ATLAS TO EXPLORE HYDROCARBON OPPORTUNITIES IN THE DUTCH OFFSHORE

UPPER CARBONIFEROUS PLAY

Upper Carboniferous Play

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Overview – Upper Carboniferous play

1 Introduction

Plan & key resources
Sub-play division
Well data selection

2 Base Permian Subcrop Map

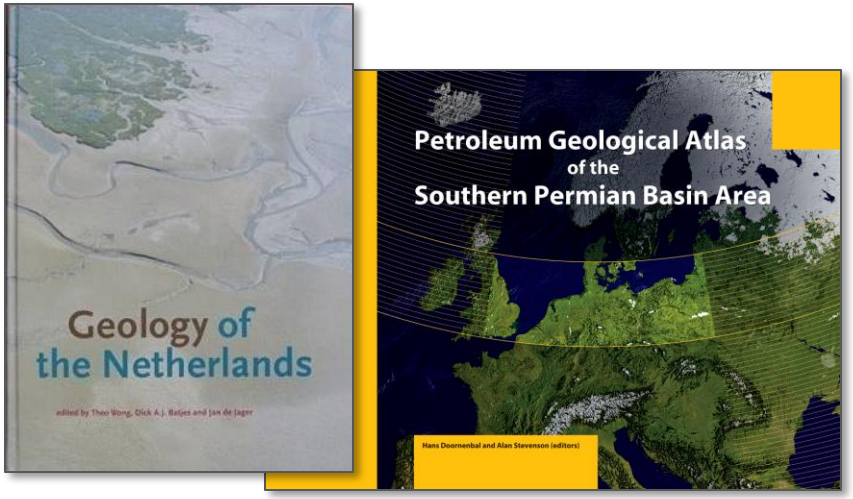
3 Play Elements

Reservoir presence & effectiveness
Top Seal
Charge

4 Wrap-up

1. Introduction

- **The Plan**
  - Compile info on the (Upper) Carboniferous in the NL Offshore from key databases and publications
  - Digest, summarise and make it accessible via the GEODE Atlas platform
- **Key resources**
  - Overview publications: see below
  - EBN- and TNO-studies



NLOG
Nederlandse Olie- en Gasportaal

Home / Datacenter

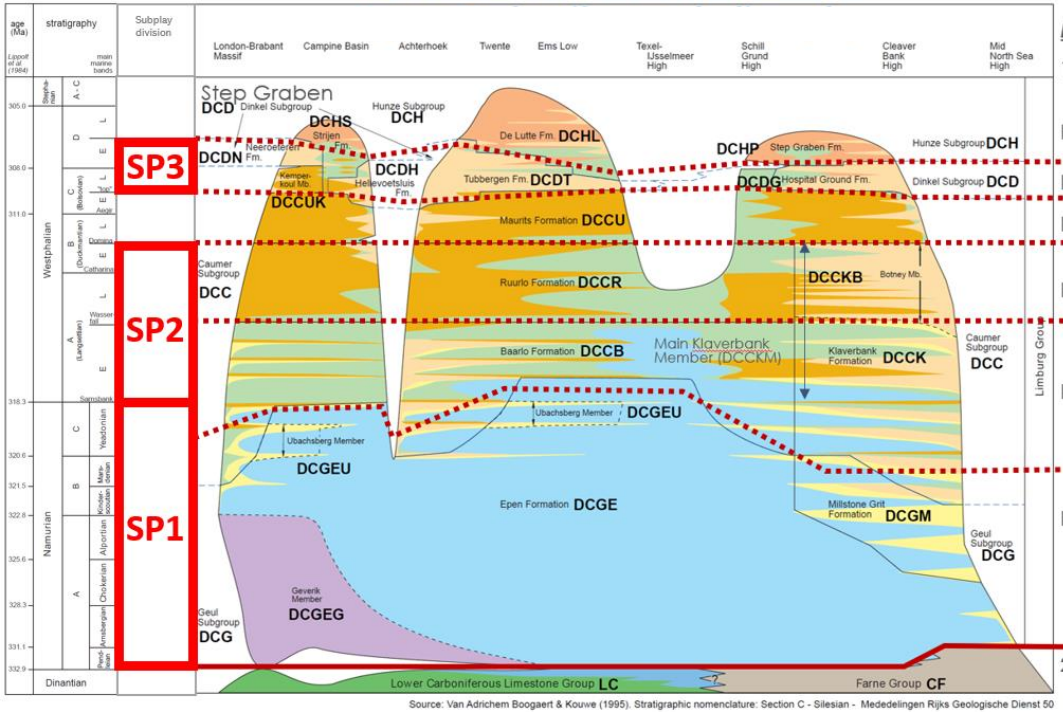
DINOloket
Data en Informatie van de Nederlandse Ondergrond

Stratigrafische Nomenclator

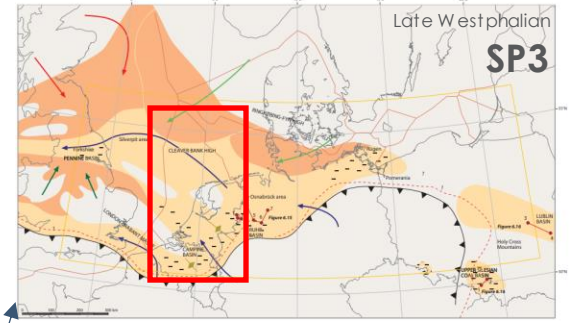
1. Sub-plays SP1, SP2, SP3

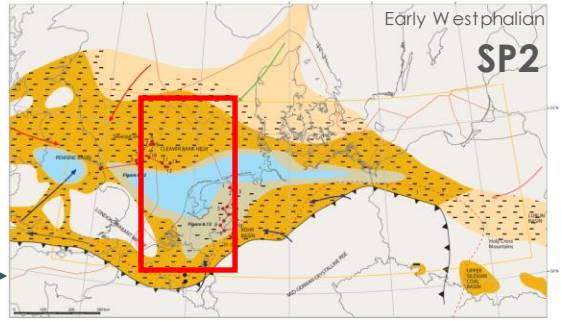
Paleogeographic Maps (SPBA) =>

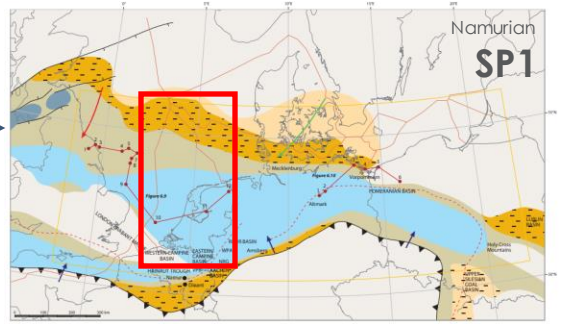
Stratigraphic scheme Upper Carboniferous (NLOG)



Source: Van Adrichem Boogaert & Kouwe (1995). Stratigraphic nomenclature: Section C - Silesian - Mededelingen Rijks Geologische Dienst 50





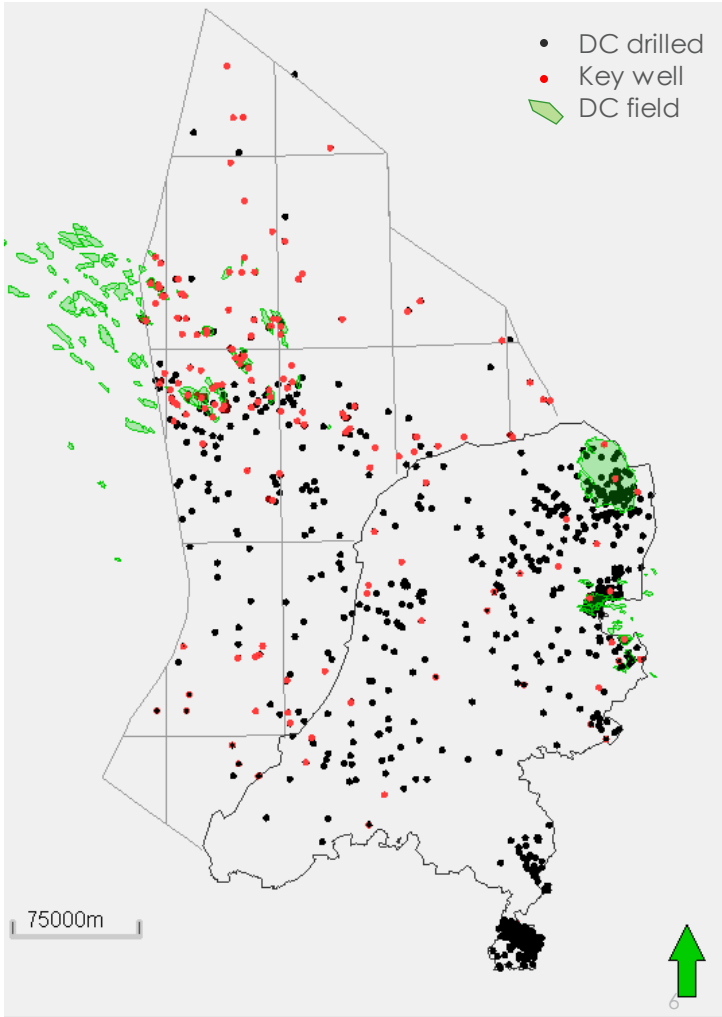


SPBA (2010), chapter 6 - Carboniferous

1. Data

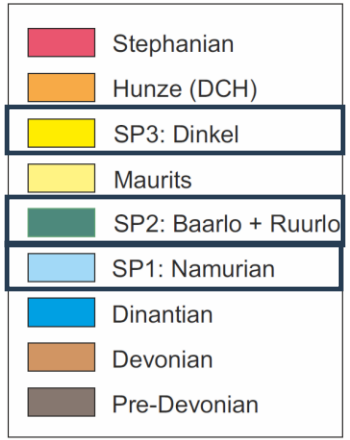
- **Well driven dataset**
  - NLOG
  - NL onshore, UK (20) and German (5) wells to capture trends
  - New seismic interpretation out of scope
- **Well data check**
  - Tops – corrections applied if needed
  - Log availability/quality
- **Key well selection**
  - SP presence/completeness
  - Spatial distribution
- **Other resources**
  - Porosity + Core databases (EBN)

