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Regional Geological Evaluation for the SCAN Geothermal Exploration Campaign, the Netherlands

Marten ter Borgh, Henk van Lochem & Harmen Mijnlieff

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Agenda

- Introduction to EBN B.V. and the SCAN program
- SCAN seismic acquisition and reprocessing
  - Examples of new insights based on newly acquired SCAN seismic data
- SCAN Data well Campaign
  - How do we select locations, define the data acquisition program and design the wells?
  - SCAN well 1: location and targets
- Acknowledgements

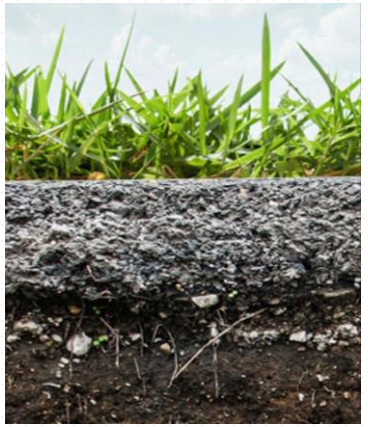
Introduction to EBN B.V.

- EBN B.V. (Energie Beheer Nederland), founded 58 years ago, is a 100% state-owned company with some 160 employees, based in Utrecht, the Netherlands

- Our mission: EBN creates economic and societal value from geological energy sources in the Dutch subsurface

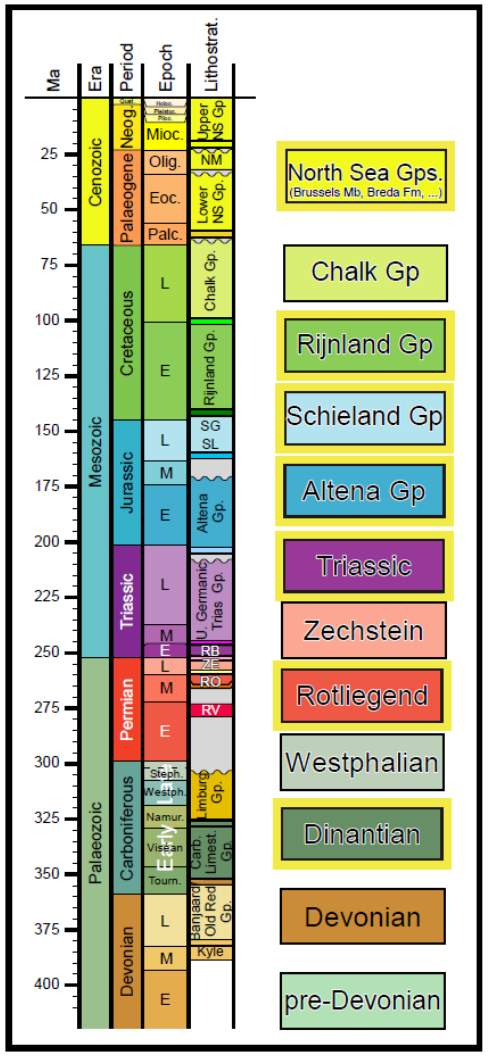
- Three strategic pillars:
  - Our Dutch North Sea Gas
  - Return to Nature
  - New Energy

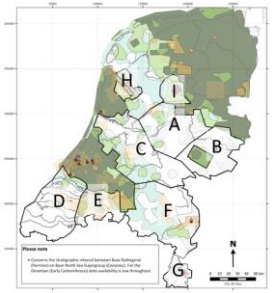
- New Energy: EBN builds partnerships for the efficient exploitation of geothermal energy and may become financial partner in future geothermal projects



Geothermal plays

- Dutch geothermal play type classified as:
  - Conduction dominated in an intracratonic basin (CD-1; c.f. Moeck 2014)
  - Hot sedimentary aquifers (HSA)
  - Low enthalpy (< 125°C)
- Reservoirs
  - both siliciclastic and carbonate intervals present
- Permeability systems
  - **Focus on:**
    - Matrix or primary permeability
    - Secondary permeability (karst or leaching)
  - No focus on:
    - Fracture / fault permeability
    - Artificial/man made permeability systems fracking, mine galleries, etc.)





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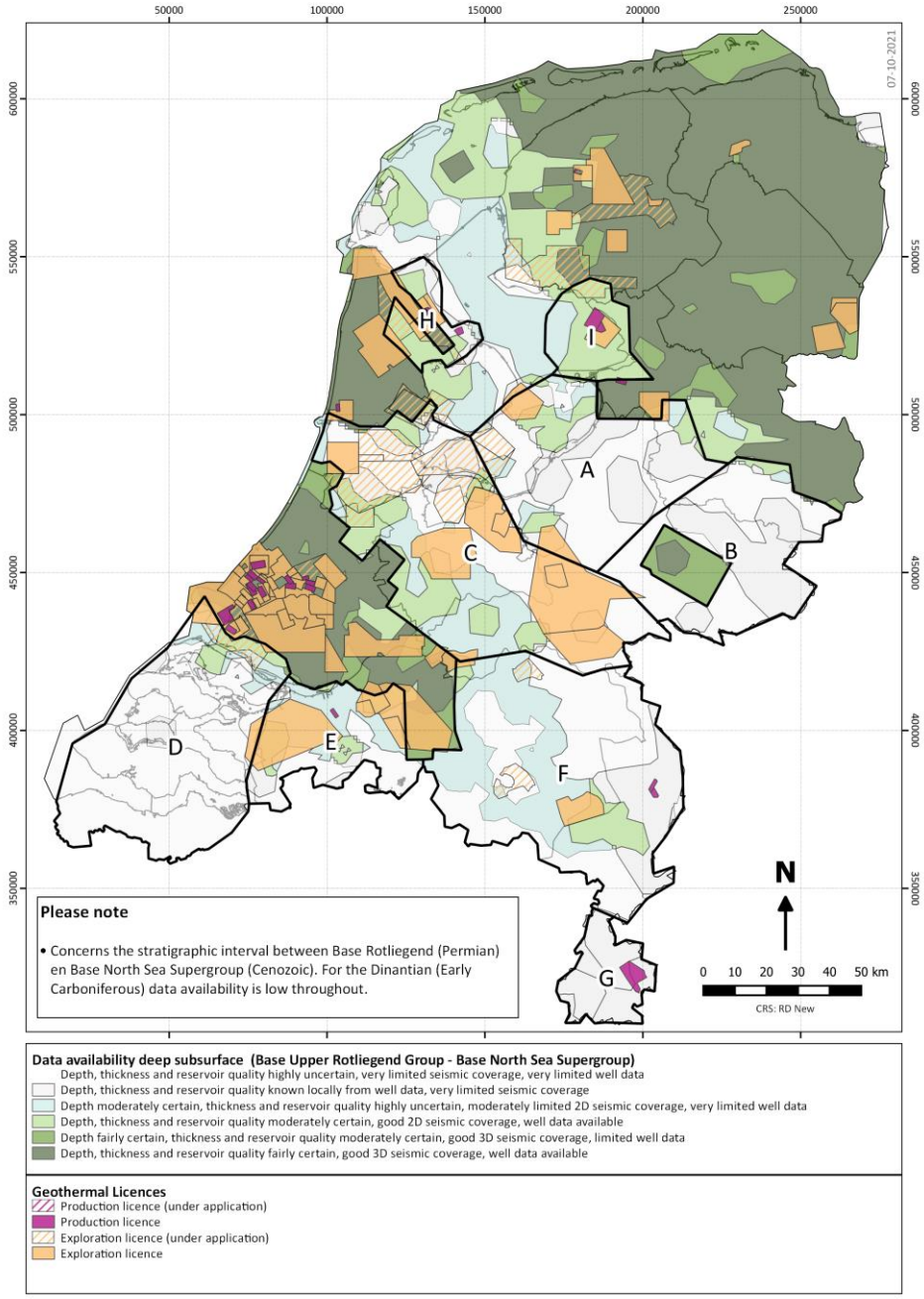
✓ Primary play • Secondary play

