November 20th, 2025

10th Dutch Exploration Day

ebn State Energy Company of the Netherlands

Dutch Geothermal Potential: Results From the SCAN Exploration Program

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A sustainable **heat transition**

Content

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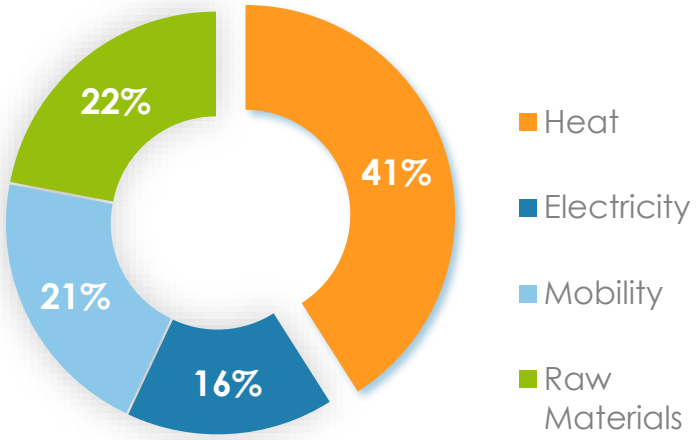
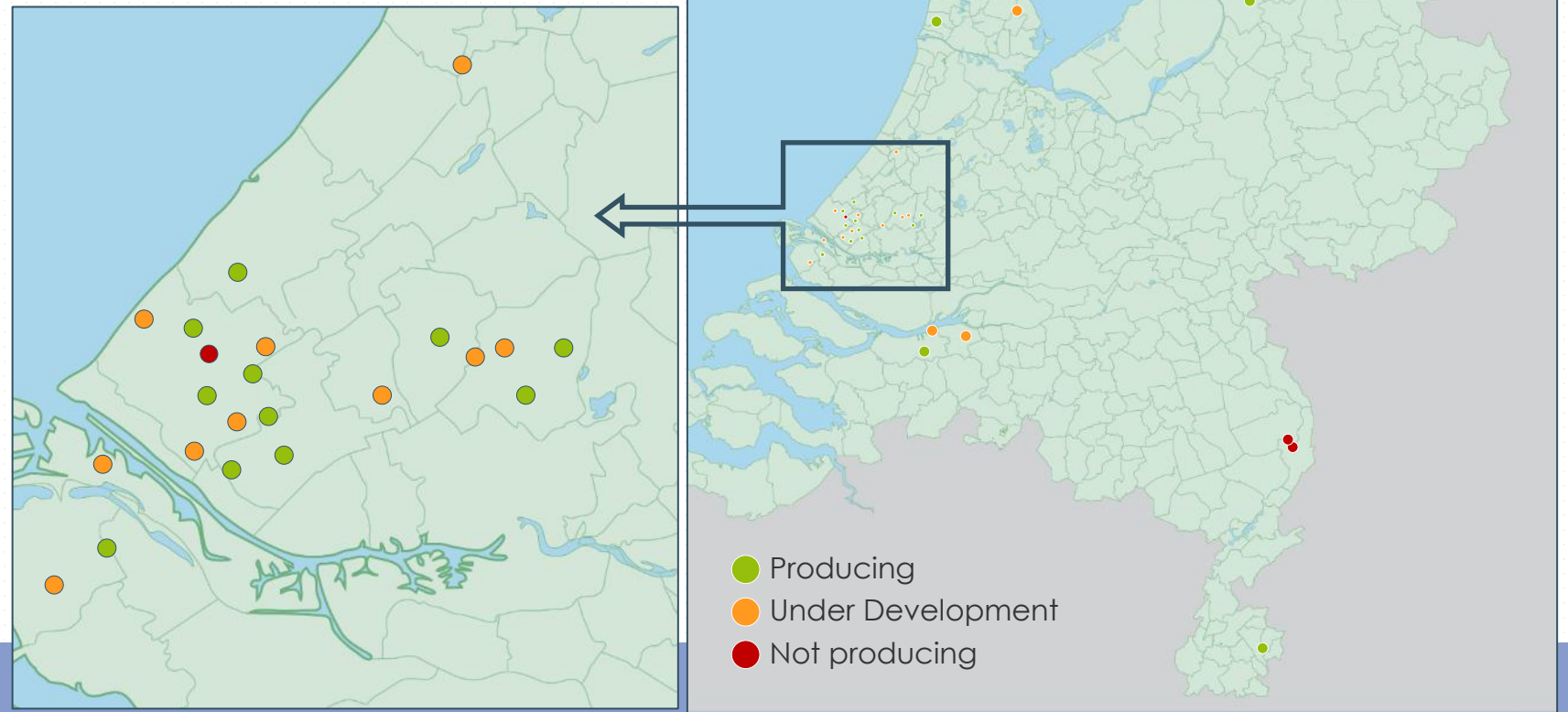
Geothermal Energy in the Netherlands

- Proven source of energy; 28 producing projects in 2024 (42 producers)
- Low enthalpy, from saline aquifers
- Direct use: heat for heat
- Between about 700 m and 3 km depth
- Between about 30 °C and 100 °C
- 7.9 PJ of heat generated (equivalent to about 263.000 households)

Energy use in the Netherlands





Sources: energieinnederland.nl, 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

