Amstelland: SCAN's first geothermal data acquisition well

Adriaan Janszen, SCAN Geoscientist, EBN

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Ministerie van Economische Zaken en Klimaat
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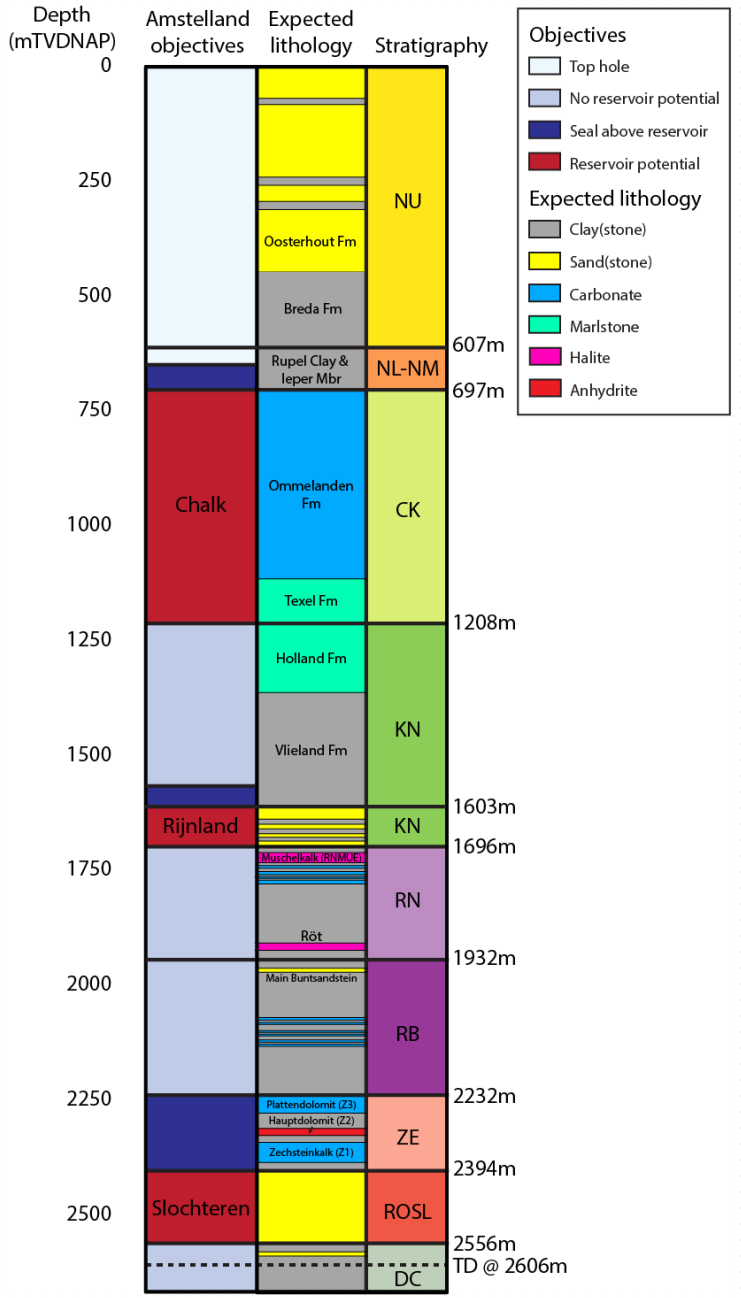
Interreg North-West Europe DGE-ROLLOUT

SCAN Well Amstelland

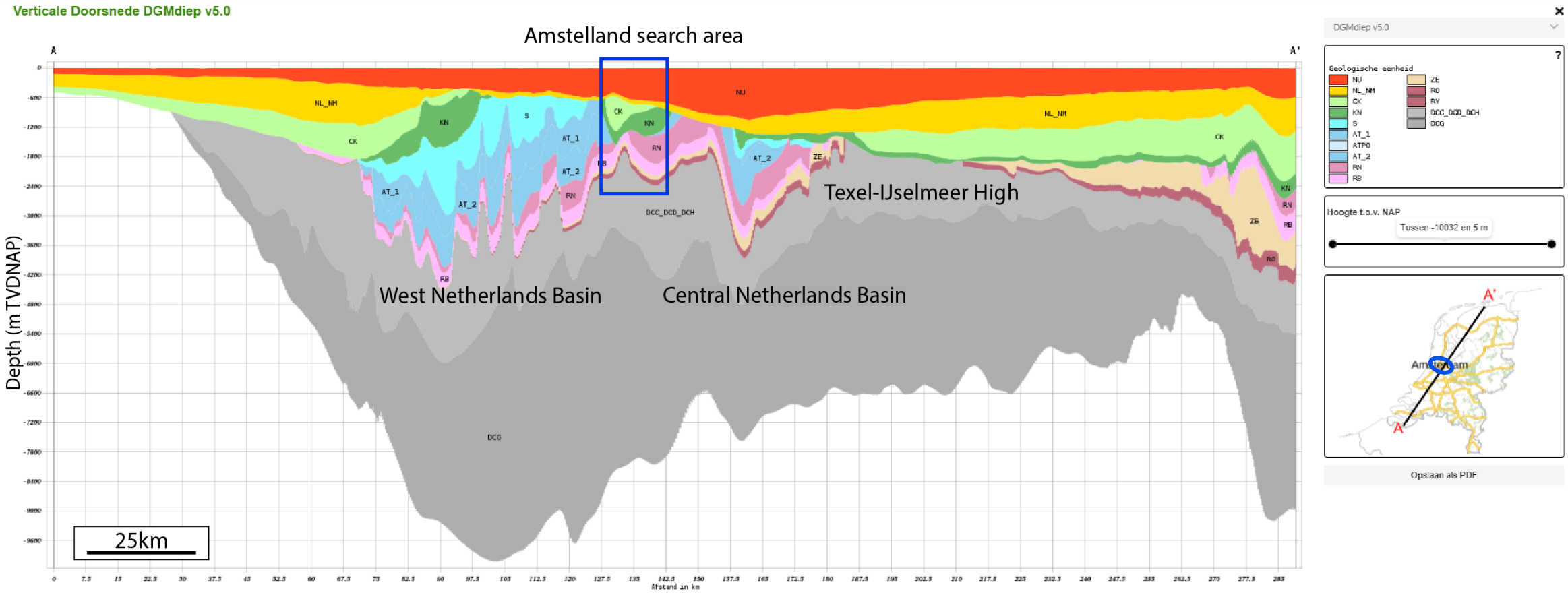
- ➜First SCAN geothermal data-acquisition well
- ➜Spud planned Q3 2023
- ➜ Geothermal targets:
  - ➜Primary: Slochteren Fm (ROSL) sandstones - ~86°C
  - ➜Secondary: Rijnland Gp (KN) sandstones - ~62°C
  - ➜Secondary: Chalk Gp (CK) - ~39°C
- ➜Main uncertainty for primary target: permeability. Chance of presence of sufficiently permeable reservoir estimated at 60%
- ➜Well will be located on the Zandvoort Ridge, where well data is very scarce
- ➜Well results will be important for large area with high heat demand. This area includes cities such as Haarlem, Amsterdam, Hilversum, Utrecht and Amersfoort.