Introduction to SCAN

- SCAN accelerates the development of geothermal energy by filling in subsurface data gaps
- The SCAN target depth for geothermal projects ranges from 500 to 4000 m depth
- Funded by the Ministry of Economic Affairs and Climate and executed by EBN and TNO. Part of the seismic acquisition is subsidised by the EU Interreg program DGE-ROLLOUT



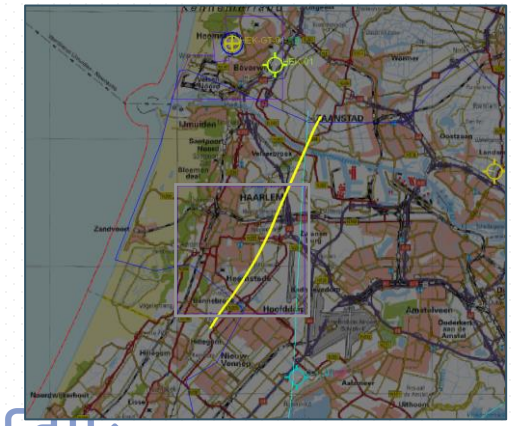
Key components of the SCAN program

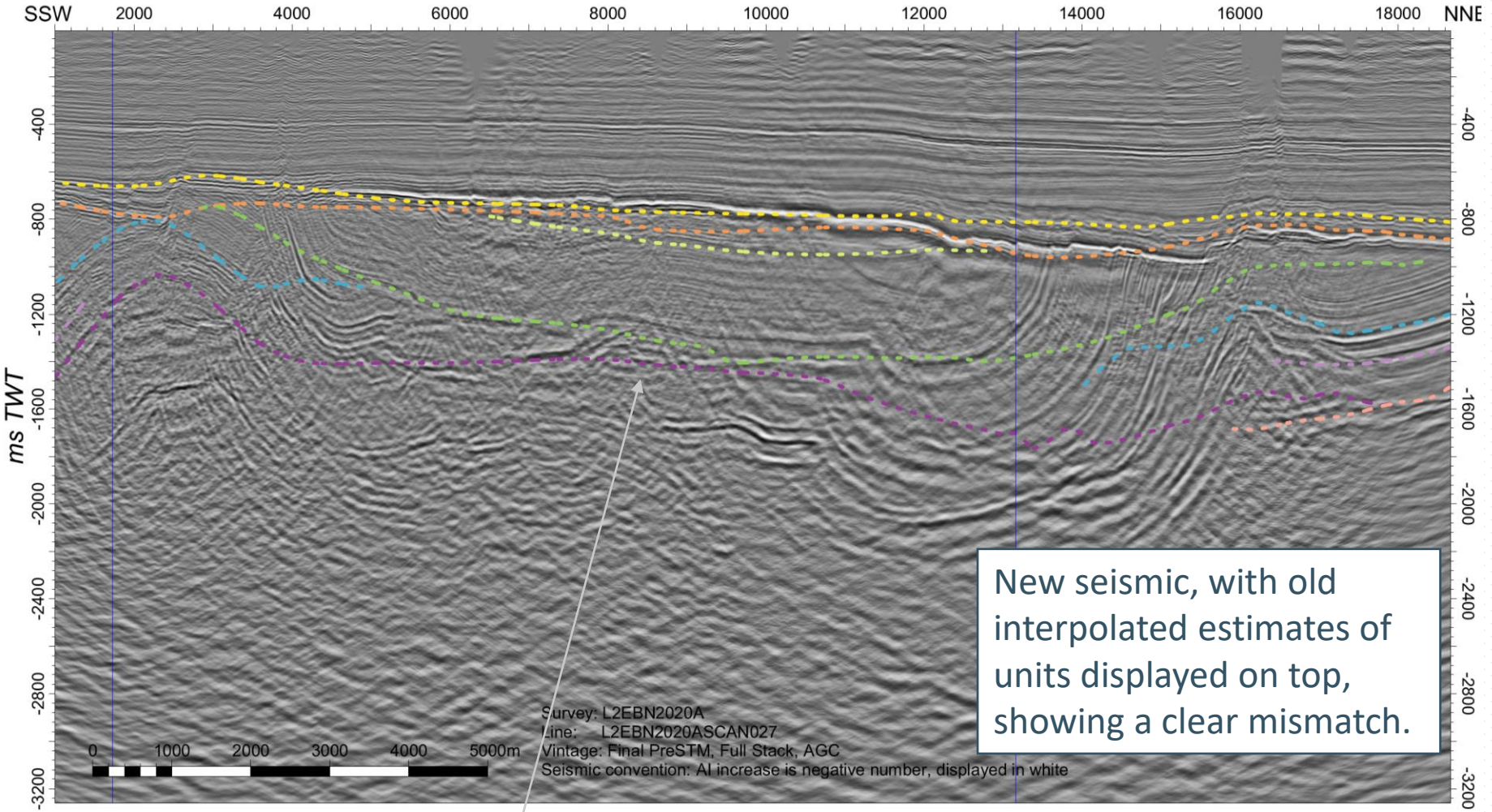
1. **Acquisition of new 2D seismic data**
   - Started in February 2019 with the EBN test line
   - Regional campaign commenced in September 2019
2. **Reprocessing of existing 2D seismic data**
   - The reprocessing effort started in October 2018
3. **Data well campaign**
   - The budget for a data well campaign of ~ 10 wells has been awarded and first spud date planned for Q1.2023