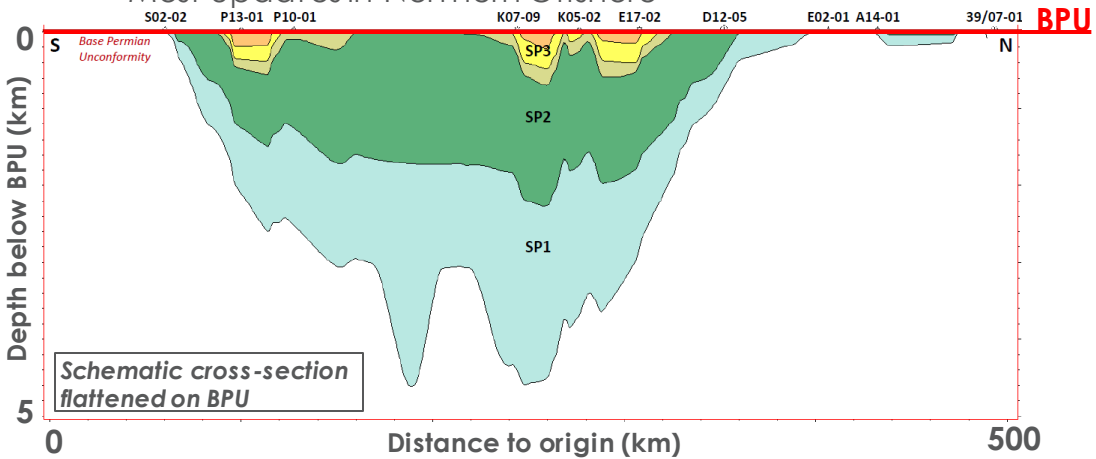
	#wells	#key wells
DC drilled	**1647**	185
SP3	238	87
SP2	461	92
SP1	67	30

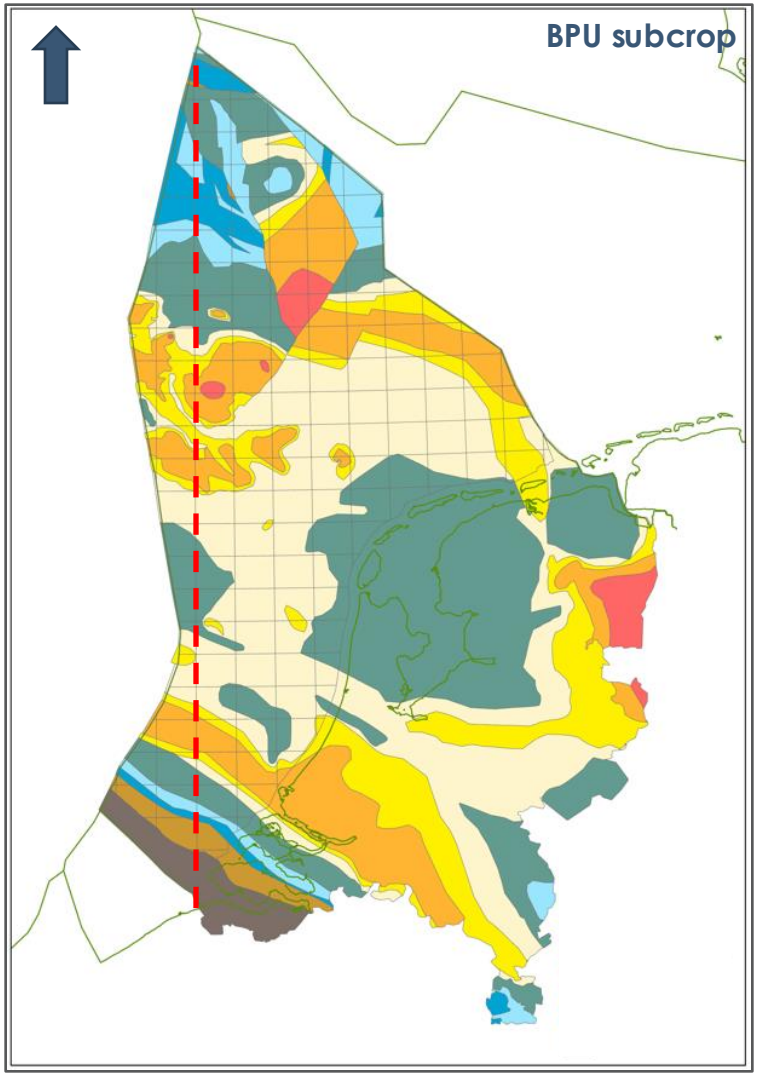


2. BPU subcrop map

- **Previous BPU subcrop maps**
  - Mijnlieff (2007)
  - SPBA (2010)
  - Northern Offshore project (2016)
- **Adjustments**
  - New study: Paleo-Five project (TNO, 2020)
  - Re-interpreted well data (update NLOG ongoing)
  - Most updates in Northern Offshore

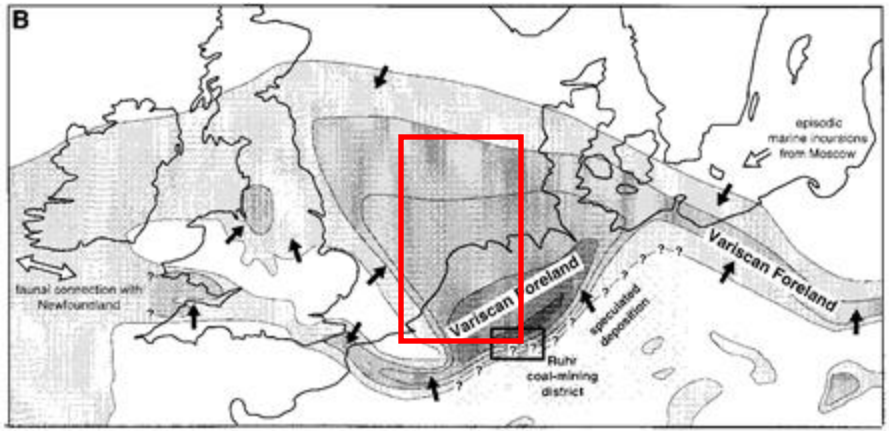




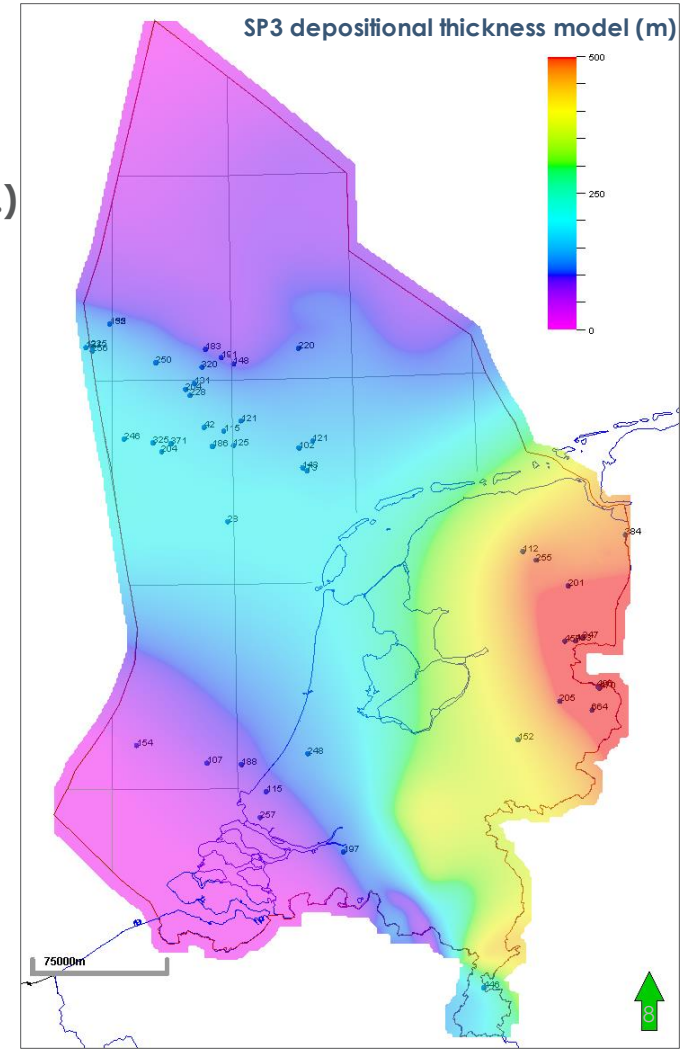


3. Reservoir presence

- **Summarized workflow reservoir gross thickness SP3 (Dinkel Sg.)**
  - Use depositional thickness after Hampson et al. (1999) model
  - Calibrate to wells with full SP3 penetration
  - Define areas of SP3 complete presence, truncation and absence
  - Grid area where top SP3 is truncated, calibrate to wells
  - Merge SP3 complete presence, truncation and absence areas
  - Cross check with wells that TD'ed in SP3



