater?



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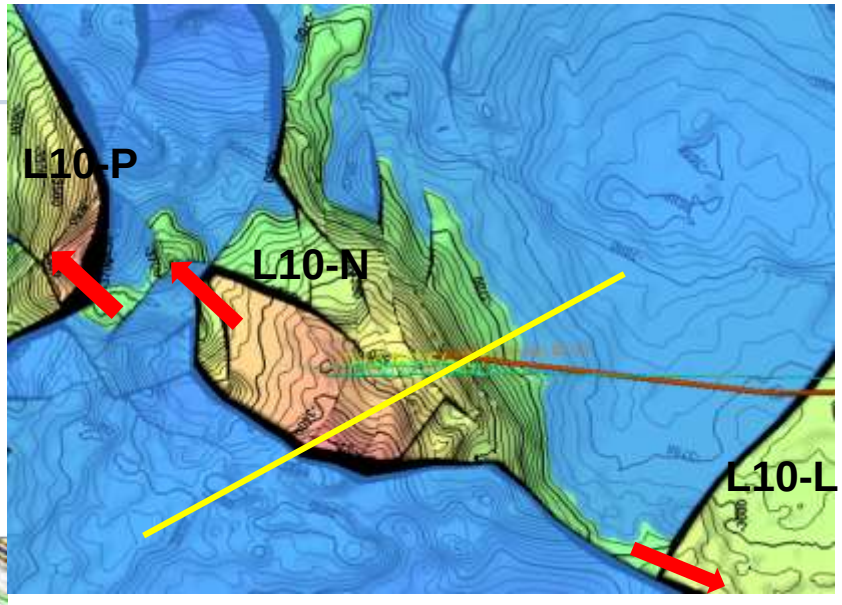