All data and study results are immediately released to the public domain at completion and published on the websites scanaardwarmte.nl and nlog.nl/scan

SCAN Line 27: existing DGM-mapping

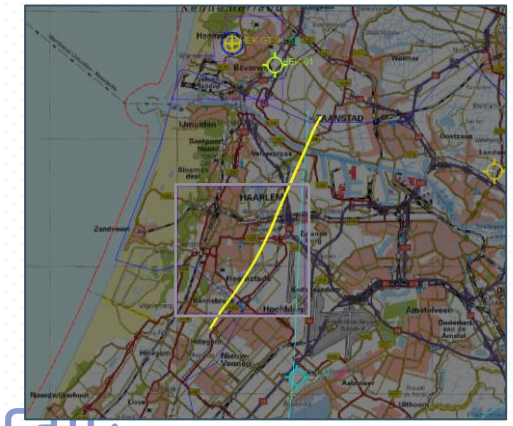
New seismic data results in significantly different interpretations from existing national DGM mapping. Main geothermal target in this area (Rotliegend) located hundreds of meters deeper, for instance.

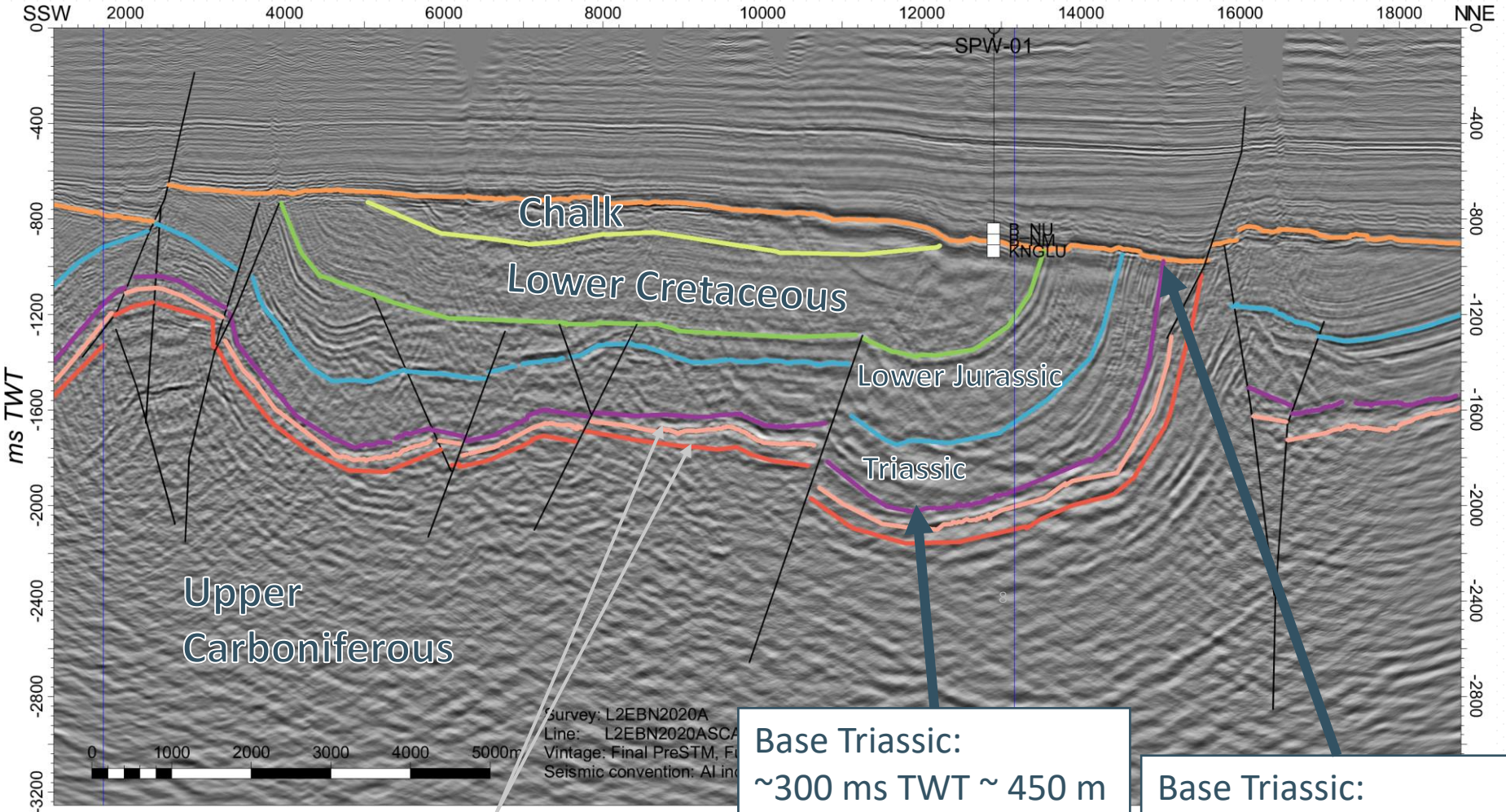




SCAN Line 27: new quick-look-interpretation

New seismic data results in significantly different interpretations from existing national DGM mapping. Main geothermal target in this area (Rotliegend) located hundreds of meters deeper, for instance.





