Hydrocarbon potential of the Lower Carboniferous in the Dutch northern offshore

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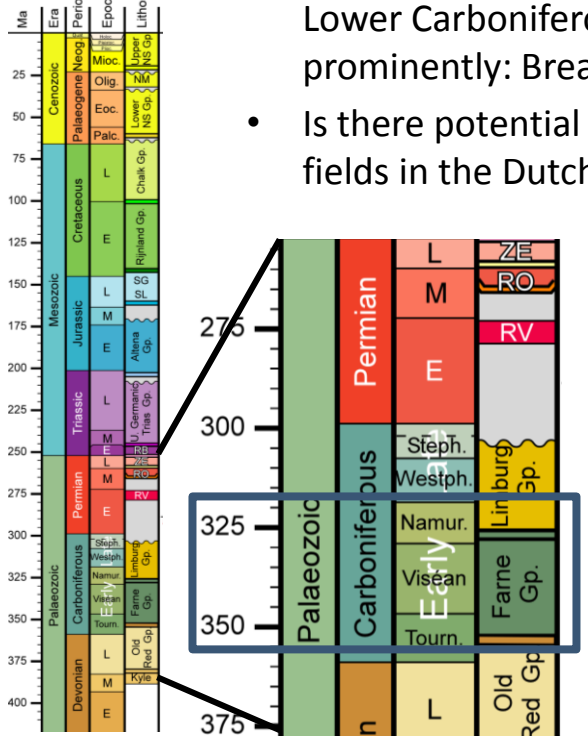
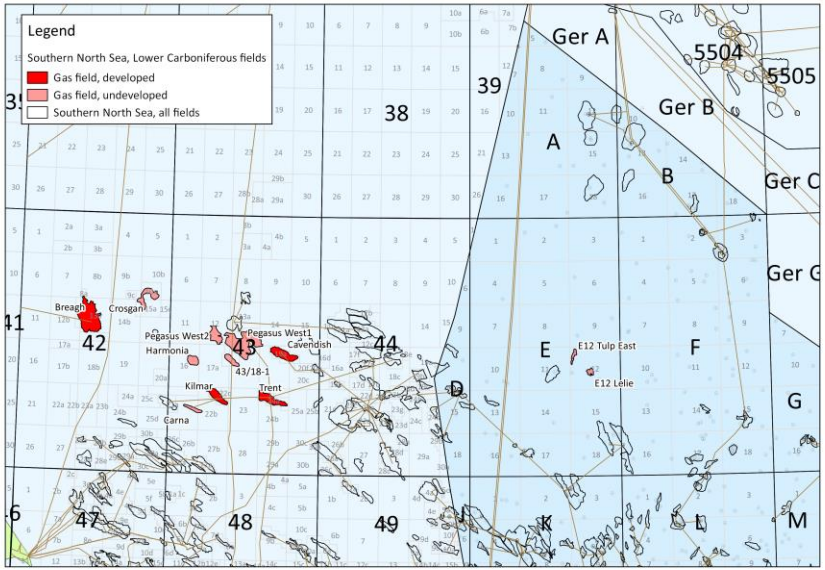
Introduction



- Recent UK gas discoveries were made in Lower Carboniferous reservoirs; most prominently: Breagh.
- Is there potential for Lower Carboniferous fields in the Dutch offshore?



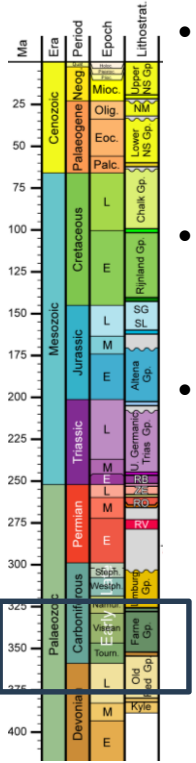
Presentation outline:

- Post-well analysis
- Reservoir potential
- Source& charge
- Closures

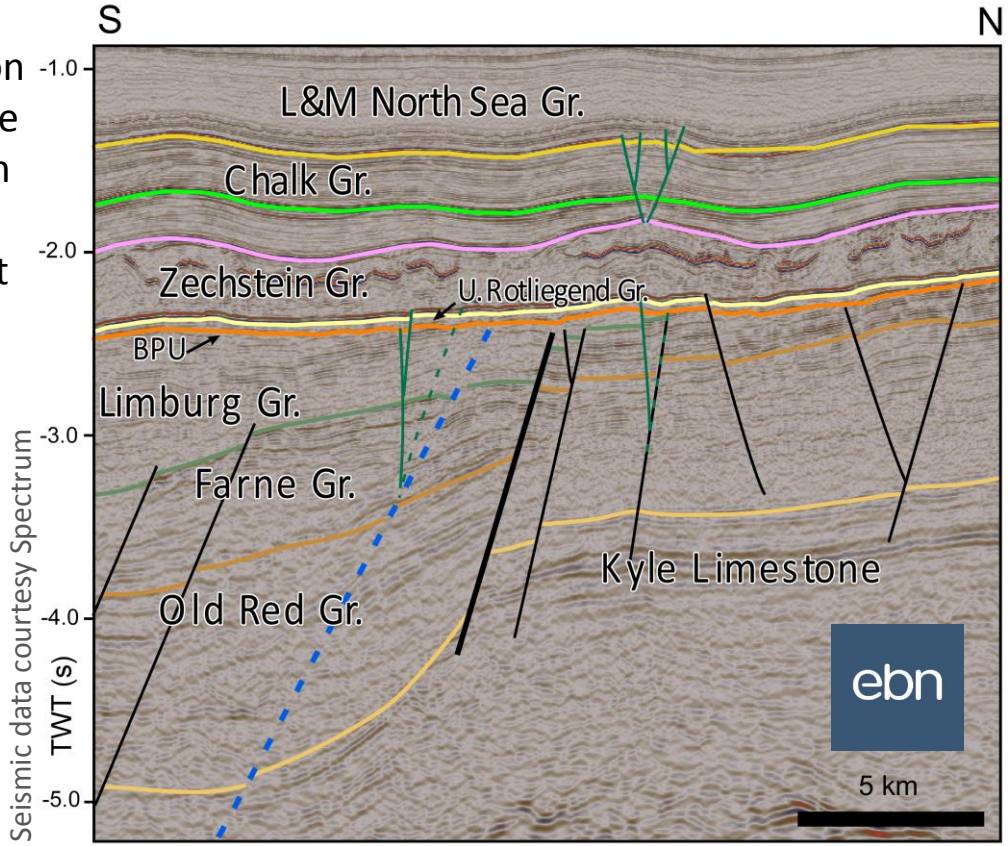
Take-home messages

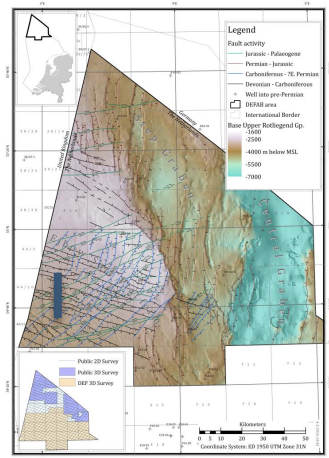
- Lower Carboniferous present in most of the Dutch northern offshore
- A mature source rock is expected to be present
- Reservoir potential looks promising
- The play is virtually untested
- Significant closures exist at BPU level, also in open blocks

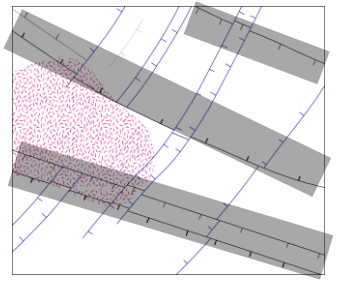
Early Carboniferous& Devonian



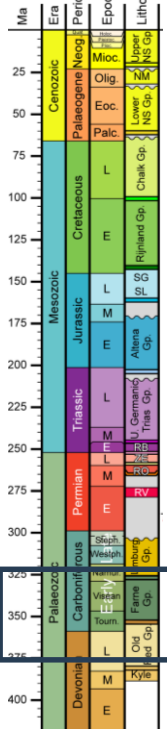
- Significant extension on the S flank of the Elbow Spit Platform
- No or little offset at Base Permian level
- Change in seismic facies across fault; faulting affects deposition