Westphalian depositional thickness model, Hampson et al (1999)



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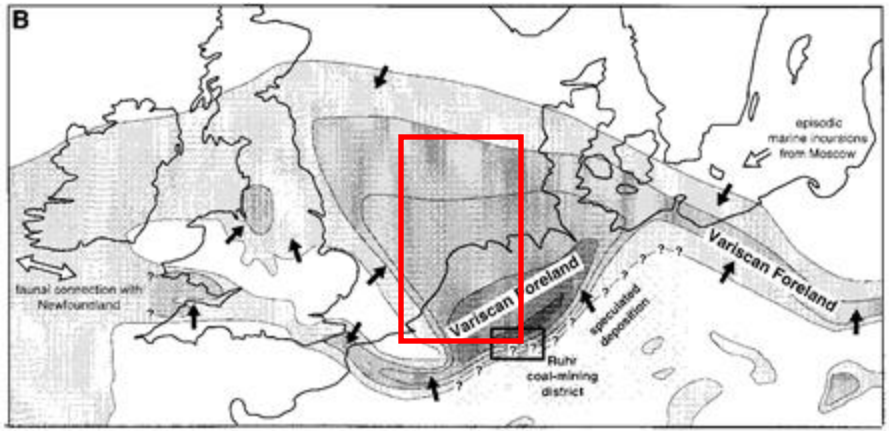

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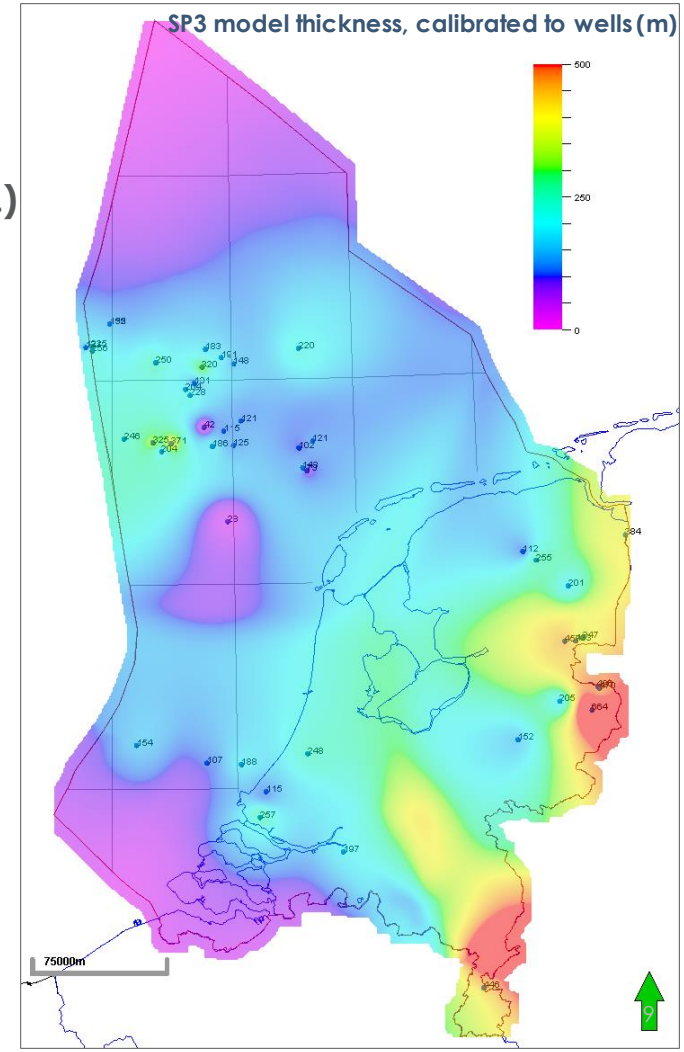

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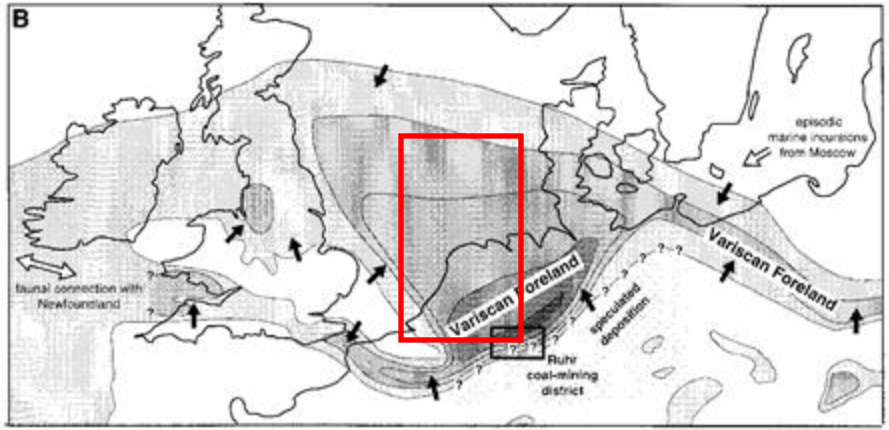

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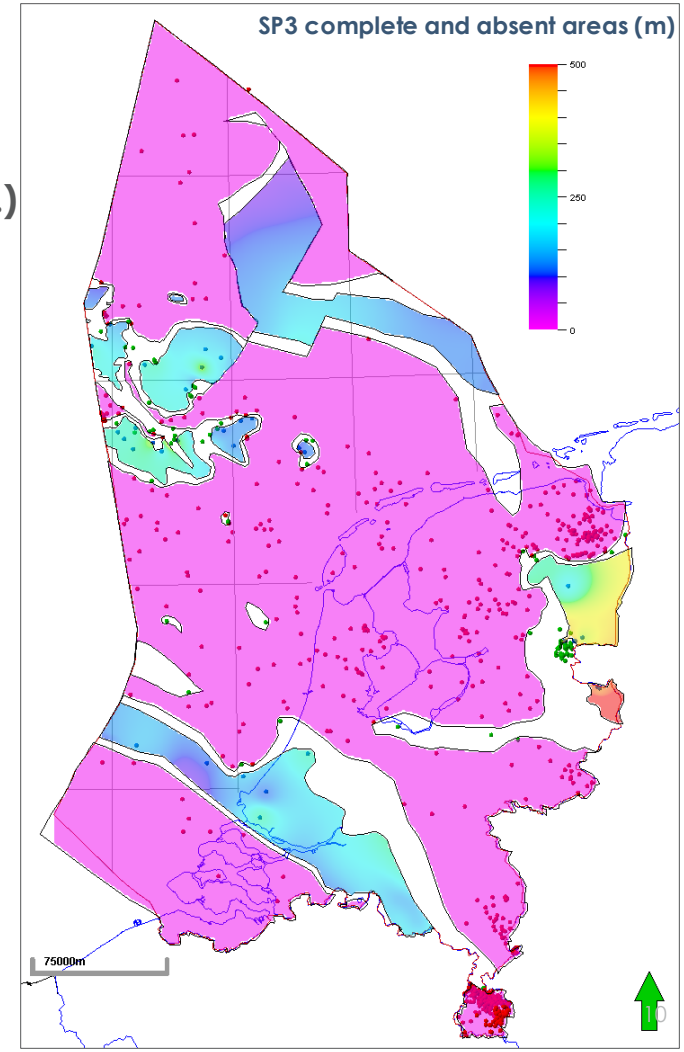

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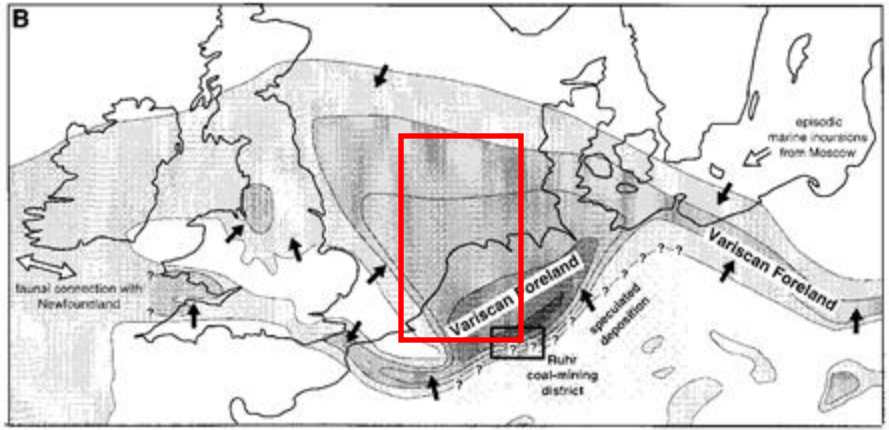

