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ROTTERDAM, THE NETHERLANDS

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GEOTHERMAL
ENERGY
CONFERENCE

GEOTHERMAL EXPLORATION IN THE NETHERLANDS: THE SCAN PROGRAMME

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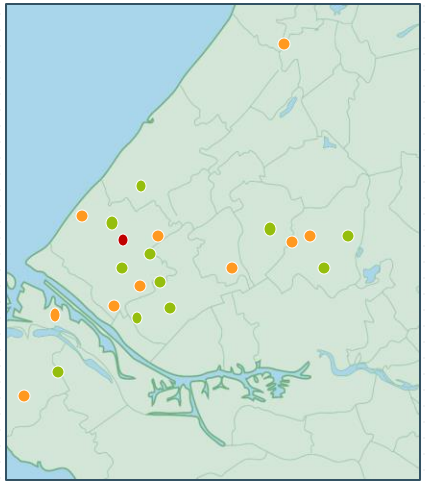
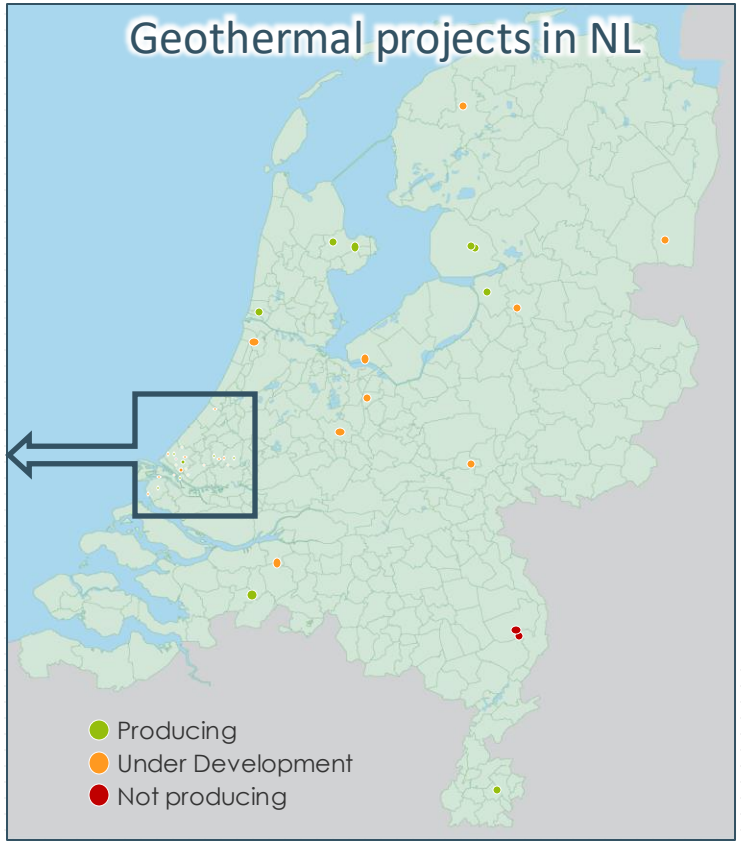
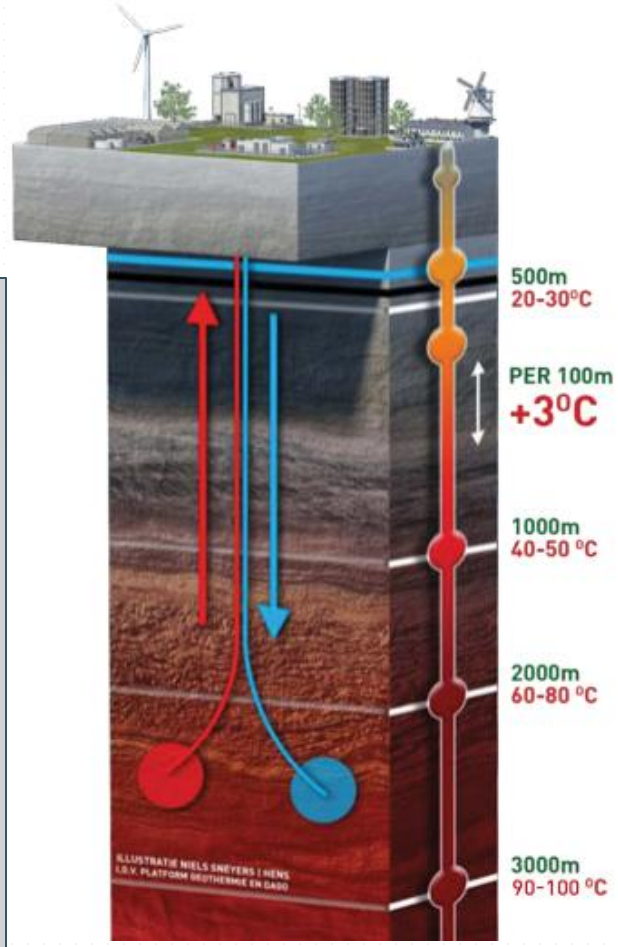
Geothermal Energy in the Netherlands

- Proven source of energy; 27 producing projects in 2023 (39 doublets)
- Low enthalpy, saline aquifers; direct use => heat for heat
- Between about 700 m and 3 km depth => 30-100 °C
- 6.8 PJ of heat generated (equivalent to demand of 165.000 households)
- Geothermal development focused on regions where abundant subsurface data exists from O&G