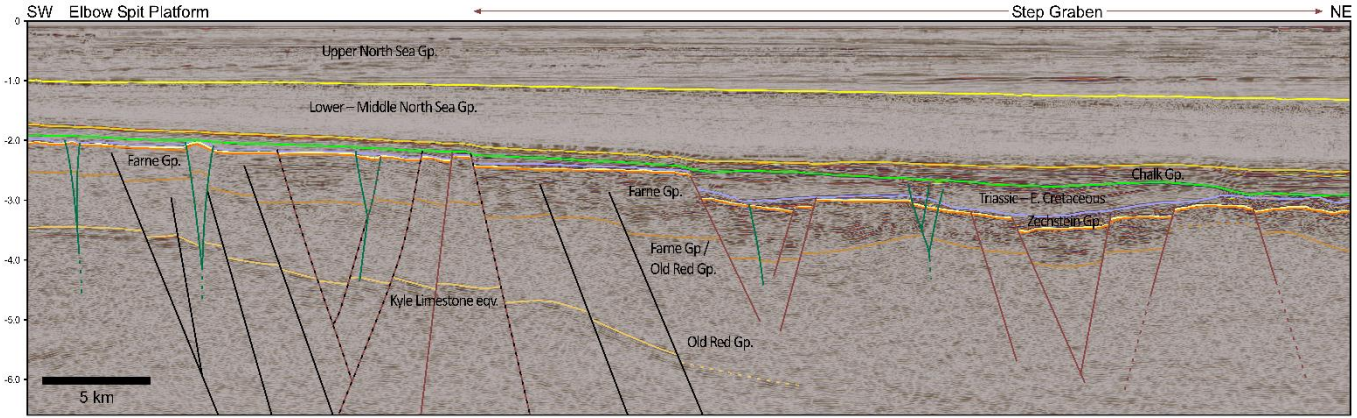


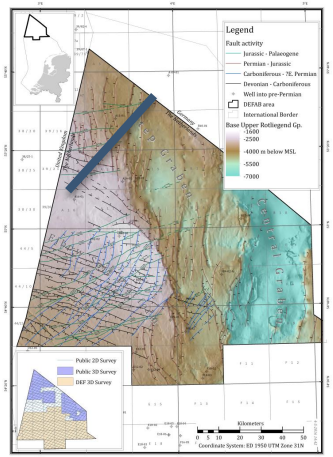


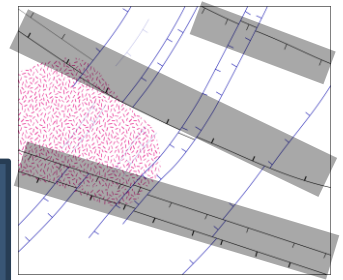


Lower Carboniferous north of Elbow Spit Platform



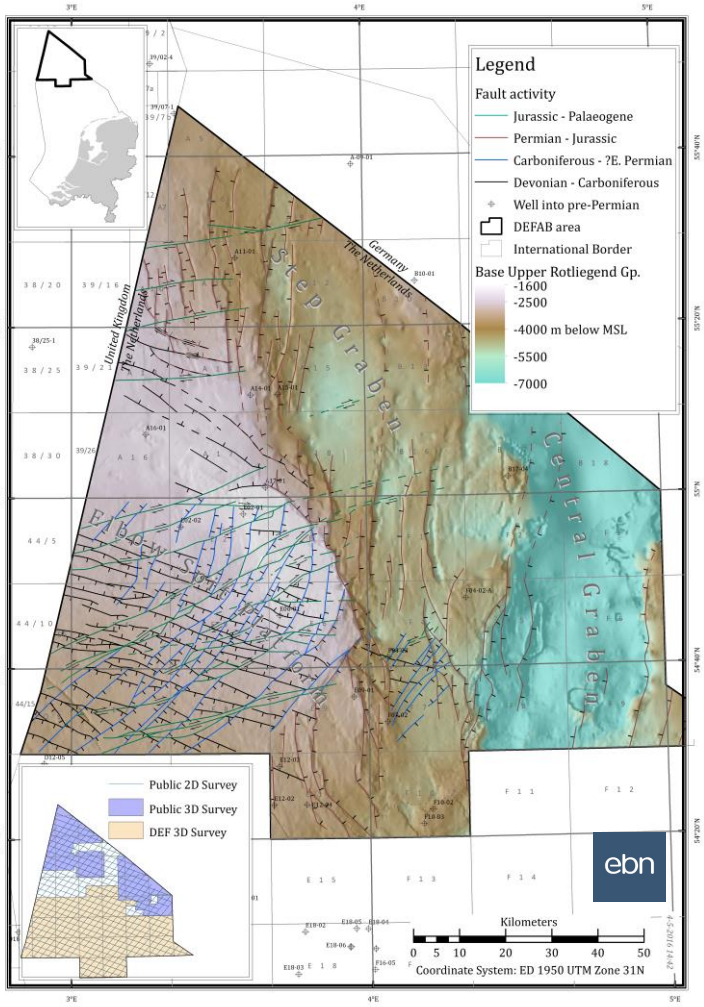


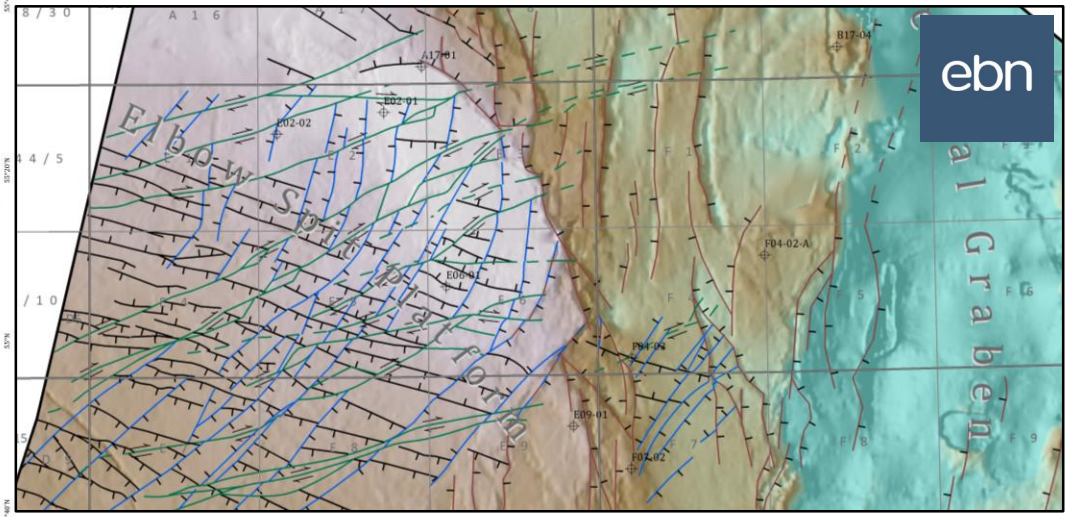




A major Carboniferous/Devonian low is present north of the Elbow Spit Platform; in line with findings by Milton-Worssell et al. (2010) for adjacent UK sector.
Lower Carboniferous deposits preserved!

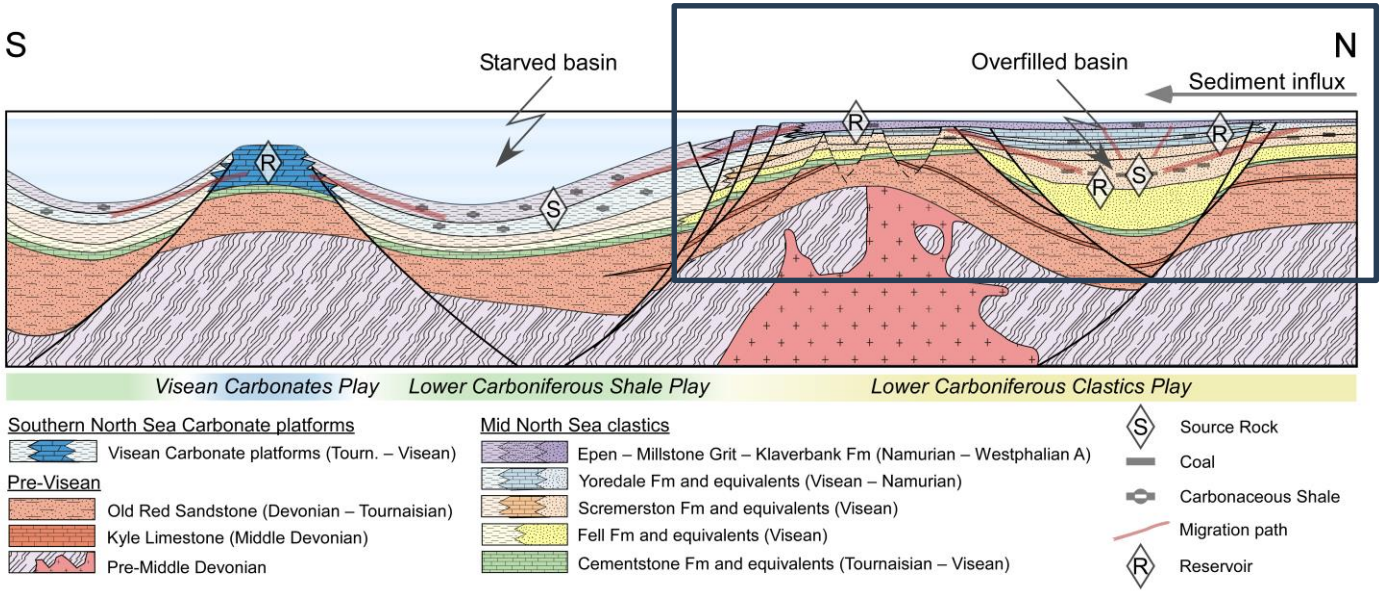
Structural framework





- A detailed structural framework was constructed for the Northern Dutch offshore.
- More details available on our poster, which is on display today.

Play elements Lower Carboniferous



- The Lower Carboniferous clastics play is established in the SNS, with fields producing from Namurian reservoirs and the Visean Breagh field.

Exploration history of the Lower Carboniferous in the Northern Dutch offshore

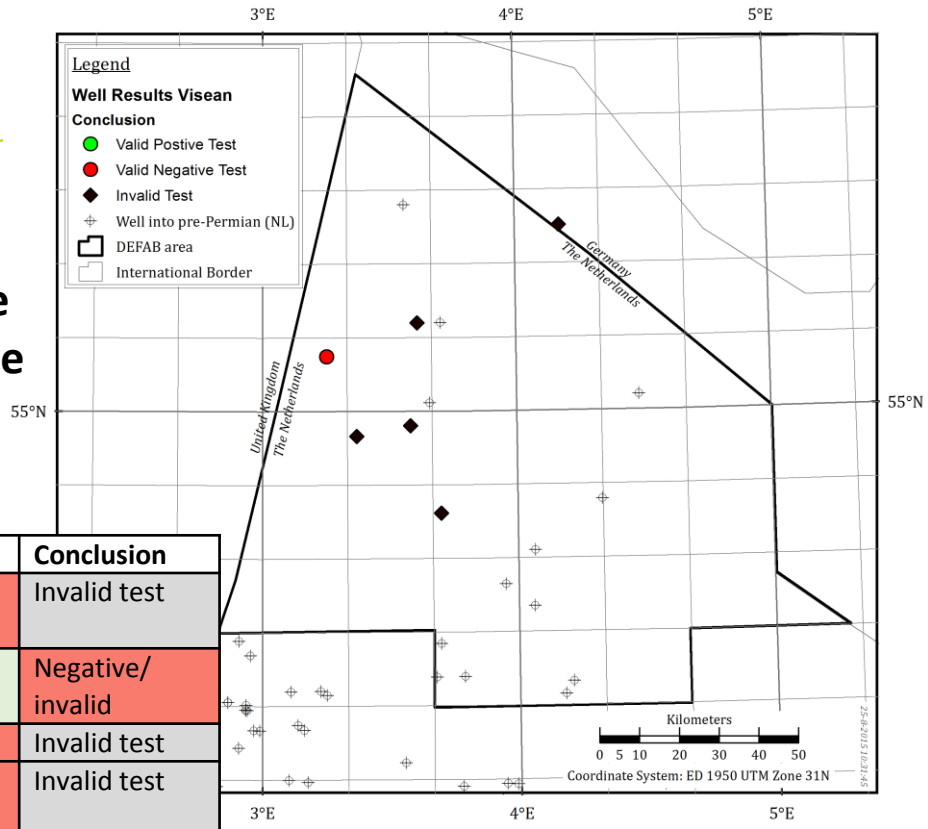
- 1972-1990: wildcats, aiming to extend the Rotliegend play towards the north.
- 1990s: Namurian in E12 (discoveries: Tulp/Lelie stranded fields).
- Last well penetrating the Lower Carboniferous was drilled in 1996.
- **Only two wells had the Lower Carboniferous as primary target!**

