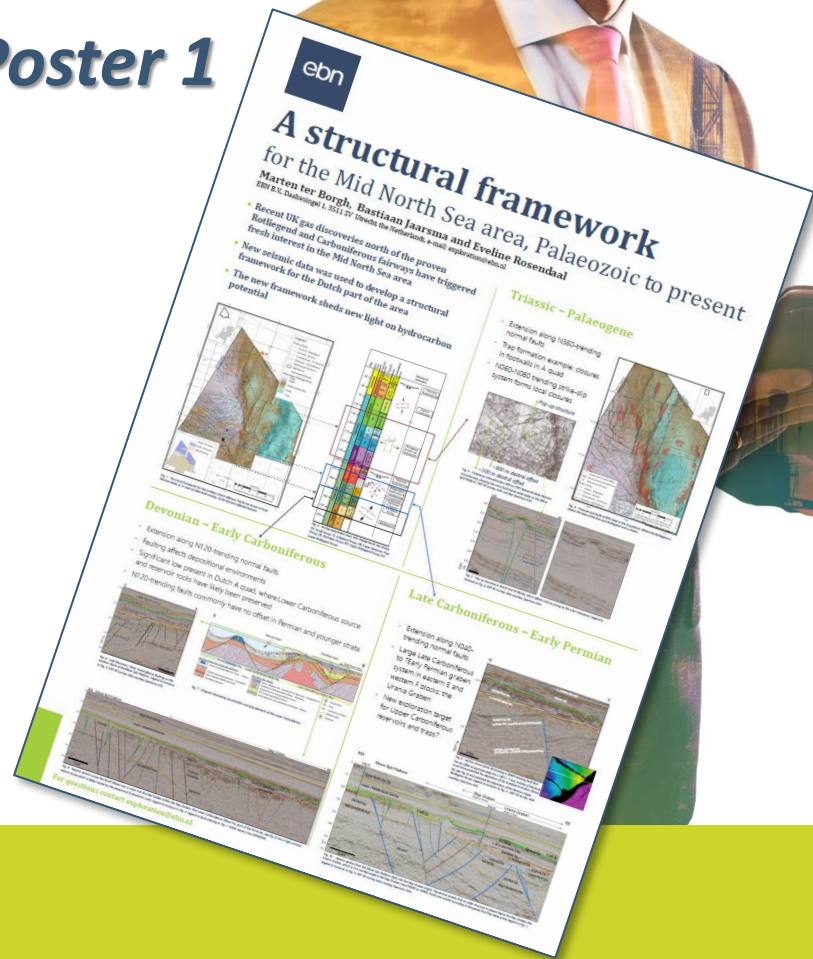


# Poster 1



## A Structural framework for the Dutch northern offshore

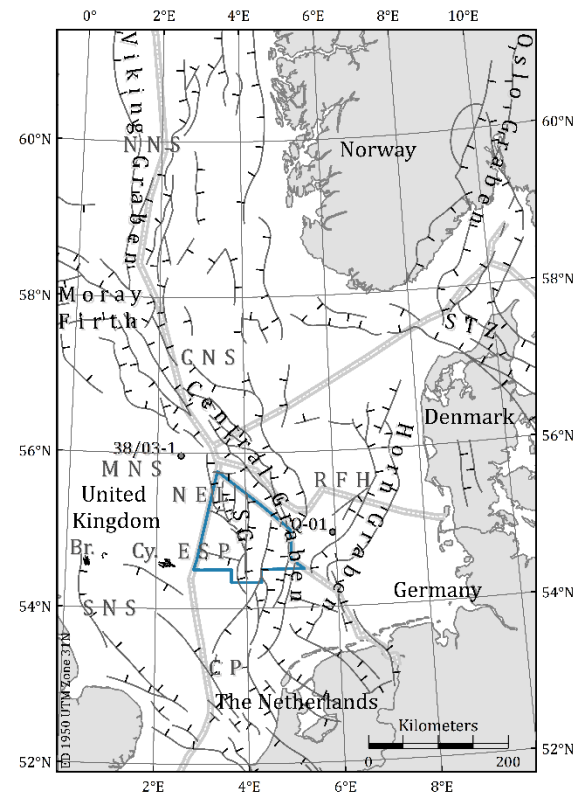
Implications for exploration  
Dutch Exploration Day, May 23, 2016

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[www.ebn.nl](http://www.ebn.nl)

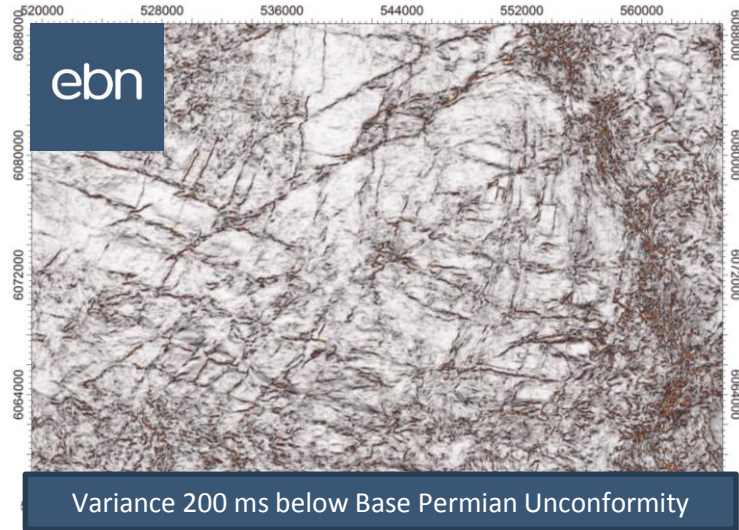
# Introduction

- Recent UK gas discoveries north of the proven Rotliegend and Carboniferous fairways have triggered fresh interest in the Mid North Sea area.
- As part of the DEFAB project we developed a structural framework.
- Newly available data: DEF 3D seismics, regional NSR 2D survey.
- The framework helps predict reservoir and source rock distribution, SR maturation and trap formation.
- This presentation provides an overview, more detail in presentations and posters focussing at individual plays.