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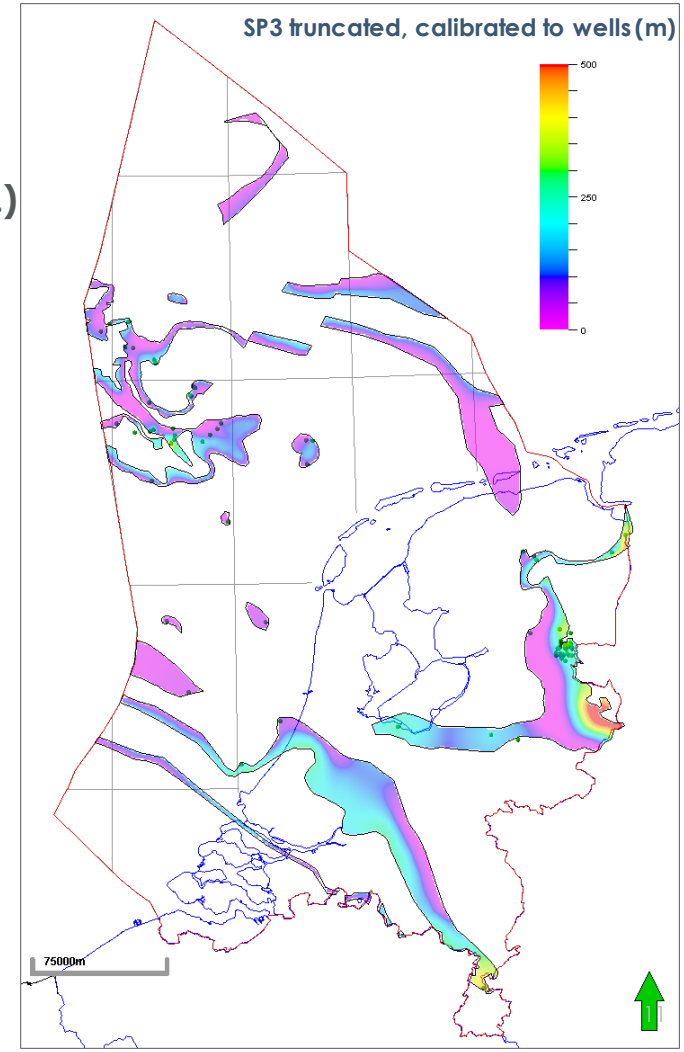

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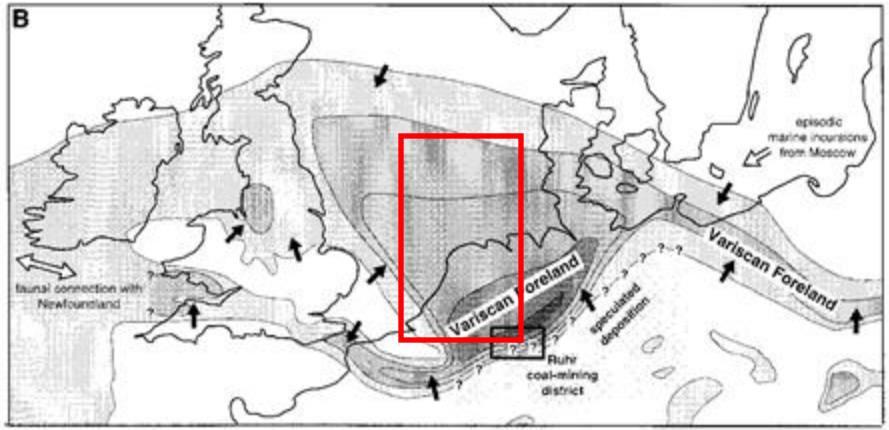

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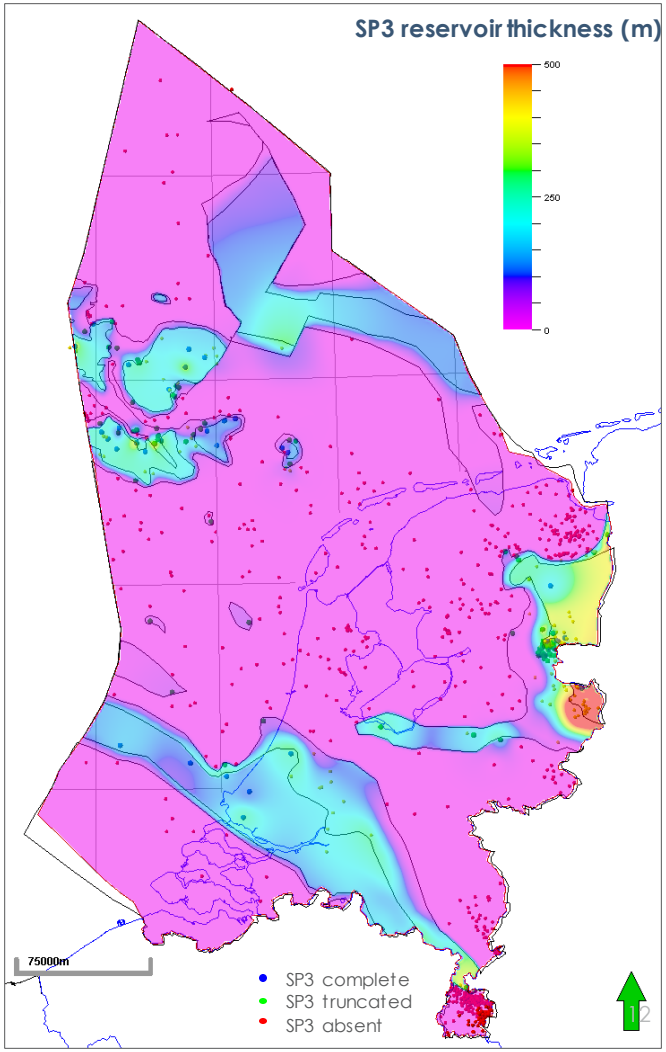
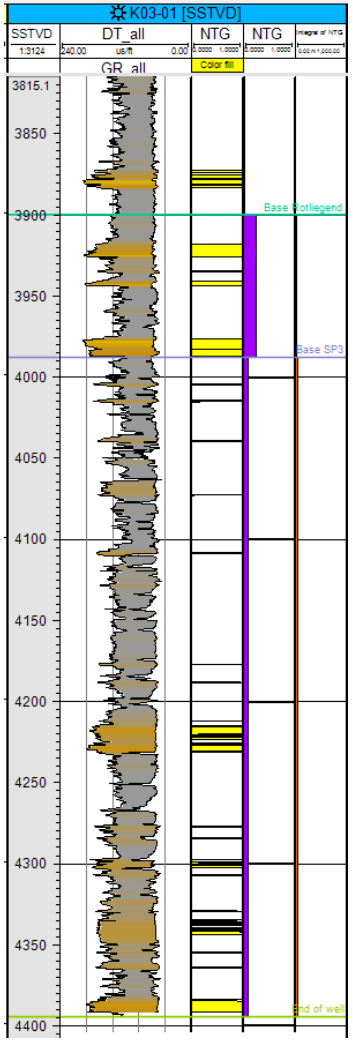
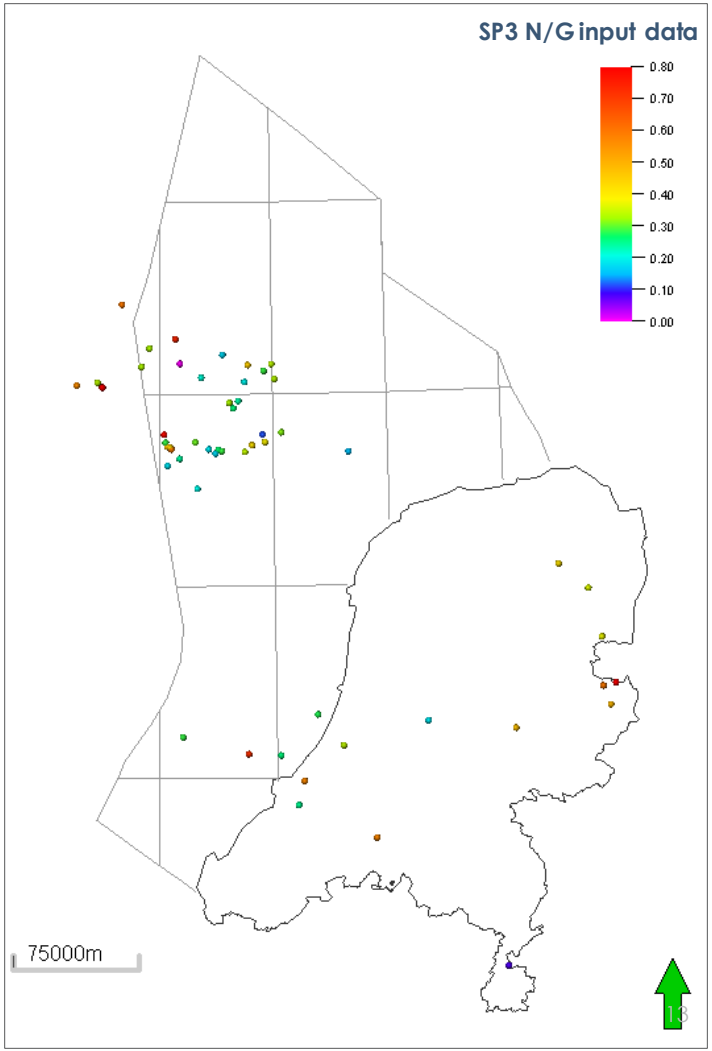


3. Reservoir net/gross

- **Summarized workflow N/G and Net sand thickness for SP3**
  - Key well selection for SP3 (54)
  - For each well, derive:
    - Sand presence log for each well using GR and/or DT cut-offs
    - N/G and net sand thickness
  - N/G point dataset, grid map
  - Multiply N/G map with gross thickness map
  - Crosscheck resulting net thickness map with estimated net thickness at well locations