Well	Spud year	Lower Carboniferous primary target?	Result	Stratigraphy				Operator
				Devonian	Tournaisian	Visean	Namurian	
A11-01	1981	No (Rotliegend)	Dry				X	Placid
A14-01	1982	No (Rotliegend)	Gas Shows			X	X	NAM
A15-01	1978	No (Zechst./Rotl.)	Gas Shows				X	Placid
A16-01	1974	No (Zechstein)	Dry			X		Elf Petroland
B10-01 (DE)	1977	Unknown	Dry			X		Amoco
B17-04	1990	**Yes**	Dry				X	Arco
E02-01	1972	No (Wildcat)	Dry		X	X		NAM
E02-02	1990	No (Zechstein)	Dry			X		Mobil
E06-01	1983	No? (Westphalian?, Rotliegend)	Dry	X	X	X	?	NAM
E09-01	1990	No (Rotliegend)	Gas, high N_2				X	NAM
E12-02	1990	No (Westphalian?)	Dry? Shows?				X	Conoco
E12-03 (Tulp)	1991	No (Westphalian)	Gas, high N_2				X	Elf Petroland
E12-04-S2 (Lelie)	1996	**Yes**	Gas, high N_2				X	Elf Petroland

Used UK wells in study as well

Well Results, Visean

- **Only two wells had the Lower Carboniferous as their primary target; one focused on the Namurian, the other on the Lower Carboniferous in general.**

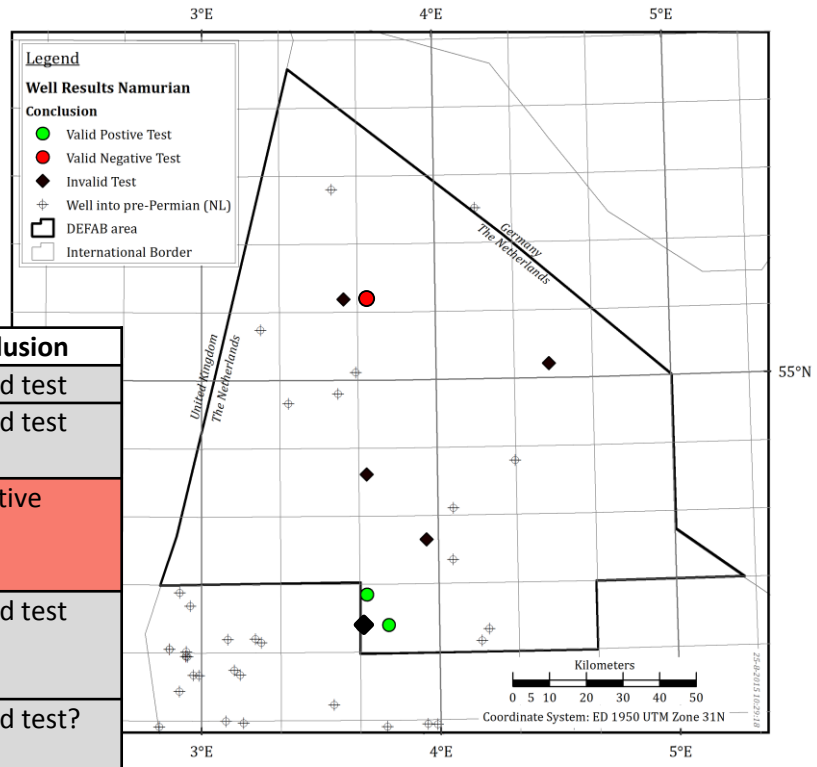


Well	Charge	Reservoir	Seal	Trap	Conclusion
A14-01	Gas shows	Present	Doubtful (Epen Fm)	Absent (2D)	Invalid test
A16-01	No shows	Present	Present, thin	Probable (2D)	Negative/ invalid
B10-01	No shows	Present	Present	Absent (2D)	Invalid test
E02-01	Doubtful shows	Present	Doubtful (Chalk)	Absent (3D)	Invalid test
E02-02	No shows	Present	Present, thin	Absent (3D)	Invalid test
E06-01	No shows	Present	Present	Doubtful (3D)	Invalid test

Well Results, Namurian

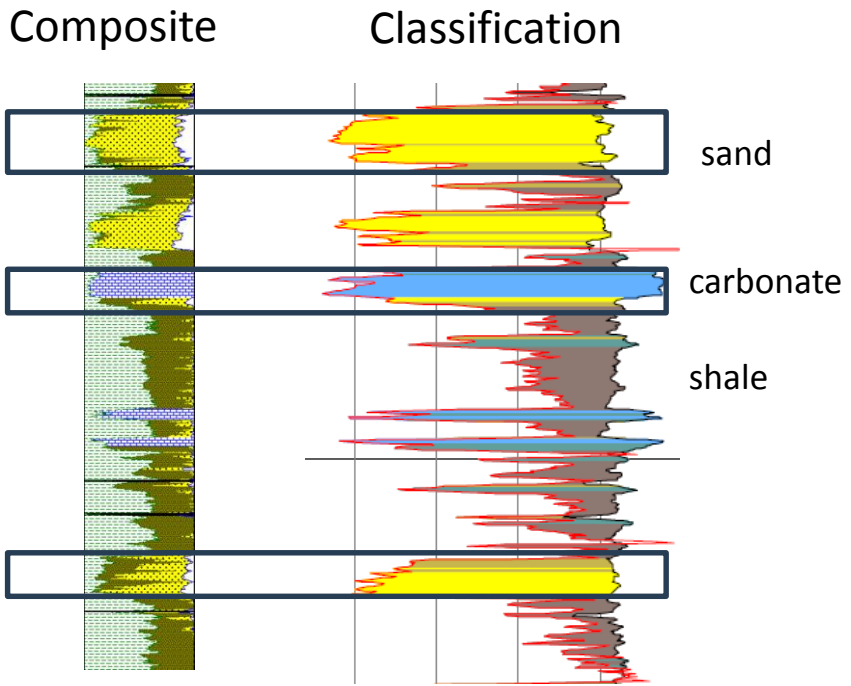
- **Only one well had the Namurian as primary target**

Well	Charge	Reservoir	Seal	Trap	Conclusion
A11-01	Weak gas shows	Present	Present	Absent (3D)	Invalid test
A14-01	Gas shows	Present	Doubtful (Epen Fm)	Absent (2D)	Invalid test
A15-01	Gas in Zechstein (16% N_2)	Inconclusive	Lower Rotliegend volc.	Present	Negative
B17-04	Mature source rock in well	Tight (large depth; 4600 m)	Present	Absent (2D)	Invalid test
E06-01	No shows	Only 17 m, possibly part of Yoredale.	Present	Doubtful (3D)	Invalid test?
E09-01	Present, 85% N_2	Inconclusive	Present	Inconclusive	Invalid test
E12-02	Gas shows	Probable	Present	Absent (3D)	Invalid test
E12-03	Present, 33% N_2	Present	Present	Present	Positive
E12-04	Present, 65% N_2	Present	Present	Present	Positive



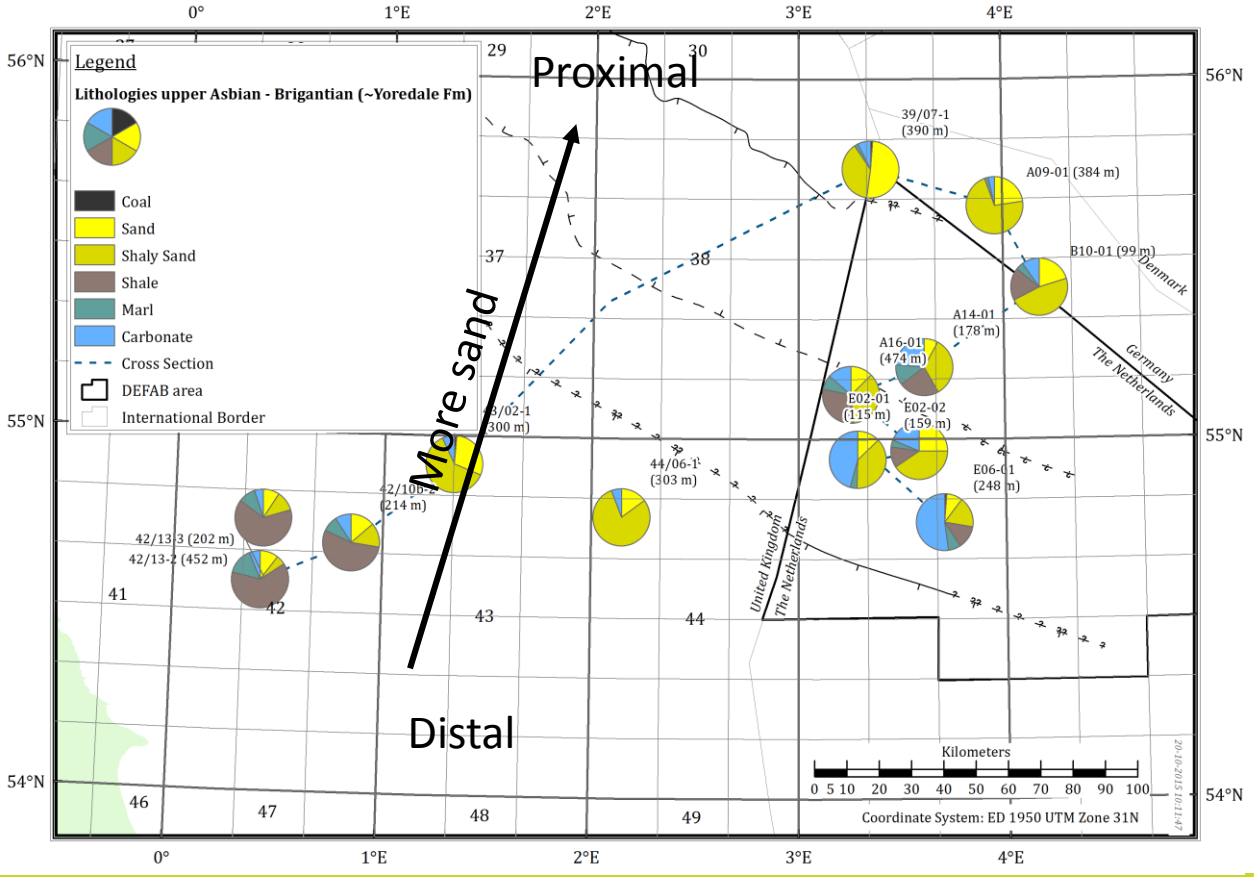
Reservoir potential

- Lithological classification based on sonic and gamma ray logs.
- 7 Lithology types distinguished: Sand, Shaly sand, Shale, Marl, Carbonate, Coal. Igneous rocks marked manually.
- QC'd using composite logs, mudlogs, density, resistivity, spontaneous potential and caliper logs, and core descriptions.
- Applied to Lower Carboniferous in 13 NL, 9 UK and 2 DE wells.