Sources: Geothermie Nederland
Production Numbers 2023 & NLOG

Introduction to SCAN

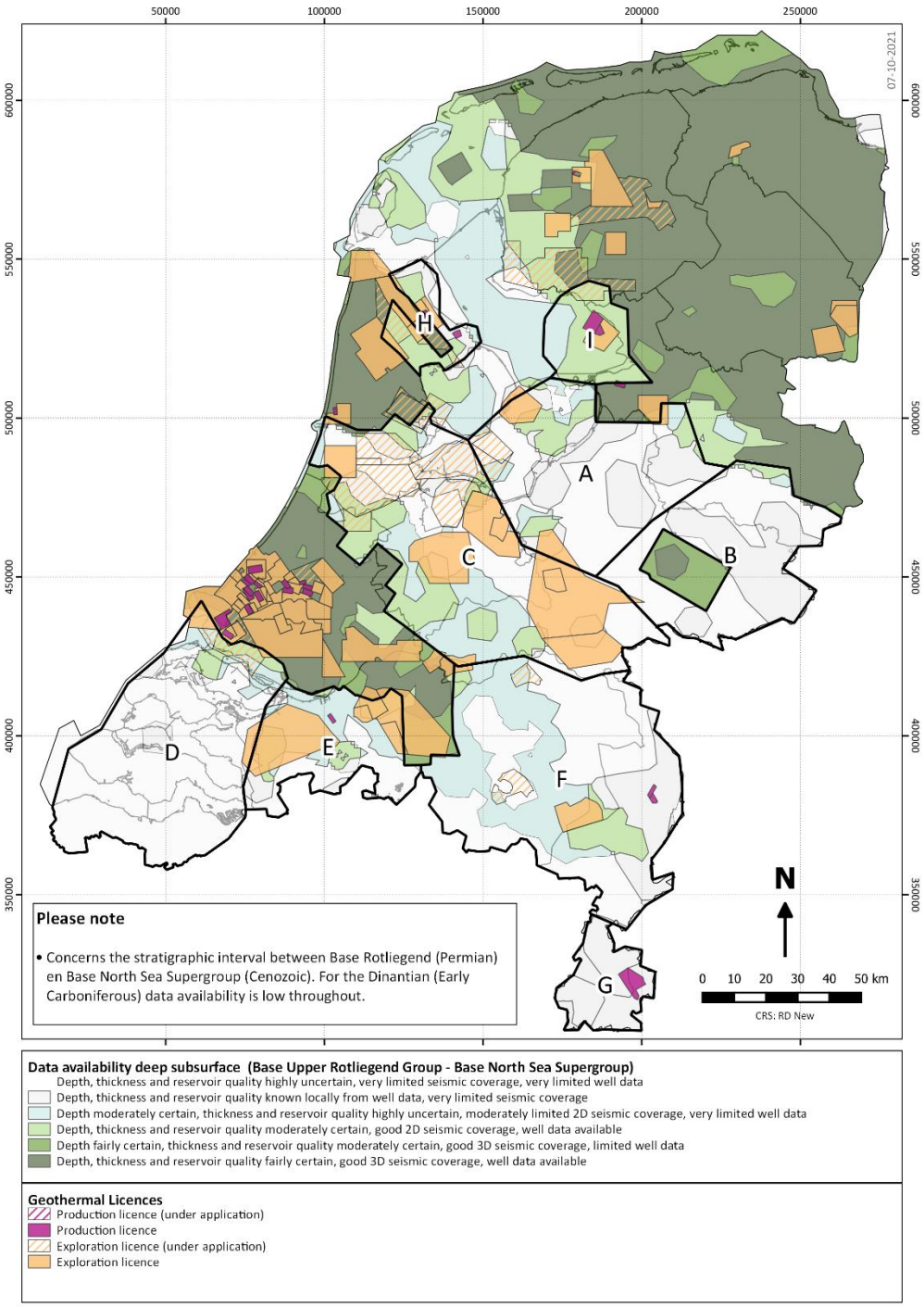
➜ SCAN stands for Seismische Campagne Aardwarmte Nederland

➜SCAN acquires new data in areas where insufficient subsurface data is presently available for a reliable estimation of geothermal potential (‘white spots’)

➜Aimed at shallow and deep geothermal (500-4000m)

➜Provides a regional exploration dataset. For development of commercial projects more seismic and studies are generally needed

➜Funded by the Ministry of Climate and Green Growth, executed by EBN and TNO.



SCAN project phases and activities

Project Proposal

Seismic Funded

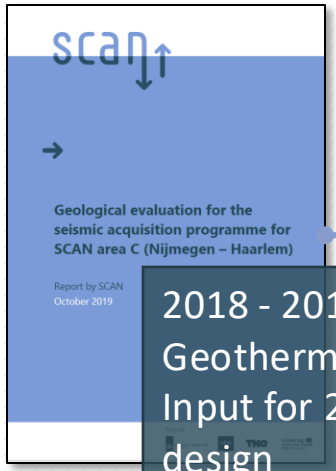
Seismic survey design complete. Long regional lines, connecting wells and infilling areas with poor seismic coverage.

Wells Funded

2021 - 2025: Planning, design& drilling of data-acquisition wells

Additional 3D and 2D Seismic Acquisition Funded

2017 2018 2019 2020 2021 2022 2023 2024 2025 2026



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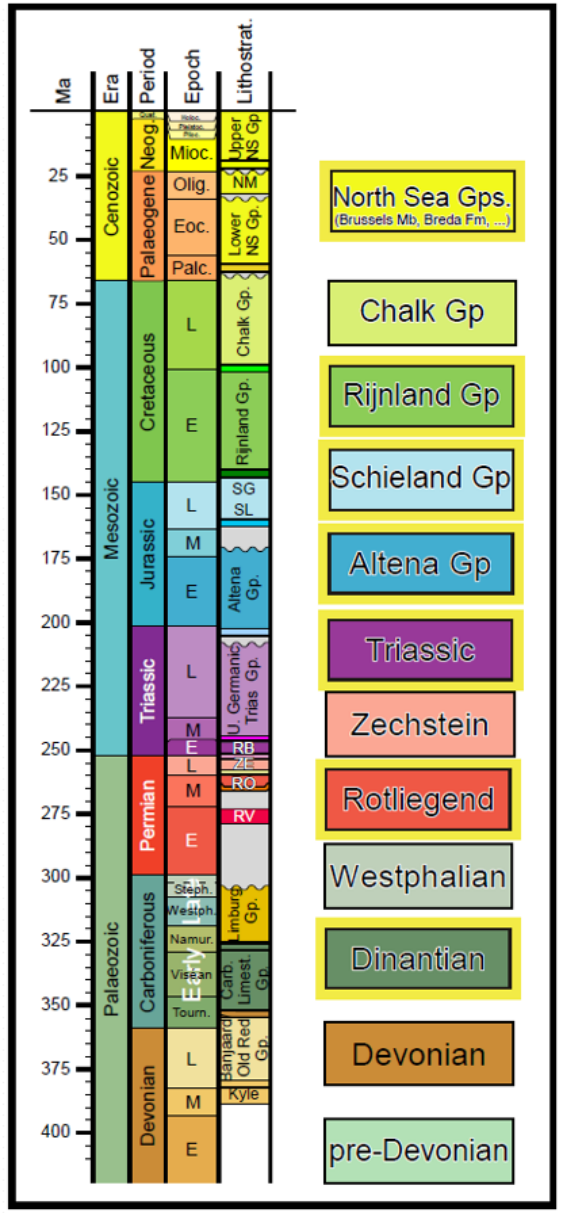
2019 - 2022: Regional Seismic acquisition& processing

2019 - 2023: Seismic reprocessing (in batches)

First well: Amstelland

SCAN: Geothermal plays

- SCAN looks at a wide range of geothermal plays
- **Focus on:**
  - Deep and Shallow geothermal (500 m – 4000 m)
  - Primary permeability
  - Secondary permeability (from karst or leaching)
- **<u>No</u> focus on:**
  - Ultra Deep Geothermal (UDG; >4000 m)
  - Fracture / fault permeability
  - Artificial/man made permeability systems (fracking, mine galleries, etc.)