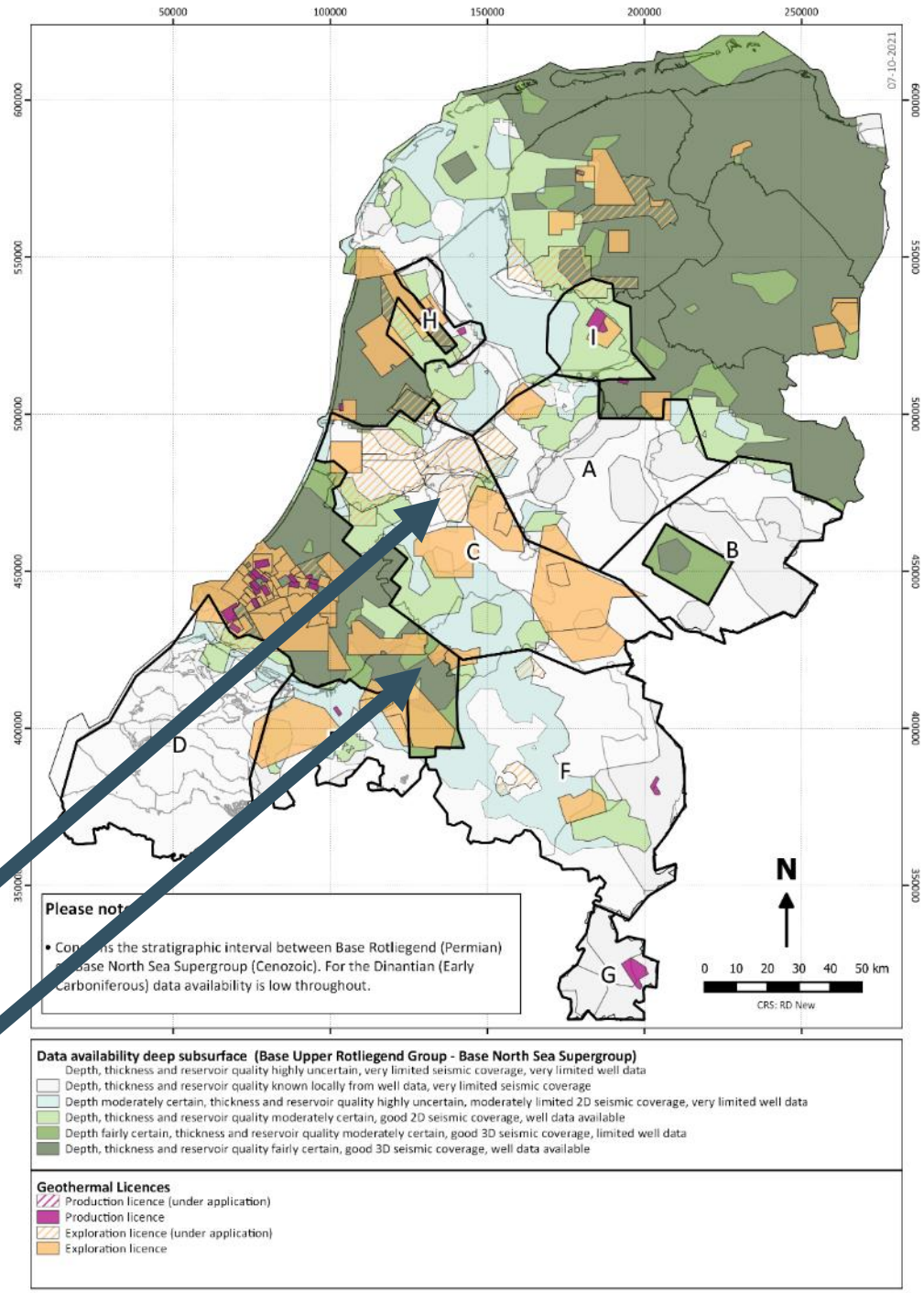
➜Aimed at shallow and deep geothermal (500-4000m)

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

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

SCAN focuses on the ‘white spots’. On this map they’re actually coloured white, grey and light green

3D seismic and abundant well data available: <u>not</u> a ‘white spot’, <u>not</u> part of SCAN