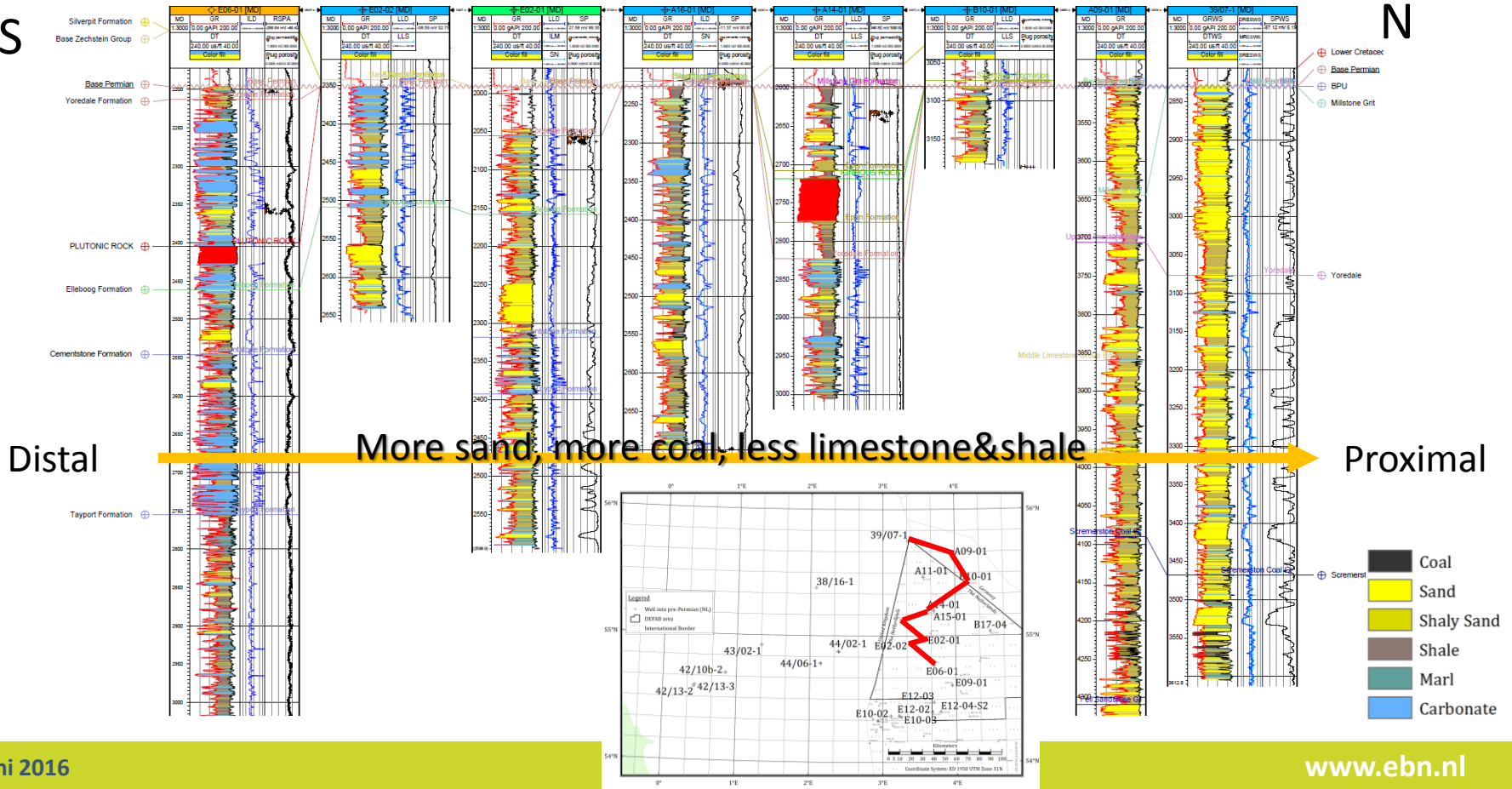


Lithological trends, upper Asbian-Brigantian

- Roughly coincides with the Yoredale Fm in the Elbow Spit High area.
- Less shale and carbonates, more sand toward the N.