Contents

- Geological setting
- Intervals with geothermal potential
  - Slochteren Fm
  - Rijnland Gp
  - Chalk Gp
- Planned data acquisition
- Next steps

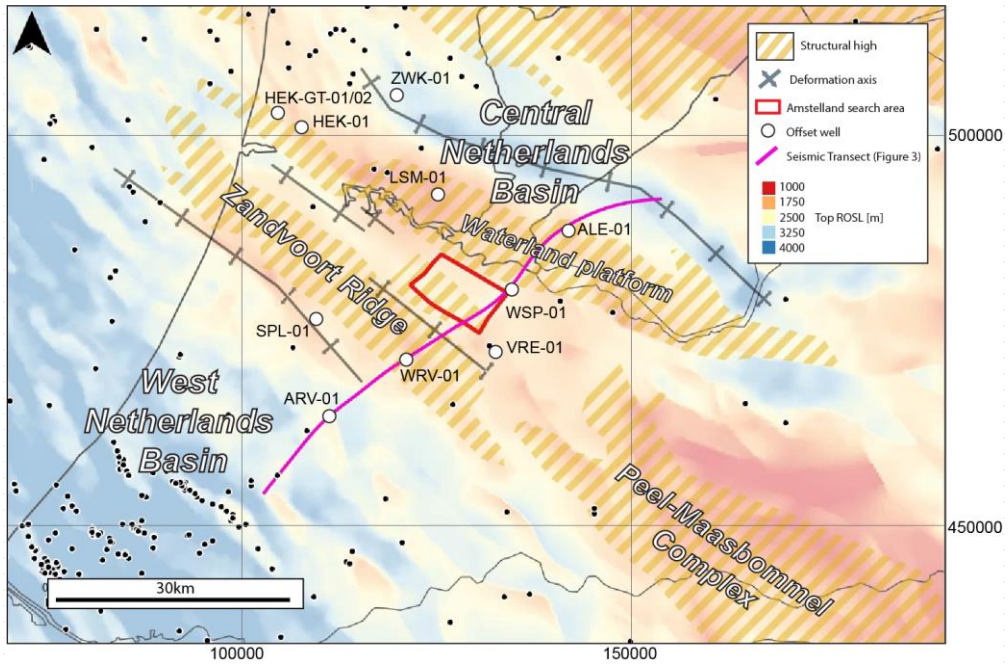
SCAN Search Area Amstelland: regional setting



Source: www.dinoloket.nl

SCAN Search Area Amstelland: regional setting

- Situated on “Amstelland horst”, part of complex series of highs delineating the boundary between West and Central NL Basin (Zandvoort Ridge - Peel-Maasbommel Complex)
- Relatively inactive geological history compared with surrounding basins: Less intensive uplift and erosion in Late Cretaceous and Early Tertiary resulted in preservation of stratigraphy not penetrated in offset wells and might allow for better reservoir quality
- Very limited well data available at present to delineate geothermal potential



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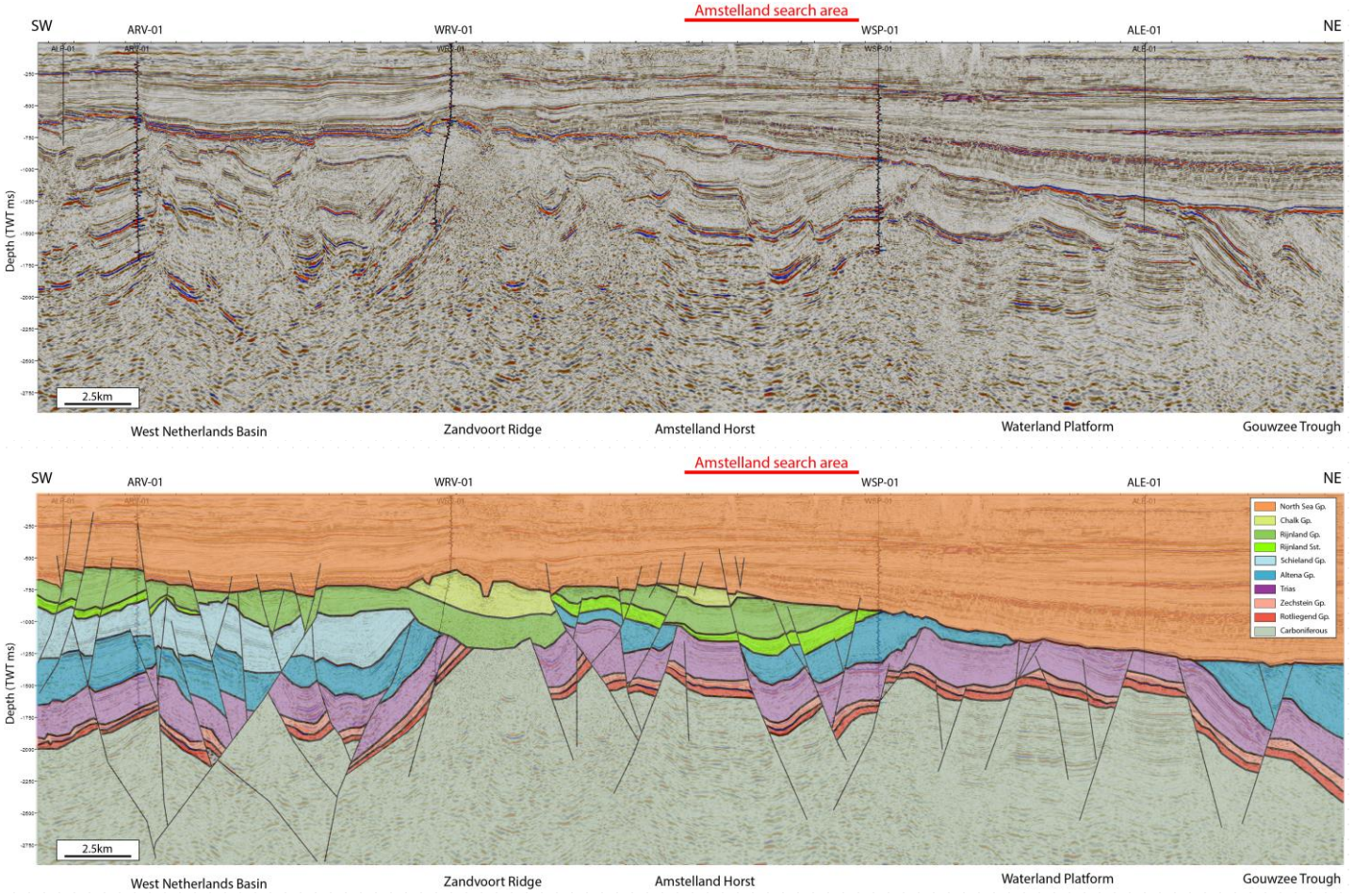
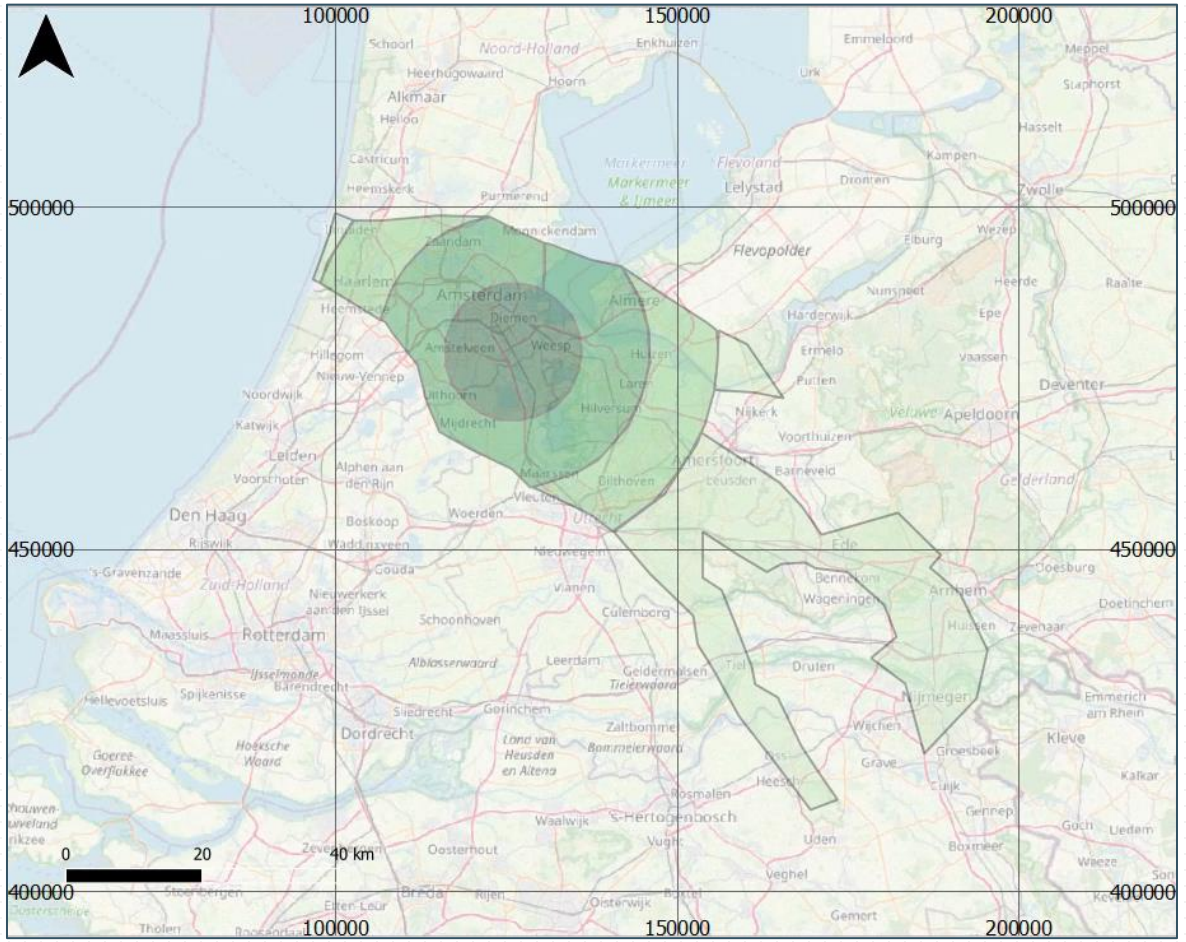