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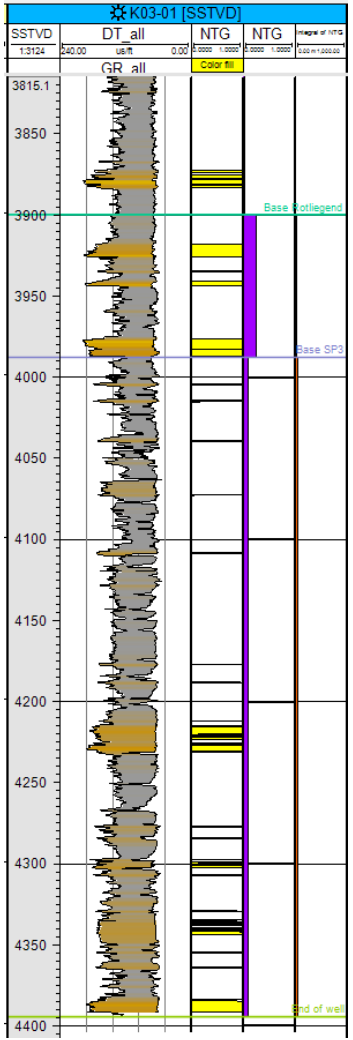

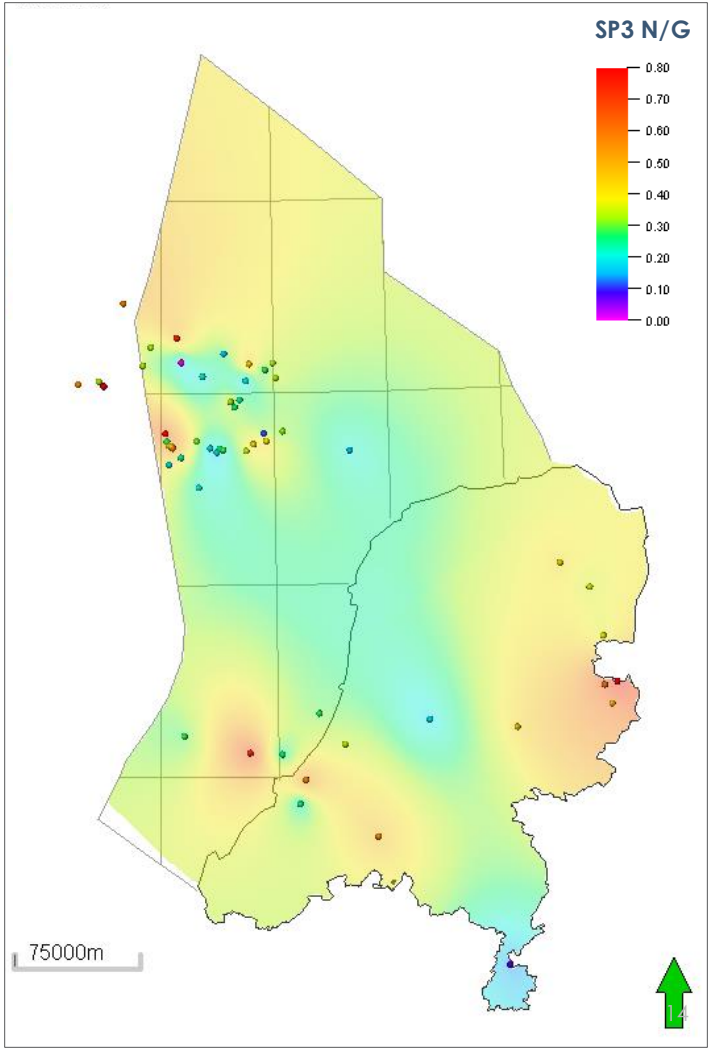

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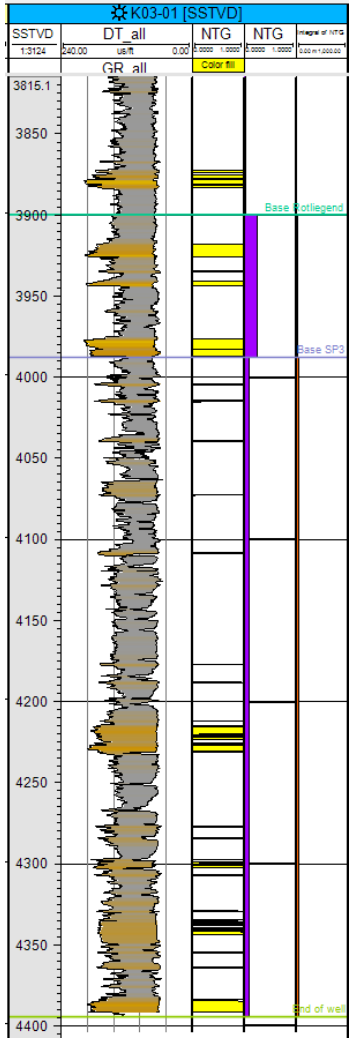

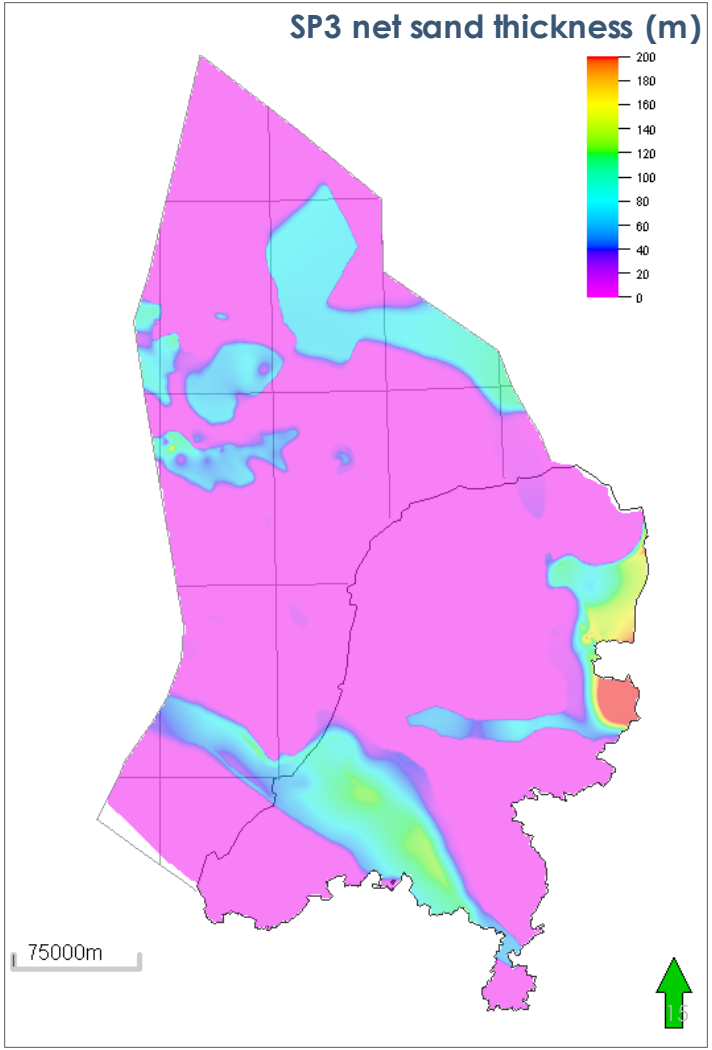

3. Reservoir porosity

- **Proxy for reservoir effectiveness**
  - Observation: strong relationship between present-day depth and porosity
    (from EBN core plug database, all DC plugs which also have a K value)
- **Summarized workflow total porosity SP3:**
  - Point dataset from NLOG data, Winningsplannen and EBN Basisregistratie
  - Gridding: collocated co-kriging with depth trend, R=0.8, range=100km
  - Take out eroded areas

Bin depth range, m TVSS	Average bin depth, m TVSS	Number of core plugs in bin	Average porosity, %
750-1050	900	35	16.0
1050-1350	1200	69	13.8
1350-1650	1500	179	10.9
1650-1950	1800	424	12.2
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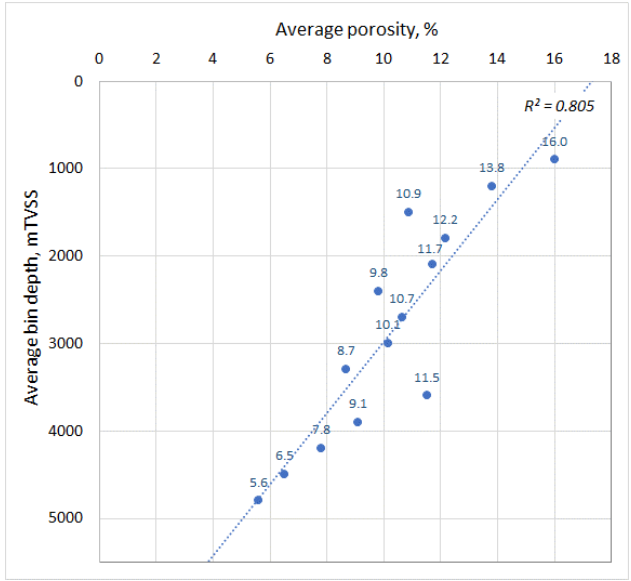