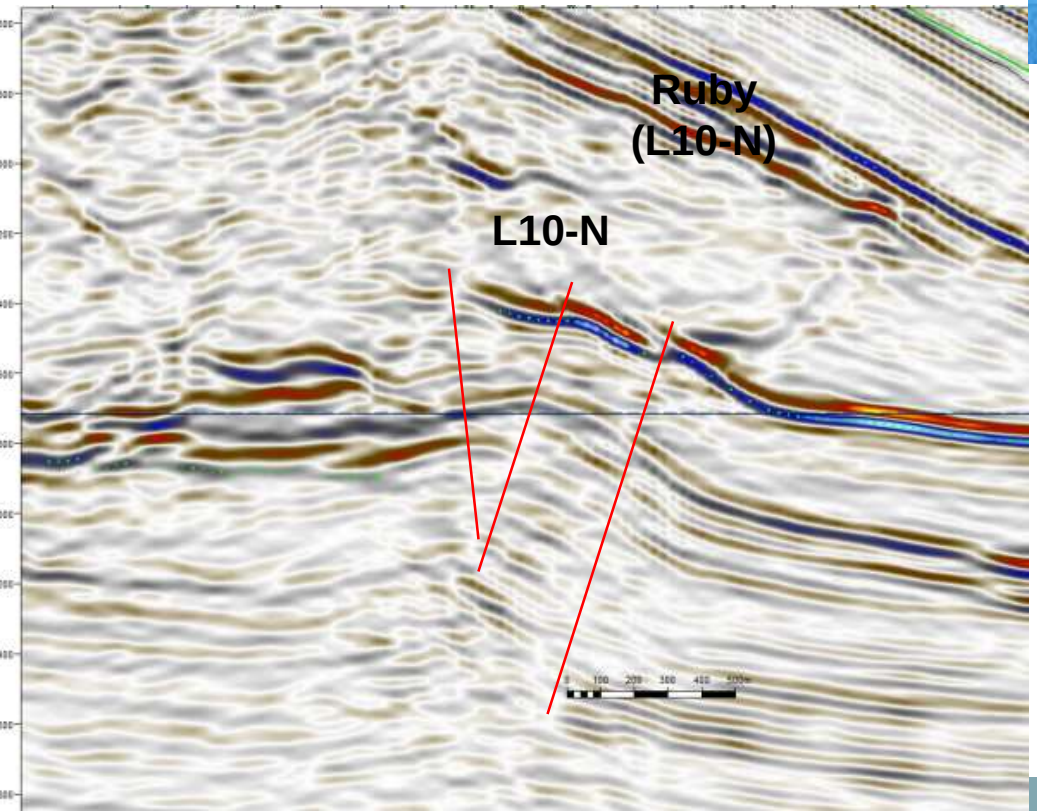
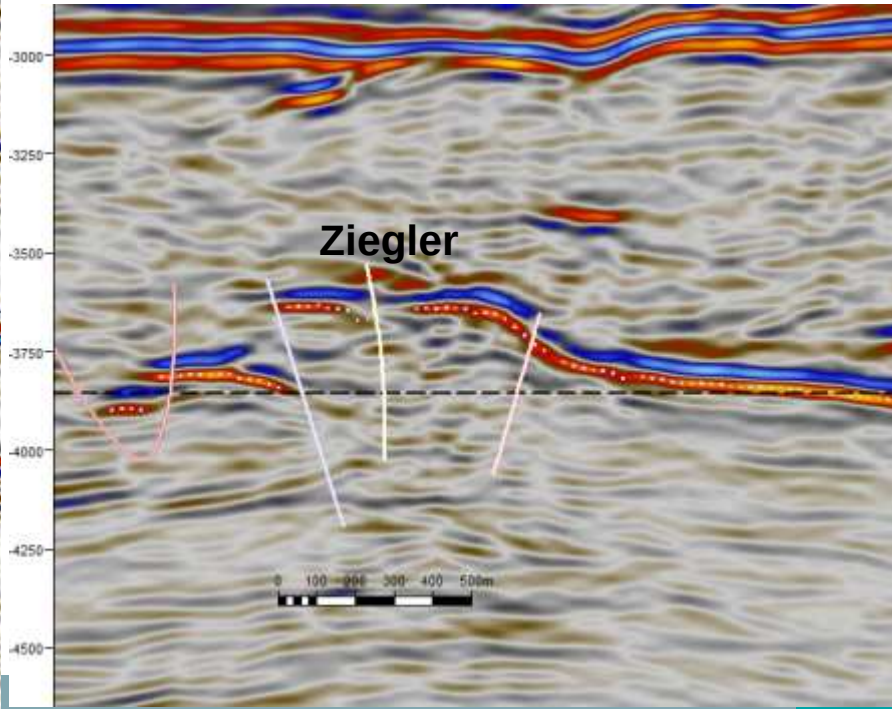
Analogue Ruby (L10-N)