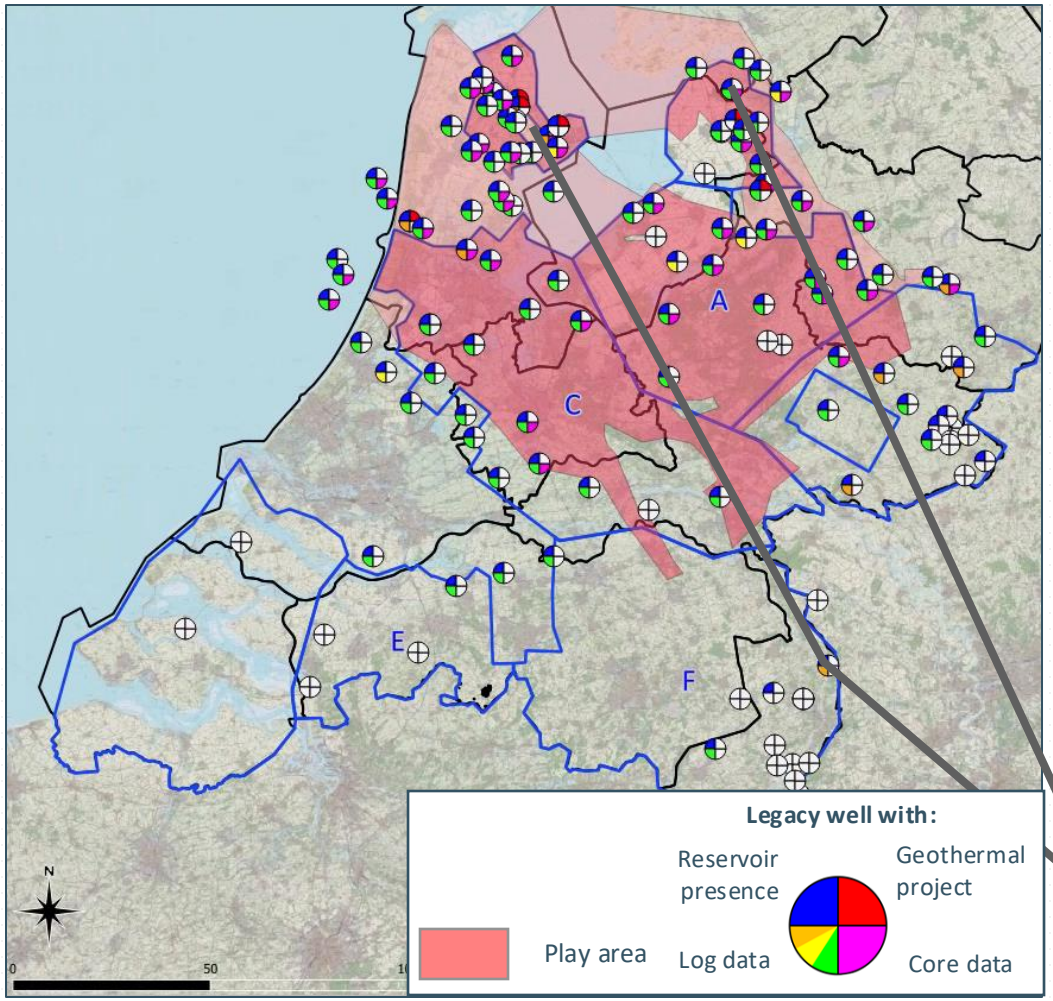


✓ Primary play

• Secondary play

Play-Based Exploration for Geothermal

North Sea Gps. (Brussels Mb, Breda Fm, ...)
Chalk Gp
Rijnland Gp
Schieland Gp
Altena Gp
Triassic
Zechstein
Rotliegend
Westphalian
Dinantian
Devonian
pre-Devonian



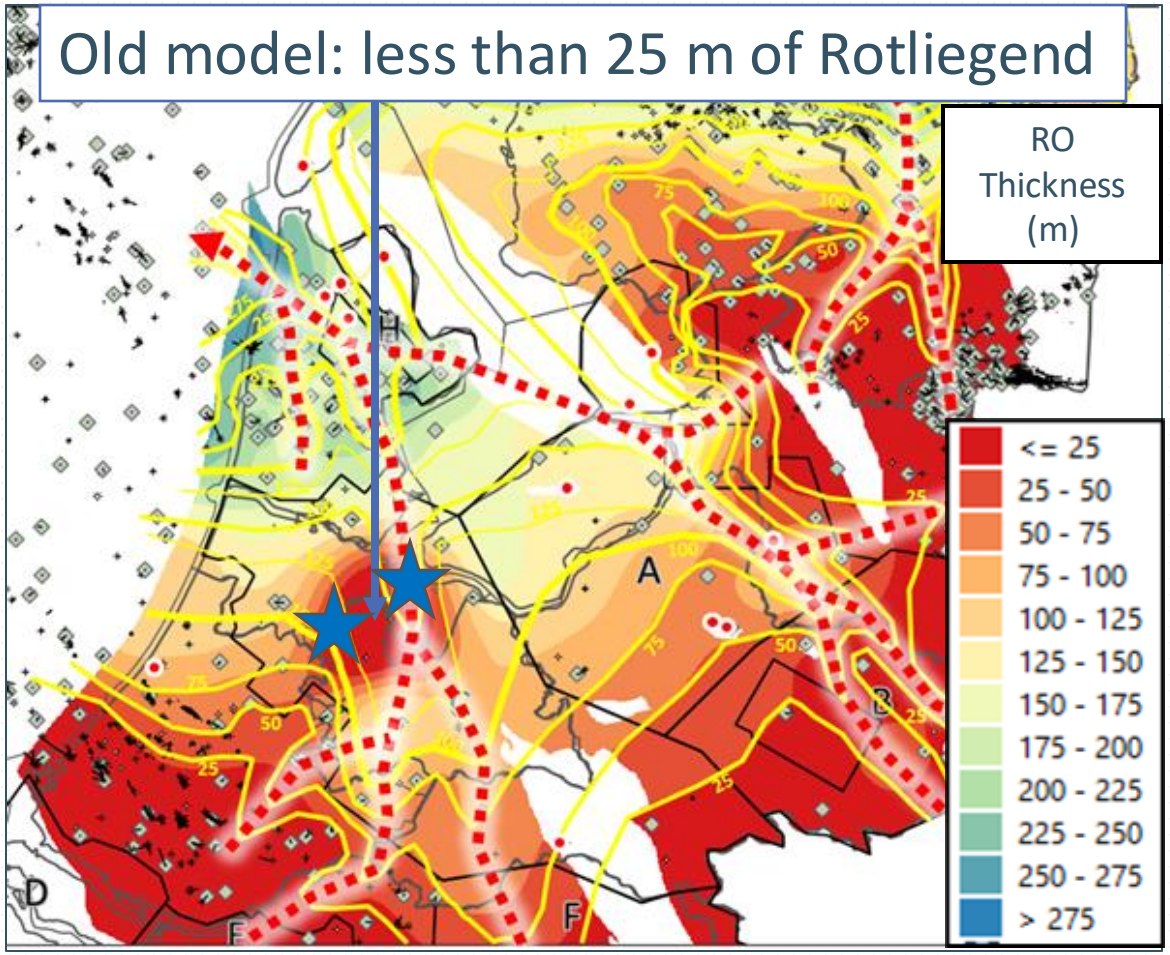
➜Play-Based Exploration forms the basis for SCAN