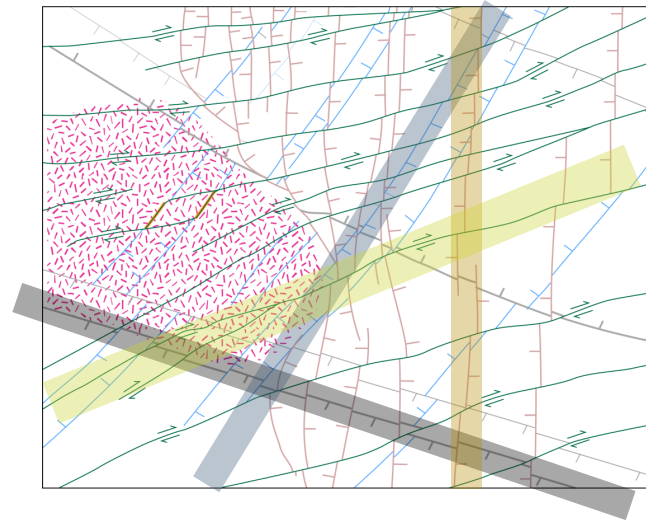


# Structural mapping

Method used for identifying fault trends:  
coherency cubes

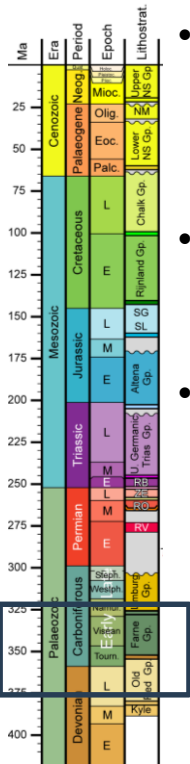


Four important fault trends identified

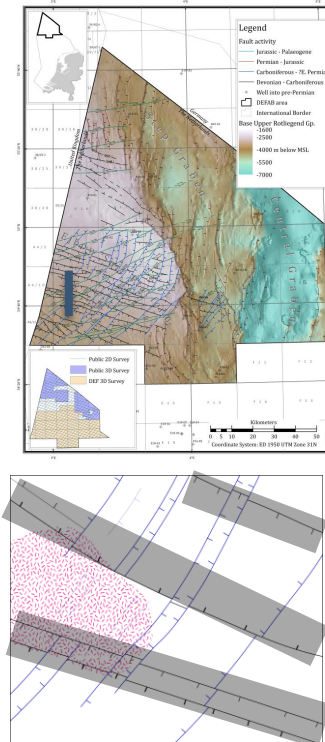
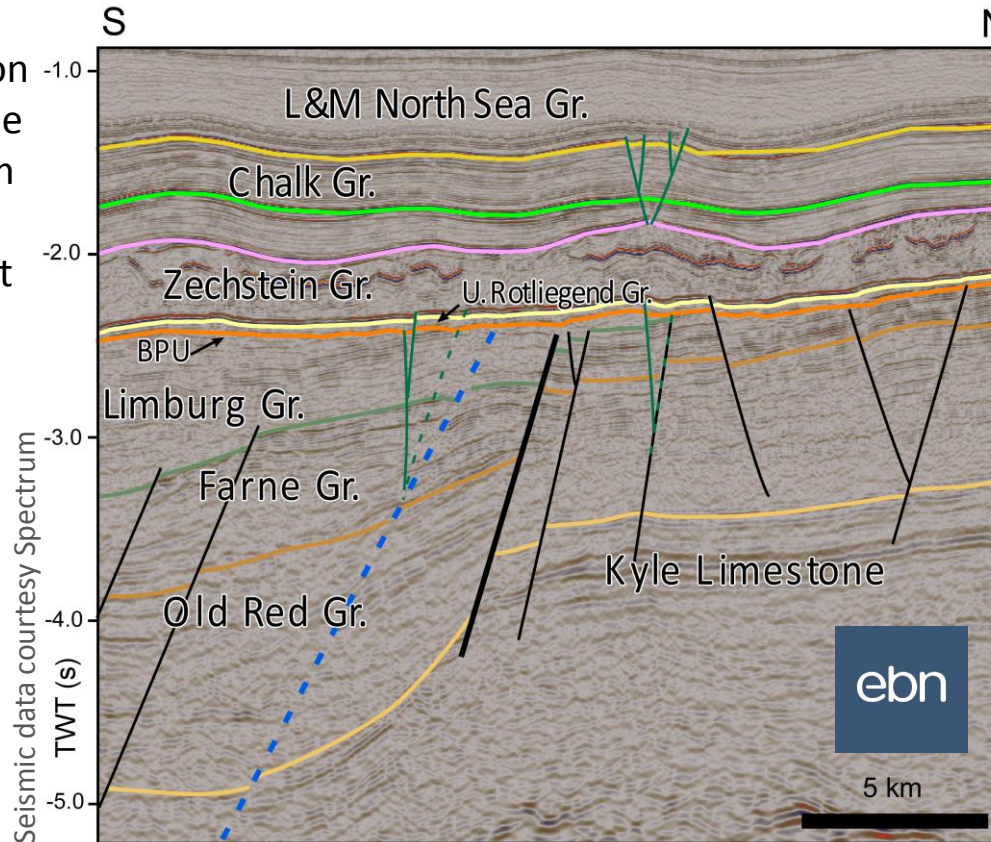


- When were these faults active?
- How do they affect deposition, source rock maturation, trap formation?