No under-fill

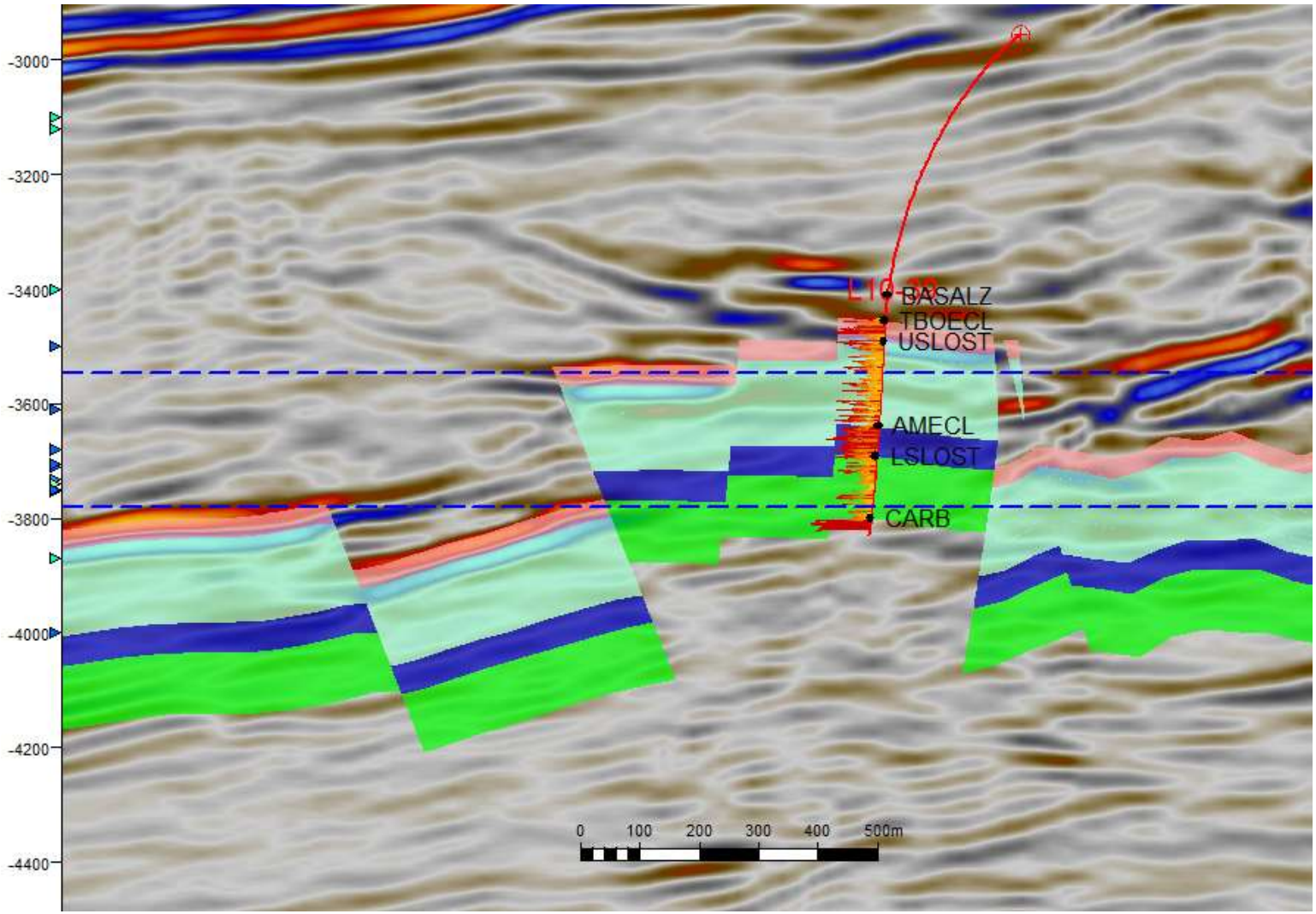
- L10-N analogue to L10-Ziegler
- L10-N is filled to spill







Pop-up reconstructed (1)