Top & Base Rotliegend

Base Triassic:
~300 ms TWT ~ 450 m deeper

Base Triassic:
600 ms TWT ~ 900 m shallower

SCAN Wells

- ➜ Some important reservoir data can only be obtained by drilling wells
- ➜ Wells will be drilled at the location that provides the best chance to obtain as much relevant data as possible, often combining several potential reservoirs
- ➜ Wells are P&A-ed at the end of the evaluation program

Information	2D-Seismic data	3D-Seismic data	Well
Economical evaluation: presence and quality of aquifer, temperature			
Presence, continuity, depth and thickness aquifer	+	++	+++
Porosity	–	+/–	+++
Permeability (transmissivity)	– –	– –	+++
Temperature	+	+	+++
Safety, well planning and regional geological knowledge			
Regional geological model	++	+++	++
Presence of faults	+	+++	+/–
Character of overburden on well trajectory	+	++	+
Risk-assessment of presence of hydrocarbons	+	++	+/–
Water composition	– –	– –	++

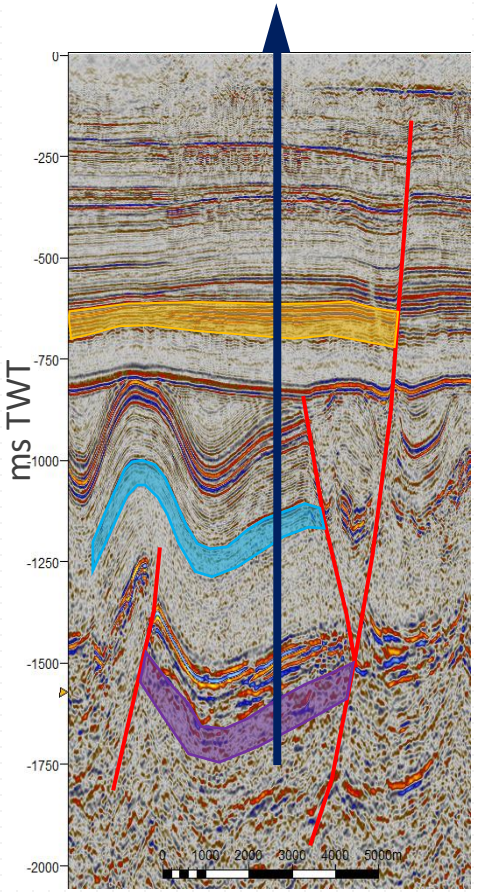


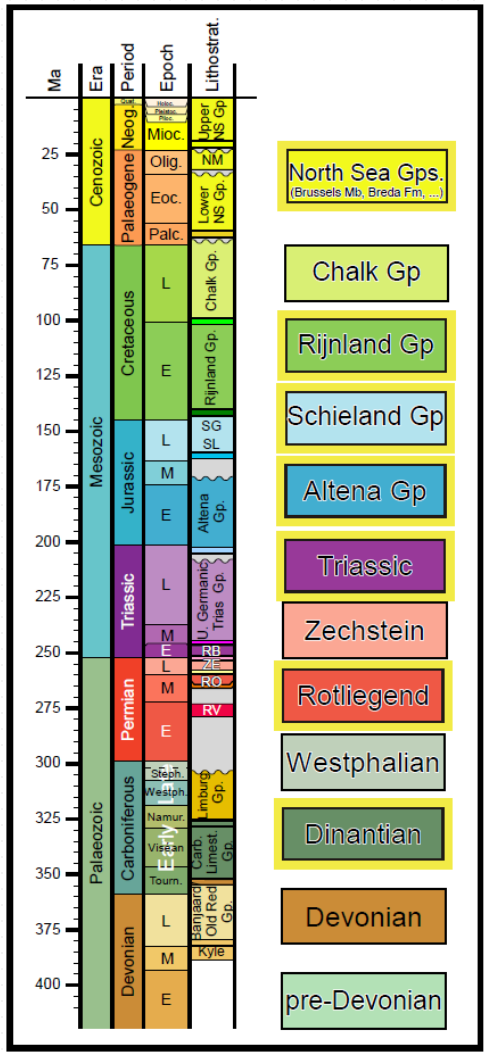
Figure only for illustration
No actual proposed location

Data acquisition programme for SCAN wells

Where possible, wells will test multiple geothermal plays

➜For each of the geothermal plays an inventory is made of the geological research questions that need to be answered to assess geothermal potential

➜For each of the research questions it is assessed what data acquisition is required, providing input for the data acquisition program

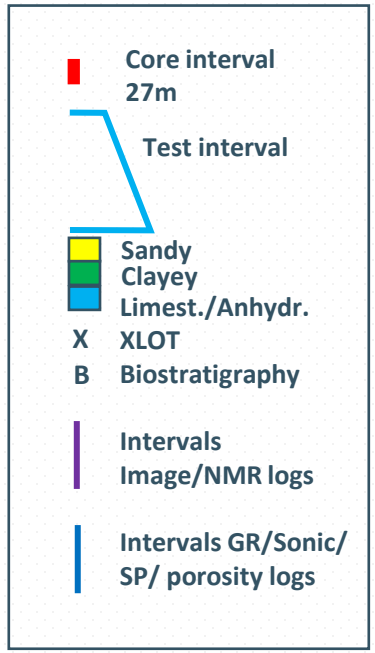


Data-acquisition in SCAN wells: generic example

Extensive data acquisition is planned in the SCAN wells

Programme to be determined per well. At least the following items will be considered:

- ➜ Cores of target reservoirs
  - ➜ Porosity/permeability data
  - ➜ Sedimentology and diagenesis (incl. descriptions and thin sections)
  - ➜ Geomechanical tests (note: also possible for non-reservoir)
- ➜ Production / injection test(s)
  - ➜ Flow rate and transmissivity
  - ➜ Temperature, pressure and water composition
- ➜ Well Logs, both reservoirs and overburden
  - ➜ Gamma Ray, Sonic (Vp/Vs), SP, porosity-logs (whole well section)
  - ➜ Image logs (for sedimentology and diagenesis, fractures and stress directions)
  - ➜ NMR log (for permeability)
  - ➜ Temperature
- ➜ Checkshot/VSP (for robust correlation onto regional seismic grid)
- ➜ XLOT (eXtended Leak-Off Test)
  - ➜ Determination of maximum injection pressures
- ➜ Cuttings and biostratigraphy
  - ➜ Vitrinite reflectance, apatite fission track, U/Th/He?
  - ➜ Dating and correlation of relevant intervals