Area of influence

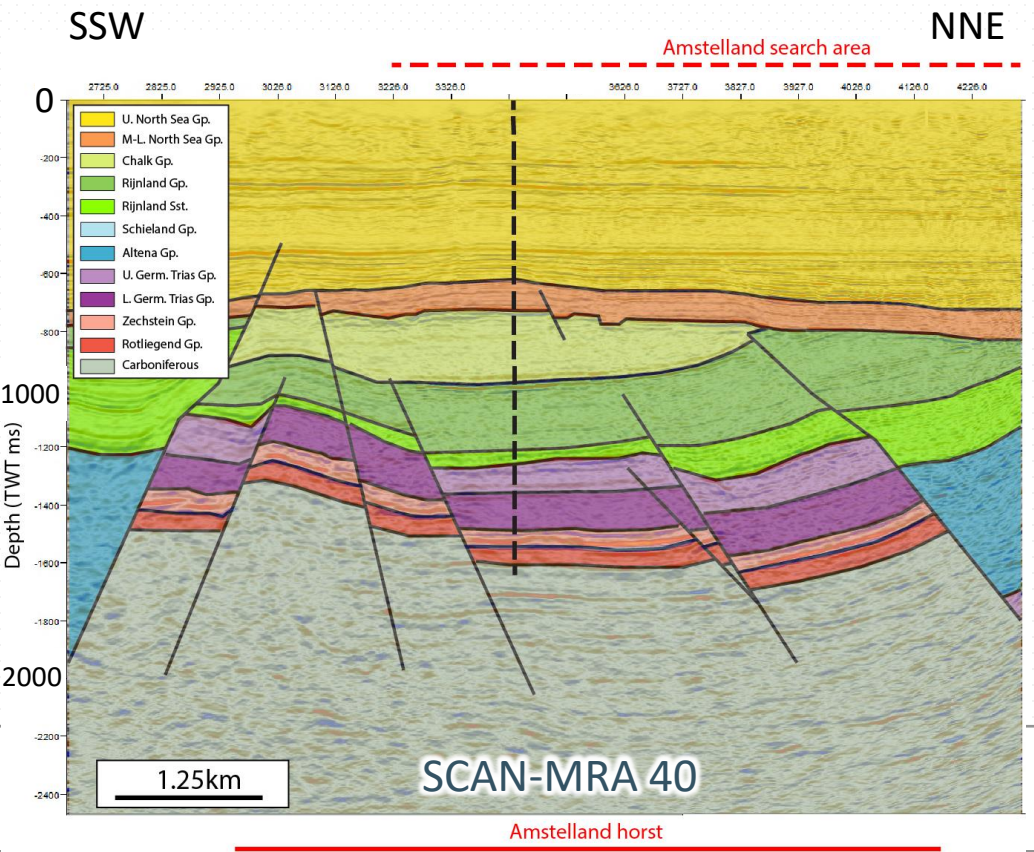
- Amstelland search area and well location selected so that data collected is representative and relevant for a large area with high heat demand
- Three geothermal “plays” of varying depth and temperature will be tested extensively