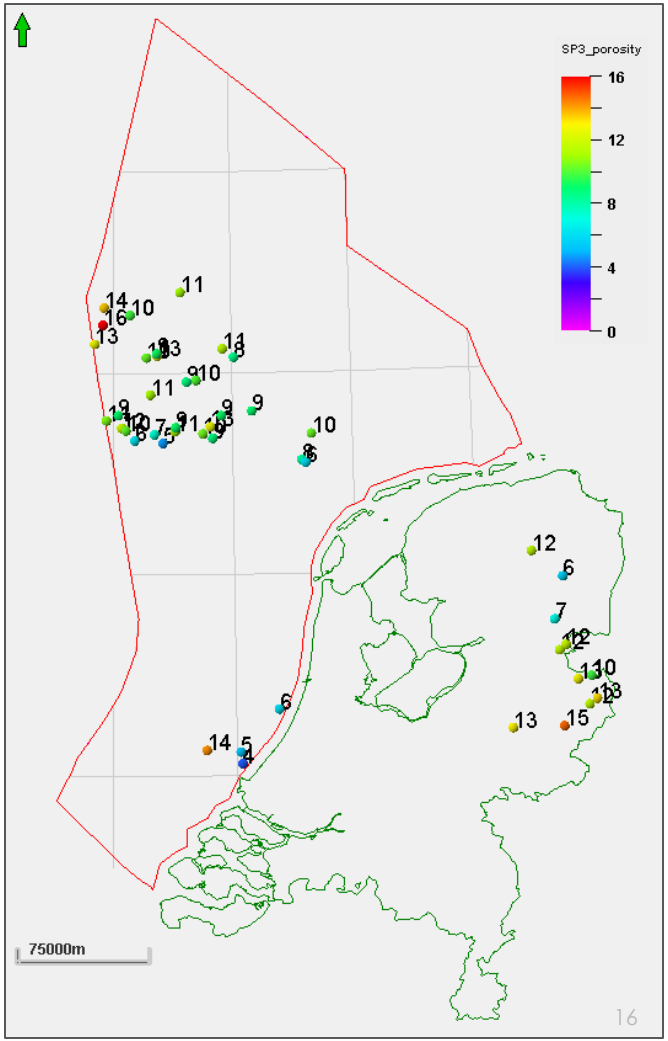

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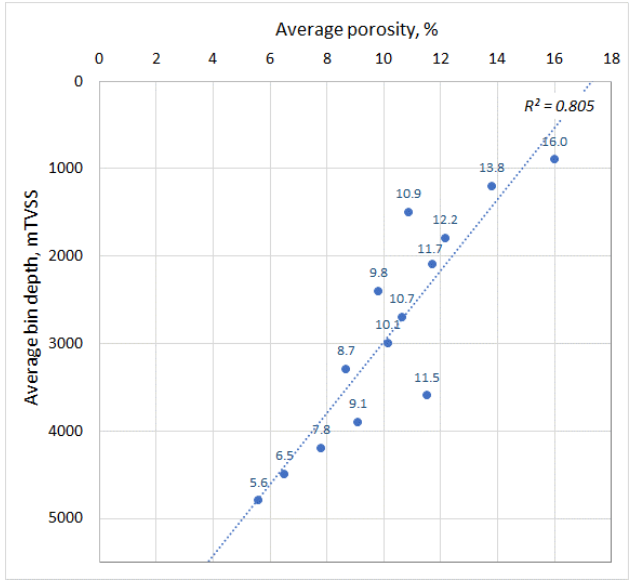

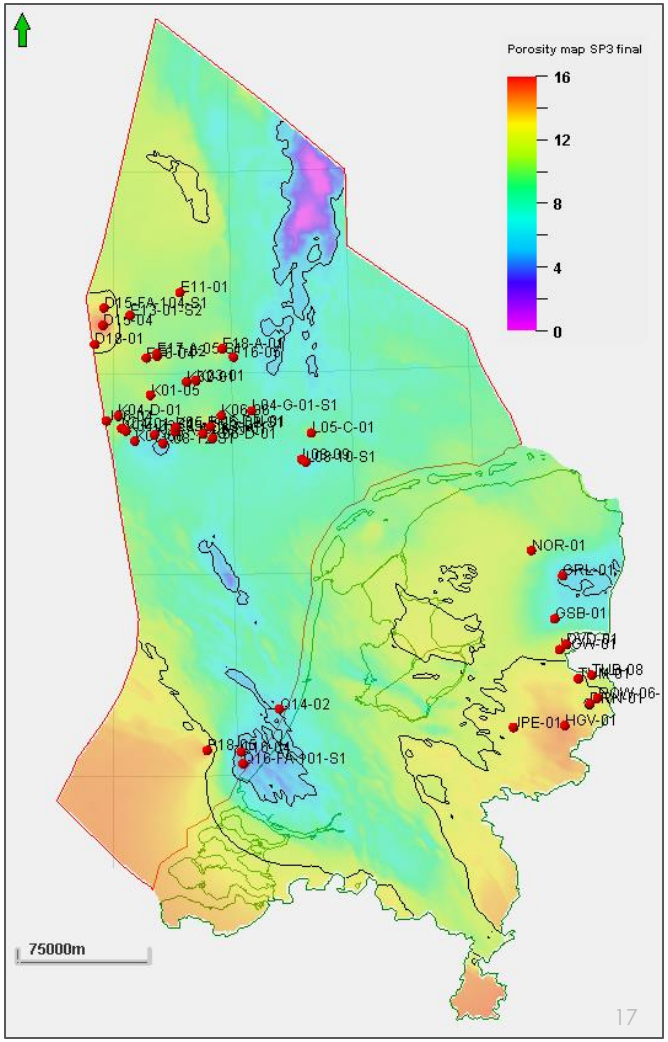

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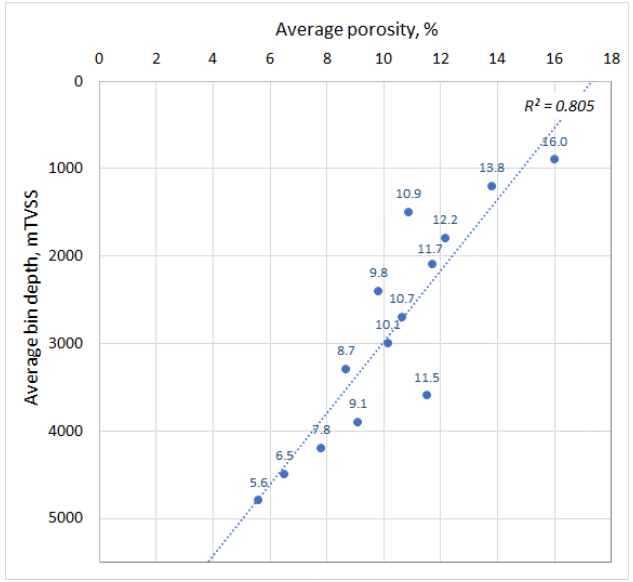
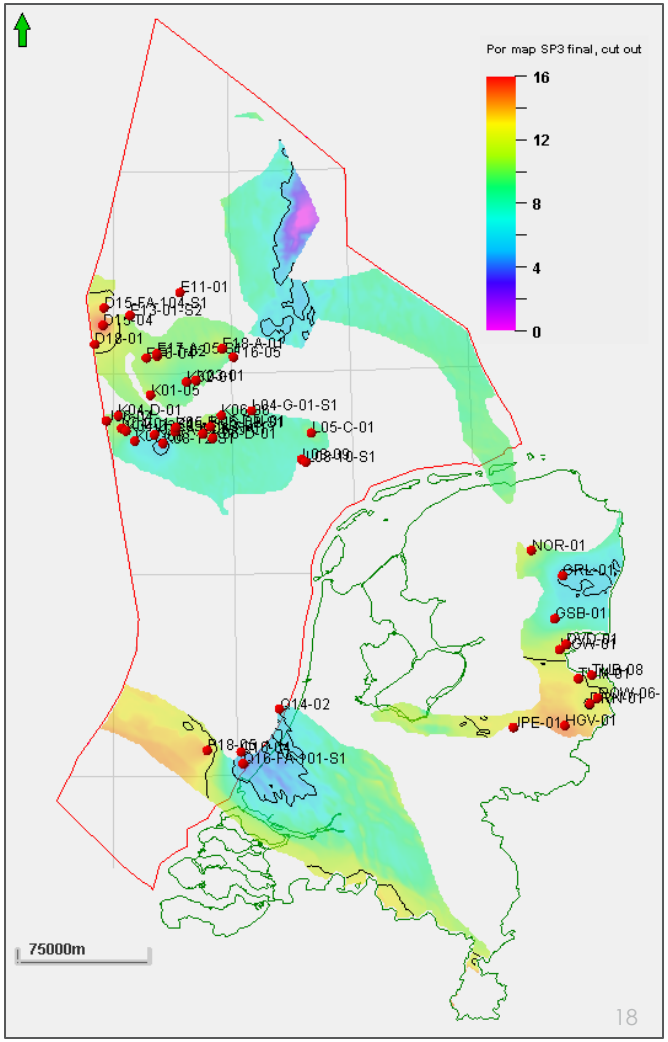
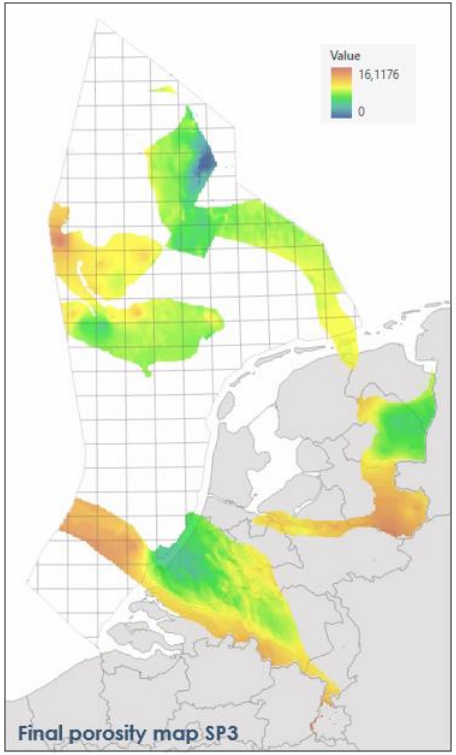