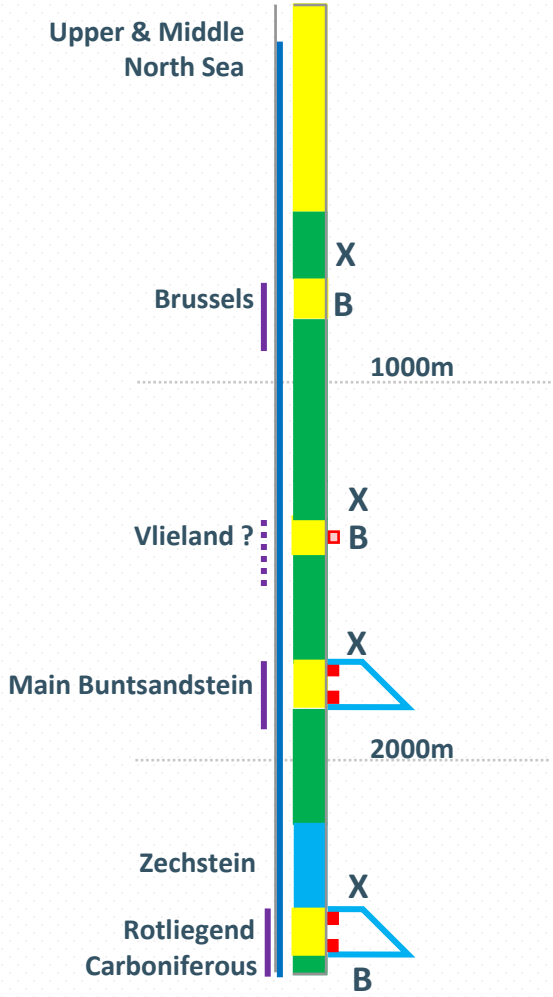
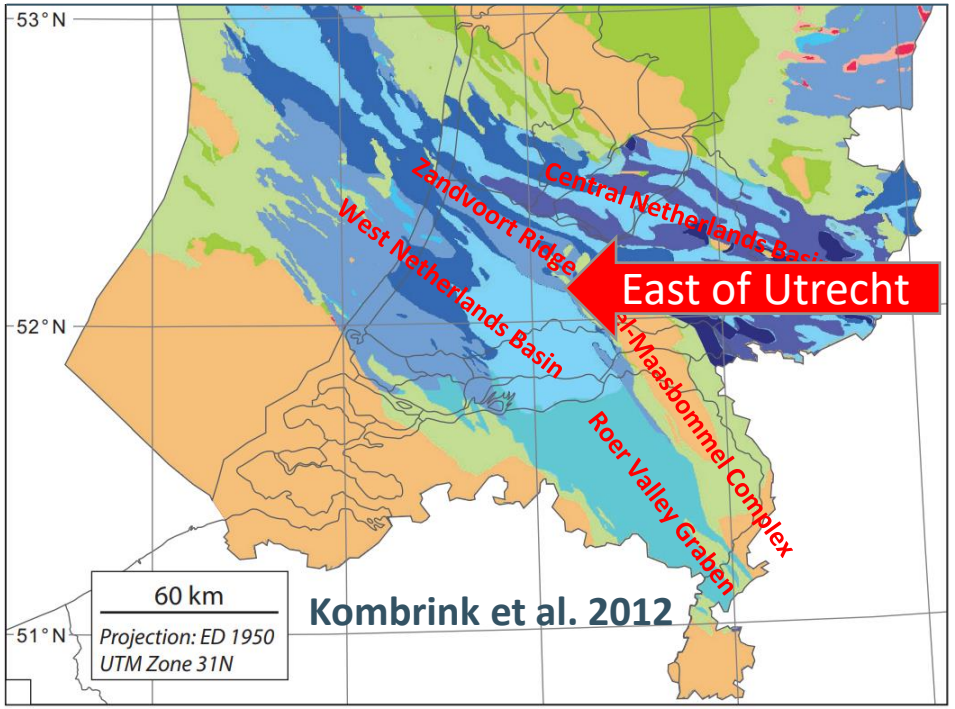
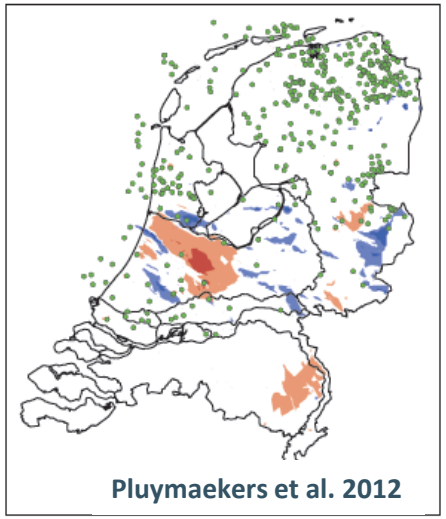


Figure only for illustration
No actual proposed location
or programme

SCAN search area East of Utrecht

- ➜SCAN is planning to drill its first data acquisition well east of Utrecht
- ➜Primary target is the Rotliegend play, other plays are the Main Buntsandstein, Vlieland Sandstone and Chalk
- ➜Well will be located on the Zandvoort Ridge, where well data is very scarce
- ➜Search area has high heat demand, while well results will be important for whole of Zandvoort Ridge area and its continuation, the Peel Maasbommel Complex. This area includes cities such as Haarlem, Amsterdam, Hilversum, Utrecht and Amersfoort