# Early Carboniferous & Devonian

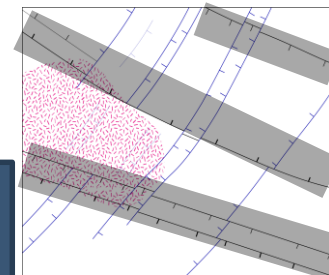
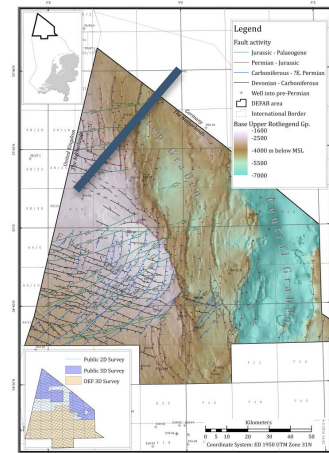
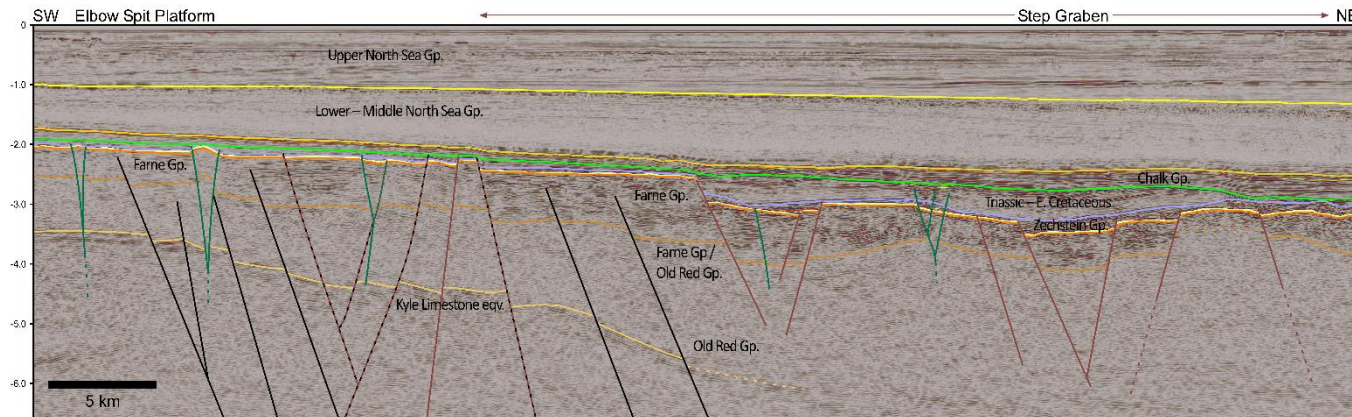
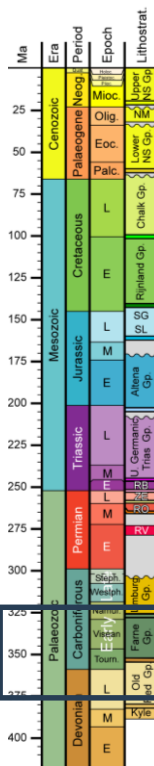


- Significant extension on the S flank of the Elbow Spit Platform
- No or little offset at Base Permian level
- Change in seismic facies across fault; faulting affects deposition





# Lower Carboniferous north of Elbow Spit Platform



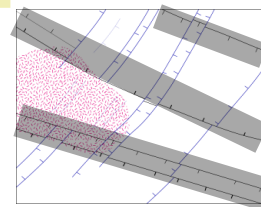
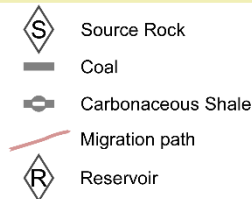
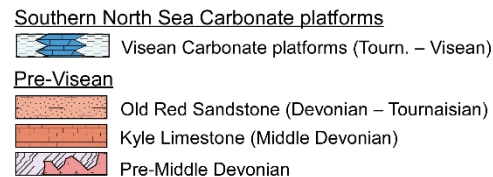
A major Carboniferous/Devonian low is present north of the Elbow Spit Platform; in line with findings by Milton-Worsell et al. (2010) for adjacent UK sector. Lower Carboniferous deposits preserved!