➜All plays were mapped and assessed based on existing data and regional knowledge

Example: Play Map of Rotliegend sandstone play , deposited in a predominantly aeolian setting

Producing geothermal projects and sufficient data in northern part of SCAN areas; no SCAN well planned

Thickness of the Permian Rotliegend reservoir



Yellow isopachs: SCAN thickness model
Colours in background: thickness in DGM-Diep v4

- ➜Thickness of the main geothermal reservoir in the Amsterdam area (Rotliegend) was uncertain prior to SCAN: according to some models hardly any Rotliegend was present
- ➜These models were based on two vintage wells drilled in the 1970s
- ➜Our hypothesis: wells are anomalous. Actual Rotliegend thickness > 100 m.
- ➜Insufficient seismic data was present at the well locations, new seismic lines planned that tie vintage wells

SCAN project phases and activities

Seismic survey design complete. Long regional lines, connecting wells and infilling areas with poor seismic coverage.

SCAN Seismic Acquisition discussed in more detail: Johannes Rehling, *Look-back on 5 years of SCAN 2D seismic acquisition and (re)processing*

Project Proposal

Seismic Funded

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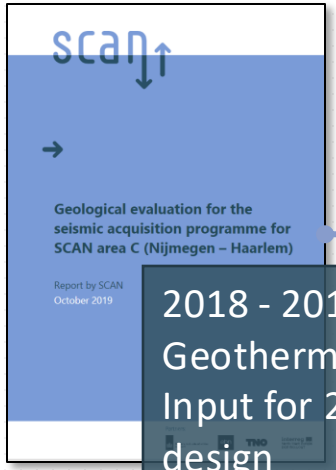

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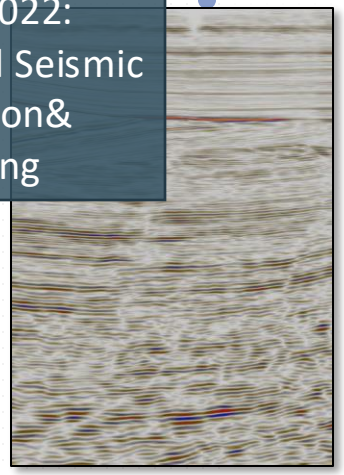

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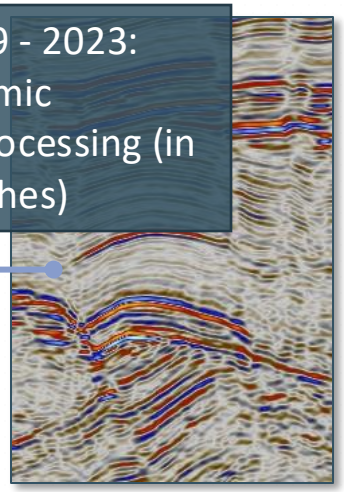
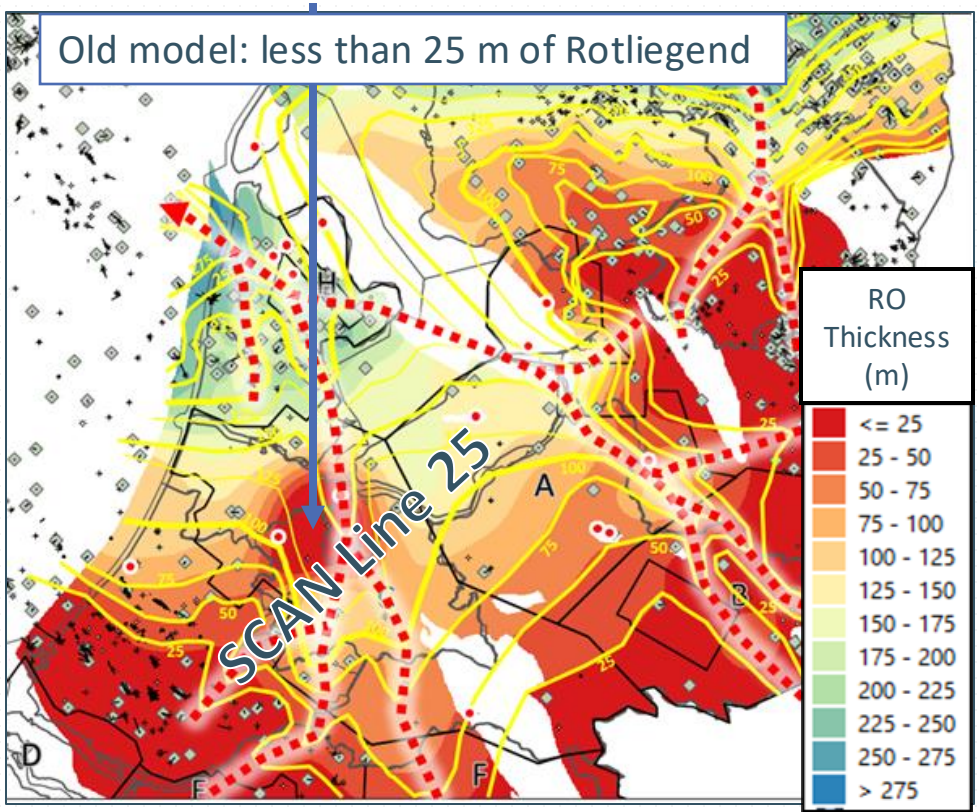