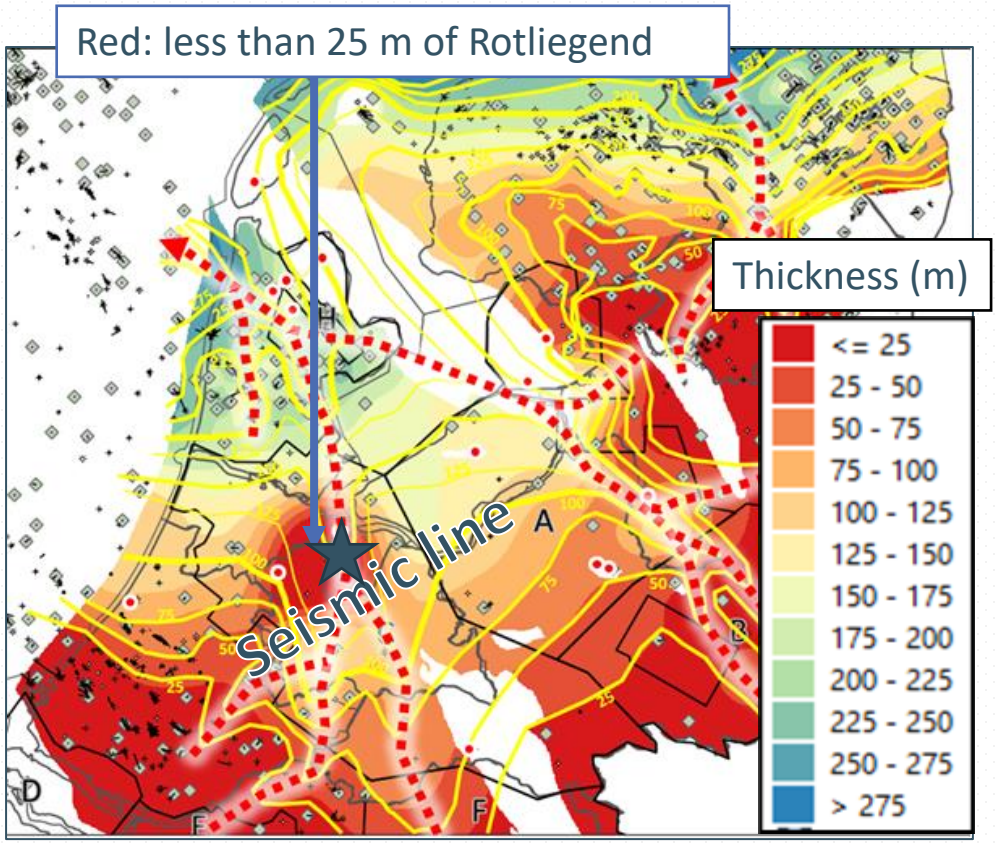




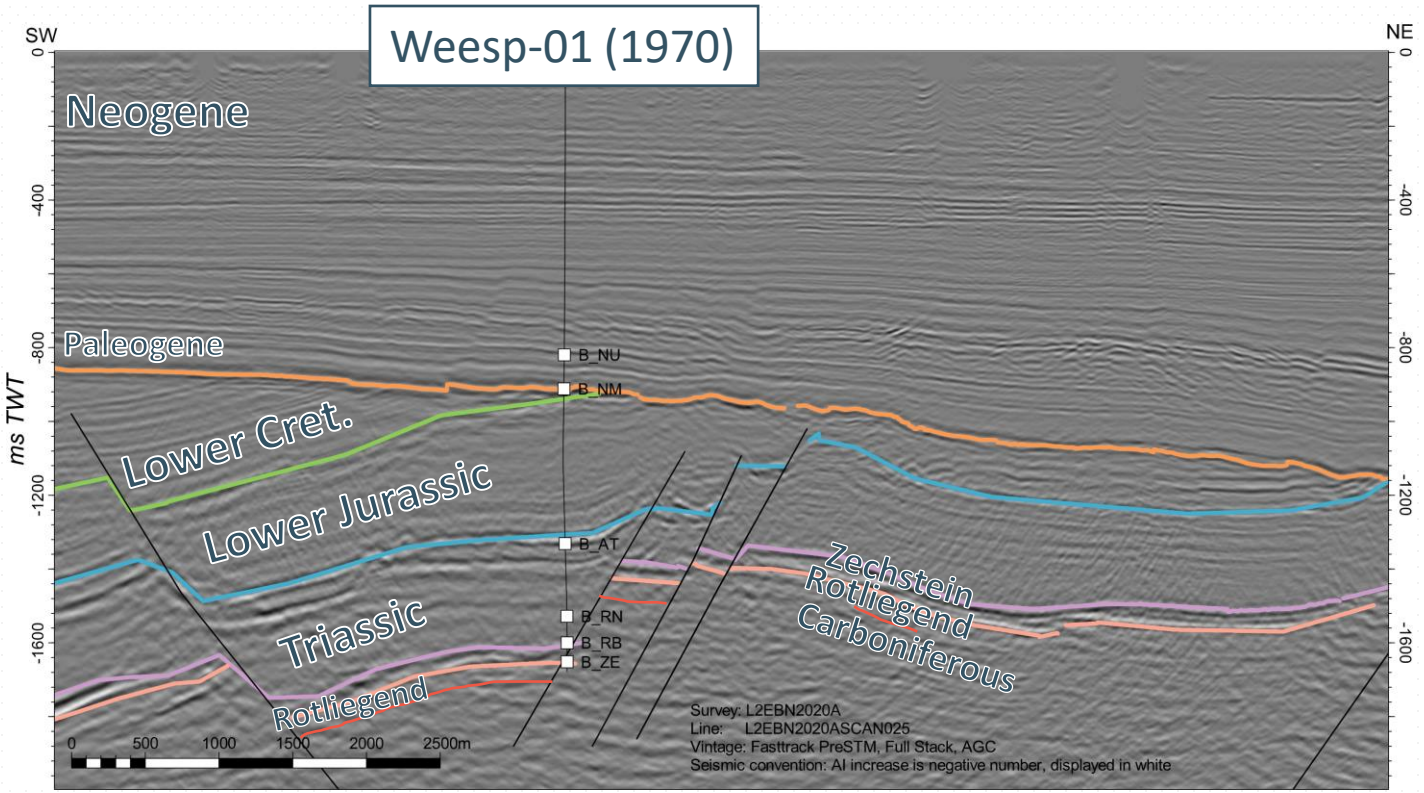
Thickness of the Rotliegend reservoir

➜Thickness of the main geothermal reservoir in the Amsterdam/Almere area (Rotliegend) was uncertain prior to SCAN: according to some models hardly any Rotliegend was present

➜These models were based on the Weesp and Waverveen wells, drilled in the 1970s.



Bron: DGM-Diep v4



➜Insufficient seismic data was present at the well locations.