Elbow Spit Platform North Elbow Low

Starved basin Overfilled basin

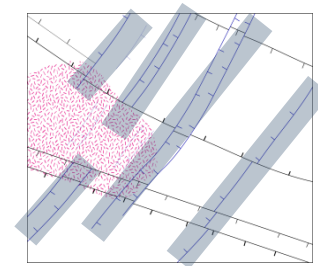
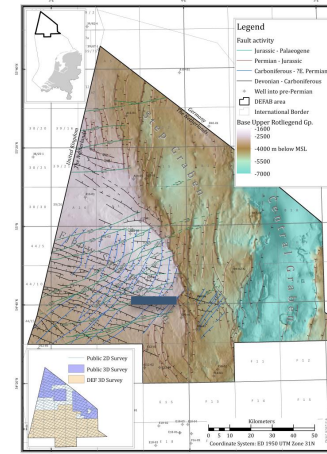
Sediment influx

Visean Carbonates Play Lower Carboniferous Shale Play Lower Carboniferous Clastics Play



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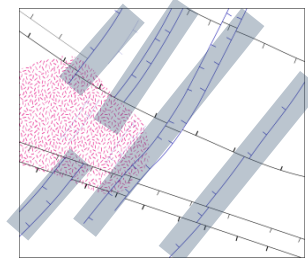
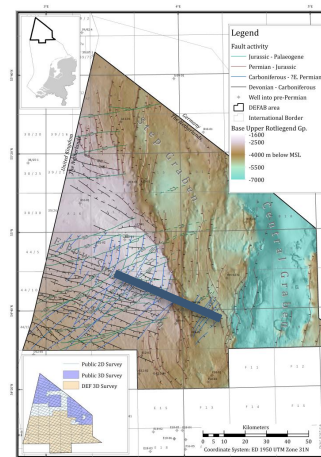
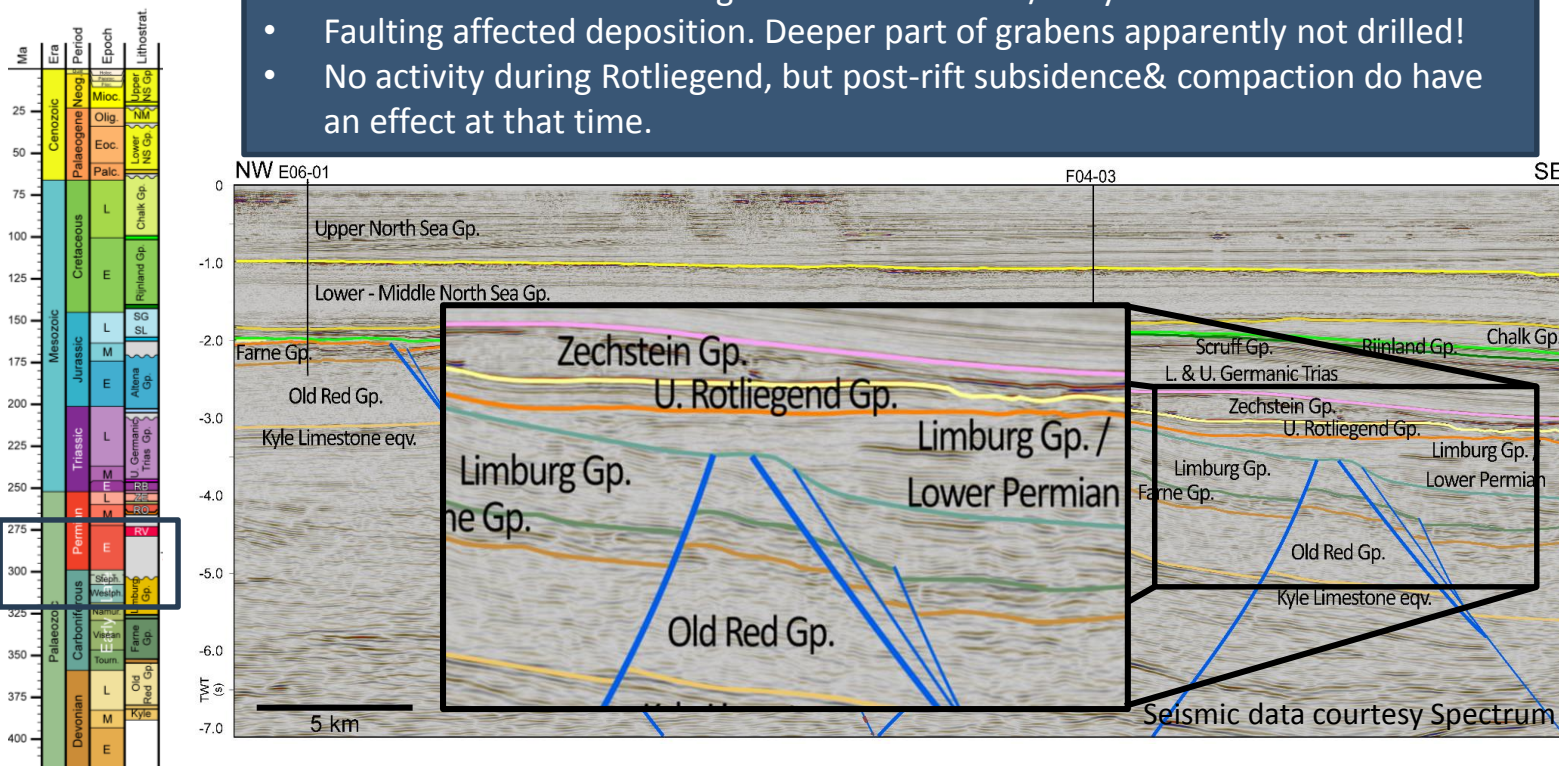
| Ma  | Era        | Period        | Epoch          | Lithostrat.           |
|-----|------------|---------------|----------------|-----------------------|
| 25  | Cenozoic   | Palaeogene    | Nearc.         | Lower NS Gp.          |
|     |            |               | Mioc.          | NS Gp.                |
| 50  |            |               | Olig.          |                       |
|     |            |               | Eoc.           |                       |
| 75  | Mesozoic   | Cretaceous    | Paleo.         | Chalk Gp.             |
| 100 |            |               | L.             |                       |
| 125 |            |               | m              |                       |
| 150 |            |               |                |                       |
| 175 |            |               | L.             | SG SL                 |
|     |            |               | M.             |                       |
| 200 |            |               | m              |                       |
|     |            |               |                |                       |
| 225 |            |               | L.             | Alvans Gp.            |
| 250 |            |               | M.             |                       |
|     | Palaeozoic | Triassic      | m              | U. Germanic Trias Gp. |
|     |            |               | m              |                       |
|     |            |               | m              |                       |
|     |            |               | m              |                       |
|     |            |               | m              |                       |
|     |            |               | m              |                       |
|     |            |               | m              |                       |
|     |            |               | m              |                       |
|     |            |               | m              |                       |
|     |            |               | m              |                       |
| 275 |            | Permian       | m              | RV                    |
| 300 |            |               |                |                       |
| 325 |            | Carboniferous | Slack Washburn |                       |
|     |            |               | Nashville      |                       |
| 350 |            | Devonian      | L.             | Formal Red Gp.        |
|     |            |               | M.             |                       |
| 375 |            |               |                |                       |
| 400 |            |               |                |                       |