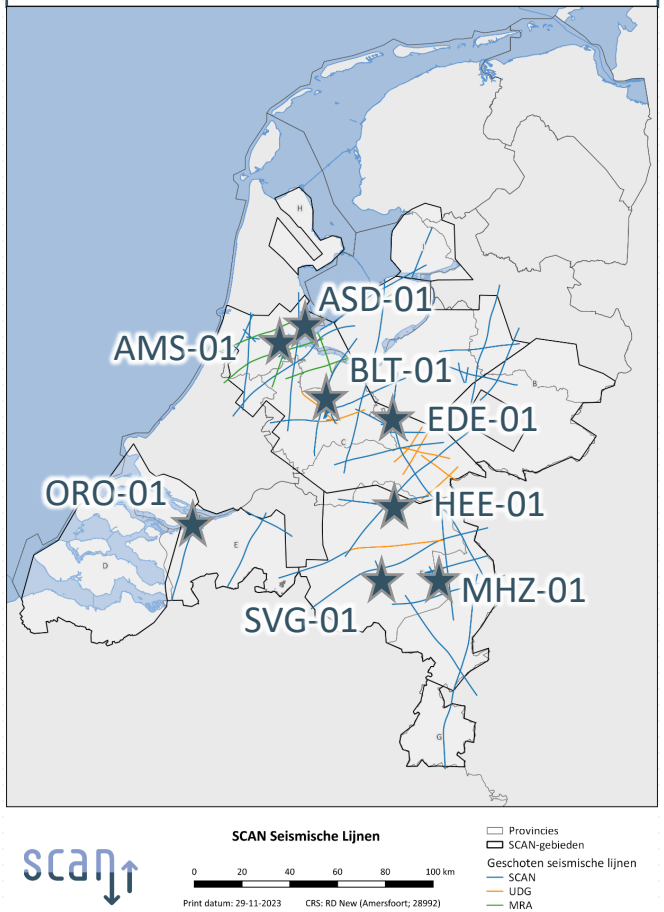


Components of the SCAN-programme

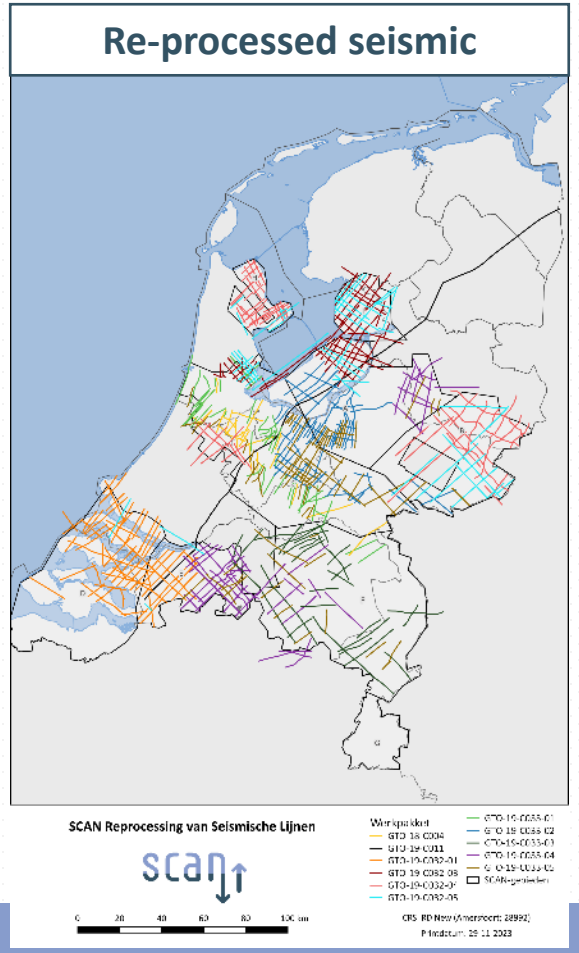
1. **Acquisition of 1900km new 2D seismic data**
   - ➜ Completed
2. **Re-processing of 7500km old 2D-seismic data**
   - ➜ Completed
3. **SCAN-drilling**
   - ➜ Well locations based on acquired 2D seismic
   - ➜ All wells drilled, two wells to be tested
4. **Acquisition of seismic for developments**
   - ➜ When well has proven geothermal potential
   - ➜ Currently acquiring first 3D survey

All data and results are published on scanaardwarmte.nl and nlog.nl/scan

New 2D Seismic& wells

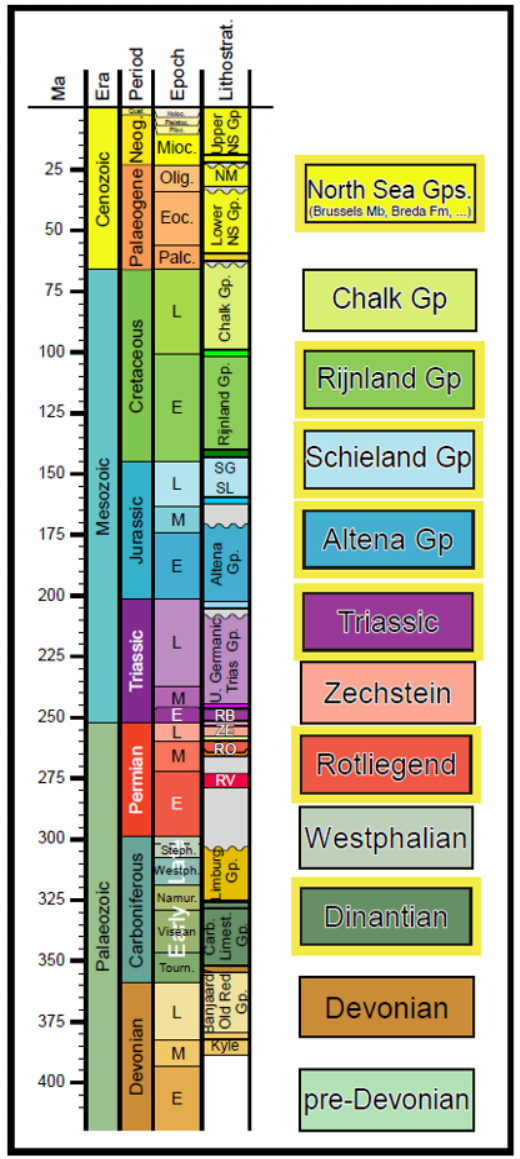


Re-processed seismic



SCAN: Geothermal plays

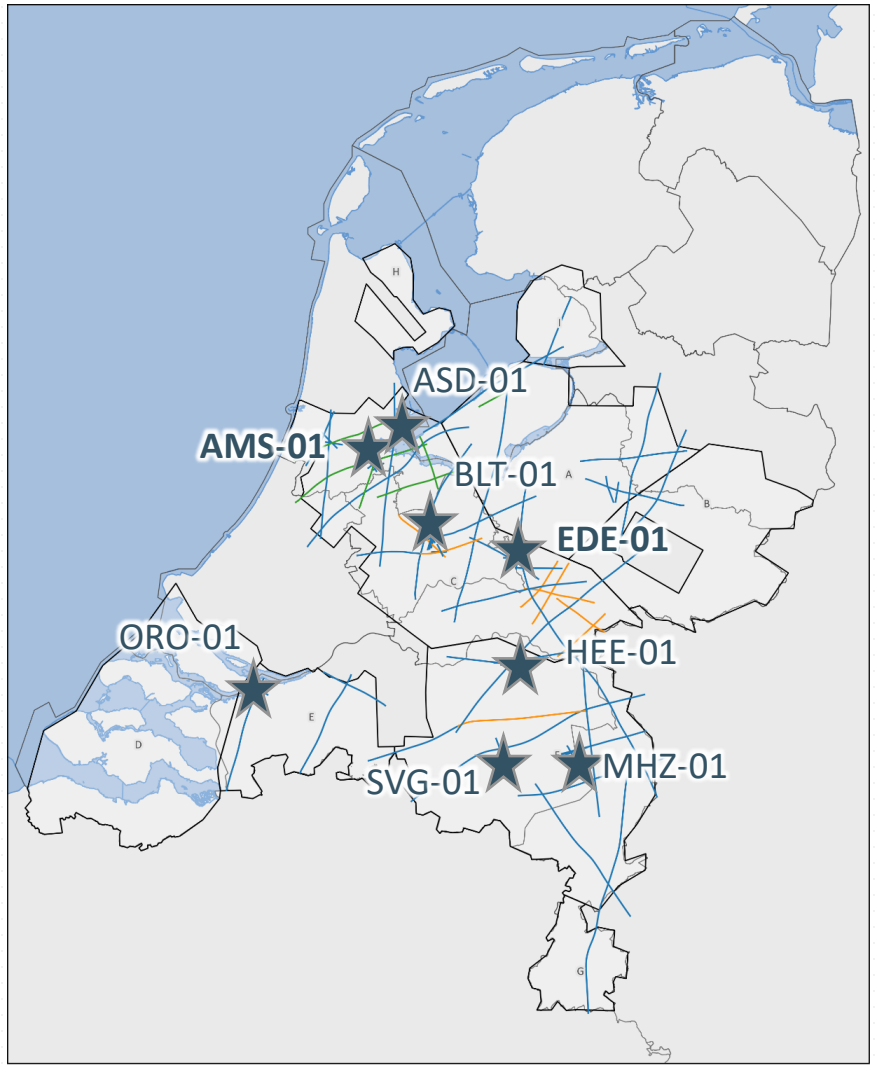
- SCAN looks at a wide range of geothermal plays
- **Focus on:**
  - Deep and Shallow geothermal (500 m – 4000 m)
  - Primary permeability
  - Secondary permeability (from karst or leaching)
- **<u>No</u> focus on:**
  - Ultra Deep Geothermal (UDG; >4000 m)
  - Fracture / fault permeability
  - Artificial/man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