Well correlation, Visean, NL



Well correlation, Visean, UK

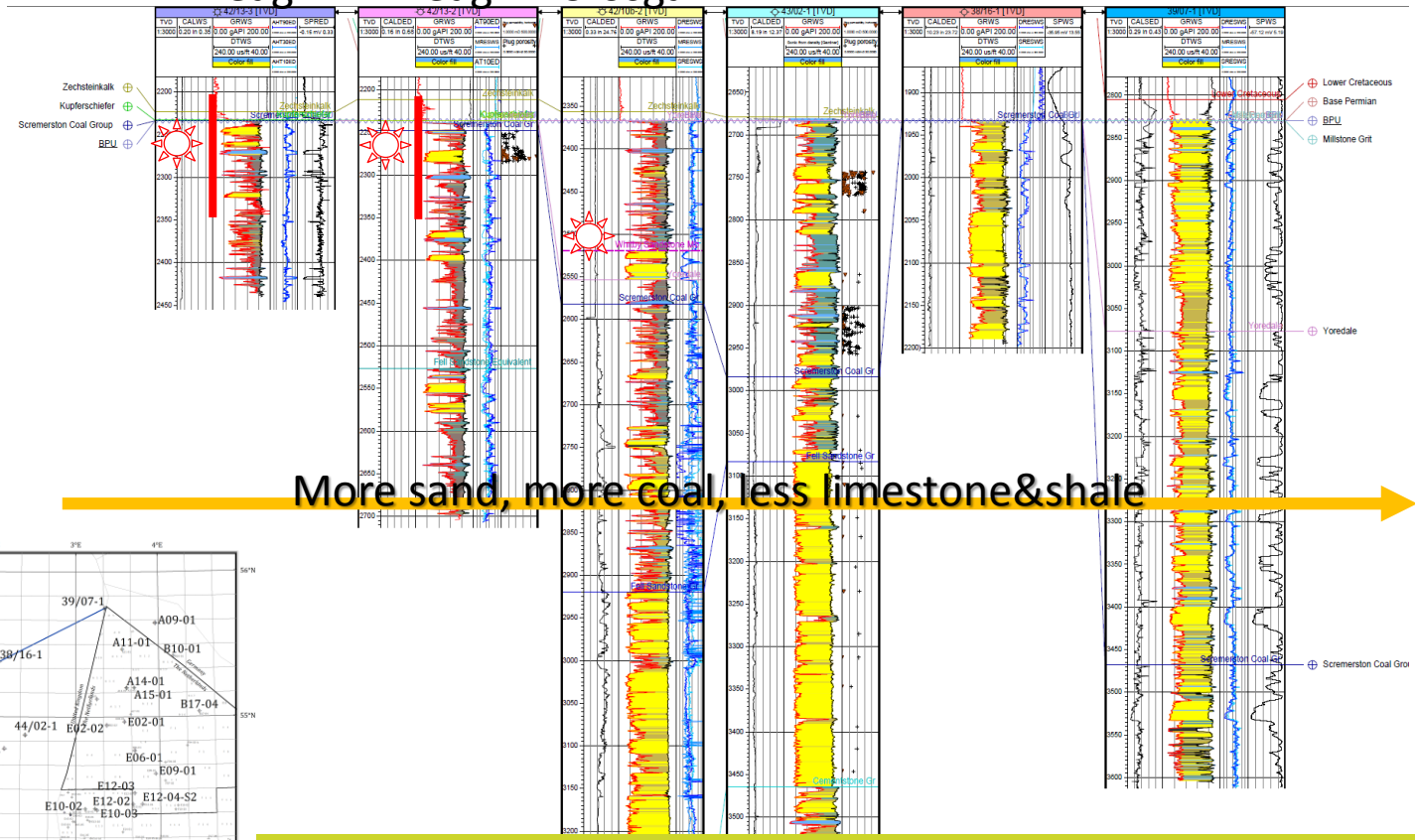
SW

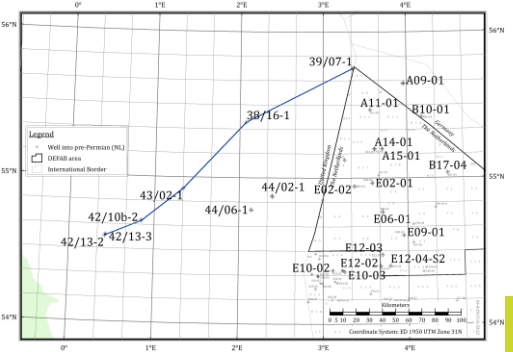
Breagh

Breagh

Crosgan

NE





Coal
Sand
Shaly Sand
Shale
Marl
Carbonate

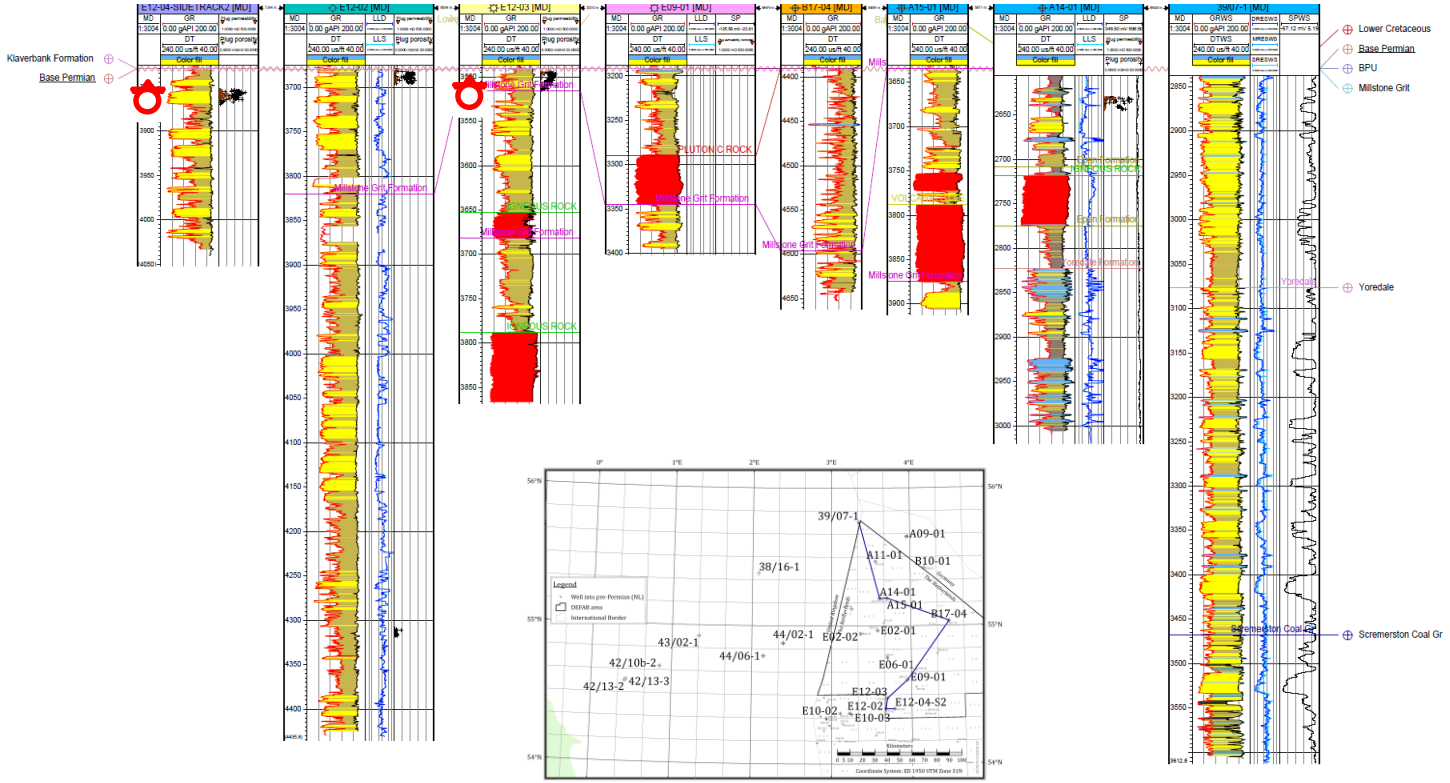
Well correlation, Namurian, NL

S

Lelie

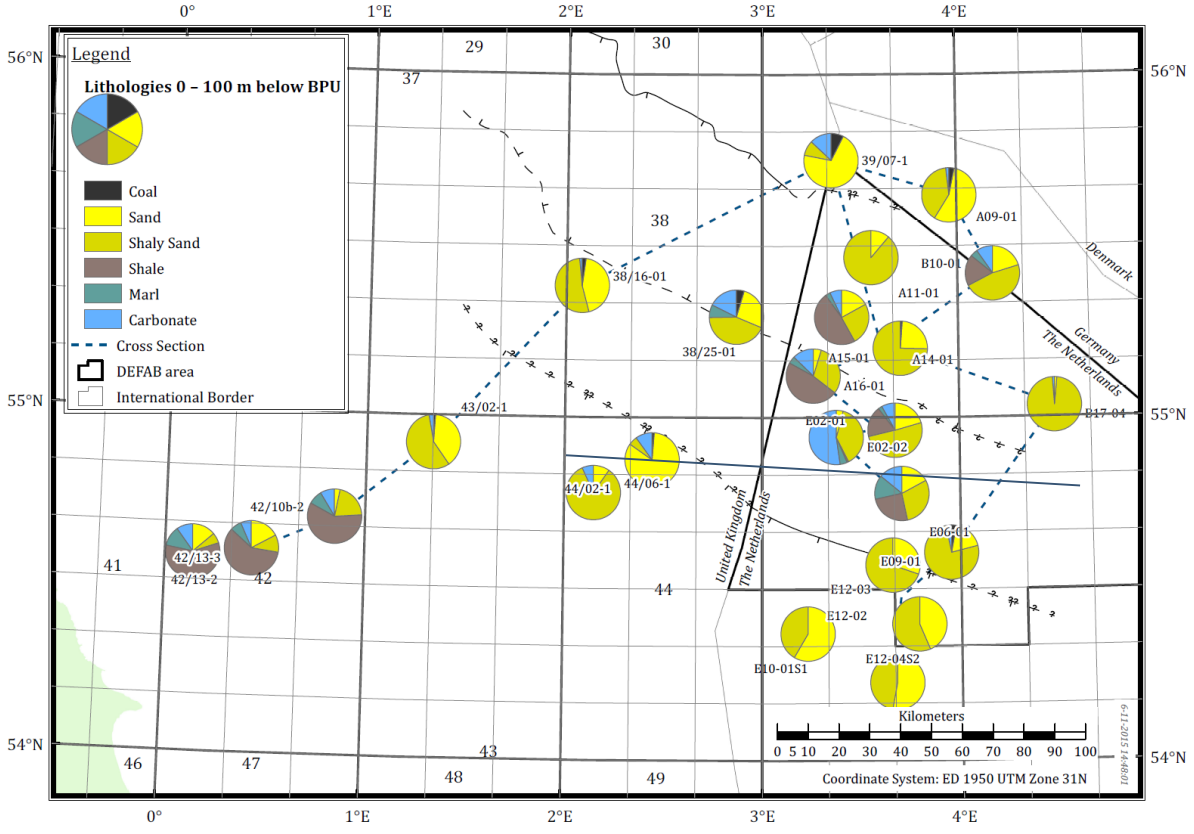
Tulp

N



Lithological characteristics, BPU subcrop

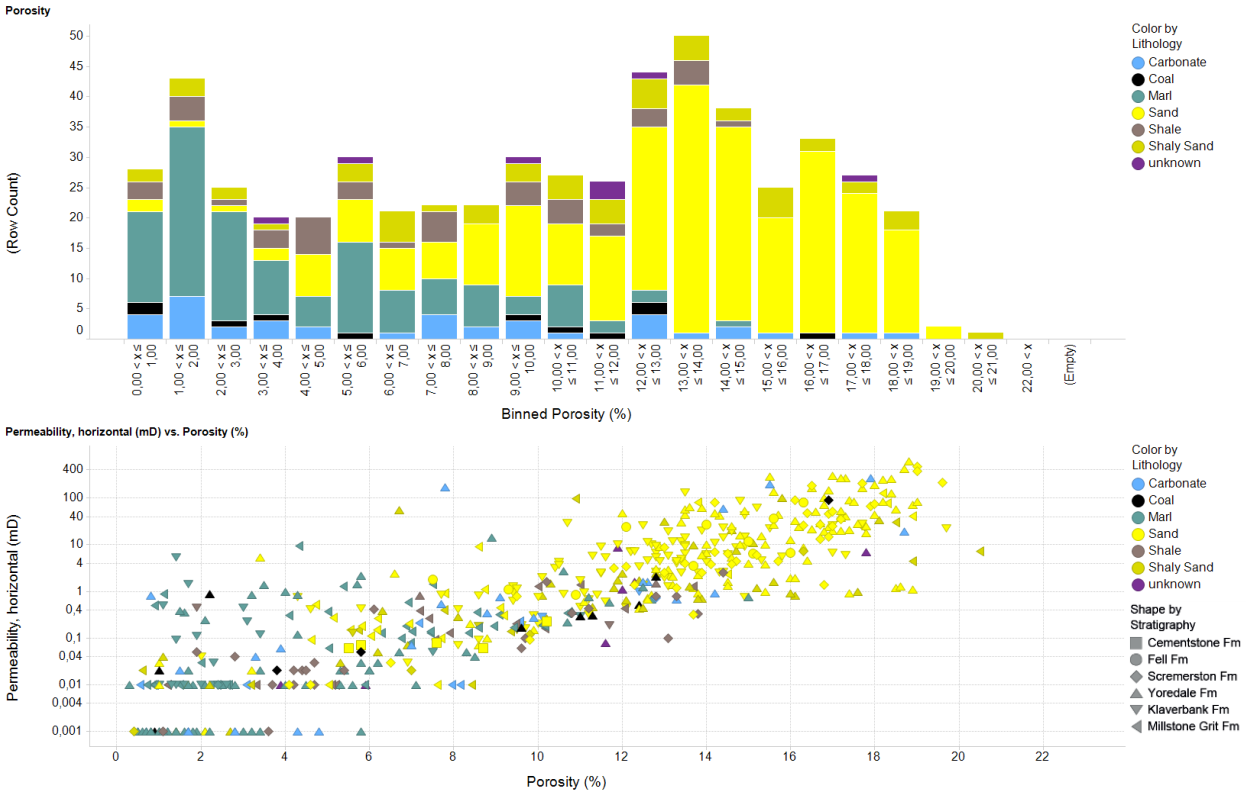
- Wells shown where the Lower Carboniferous subcrops the BPU.
- Averages for the first 100 m below the BPU.
- Breagh& Crosgan appear to be at the margin of the play; more sand further north.



Porosity& permeability data

- Same color coding as lithologies on well correlation panels.
- 6 NL wells, 2 UK wells.
- All data from Visean& Namurian.

- **Intervals classified as sand have favourable reservoir characteristics.**



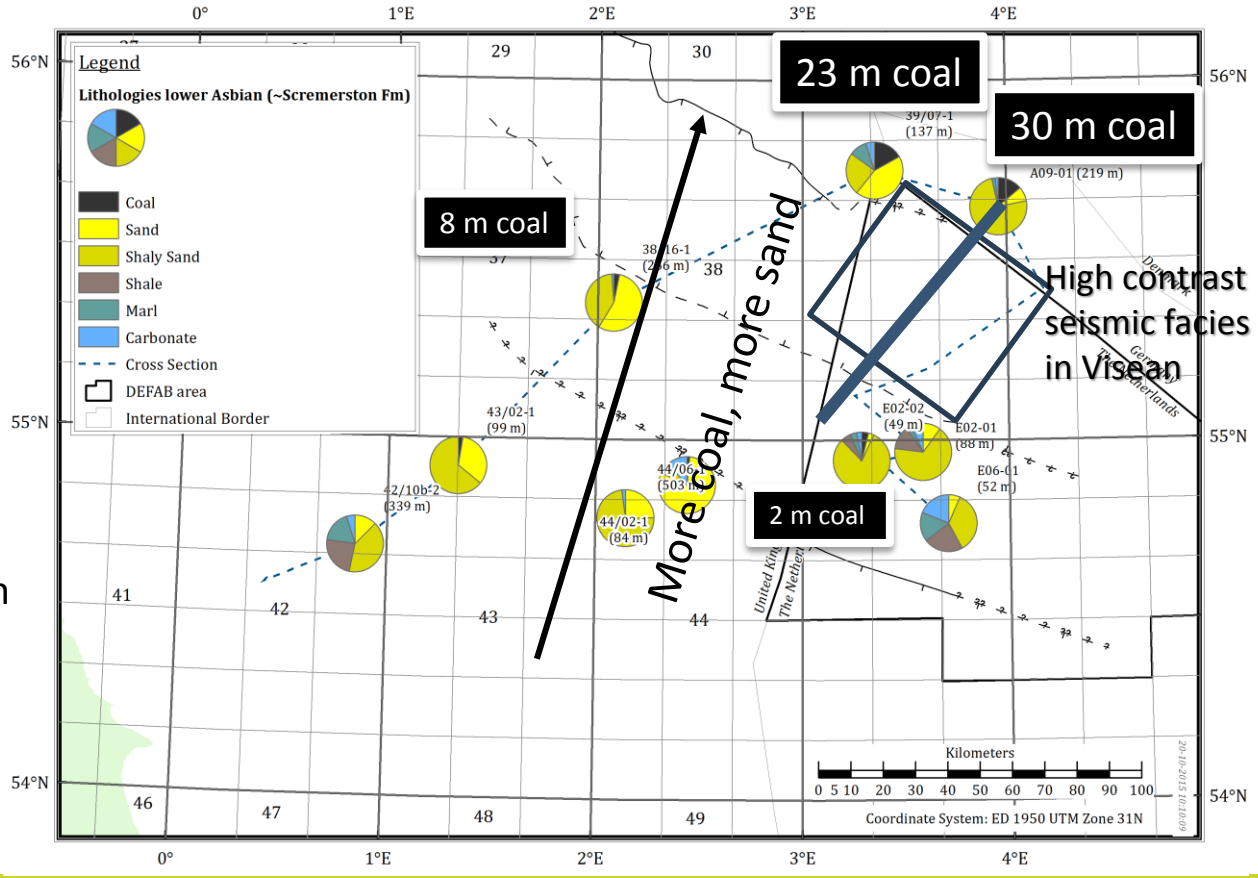
Source Rock potential

Coals

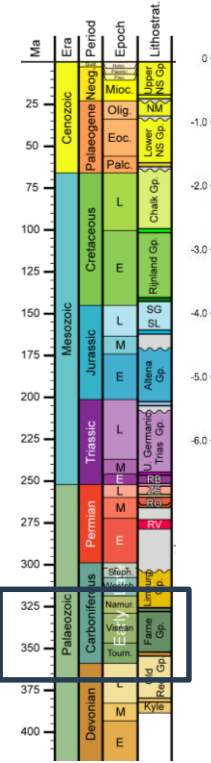
- N-ward increase in coal content in Scremerston Fm.
- Yoredale Fm and Namurian also contain coal; up to 7.5 m encountered in wells.