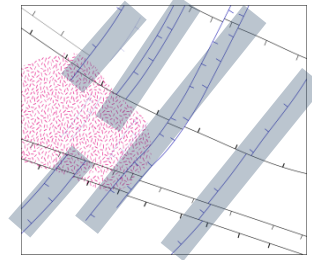


# Fault activity Late Carboniferous / E. Permian

- Normal faults active during Late Carboniferous/Early Permian
- Faulting affected deposition. Deeper part of grabens apparently not drilled!
- No activity during Rotliegend, but post-rift subsidence & compaction do have an effect at that time.

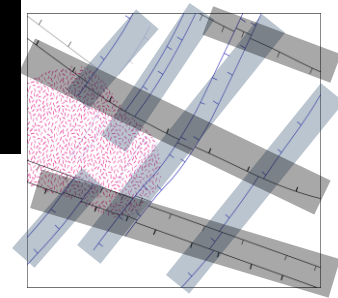
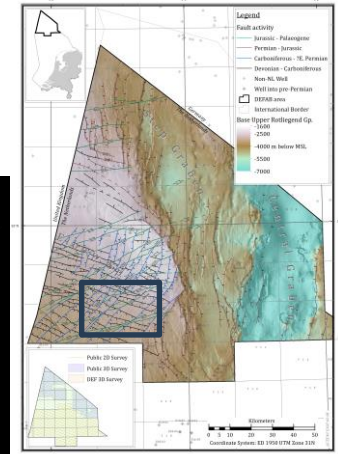






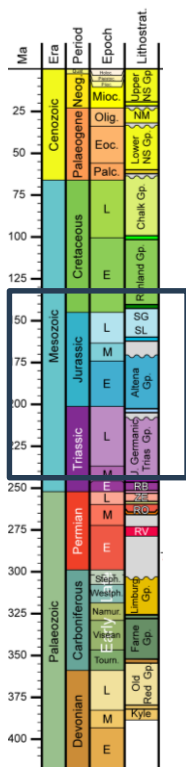
- www.ebn.nl**

| Ma  | Era        | Period        | Epoch          | Lithostrat.  |
|-----|------------|---------------|----------------|--------------|
| 25  | Cenozoic   | Palaeogene    | Neog.          | Mioc.        |
|     |            |               | Olig.          | Lower NS Gp. |
| 50  |            |               | Eoc.           | Lower NS Gp. |
|     |            |               | Palc.          | Chalk Gp.    |
| 75  |            |               | L.             | Chalk Gp.    |
| 100 | Mesozoic   | Cretaceous    | m              | Ryland Gp.   |
| 125 |            |               | L              | Ryland Gp.   |
| 150 |            |               | M              | SG SL        |
| 175 |            |               | L              | SG SL        |
| 200 |            |               | m              | Alanya Gp.   |
| 225 |            | Triassic      | L              | Trias Gp.    |
| 250 |            |               | M              | Trias Gp.    |
|     |            |               | L              | Trias Gp.    |
|     |            |               | M              | Trias Gp.    |
|     |            |               | M              | Trias Gp.    |
| 275 | Palaeozoic | Permian       | Stroph. Weigh. | RV           |
| 300 |            |               | Stroph. Weigh. | RV           |
| 325 |            |               | Stroph. Weigh. | RV           |
| 350 |            |               | Stroph. Weigh. | RV           |
| 375 |            |               | Stroph. Weigh. | RV           |
| 400 |            | Carboniferous | Visean         | Faine Gp.    |
|     |            |               | Tourn.         | Faine Gp.    |
|     |            |               | L.             | Faine Gp.    |
|     |            |               | L.             | Faine Gp.    |
|     |            |               | L.             | Faine Gp.    |
| 425 |            | Devonian      | M              | Kyle         |
|     |            |               | m              | Kyle         |
|     |            |               | m              | Kyle         |
|     |            |               | m              | Kyle         |
|     |            |               | m              | Kyle         |