First well: Amstelland

Thickness of the Permian 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



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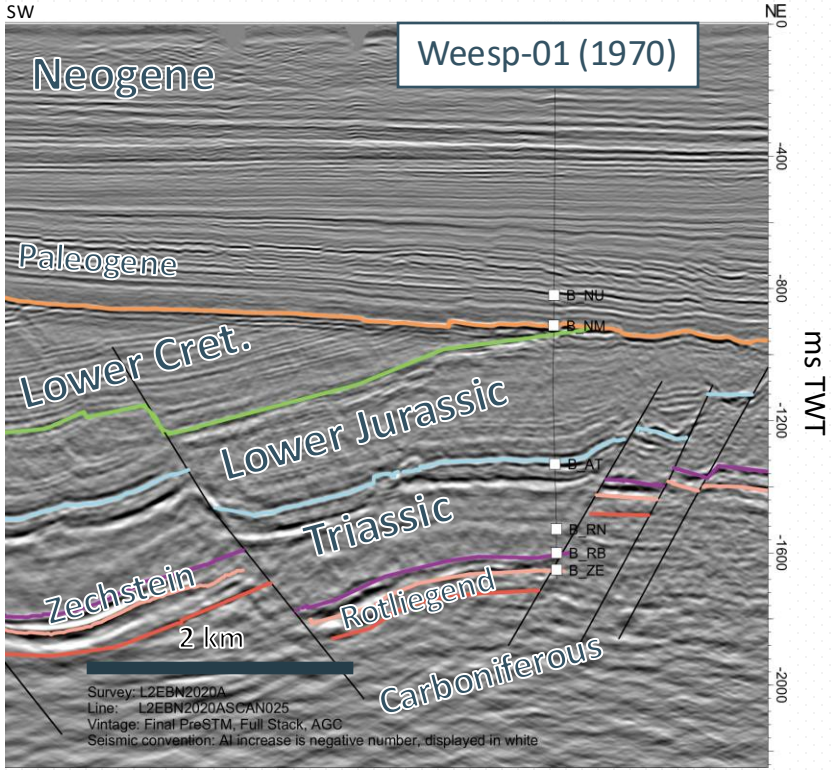

➜Insufficient seismic data was present at the well locations.

➜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 remained; a new well would provide much relevant data.

SCAN project phases and activities

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Wells Funded

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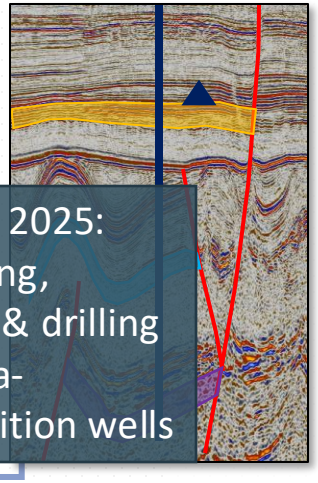

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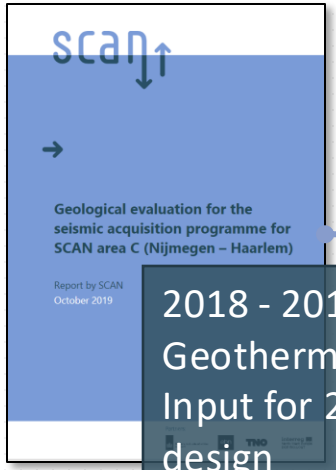

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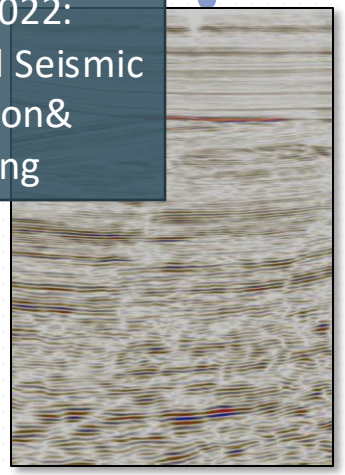

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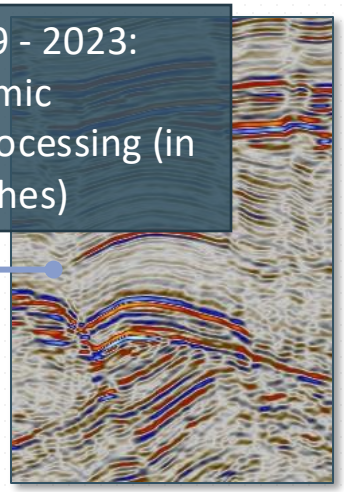


First well: Amstelland

A Play-Based Exploration approach for Geothermal

➔Portfolio defined based on Regional Geological Analysis of plays incorporating new and reprocessed seismic data

➔Search areas for data-acquisition wells selected from portfolio

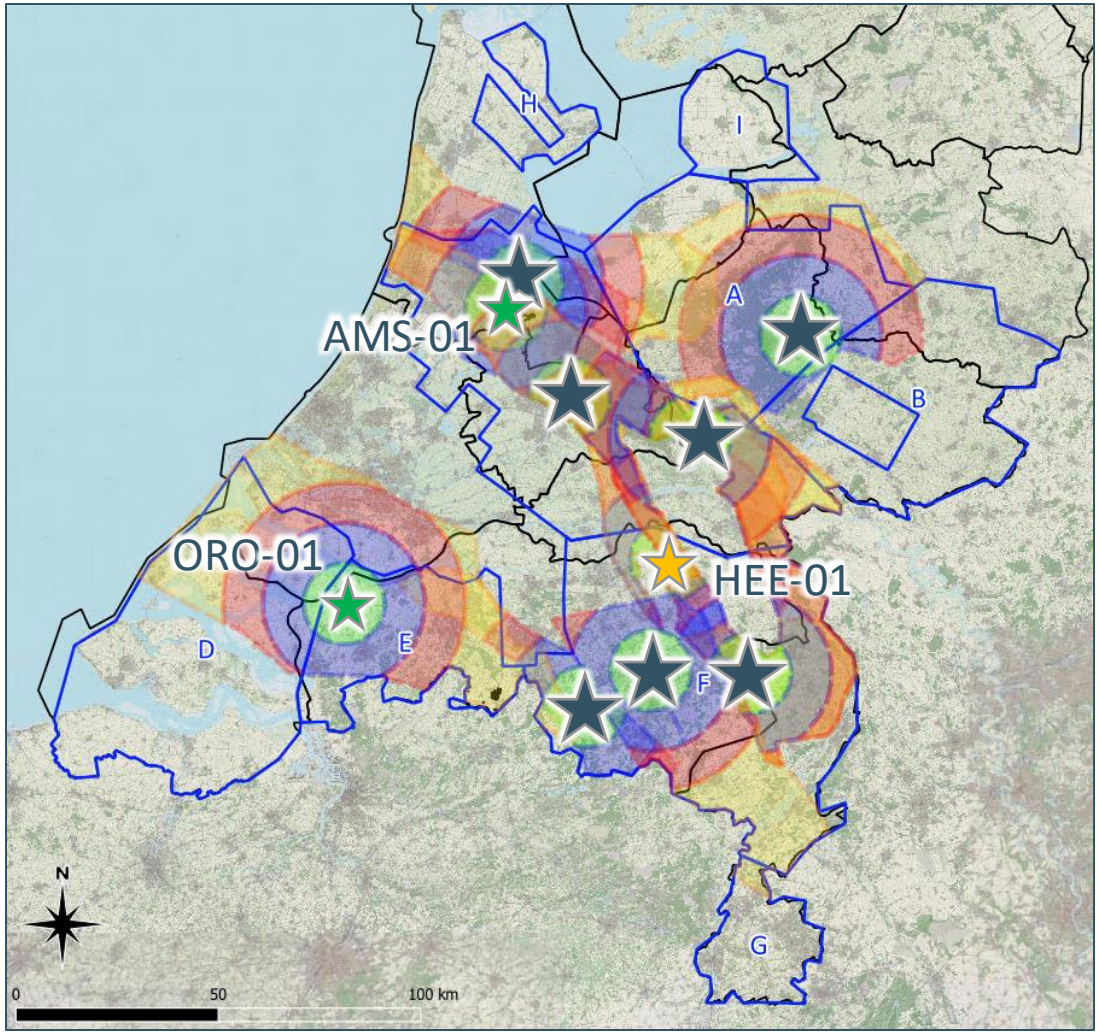
➔Metropolitan areas with high heat demand covered