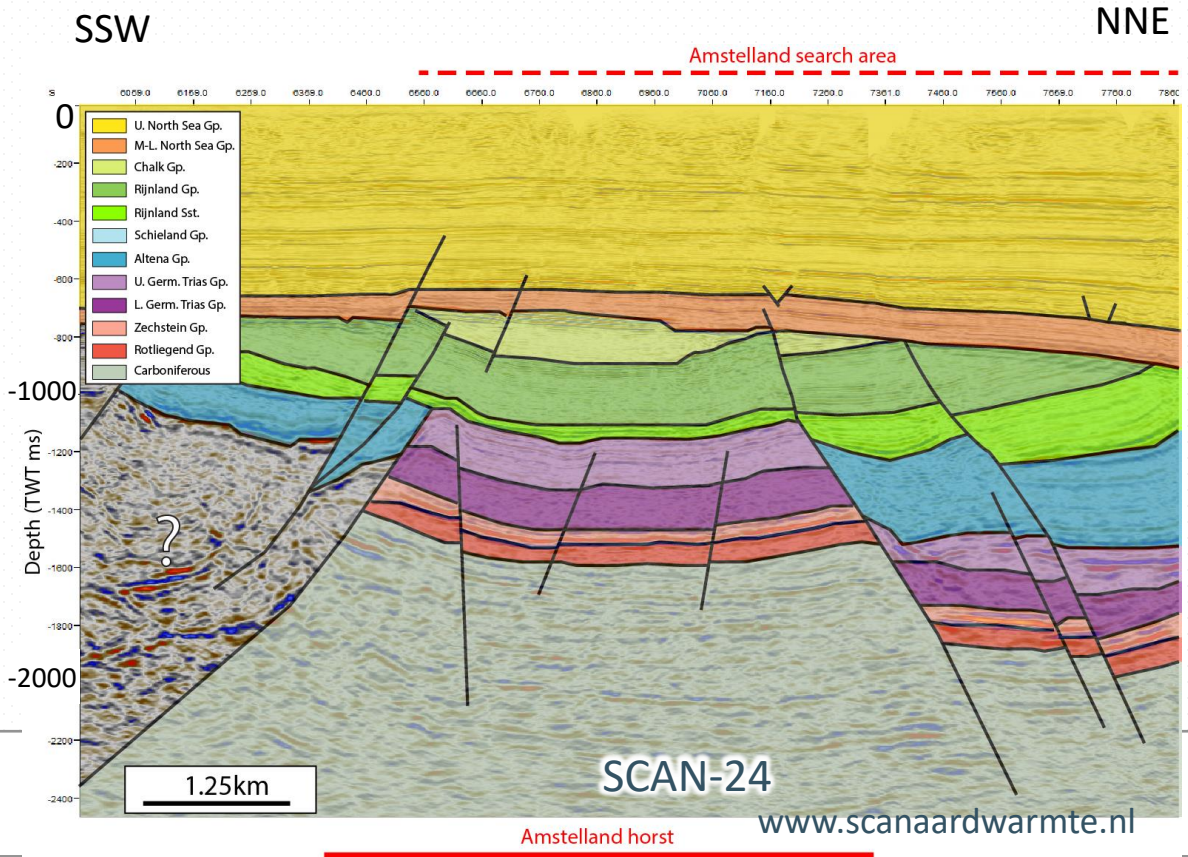
Area of influence Amstelland well



“Amstelland Horst”

- Newly mapped structural element on SCAN 2D seismic data
- Horst of 10x4km underlying SE Amsterdam, Abcoude and Ouderkerk aan de Amstel
- Significant interval of Rijnland and possibly Chalk Gp preserved
- Slochteren Fm present throughout the horst
- Relatively low structural complexity

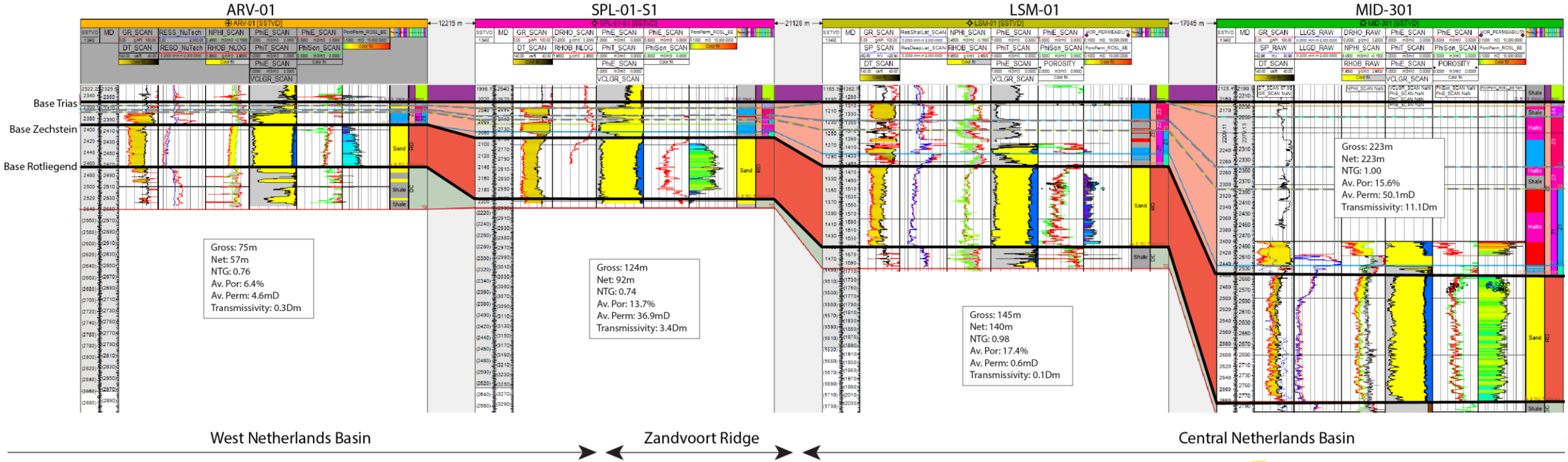




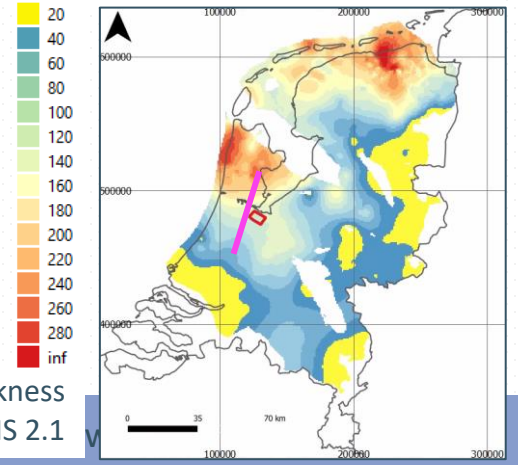
www.scanaardwarmte.nl

Slochteren Fm

South — Flattened on Base Triassic — North



- Gentle thickening of Slochteren to north, substantial thickening of Zechstein reflecting accommodation space
- Expected to be approximately 160m thick on the Amstelland horst based on seismic data
- Highly variable reservoir quality



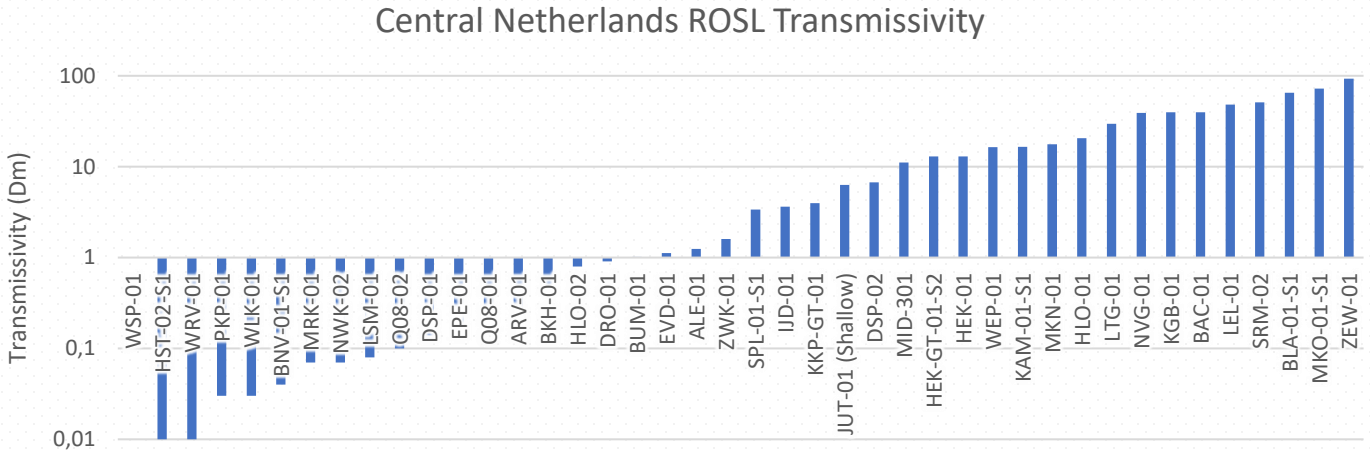
Rotliegend thickness modified from ThermoGIS 2.1