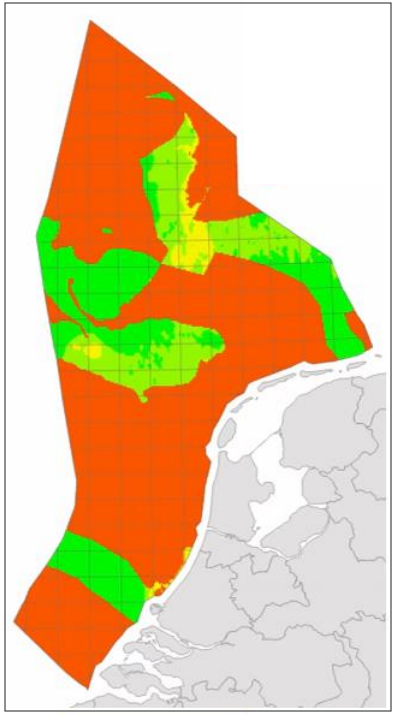


3. Reservoir risking: CRS maps

Example for SP3 Reservoir Effectiveness

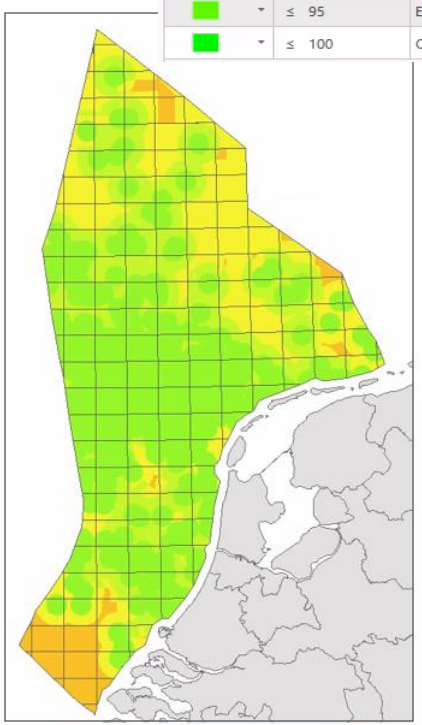
Symbol	Upper value	Label
	≤ 0	Excluded
	≤ 5	Extremely unlikely
	≤ 15	Very unlikely
	≤ 33	Unlikely
	≤ 50	Equivocal
	≤ 66	Likely
	≤ 85	Very likely
	≤ 95	Extremely likely
	≤ 100	Certain





Play POS

X



Repeatability POS

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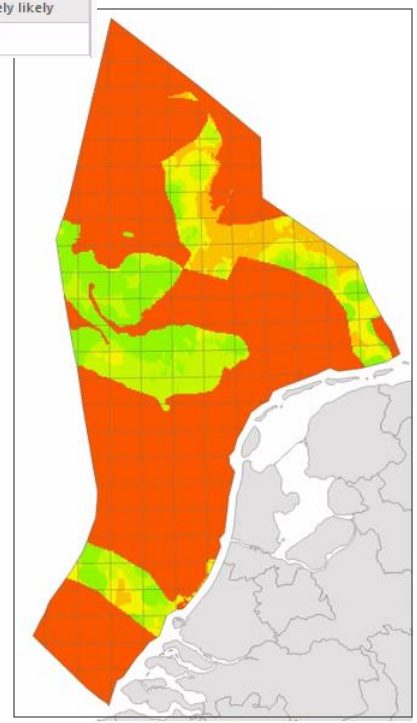


Total POS

3. Top Seal

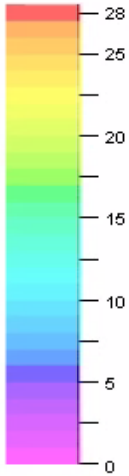
1. Construct SP3 supracrop map

- Potentially sealing units above SP3 (cut-off methodology)

2. SP3 Top seal play POS map

- Chance of (combination of) units to form a seal

Colour legend, supracrop map



28. NS North Sea Group
26. CK Chalk Group
24. KN Rijnland Group

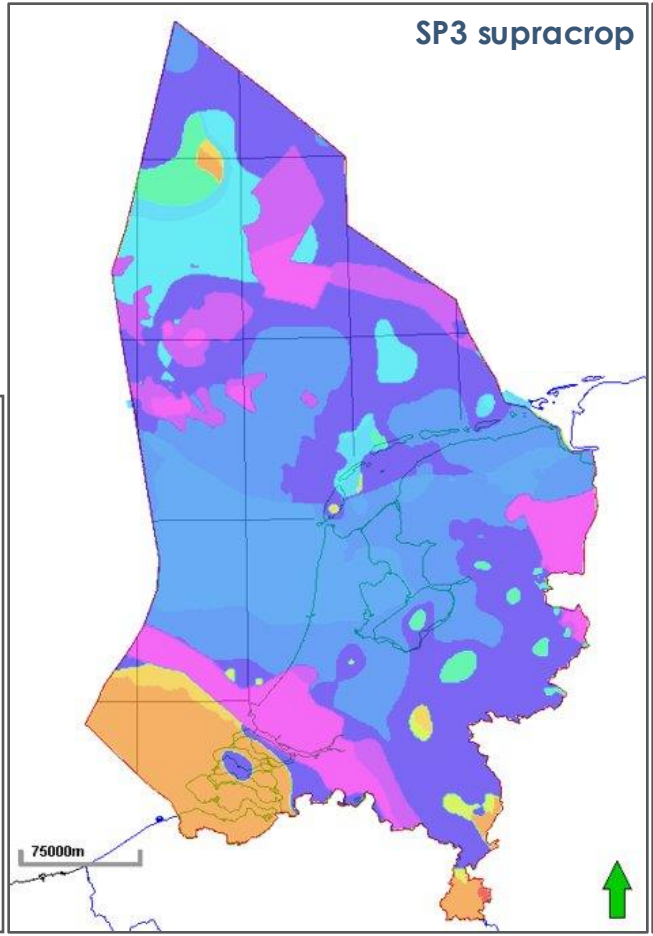
20. RBS Lower Bunter Claystone

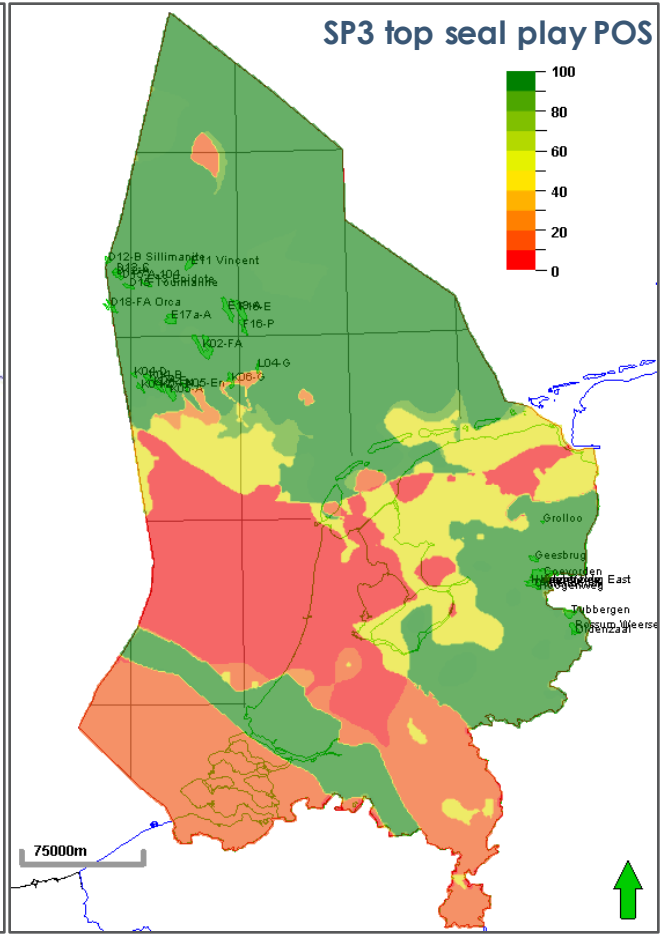
15. ZEZ1-ZEZ2A Basal Zechstein >20m

10. ROCL(A) Silverpit/Ameland Clst >100m
09. ROCL(A) 50-150m

07. ROSL(L) (Lower) Slochteren Sst >150m
06. ROSL(L) 50-150m
05. ROSL(L) present, <50m

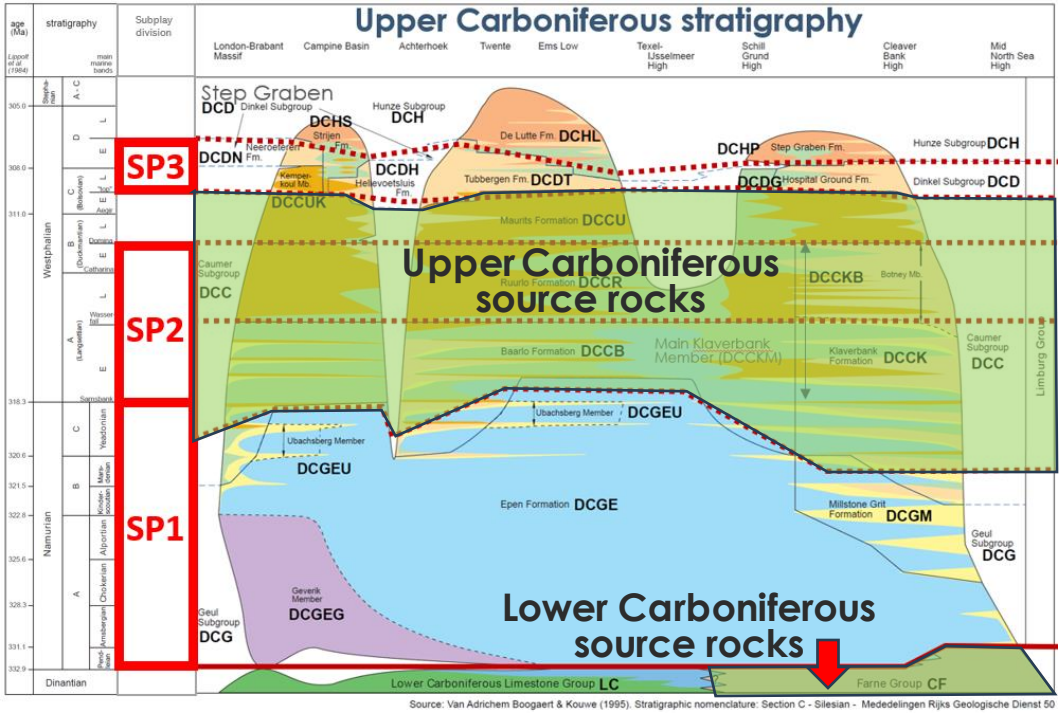
02. DCH Hunze Subgroup 50-150m
00. DCH >150m