Search area

Drilling completed

Drilling ongoing

Combined extent of play segments for SCAN search areas



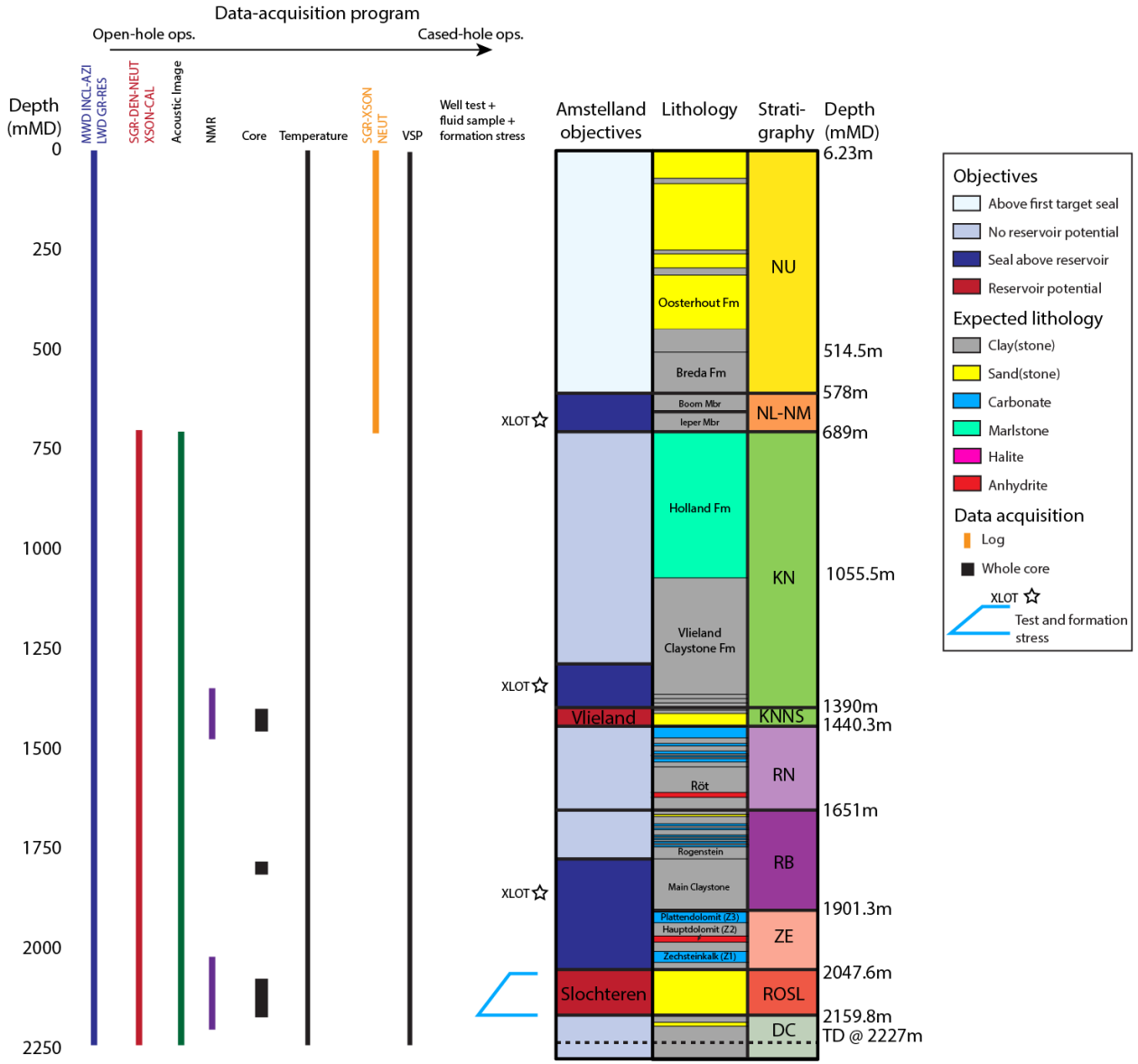
Data-acquisition in wells

Extensive data acquisition is performed in each SCAN well

Amstelland well shown as example:

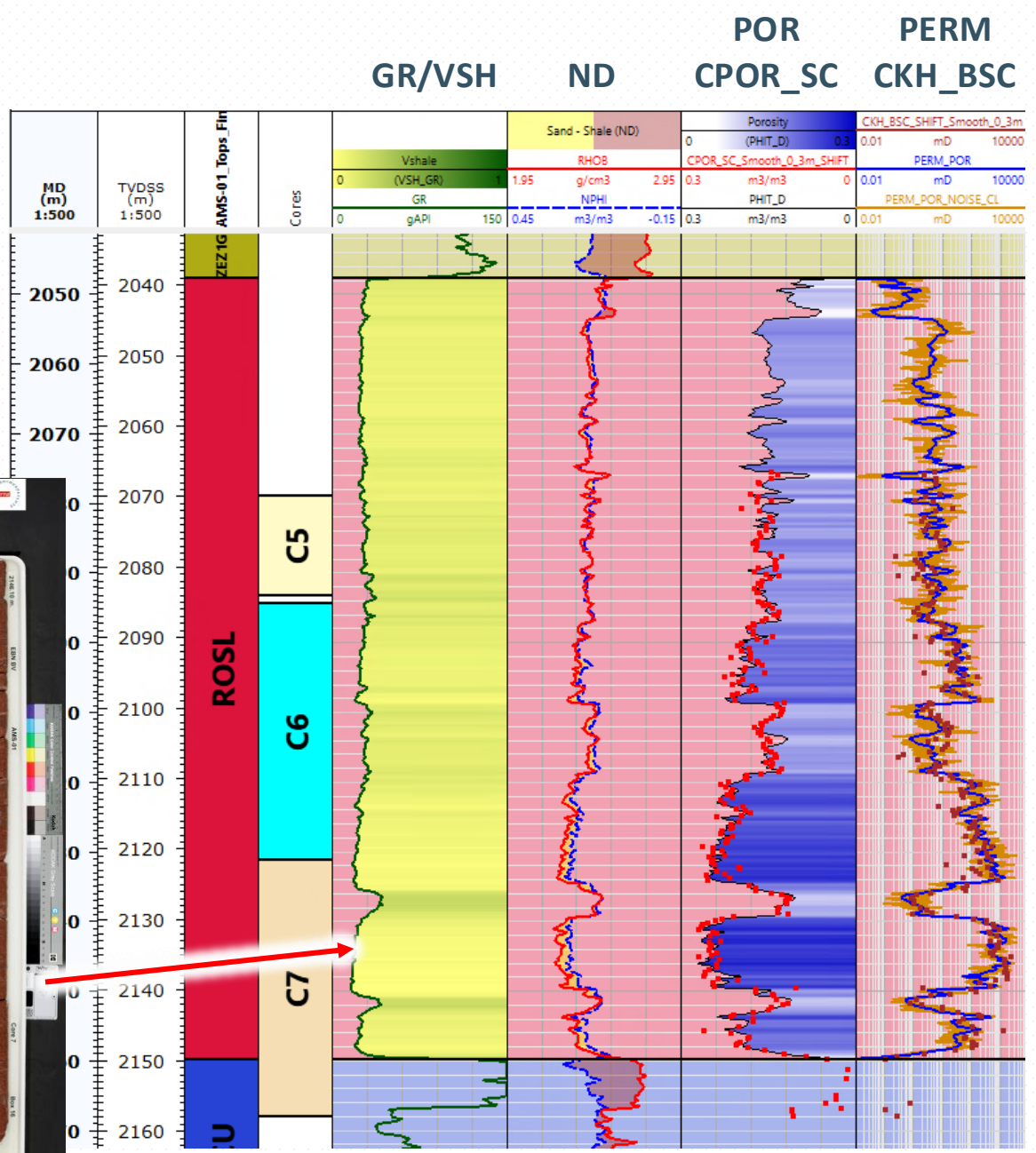
- **Cores**
  - Reservoirs: Porosity/permeability data
  - Reservoirs: Sedimentology and diagenesis (incl. descriptions and thin sections)
  - Geomechanical tests (note: also for caprocks)
- **Production / injection tests**
  - Flow rate and transmissivity
  - Temperature, pressure and water composition
- **Well Logs, both reservoirs and overburden**
  - Gamma Ray, Sonic (Vp/Vs), density/neutron, resistivity (whole well)
  - Image logs (for sedimentology and diagenesis, fractures and stress directions)
  - NMR log (for porosity, pore system and permeability)
  - Temperature
- **Vertical Seismic Profile** (for robust correlation onto regional seismic grid)
- **XLOT (Extended Leak-off Test)**
  - Determination of caprock integrity
- **Cuttings and biostratigraphy**
  - Vitrinite reflectance, apatite fission track, …
  - Dating and correlation of relevant intervals