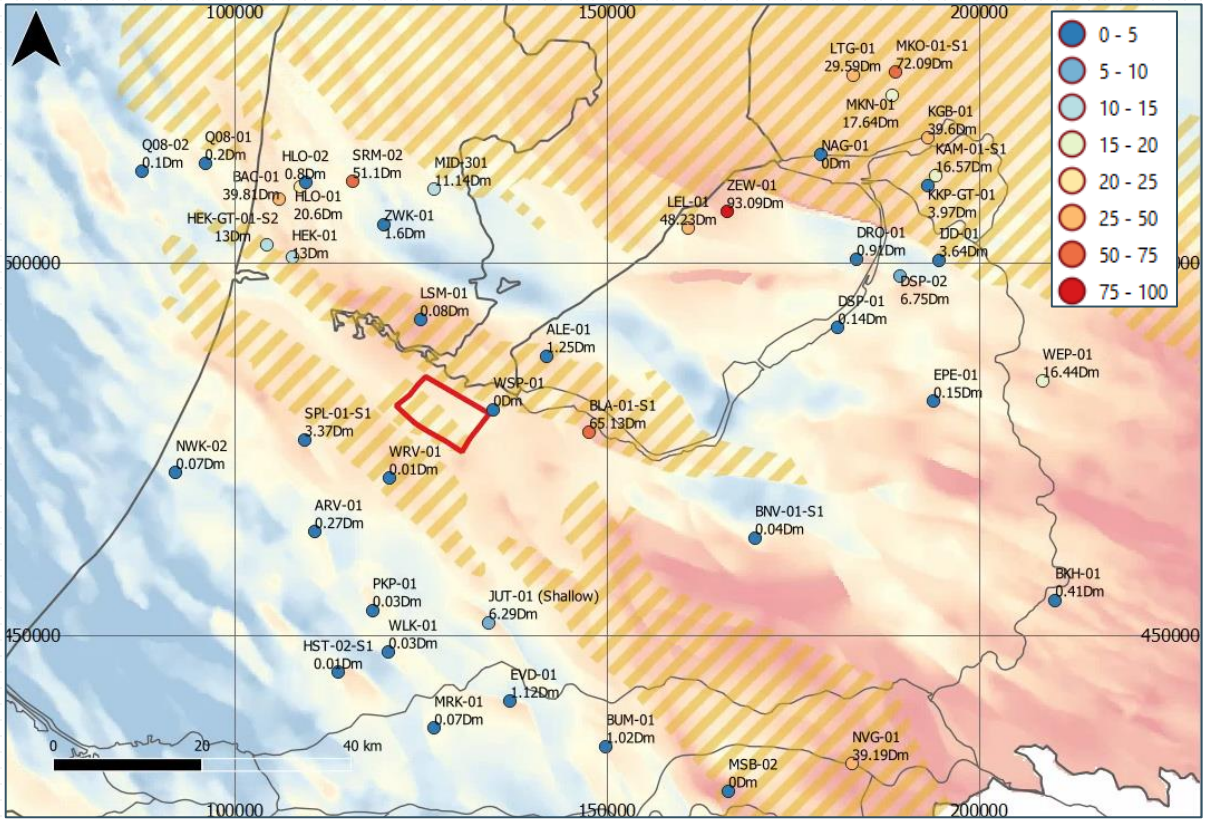
Slochteren Fm Reservoir Quality

Controlling factors by level of importance - according to Gaupp and Okkerman (2011)

1. **Environment of deposition => Amstelland in dominantly eolian facies belt**
2. **Mechanical compaction => Amstelland outside of strongly inverted basins**
3. Carbonate and anhydrite cementation
4. Initial mineralogy, grain size, clay matrix content
5. **Diagenetic clay association (illitisation) => Amstelland well away from fault zones**
6. **Diagenetic quartz => Amstelland horst never expected to be buried deeper than present day and ROSL not exposed to high temperatures**
7. Feldspar dissolution

Chance of presence of sufficiently permeable reservoir estimated at 60%

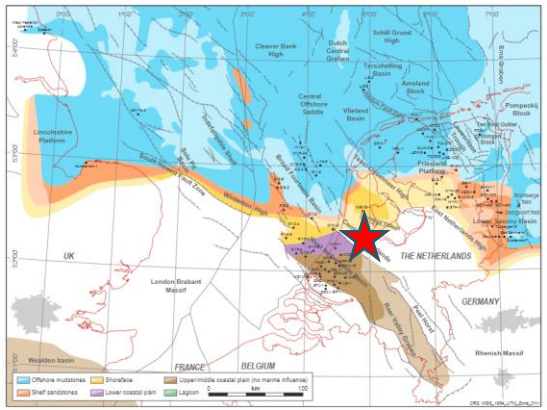




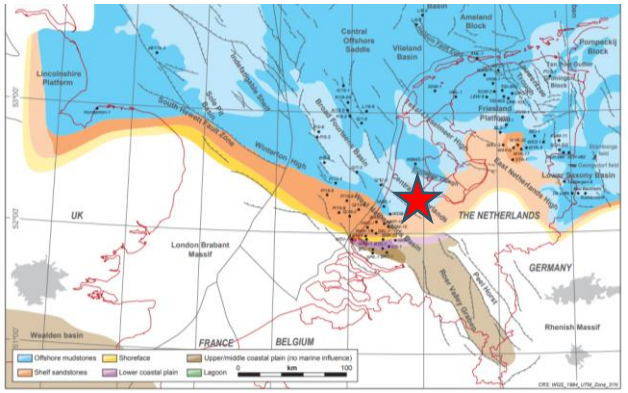
Rijnland Group

- Transgressive system covering the Netherlands during thermal subsidence following the Kimmerian rifting event (Verreussel et al., 2018)
- Regional reconstruction suggests shallow marine shelf and shoreface deposition around Amstelland search area during the Hauterivian (Rijswijk and Friesland Mbr. Sandstones (Jeremiah et al., 2010)