FWL pop-up

Spill point structure

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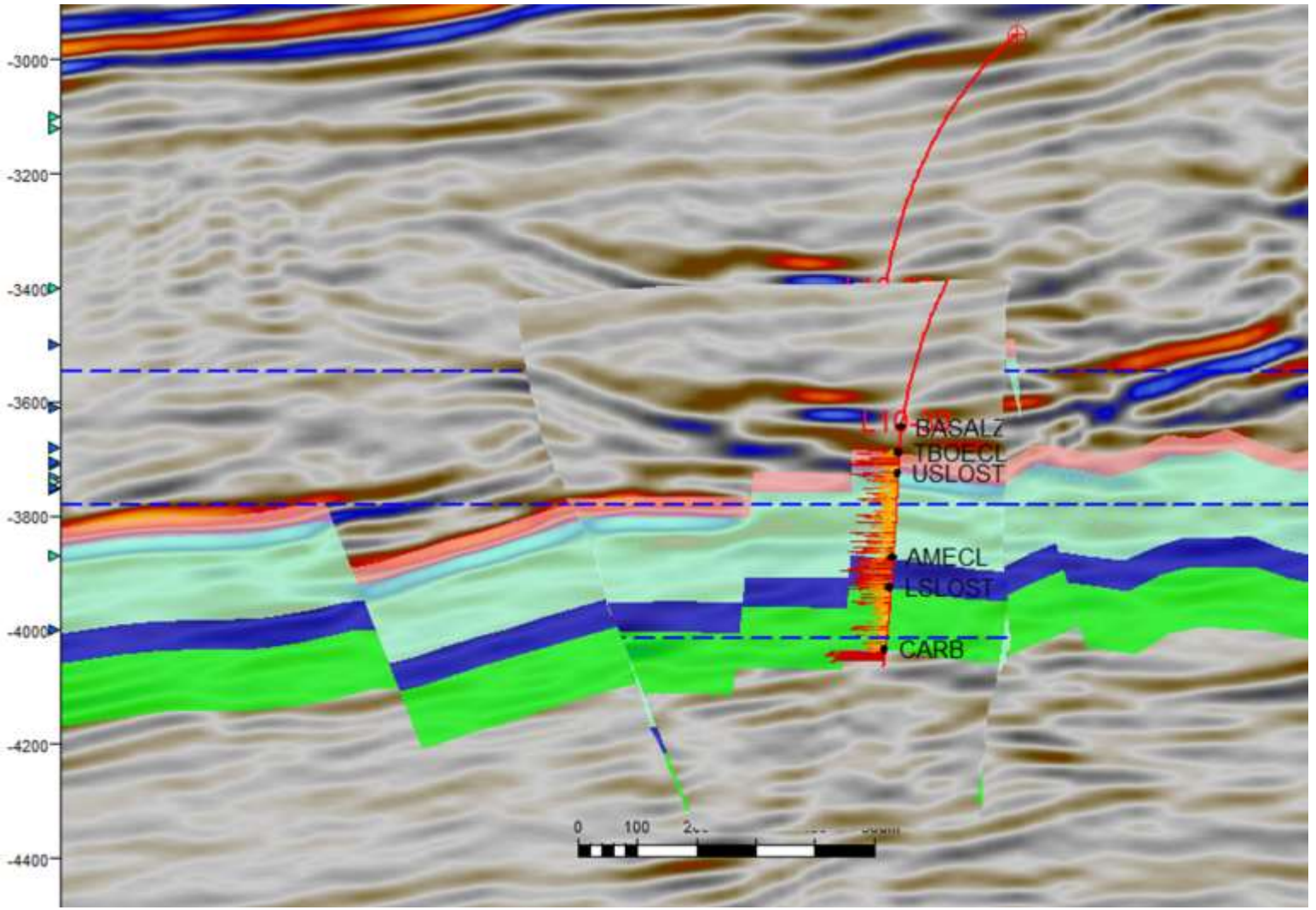
Pop-up reconstructed (2)



Spill point structure

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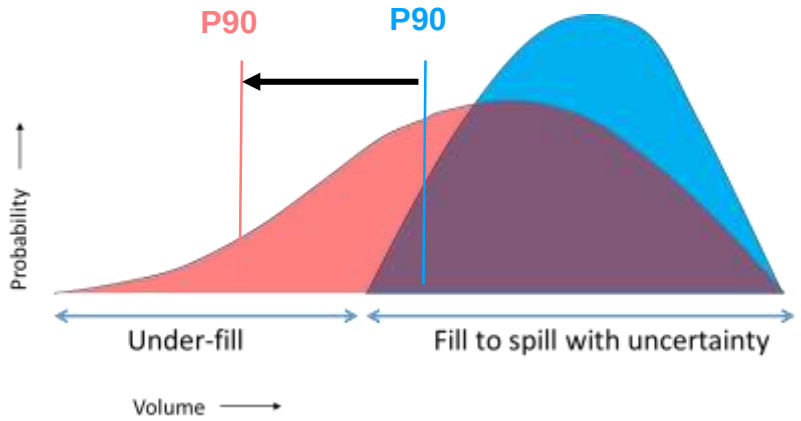
How do risk under-fill?