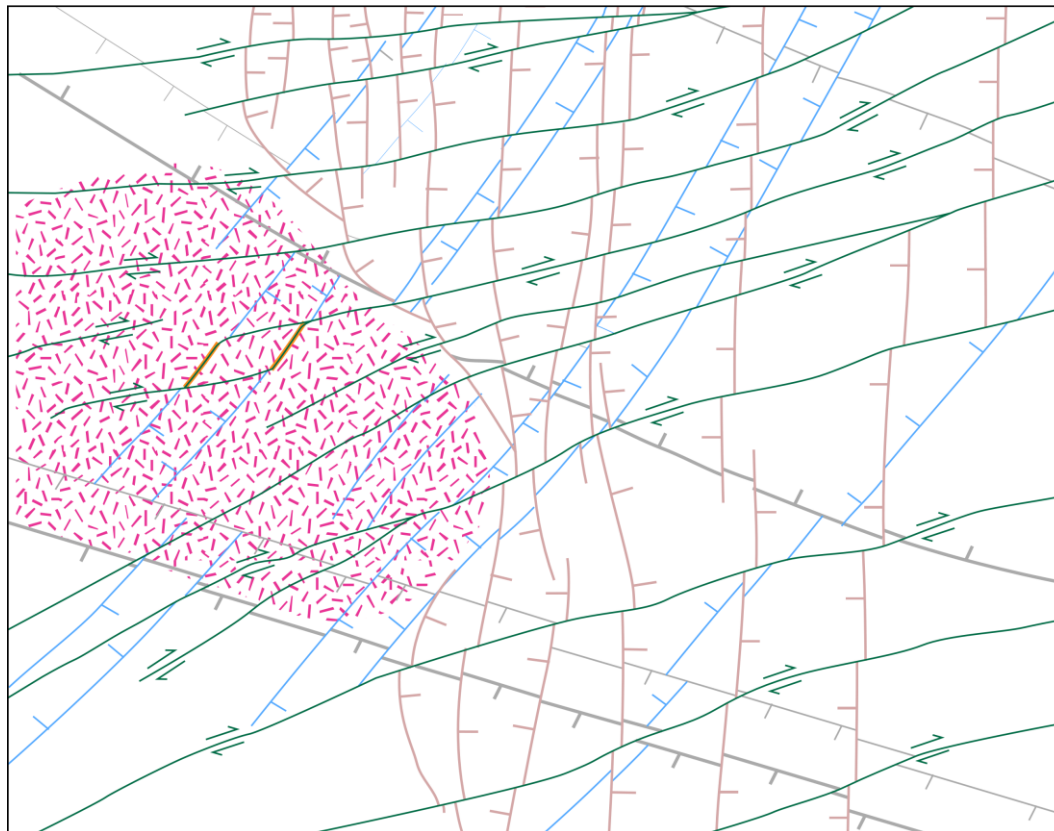


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# Mesozoic structural development

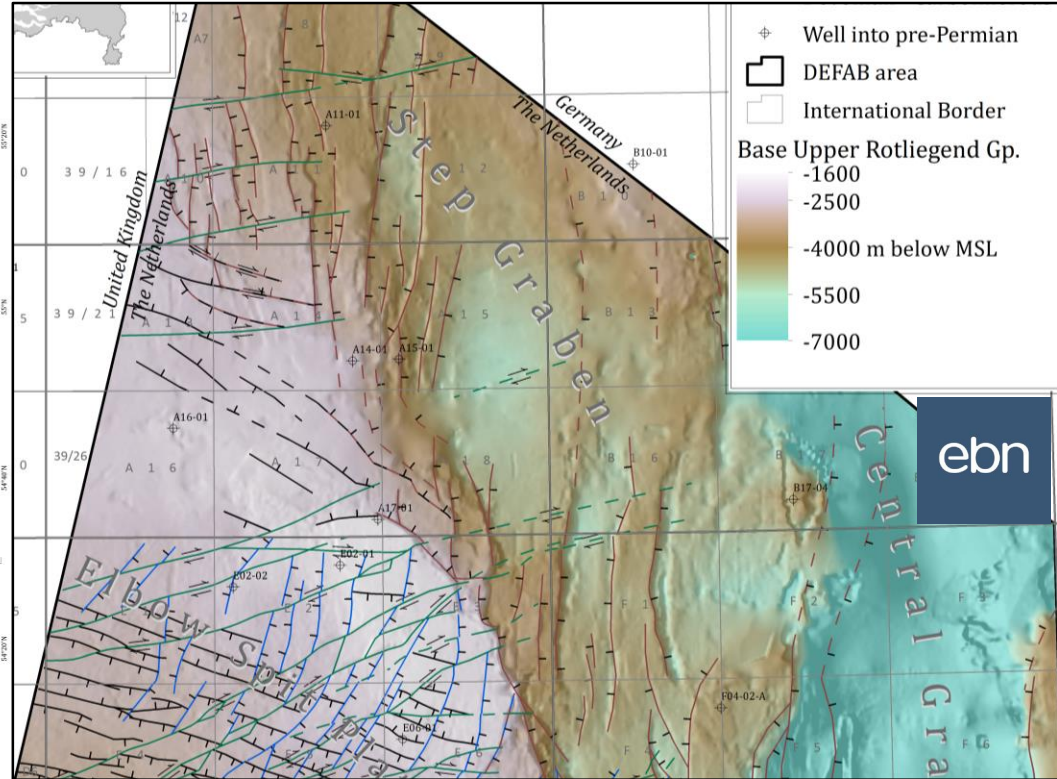
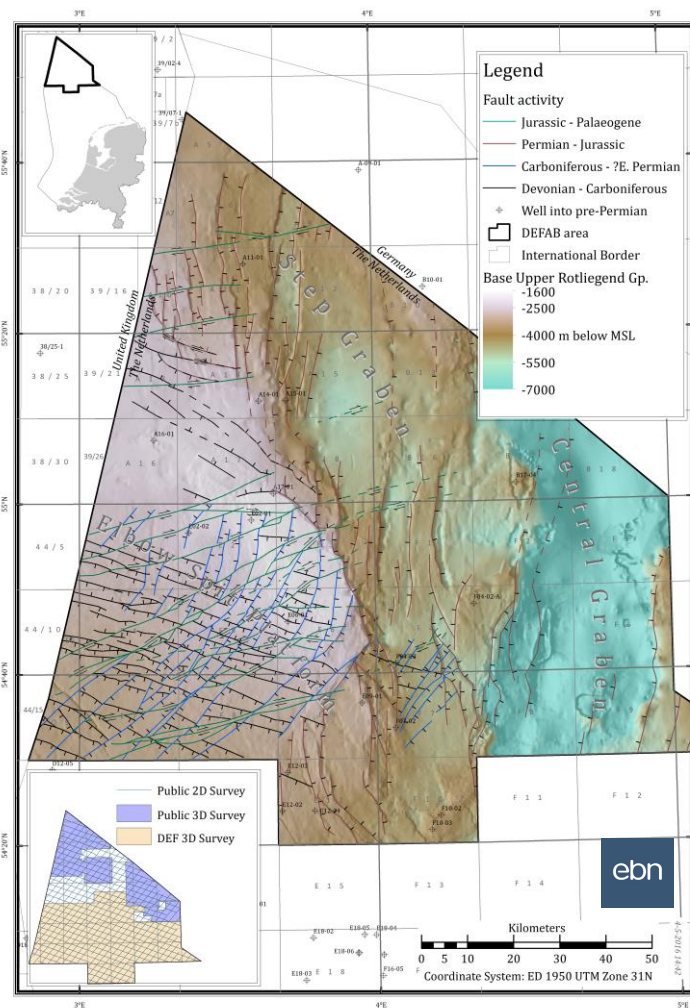