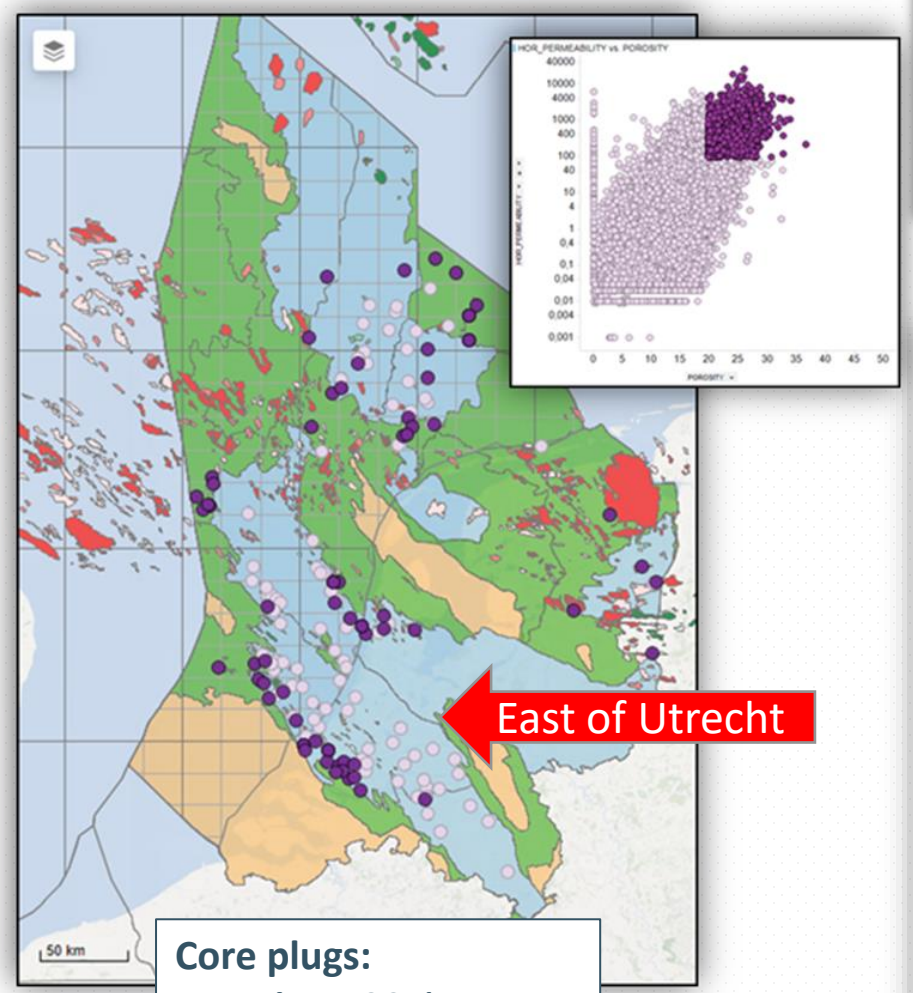
➜New SCAN-seismic data shows that the Weesp well drilled the Rotliegend at a location where the reservoir is truncated by a fault. The well is therefore not representative for the region.

➜Thickness is now de-risked, which is good news for the geothermal potential of the region.

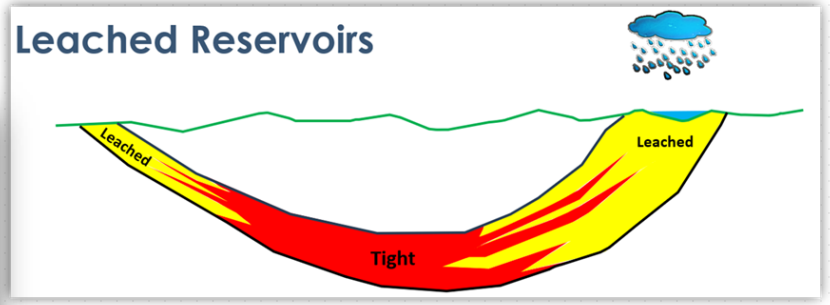
➜Uncertainties remain; a well would provide much relevant data.

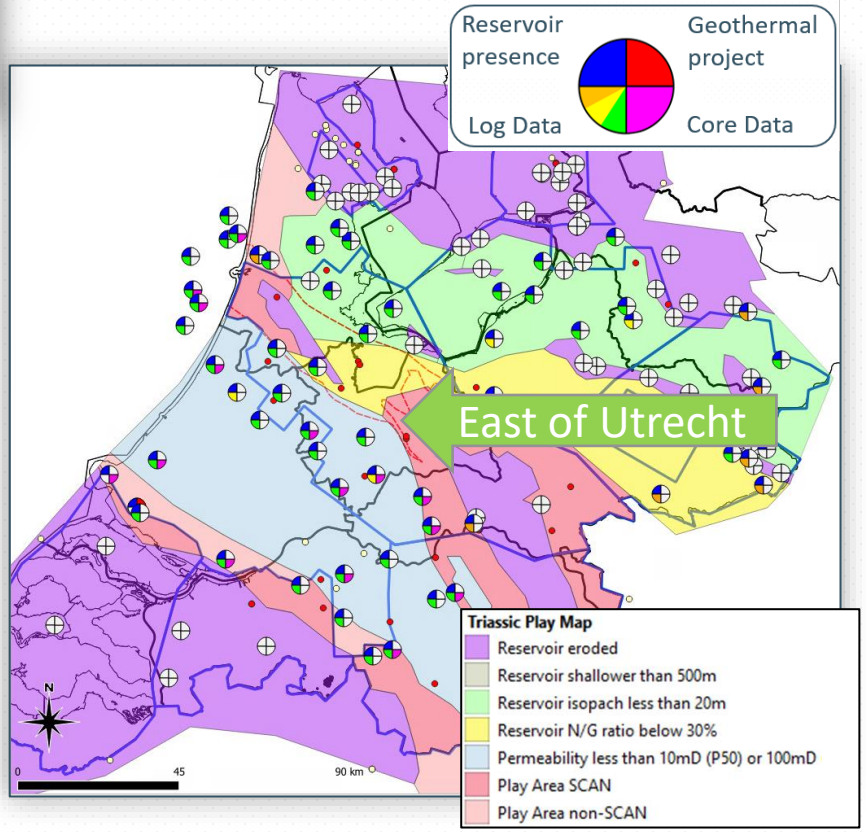
Secondary target: Buntsandstein

- Secondary porosity created by leaching may be an important mechanism for enhanced permeability
- Occurs at basin edges where reservoirs are present below an unconformity
- Untested concept around Peel-Maasbommel Complex