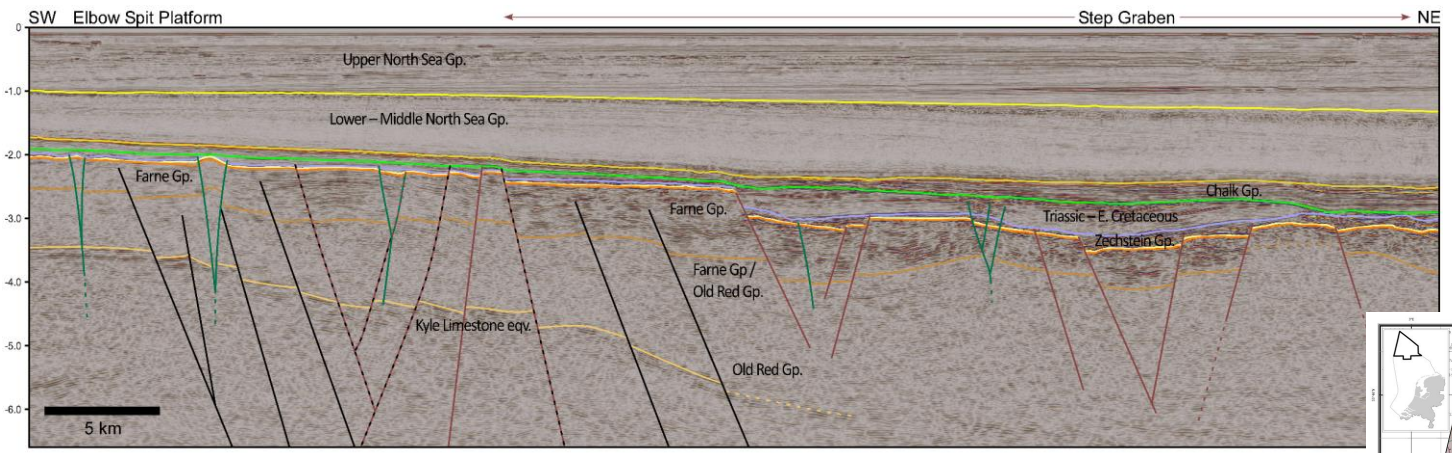
Potential additional source rocks

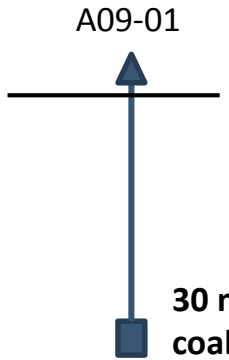
- Namurian marine shales; potential in the S
- Lateral charge from Westphalian
- Bituminous limestones Yoredale
- Lateral migration from downthrown proven Posidonia Shale, Zechstein.



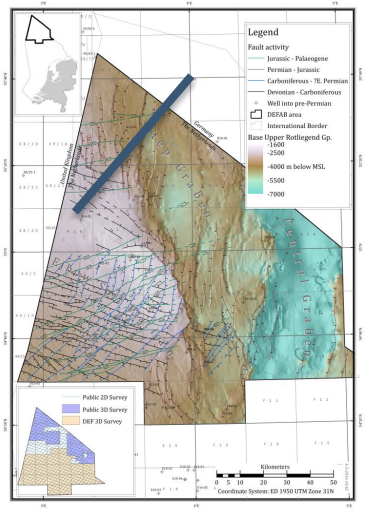
Coals in Lower Carboniferous north of the Elbow Spit Platform





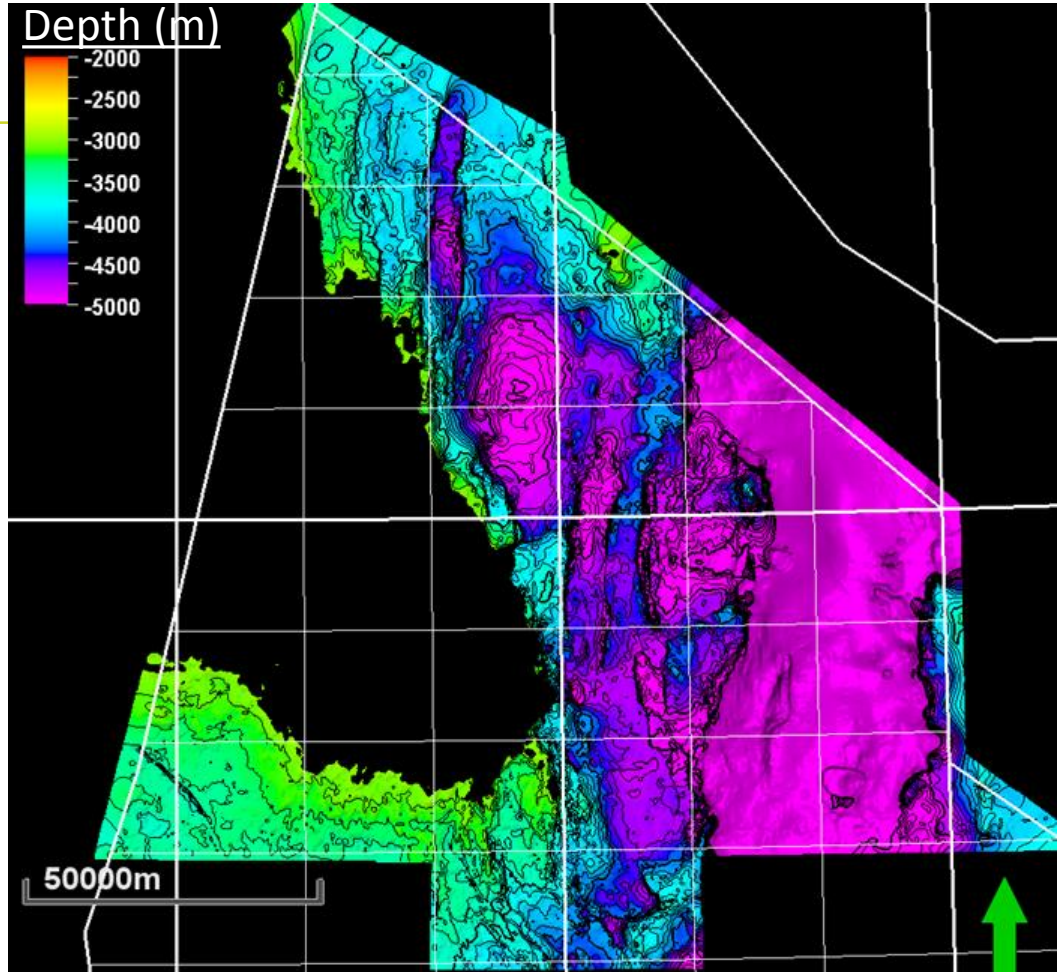


- Lower Carboniferous is present north of the Elbow Spit Platform.
- Has a high contrast seismic facies.



Maturity - BPU below 3.0 km

- Basin modelling by TNO shows that Scremerston coals become mature at approximately 3 km burial.
- Region where Base Permian Unconformity is below 3 km is shown in figure.
- Coals are commonly located a few hundred metres below the BPU.
- **Carboniferous expected to be in gas window in most of the area.**