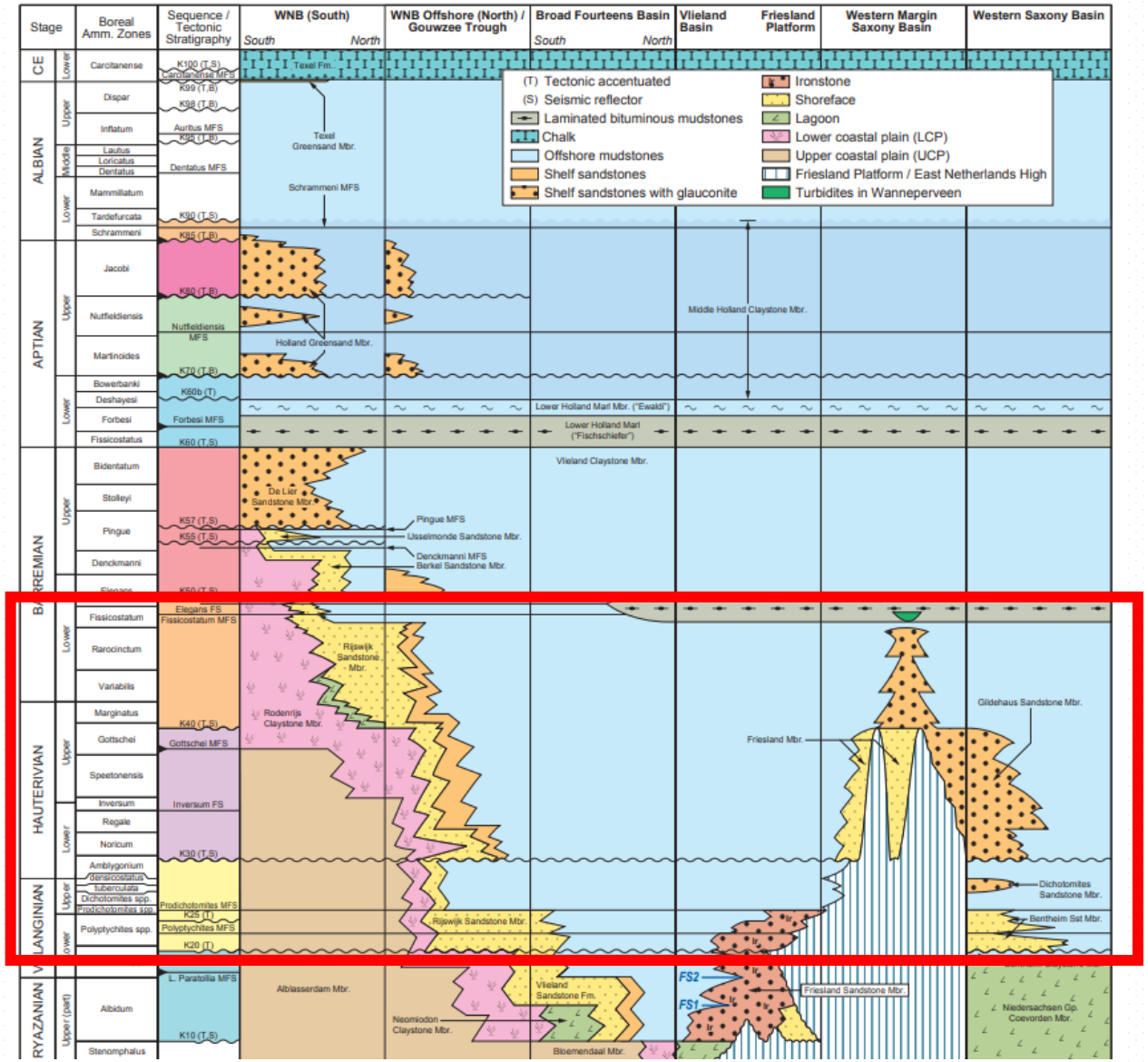
Early Hauterivian



Latest Hauterivian



Jeremiah et al., 2010



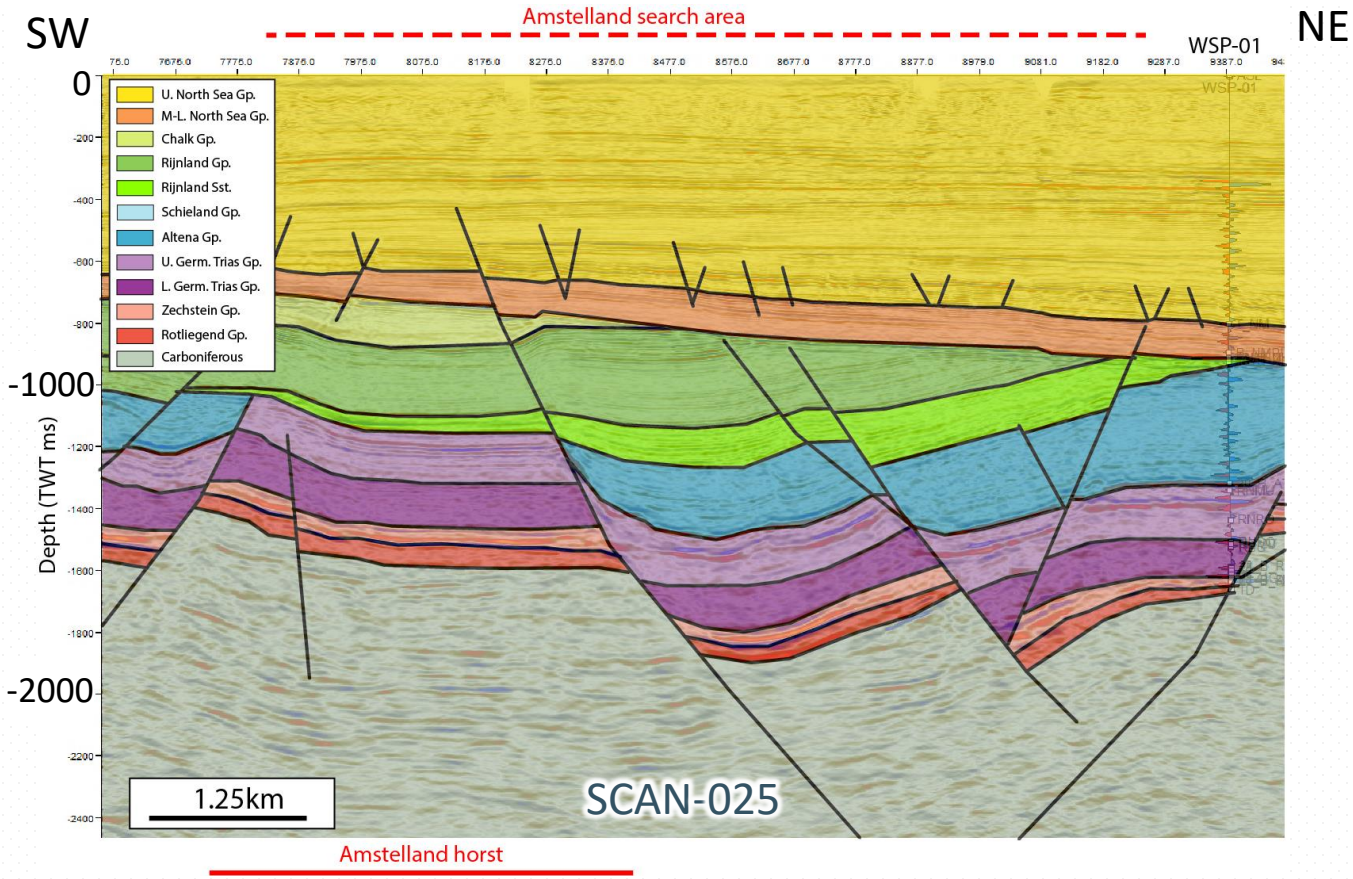
Lower Cretaceous stratigraphy of the Netherlands. From Jeremiah et al., 2010

Rijnland Group

➜Wells that tested the Rijnland on Zandvoort Ridge and Maasbommel-Peel Complex very rare.

➜SCAN seismic facies suggests Rijnland reservoir may be present. Chance of presence estimated at 50% for Amstelland Search Area.

➜If present, chance of sufficient permeability estimated at 60%.