- Opening of Central Graben and Step Graben along N-S trending faults (Triassic – Jurassic).
- Dextral strike-slip faulting along N060-N080 trending faults.
- Salt tectonics discussed in separate presentation.

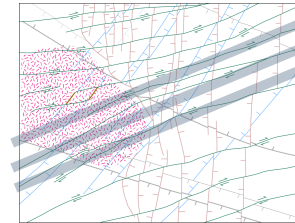




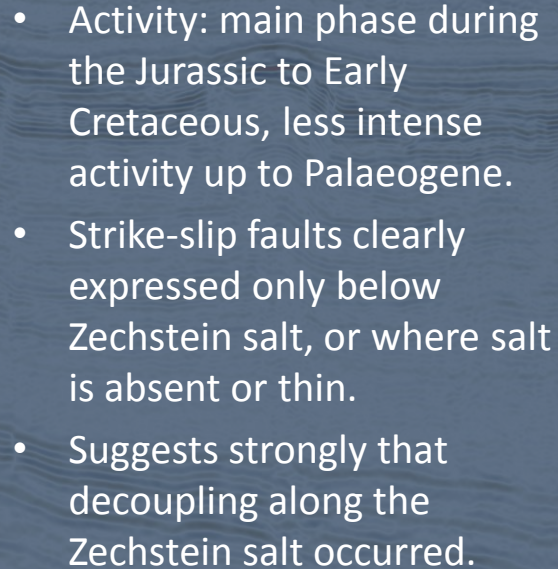
# Step Graben



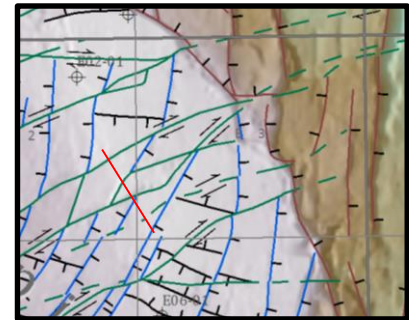
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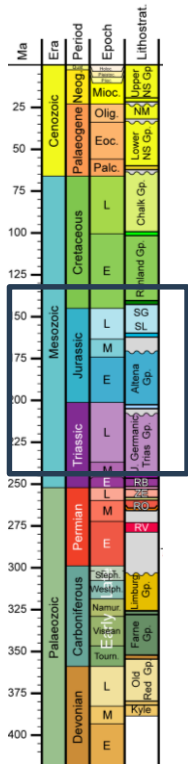