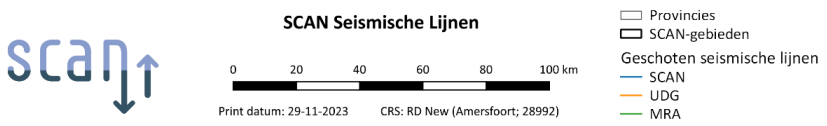


✓ Primary play

• Secondary play

SCAN Geothermal Exploration Wells





	SCAN Well	Primary objective	Secondary objective(s)
AMS-01	**Amstelland-01**	**Rotliegend (Permian)**	**Chalk, Rijnland (E. Cret)**
ASD-01	Amsterdam-01	Rotliegend (Permian)	North Sea (Neogene)
BLT-01	De Bilt 01	Rotliegend (Permian)	Triassic, Rijnland (E.Cret), Chalk
EDE-01	**Ede-01**	**Rotliegend (Permian)**	**Rijnland (E. Cret)**
HEE-01	Heesch-01	Triassic	Rijnland, Rotliegend, Chalk Gp
MHZ-01	Milheeze-01	Triassic	Chalk Gp
ORO-01	Oranjeoord-01	North Sea (Paleogene)	None
SVG-01	Stad van Gerwen-01	North Sea (Neogene)	North Sea (Paleogene)

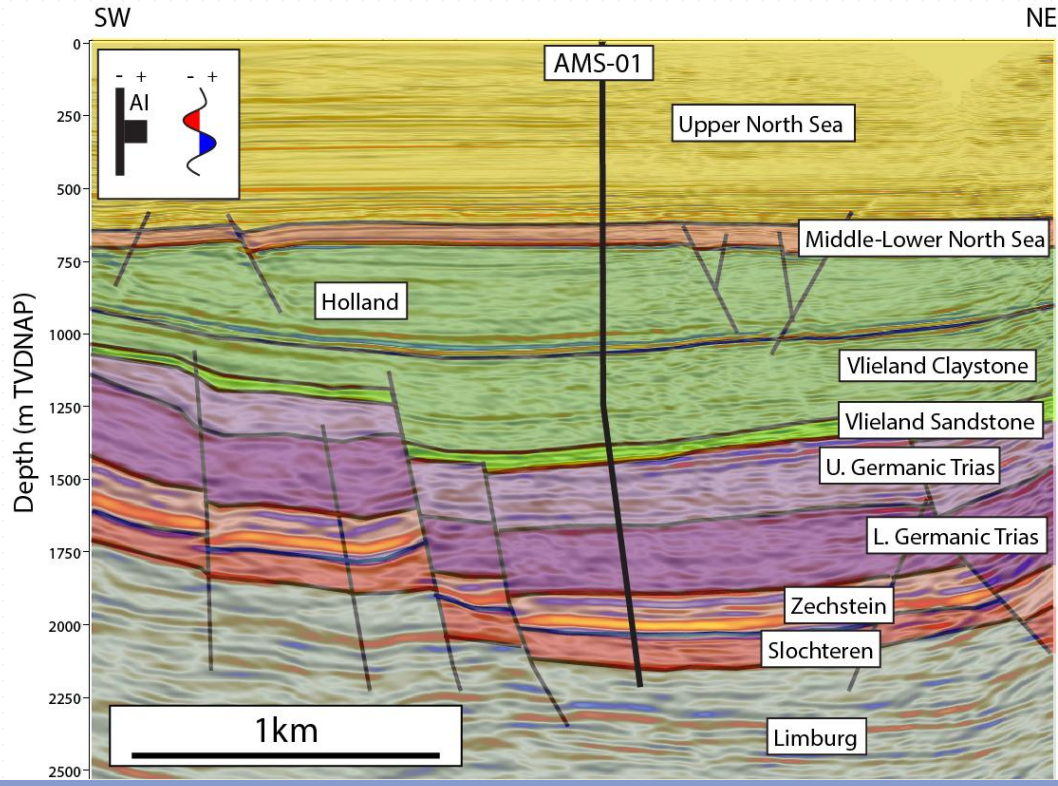
➔8 Wells Drilled

➔Well tests on Amsterdam-01 and Milheeze-01 in November& December 2025

SCAN Well Amstelland-01: Recap

- ➜Geothermal Exploration well in an area with **major heat demand**
- ➜Successfully drilled in Q4 2023, within budget, zero LTIs
- ➜Well proved 111m thick sand-dominated aeolian Rotliegend Slochteren sandstone
- ➜Extensive data acquisition performed throughout well, including over reservoirs, caprocks and overburden
- ➜Good reservoir quality: overall transmissivity approximately 13 Dm (avg. permeability: 120mD)