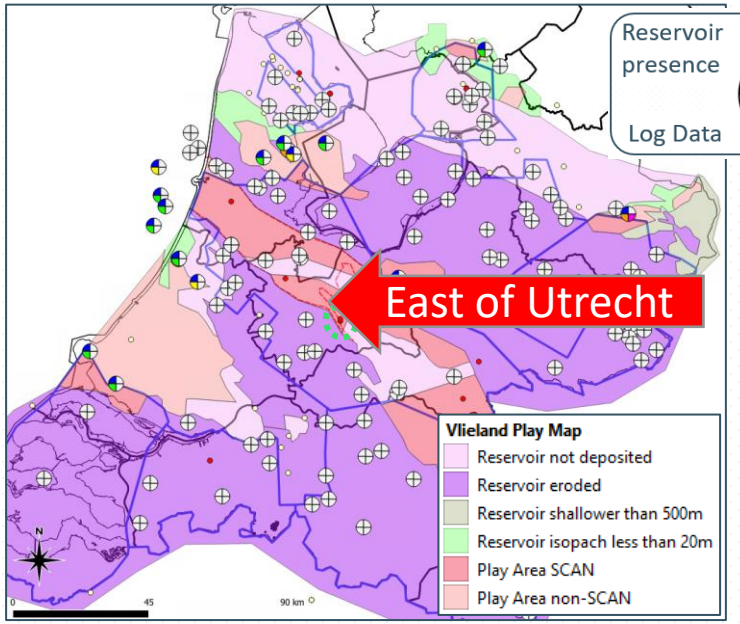
Core plugs:
Porosity > 20%
Permeability > 100 mD

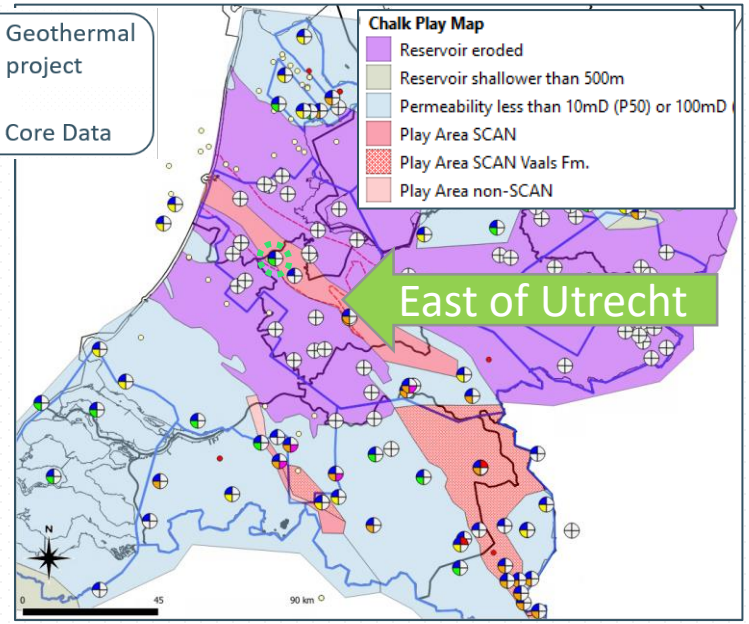


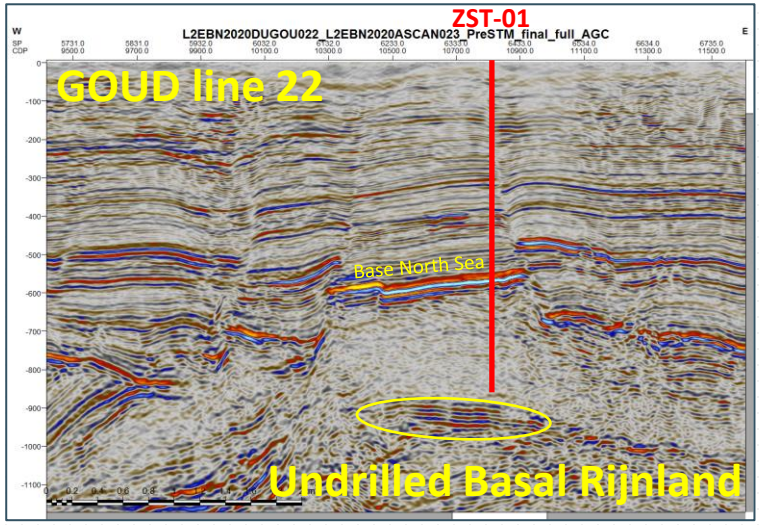


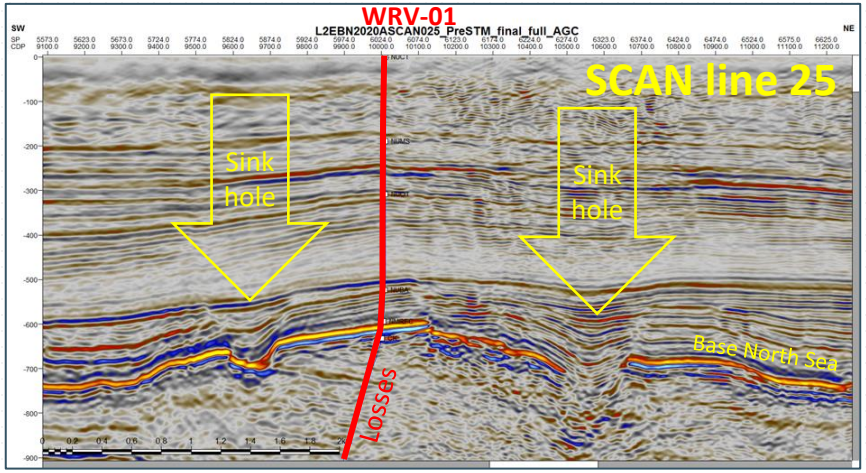
Secondary Targets Vlieland Sandstone and Chalk

- Very few wells drilled Upper and Lower Cretaceous on Zandvoort Ridge and Peel-Maasbommel Complex
- Mapped thicker undrilled pods of Rijnland (Lower Cretaceous) in which coastal sandstones may be preserved
- Chalk may have karst permeability, see WRV example









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Daalsesingel 1
3511 SV Utrecht
info@scanaardwarmte.nl

www.scanaardwarmte.nl

nlog.nl/scan

Ministerie van Economische Zaken en Klimaat

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