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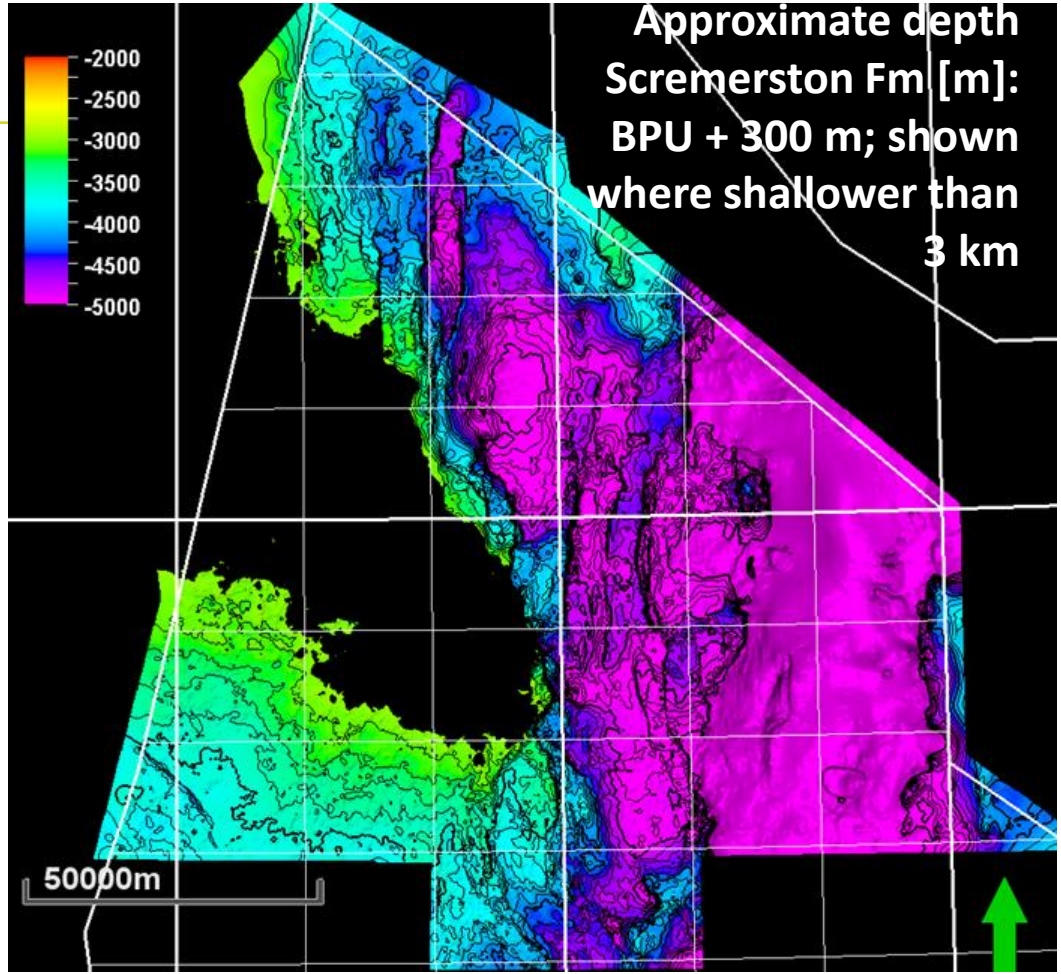
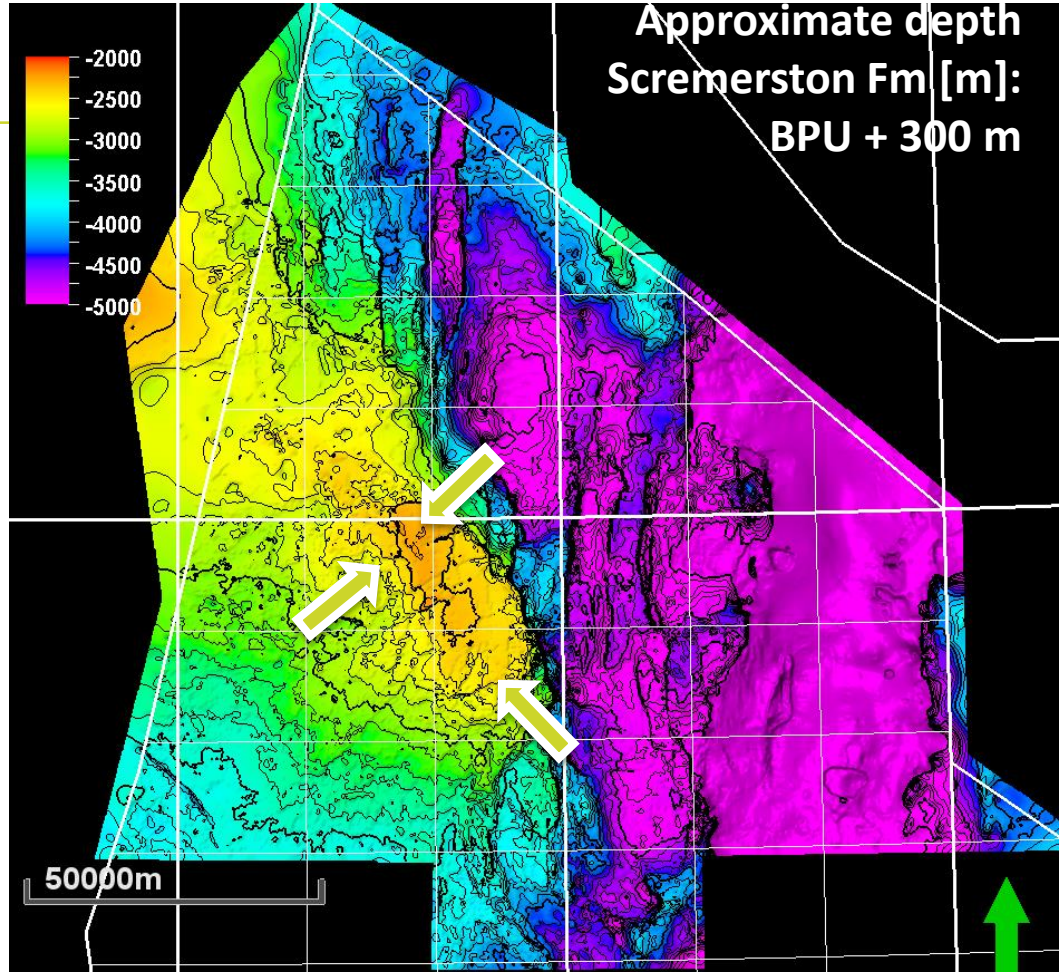
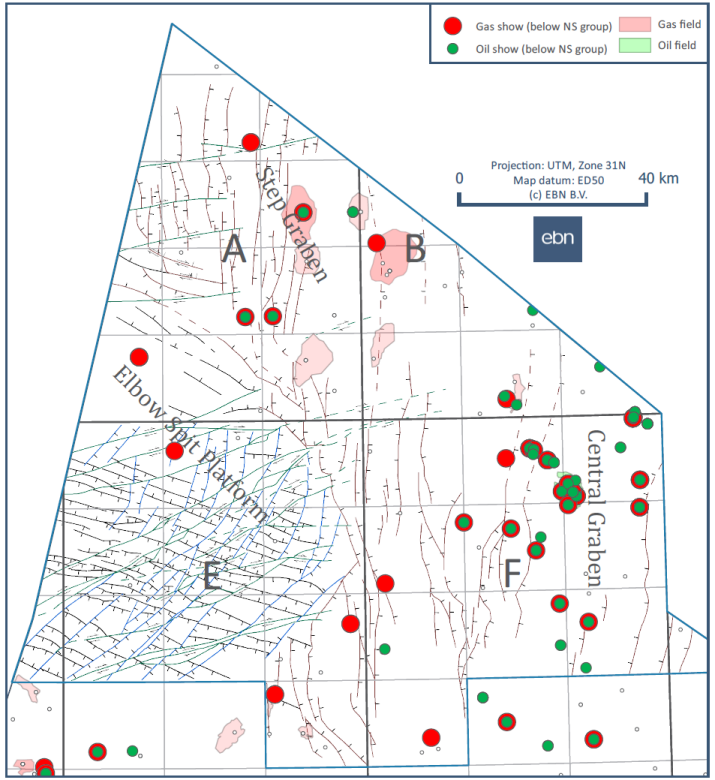


Lateral migration

- Carboniferous expected to be in gas window in most of the area.
- **Lateral migration from kitchen areas may have charged areas located updip.**

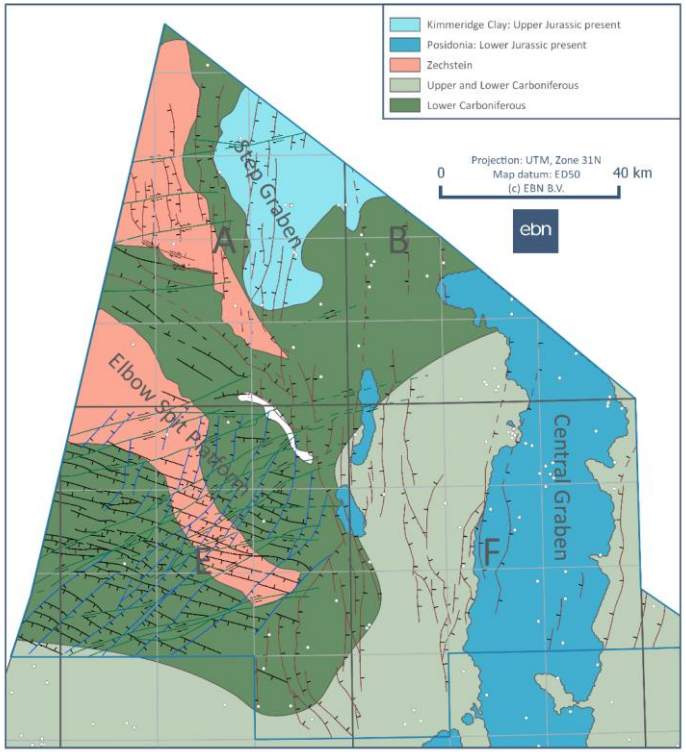


Positive indications for Palaeozoic source rocks



Shows, below North Sea Group

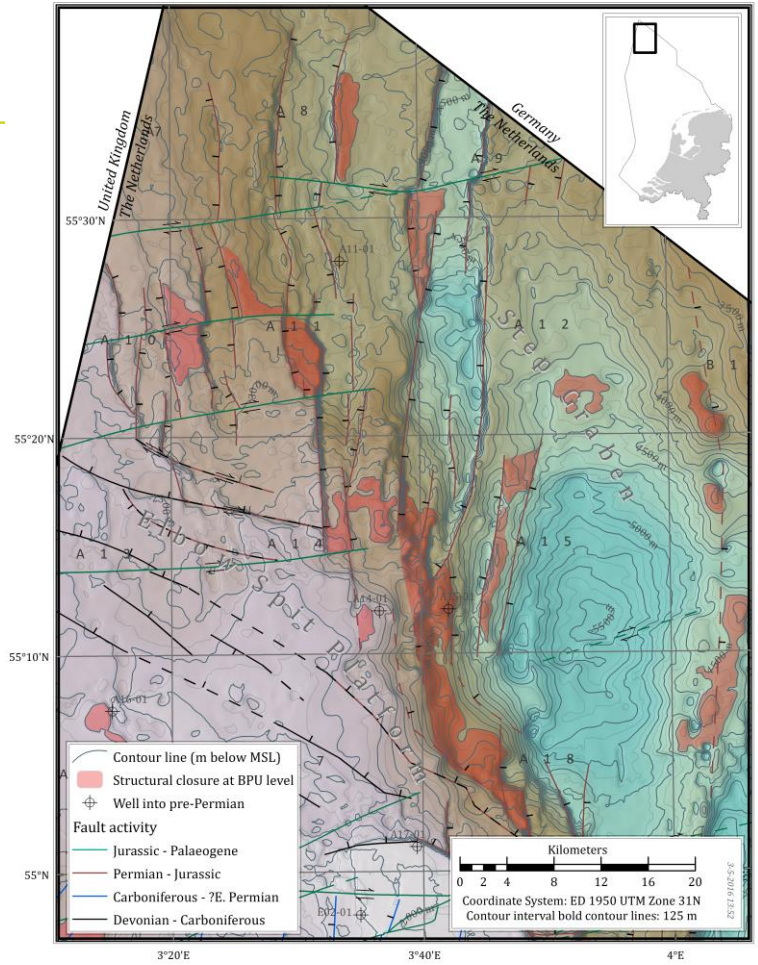
- Hydrocarbon shows also occur <u>below</u> the Posidonia & Kimmeridge Clay Fm.
- Shows also occur outside the extent of these source rocks.