- ➜**Play opener for the Slochteren Geothermal Play in the Metropolitan Region Amsterdam**
- ➜**Next step: working towards development. 3D Seismic needed**



SCAN 4 Amstelland 3D survey – Outline

SCAN 4 Amstelland 3D survey:

- Area of Interest (yellow): 93 km^2
- Area of Operations (blue): 162 km^2

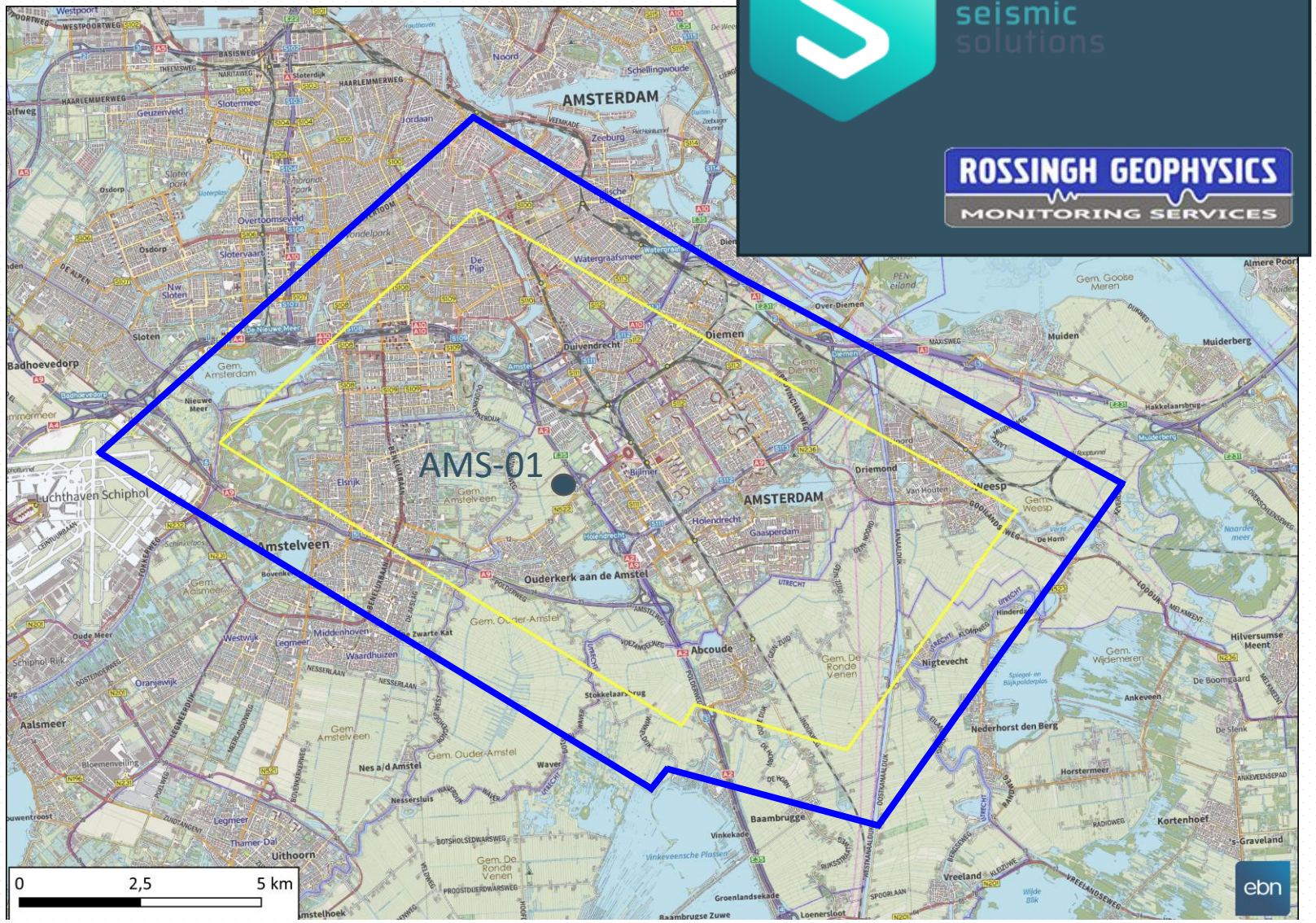
Area of Operations: 500.000 inhabitants.

Geophysical objectives:

- Acquire a high-quality and broadband 3D seismic survey
- Data must be “future proof”
- Superior data quality through teamwork, technology, planning & operational flexibility

HSSE objectives:

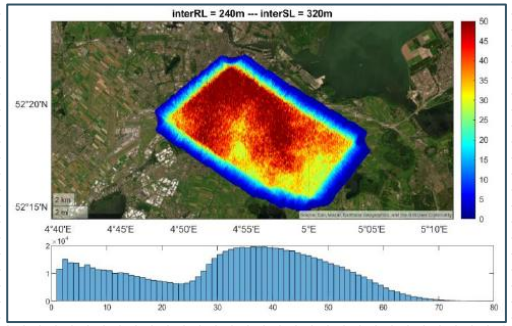
- Zero LTI
- No harm to the general public
- No harm to the environment
- Plan operations such that disturbances to residents in the Area of Operations will be as low as reasonably possible