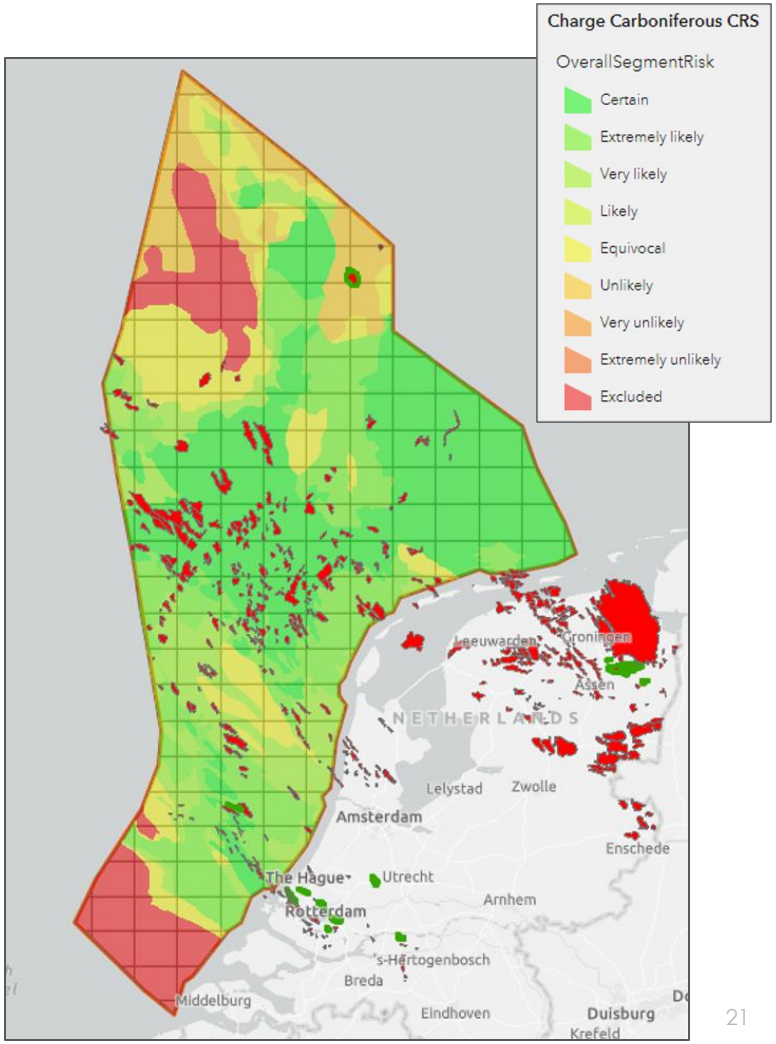




3. Charge

- Direct charge from Upper and Lower Carboniferous source rocks – **Gas only**
- Charge risk in some areas due to absence of source rock intervals and/or low maturity



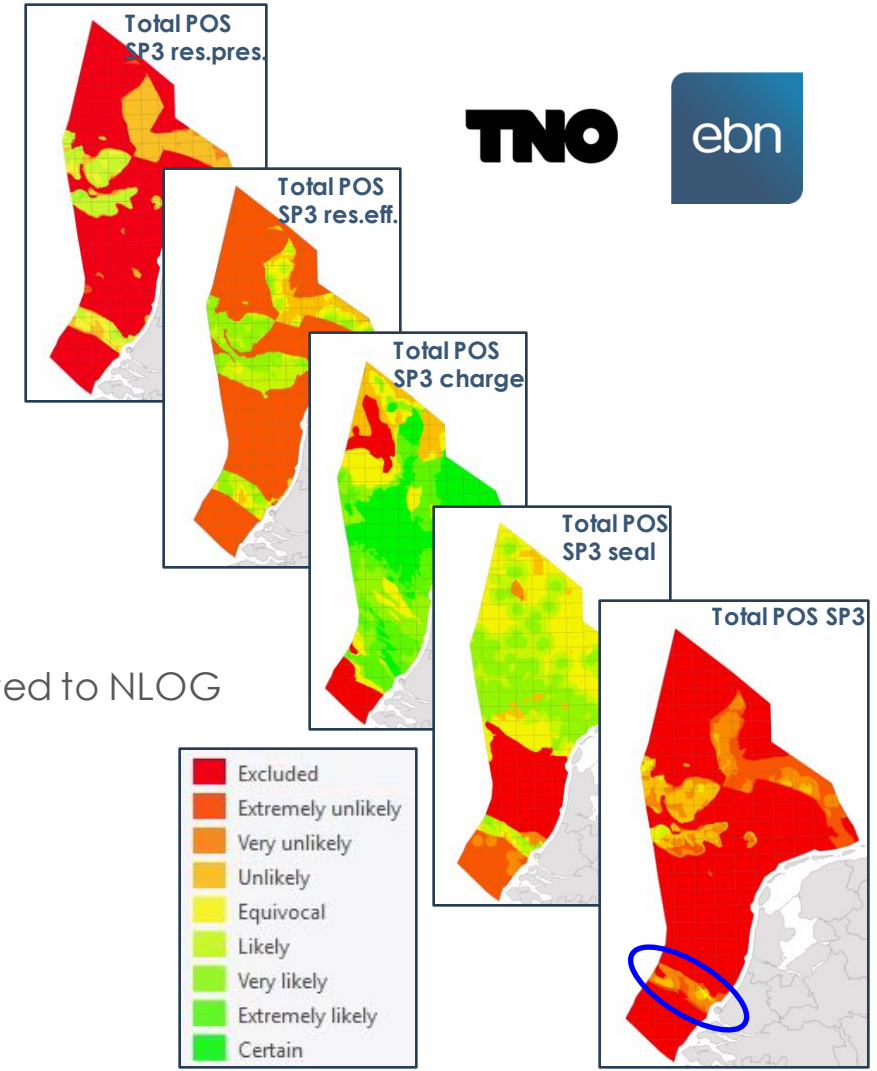


4. Wrap-up

- **Key products of this study**
  - Updated well data and field analyses
  - Updated BPU subcrop map
  - Regional overview + risking of play elements
  - → Identification of new prospective areas

- **To be finished**
  - Annotated playmap (December)
  - Field/well modifications suggestions communicated to NLOG

- **GEODE dashboard**
  - www.geodeatlas.nl/pages/play-8-carboniferous
  - Light version already available
  - Final version ready in December



Explore in a mature basin

GEODE is a joint initiative between EBN B.V. and TNO. We aim to provide an easy accessible web-based GIS environment where play-based exploration data, such as maps and post-drill well analysis data, for the main hydrocarbon (sub)plays of the Dutch offshore, are available and can be displayed and downloaded.

3. Play Elements

Reservoir

- SP3 example

- Workflow reservoir thickness map

Map no	Description
1	**Model map**: depositional thickness from Hampson model Restricted to NL only by eliminating area outside
2a	**Calibrated model map**: map 1 matched to wells A with 100km radius Longest wells D may already be incorporated at this stage
2b	**Full occurrence map**: map 2, deleted where top is truncated Use Top Unit X truncation polygon from updated subcrop map
3	**Absence map**: define absence area (use Base Unit X truncation polygon from subcrop map) Use Base Unit X truncation polygon from subcrop map. Confirm with wells B. Update wells or polygons if required
4	**Merge of maps 2b and 3** Combination of 1) complete absence and 2) complete presence, confirmed by wells
5	**Present-day thickness map, first pass** Map 4 with empty area (= top truncation area) filled by convergent gridding
6	**Calibrated present-day thickness map for top truncation area only** Map 6 with absence and full occurrence areas deleted Match to wells C with 50km radius, include (nearby) wells D with long penetrations
7	**Present-day thickness map, second pass** Merge maps 5 and 6 with preference to 6
8	**Present-day thickness map, final** Map 7 modified with wells D if their thickness is reliable and exceeds the map If well data unreliable: earmark for NLOG update

2. BPU subcrop map

Input

- **Previous BPU subcrop maps**
  - Mijnlieff (2007)
  - SPBA (2010)
  - Northern Offshore project (2016)
- **Adjustments**
  - New study; Paleo-Five project (TNO, 2020)
  - Re-interpreted well data