In an area like L10 we either acknowledge the under-fill ….

- How do we estimate the likelihood of under-fill? (do we understand the mechanism?)
- What is the minimum column in the volume distribution? What shape of the distribution to apply?
- P90 volumes will be much smaller, killing effect on some small prospects in mature area



Or not …….

- Under-fill case is in fact “failure” case
- In the POS estimation process it should be clear on which volume distribution the POS is based

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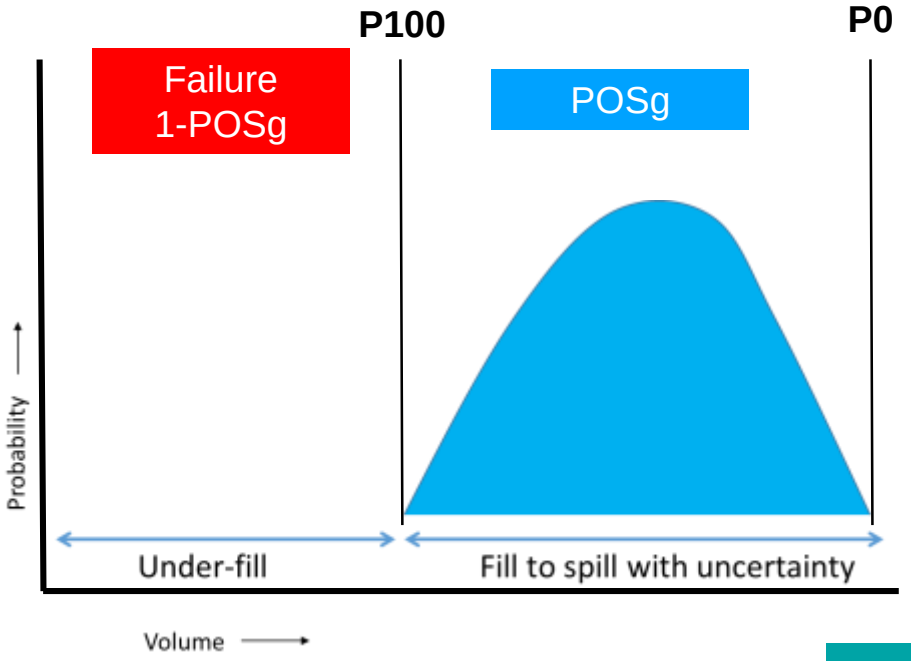
POS and Volume distribution

- Geological POS (Probability Of Success) of a prospect is the likelihood of finding a volume: P100<Volume<P0
- POSg = Pcharge x Pclosure x Pseal x PEffRes
- If the assumption is that a structure is filled to spill an under-fill scenario is a failure scenario (1-POSg)

- In case a well is drilled from a platform in practice also these “failure cases” most of the under-fill cases will be developed
- Need understanding of the reason of under-fill to adequately evaluate prospects. When to apply the risk of under-fill?



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Conclusions

- After 40 years of production the 39th exploration well in the Dutch L10 block discovered gas
- A technically challenging well was drilled safely and within planned time
- The complicated geological structure was found at a slightly shallower depth with reservoir properties as expected
- The gas column was smaller than was anticipated based on fill and spill history of the region
- Understanding the reason of under-fill is necessary to be able to give proper input (risk and volume distribution) to the economic evaluation to prospects
- Neptune is eager to continue exploring, also in mature areas

Acknowledgements

- Special thanks to our partners XTO, Rosewood and EBN for permission to present this case study


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