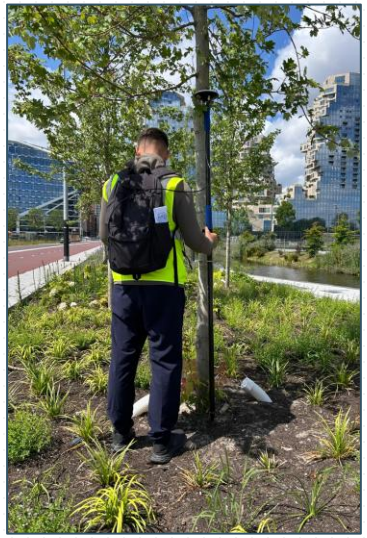
Extensive preparation

Test of effects on pipes& cables

Test near condemned building



Seismic Design Studies

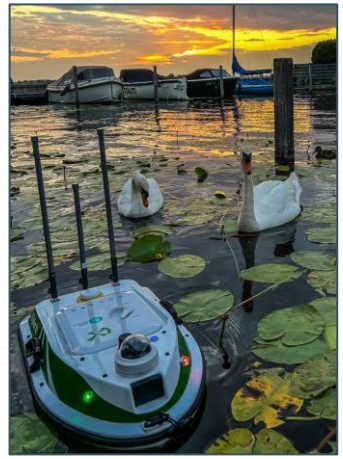


Shotpoint and receiver location surveying

Amsterdam quay wall tests

- **Prepare, prepare, prepare**
- Seismic design studies for survey geometry
- Early engagement with stakeholders
- Testing is key to plan operations properly: ensure maximum number of shotpoints and geophones can be placed, ensure we can operate safely
- Tests are key in convincing key stakeholders to allow us to carry out our survey

Water depth surveys in lakes



Permitting stakeholders & Challenges

Government organizations

- ➜ Permit from Staatstoezicht op de Mijnen
- ➜ 9 Municipalities (APV, RVV, archeology, communication etc.)
- ➜ 2 Water boards (flood defences and waterwork with airgun & shotpoint drilling)
- ➜ 2 Provinces
- ➜ Rijksdienst voor Cultureel Erfgoed (archeology)

Challenges

- ➜ General acceptance of public, proportional communication
- ➜ Traffic control for vibroseis and highway junction shotpoint drilling
- ➜ Unexploded Ordnance (UXO)
- ➜ Nighttime operations (vibroseis)
- ➜ Monumental buildings
- ➜ Animals (protected species, domestic animals)
- ➜ Preventing theft and vandalism

Utilities

- ➜ Pipe and cable operators (gas, water, sewage etc.)
- ➜ Vulnerable quay walls (Engineering dept. of Amsterdam)
- ➜ Gemeentelijk VervoerBedrijf (GVB) Amsterdam
- ➜ Metro tunnels (and other underground infra)
- ➜ Artesian wells

Landowners& users

- ➜ More than 600 land users to be permitted
- ➜ Staatsbosbeheer
- ➜ Schiphol (access, security, soil pollution etc.)
- ➜ Prorail (protection areas of railway)
- ➜ Rijkswaterstaat (protection areas of highways and access to highway junctions)
- ➜ Amsterdamse Bos
- ➜ Golf courses
- ➜ Allotment gardens (volkstuinen)

Acquisition equipment

Sonic drill tractor

nominal shotpoint depth 20 m

Sonic drill tractor on barge

(a smaller version will be used on this survey)