Amstelland-01



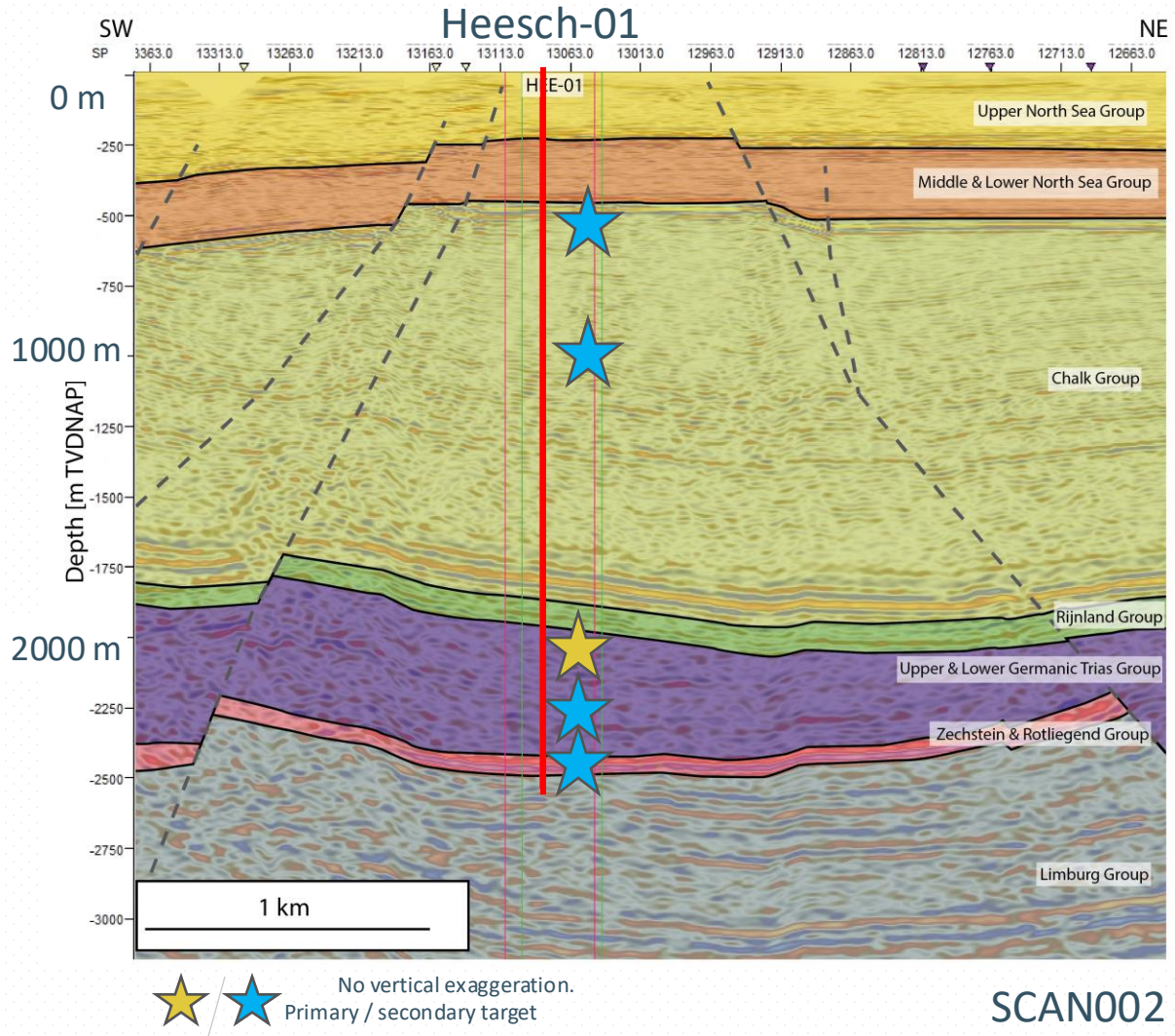
Amstelland-01 key results

- Primary target Slochteren Fm:
  - 111 mTVT thickness
  - Average matrix permeability approx. 150 mD
  - Produced and injected 1000m^3 formation water
  - Deformation bands reduce flow (<20% reduction)
  - Formation damage caused by OBM filtrate probably limited flow rates during test (lab tests ongoing)
  - Formation temperature approx. 82°C



Heesch-01 Summary

- ➔Spud 31-10-2024
- ➔Geothermal targets:
  - ➔Secondary: U. Cret. Chalk Gp limestones (CK)
    - ➔Maastricht & Gulpen Fm
  - ➔Secondary: U. Cret. Chalk Gp sandstones (CK)
    - ➔Vaals & Aken Fm
  - ➔**Primary: Lower Triassic Main Buntsandstein Subgp. (RBM) sandstones**
  - ➔Secondary: Lower Triassic Nederweert Sst. Fm (RBSN)
  - ➔Secondary: Permian Slochteren Fm (ROSL)
- ➔Extensive data acquisition on geothermal reservoirs, caprocks and overburden



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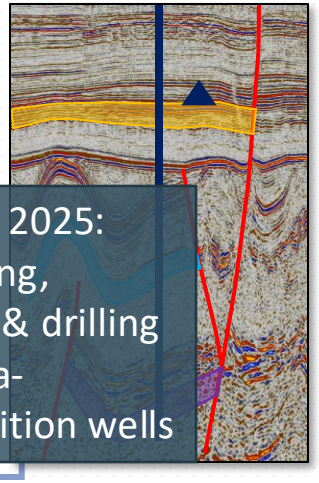

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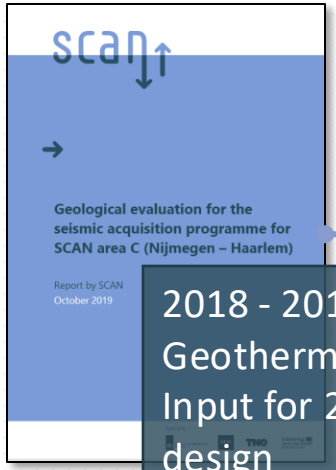

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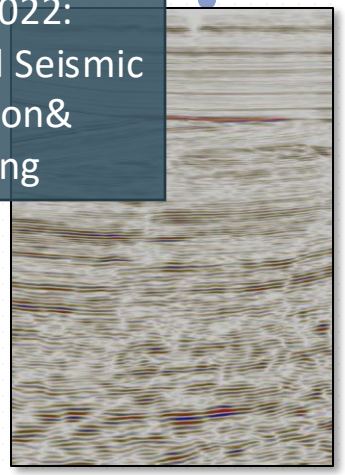

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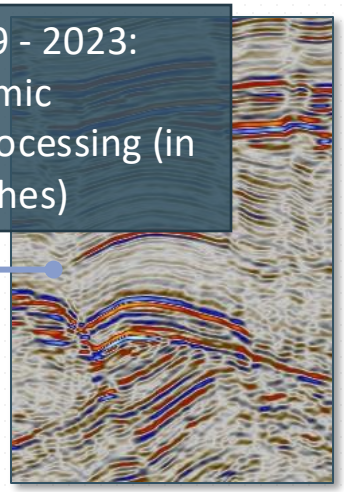


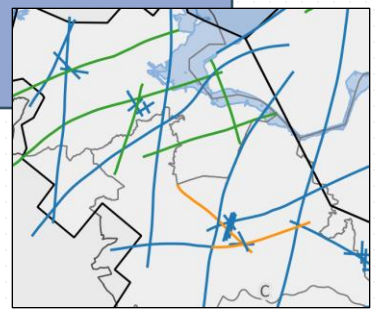
First well: Amstelland

scan

The next step: detailed seismic acquisition

Regional Exploration

- Regional 2D-seismic
- 2D-seismic for well planning

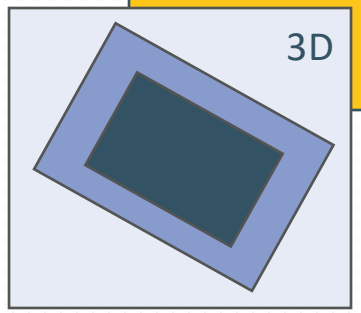


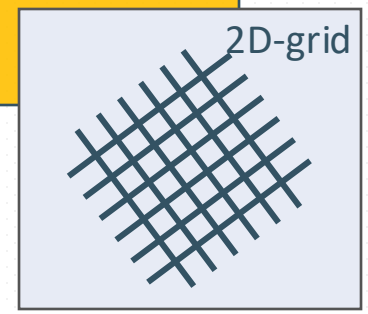
Exploration Wells

- Research/ Exploration/ Appraisal

Focused exploration

- 3D-seismic or sufficiently dense 2D-seismic grid required (depending on structural complexity)





Take home message

- ✓SCAN is a geothermal exploration project that will accelerate the development of geothermal energy projects in areas where little data is available, by:
  - ✓Acquiring new 2D regional seismic lines and reprocessing of vintage seismic data (complete)
  - ✓Drilling of data acquisition wells and publication of results (ongoing)
  - ✓Acquiring new detailed seismic data to accelerate geothermal project development
- ✓All data and results are published via **scanaardwarmte.nl** and **nlog.nl/scan**

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Ministerie van Klimaat en Groene Groei