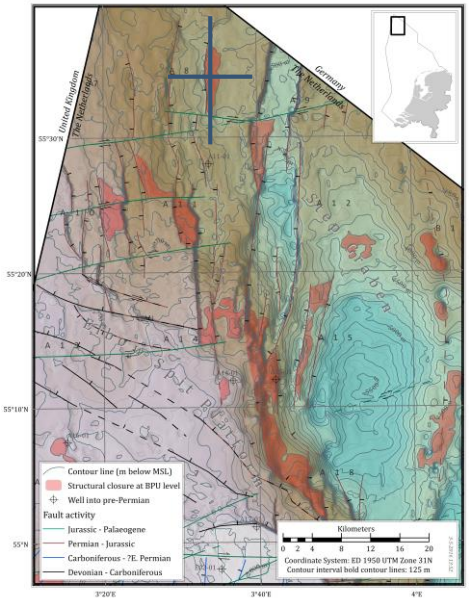
Inventory of formations with source rock potential. Where formations overlap only the shallowest formation is shown.

Closures

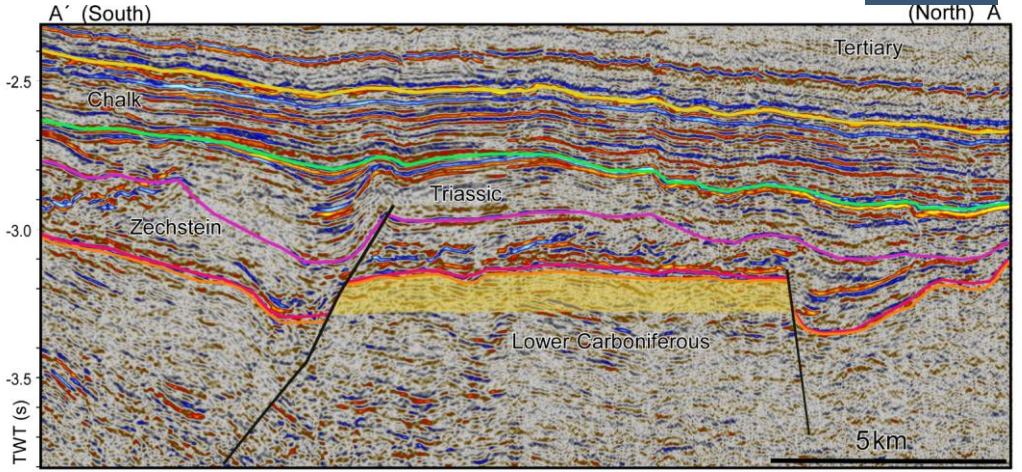
- 20 structures at BPU level have been identified with a total P50 GIIP of ~75 BCM (unrisked). A subset of these structures is indicated on the BPU depth map (right).
- Closures also located in open blocks.

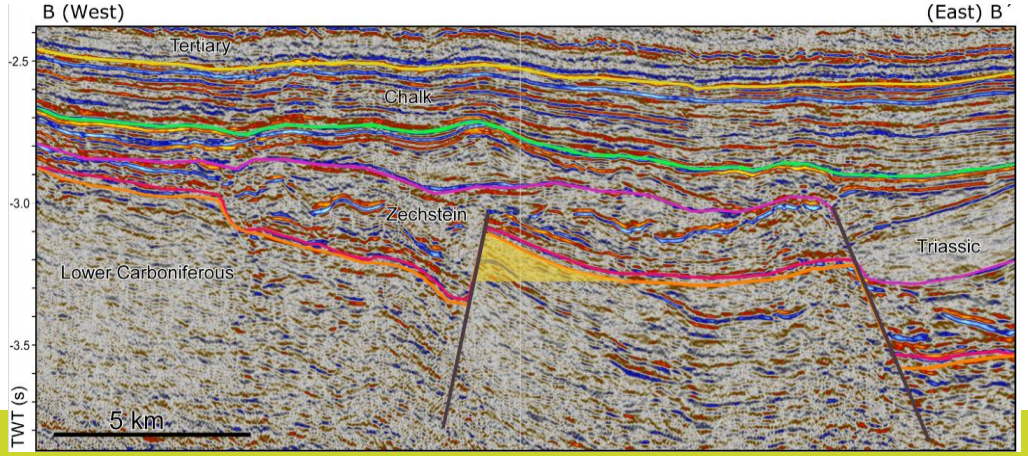


Example of a lead at BPU level: Kilimanjaro

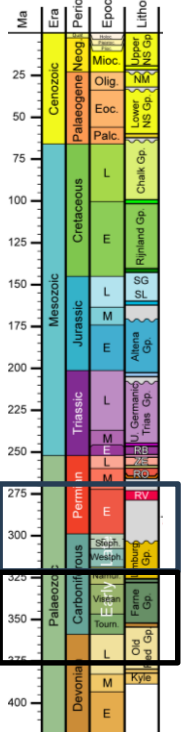


Reservoir	Namurian& Visean clastics
Seal	Silverpit shales& Zechstein salt
Source	Scremerston coals

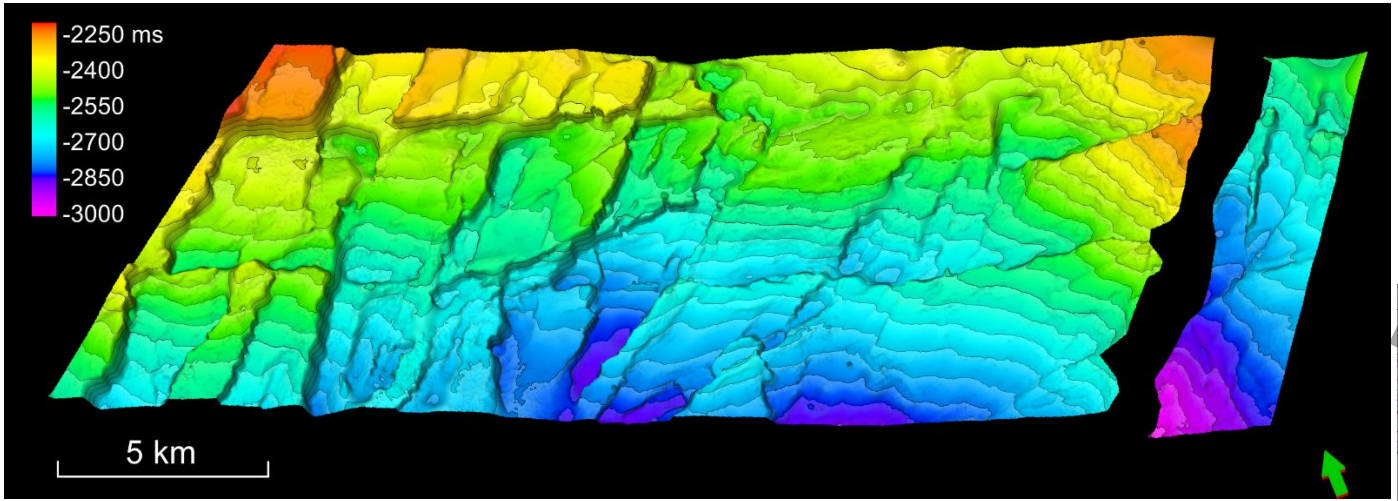




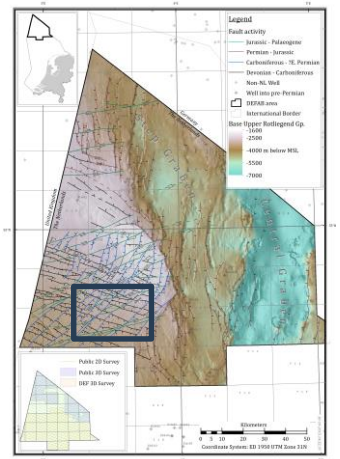
Example: Intra-Carboniferous structuration

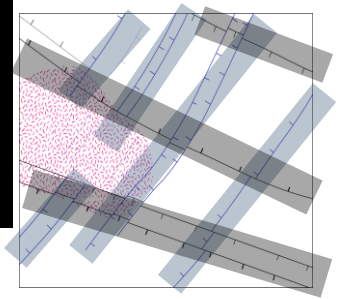


- Significant structures, formed by Lower Carboniferous faults, combined with a younger Carboniferous fault trend.
- More information about the structural evolution of the area available on poster on display today.



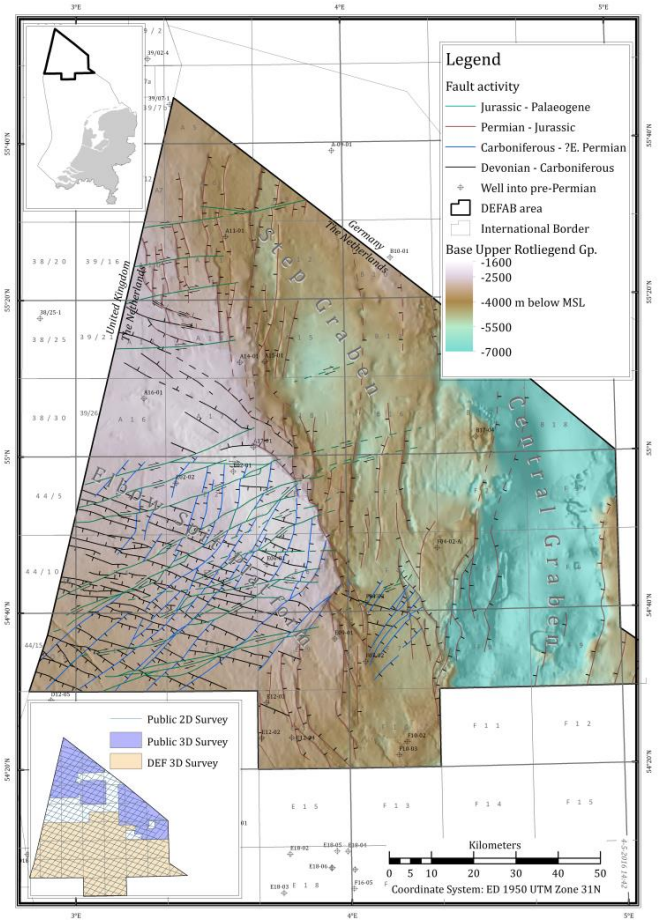
Seismic data courtesy Spectrum ASA





Take-home messages

- Lower Carboniferous present in most of the Dutch northern offshore
- A mature source rock is expected to be present
- Reservoir potential looks promising
- The play is virtually untested
- Significant closures exist at BPU level, also in open blocks



Thank you for your attention

More information about the structural evolution of the area available on poster on display today.

More information? Contact us:

exploration@ebn.nl

Acknowledgements:

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

EBN Colleagues, Rader Abdul Fattah (TNO, Basin modelling), Tacjana Litwinska-Kemperink

References:

Milton-Worssell, R., Smith, K., Mcgrandle, A., Watson, J. and Cameron, D., 2010. The search for a Carboniferous petroleum system beneath the Central North Sea. In: Vining, B.A. and Pickering, S.C. (Eds.) Petroleum Geology: From Mature Basins to New Frontiers – Proceedings of the 7th Petroleum Geology Conference, 57-75.

TNO, 2014: Basin Modelling carried out for EBN.