Vibroseis truck (large)
Weight: 32 metric tons
Peak force: 62.000 Lbs

Vibroseis truck (medium)
Weight: 16 metric tons
Peak force: 28.000 Lbs

Vibroseis truck (small)
Weight: 8 metric tons
Peak force: 15.000 Lbs

Acquisition equipment

Receivers

Dimensions:
11.5 cm x 11.2 cm x 13.7 cm,
spike: 11.6 cm, 830 gr with spike





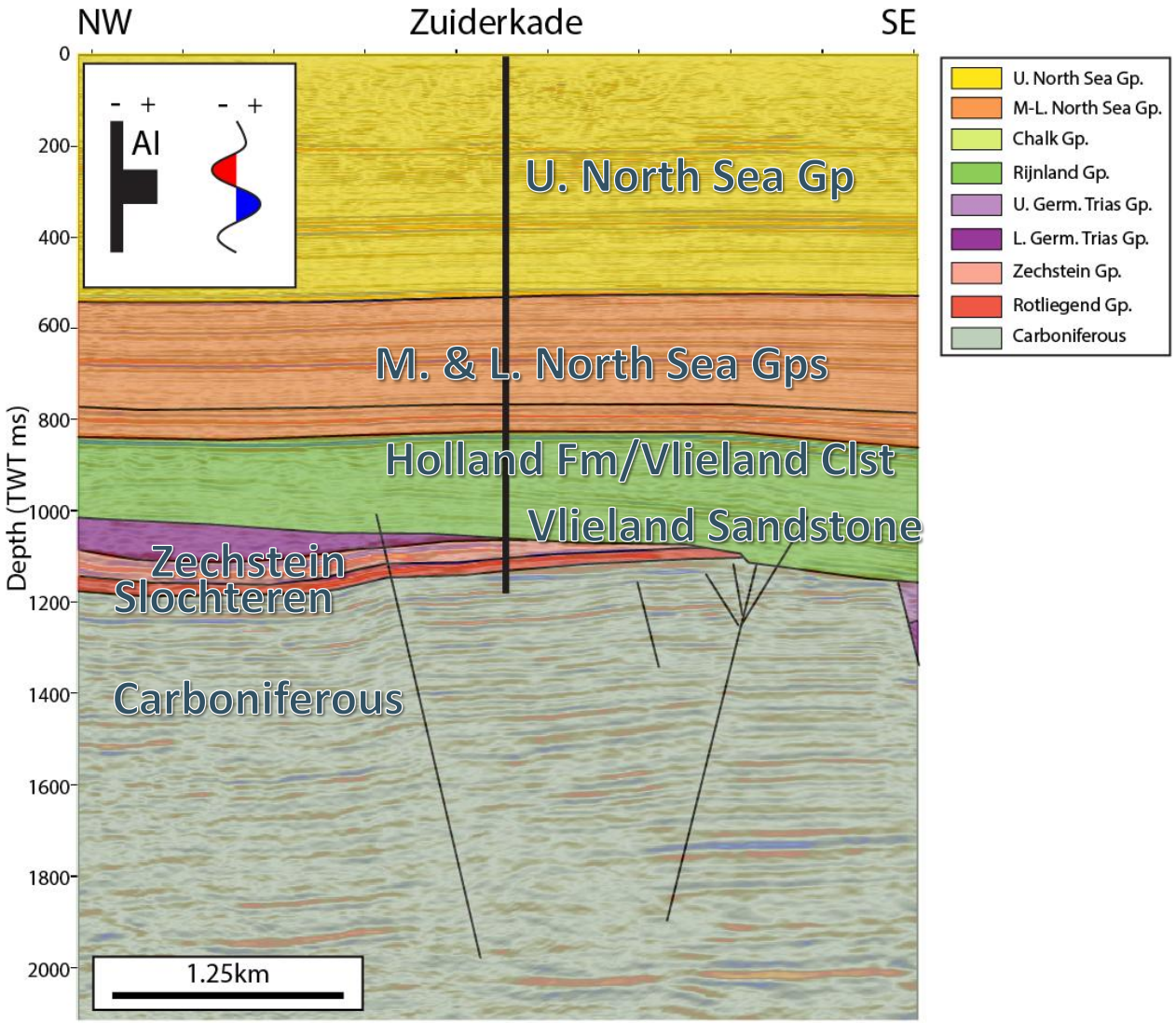
Examples of geophone placement

Airgun array
(8 guns, 320 cu.in)

Sleeve gun
(1 gun, 40 cu.in)

SCAN Well Ede

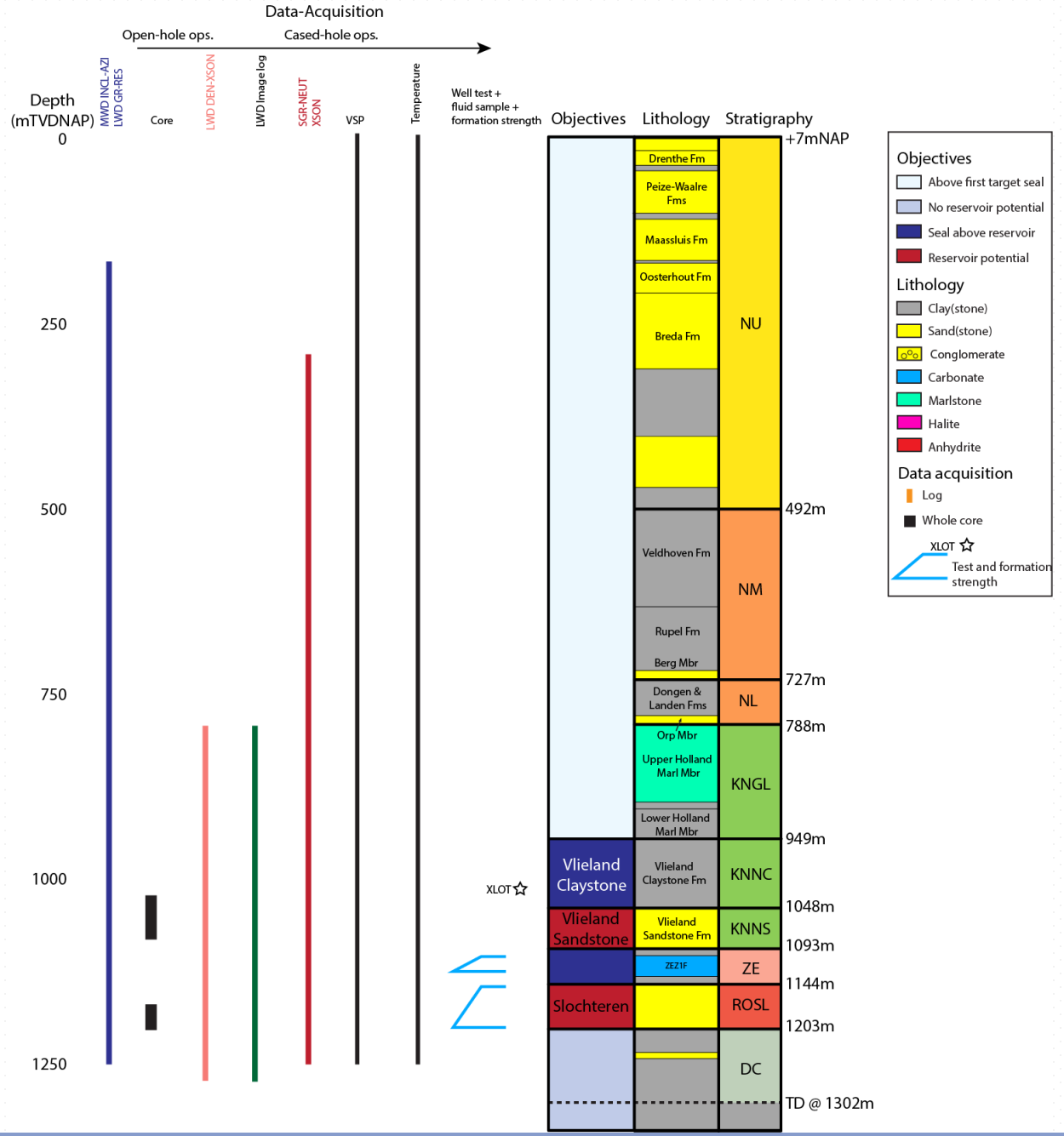
- Geothermal targets:
  - Primary: Permian Slochteren Fm (ROSL) (~48°C)
  - Secondary: Vlieland Sandstone Fm. (KNNS) (~44°C)



Ede: data-acquisition

Extensive data acquisition:

- LWD and CH wireline log data
  - (S)GR,RES,XSON,DEN,NEUT,IMAGE
  - Temperature
- VSP (geophone)
- Production/Injection test (2x)
  - PLT
  - Fluid samples
- Core (91m)
  - Screening analysis (CoreDNA)
  - RCA, SCAL, core description
  - Geomechanical tests
- XLOT
- Cuttings