Seismic data courtesy Spectrum

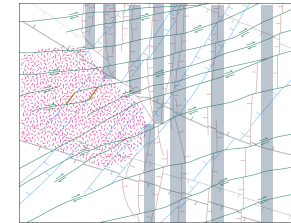
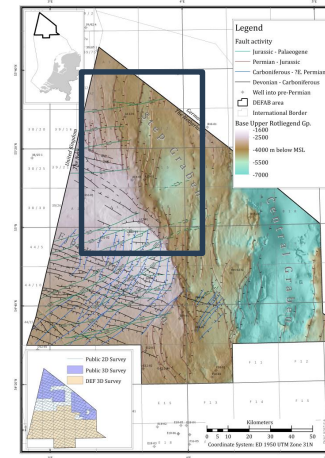
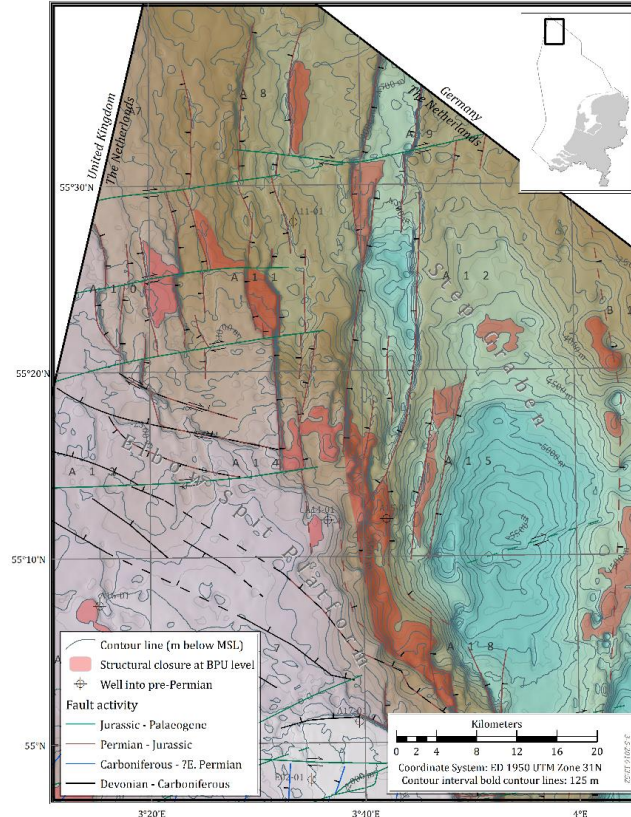




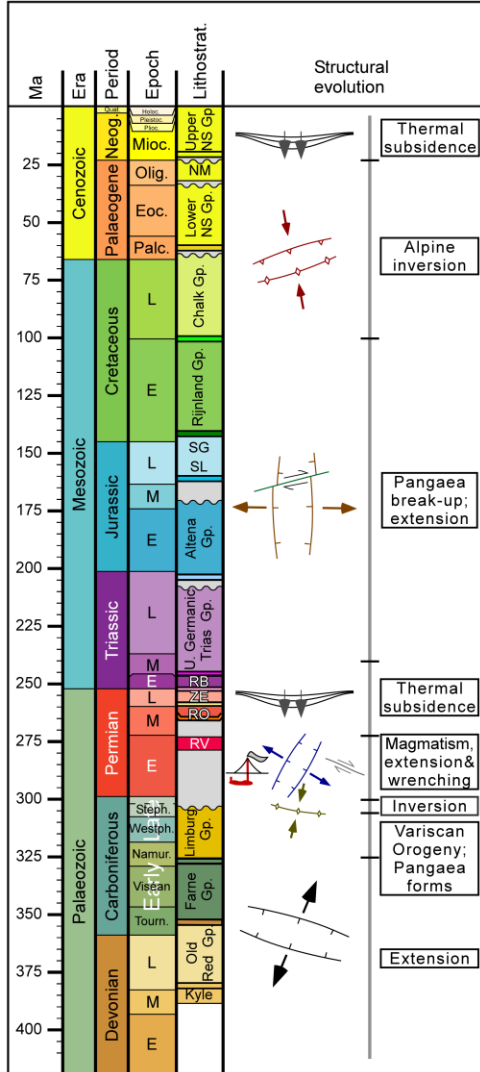
# Example: structuration in the A quad



- 4-way and fault-dip closures mapped in Step Graben area at Base-Permian (Silverpit Fm) level.
- Based on vintage seismics.
- Better seismic imaging would further improve mapping of these, and possibly more, structures.



# Summary



Better understanding of deformation in Step Graben area; affects trap formation, SR maturation

Significant extension during Late Carboniferous to Early Permian along Urania Graben. Graben infill mostly undrilled.

Better understanding of relationship between faulting and deposition during Early Carboniferous.

# Poster 1

## A structural framework for the Mid North Sea area, Palaeozoic to present

Marten ter Borgh, Bastiaan Jaarsma and Eveline Rosendal  
EBN B.V., Rotterdam, L. 1011 2P, Utrechtsestraat 100, 3015 CA Rotterdam, The Netherlands

- Recent UK gas discoveries south of the proven Rotliegend and Carboniferous fairways have triggered fresh interest in the Mid North Sea area
- New seismic data was used to develop a structural framework for the Dutch part of the area
- The new framework sheds new light on hydrocarbon potential

### Triassic – Palaeogene

- Extension along N80-trending normal faults
- Trap formation example: clstones in footwall in a sand system forms local closure

### Devonian – Early Carboniferous

- Extension along N10-trending normal faults
- Faulting affects distal Lower Carboniferous source
- Significant low present in Dutch A zone where Lower Carboniferous source and reservoir rock have likely been preserved
- N10-trending faults commonly have no offset in Permian and younger strata

### Late Carboniferous – Early Permian

- Extension along N40-trending normal faults
- Large Late Carboniferous to Early Permian graben system in eastern and western Graben
- New exploration target for Upper Carboniferous reservoirs and traps?

Thank you for your attention

More information? Contact us:

[exploration@ebn.nl](mailto:exploration@ebn.nl)

Acknowledgements:

Fugro and Spectrum ASA, for giving permission to show data from the DEF survey

EBN Colleagues

Tacjana Litwinska-Kemperink