Chalk Gp

- The Chalk can be an excellent reservoir as is known from oil production in the North Sea and groundwater production in NW Europe
- A significant amount of the flow is attributed to secondary porosity (fissures, conduits, fractures). There is large amount of matrix storage but permeability is low and matrix hardly contributes to flow
- Flow velocities through the secondary porosity derived from tracer tests are very high (>1km/d)
- Having a doublet that intersects these secondary porosity networks so that flow between the wells is possible is critical, but flow needs to be sufficiently tortuous to avoid short-circuiting

MacDonald and Allen, 2001

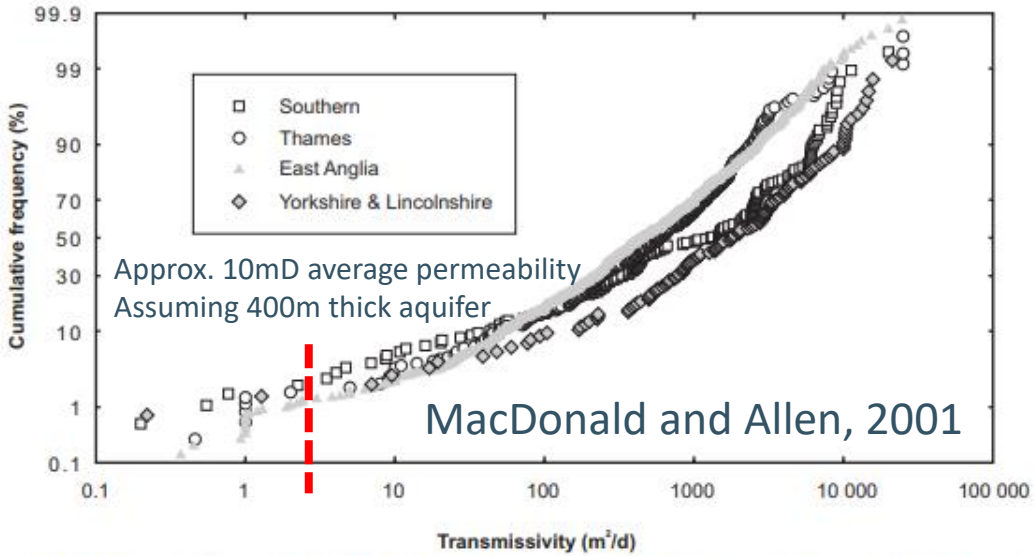
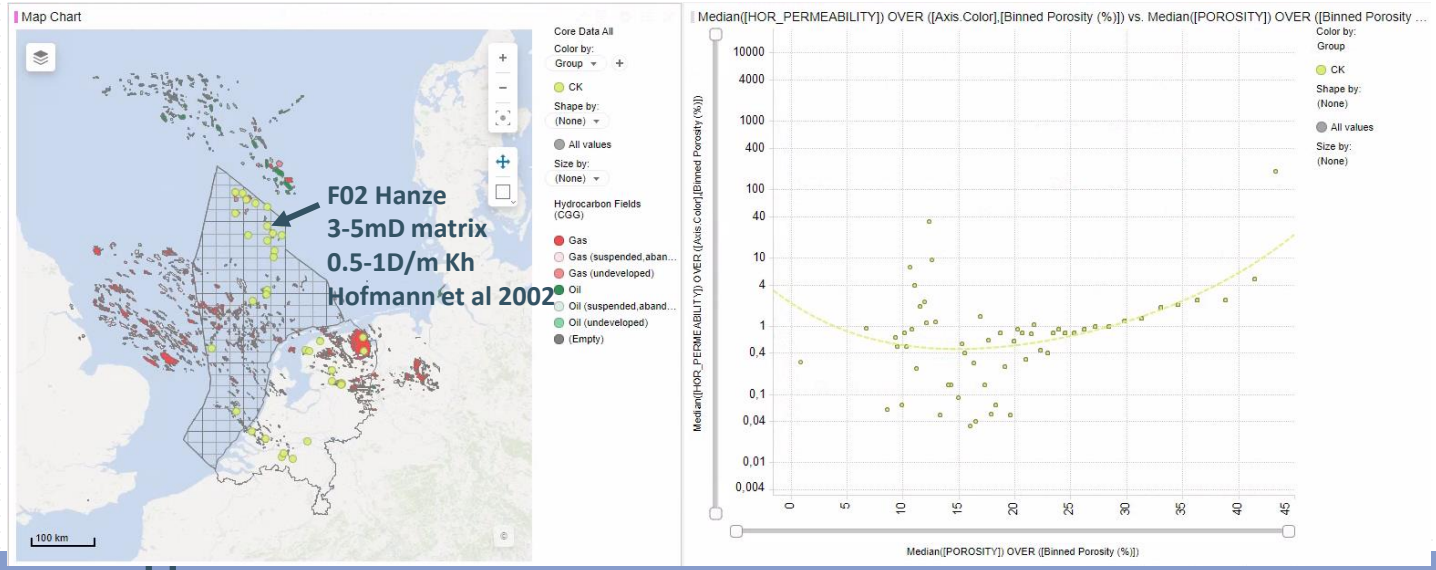


Fig. 11. Cumulative frequency distributions of transmissivity from pumping tests throughout the Chalk aquifer.



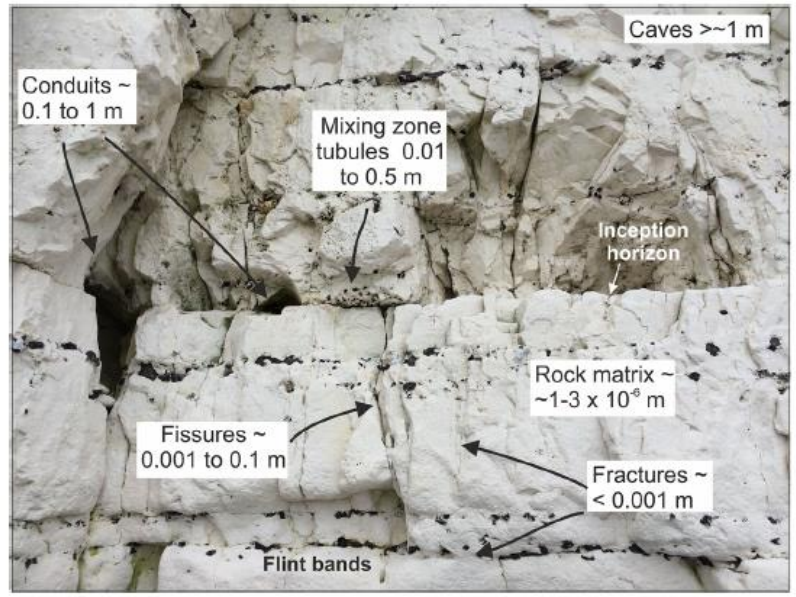


Fig. 6. Components of the Chalk aquifer.