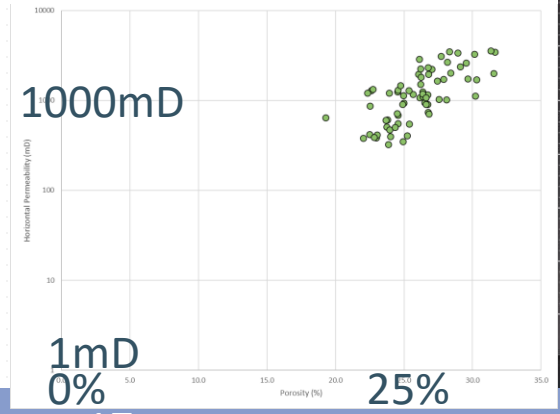


SCAN Well Ede: Results

- ➔Primary Target: Slochteren Fm (ROSL)
  - ➔Present. Very porous, very permeable. KH from well test: 70-90 Dm! (avg. perm from well test: 1180-1510 mD)
- ➔Secondary Target: Vlieland Sandstone Fm.
  - ➔Present. Good (total) porosity, limited permeability. Not flow tested

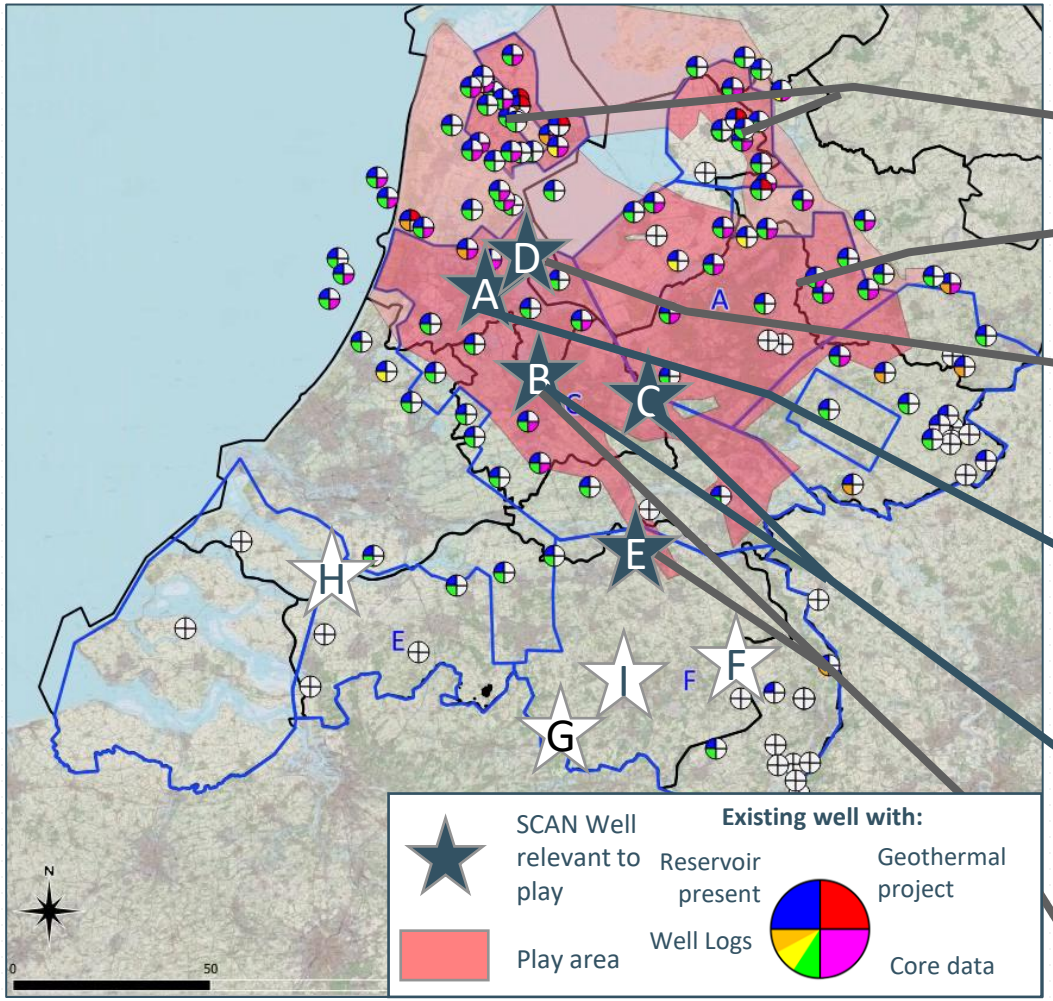
- ➔**A surprise:**
  - ➔The Zechstein 1 Fringe Carbonate Member was found to be porous. To assess its transmissivity, a flow test was performed. Result: permeable; KH=4-6 Dm (avg. perm: 150-224 mD)

Slochteren poro-perm (Klinkenberg, air)



Rotliegend Play (Slochteren Formation)

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



Target: Rotliegend Slochteren Formation sandstones, deposited in aeolian environment

Producing geothermal projects. No SCAN Wells necessary

Apeldoorn-Deventer area strongly faulted

SCAN Well Amsterdam-01 to assess geothermal potential near Almere and north of IJ. Well test ongoing

SCAN well Amstelland-01 shows feasibility of geothermal production in Metropolitan Region Amsterdam south of the IJ. **3D acquisition ongoing**

SCAN wells Ede-01 and De Bilt-01 have shown that geothermal production in NE part of province of Utrecht and adjacent part of Gelderland is technically feasible. **Evaluation of options for additional seismic acquisition ongoing**

Wells De Bilt-01 and Heesch-01 show that geothermal production in SW part of Utrecht and adjacent part of Gelderland would be challenging.

Take Home Messages

SCAN is a **geothermal exploration project** that is accelerating the development of **geothermal energy projects** in areas where little data was previously available, by:

➔Acquiring over 1900 km of **new** 2D regional **seismic** lines (complete)

➔**Reprocessing** over 7500 km of vintage seismic data (complete)

➔Drilling& testing of **8 data acquisition wells** (ongoing)

➔Seismic Acquisition to facilitate geothermal developments (first **3D** ongoing)

Multiple discoveries made, opening up development possibilities

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Thank you for your attention

All SCAN data is made publicly available at no charge through https://www.nlog.nl/ and https://www.scanaardwarmte.nl