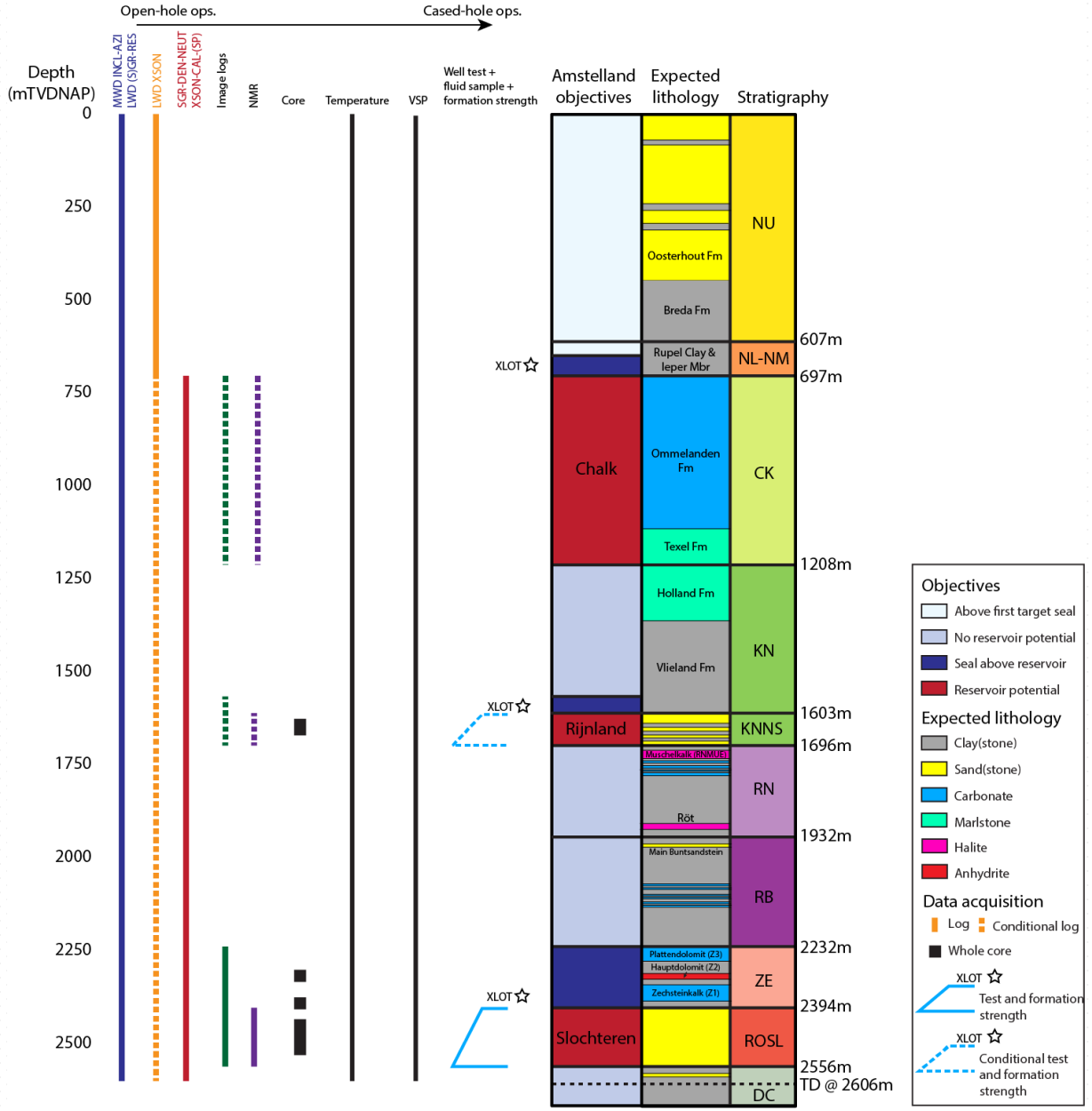
Maurice et al, 2021

Data-acquisition

Extensive data acquisition planned in Amstelland well

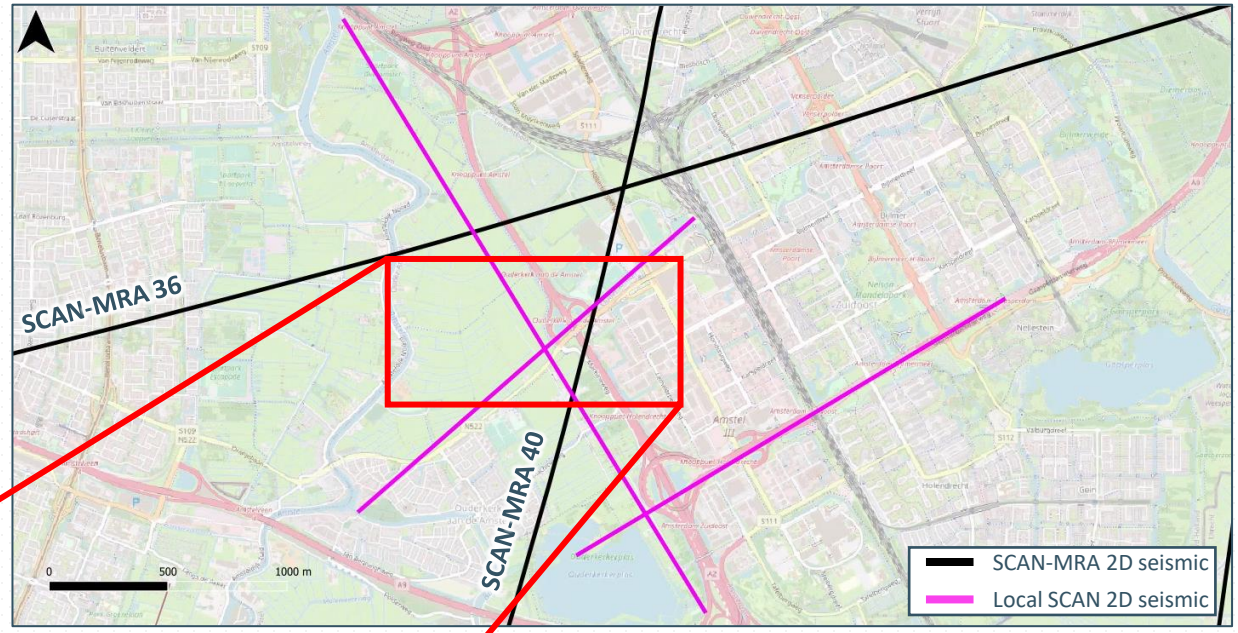
- ➜ Cores
  - ➜ Reservoirs: Porosity/permeability data
  - ➜ Reservoirs: Sedimentology and diagenesis (incl. descriptions and thin sections)
  - ➜ Geomechanical tests (note: possibly also for sealing intervals)
- ➜ Production / injection tests
  - ➜ Flow rate and transmissivity
  - ➜ Temperature, pressure 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 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

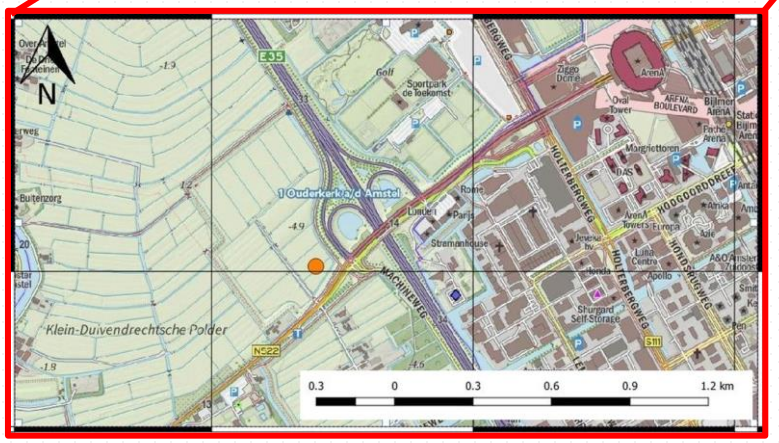
Notional data-acquisition program



Next steps

- ➜Acquisition local 2D seismic data completed in August ’22
- ➜Processing of seismic data ongoing
- ➜Permitting ongoing
- ➜Start work on site August 2023, spud Q3
- ➜All acquired data made public on scanaardwarmte.nl and nlog.nl/scan





Geothermal drilling in Leeuwarden (2021)

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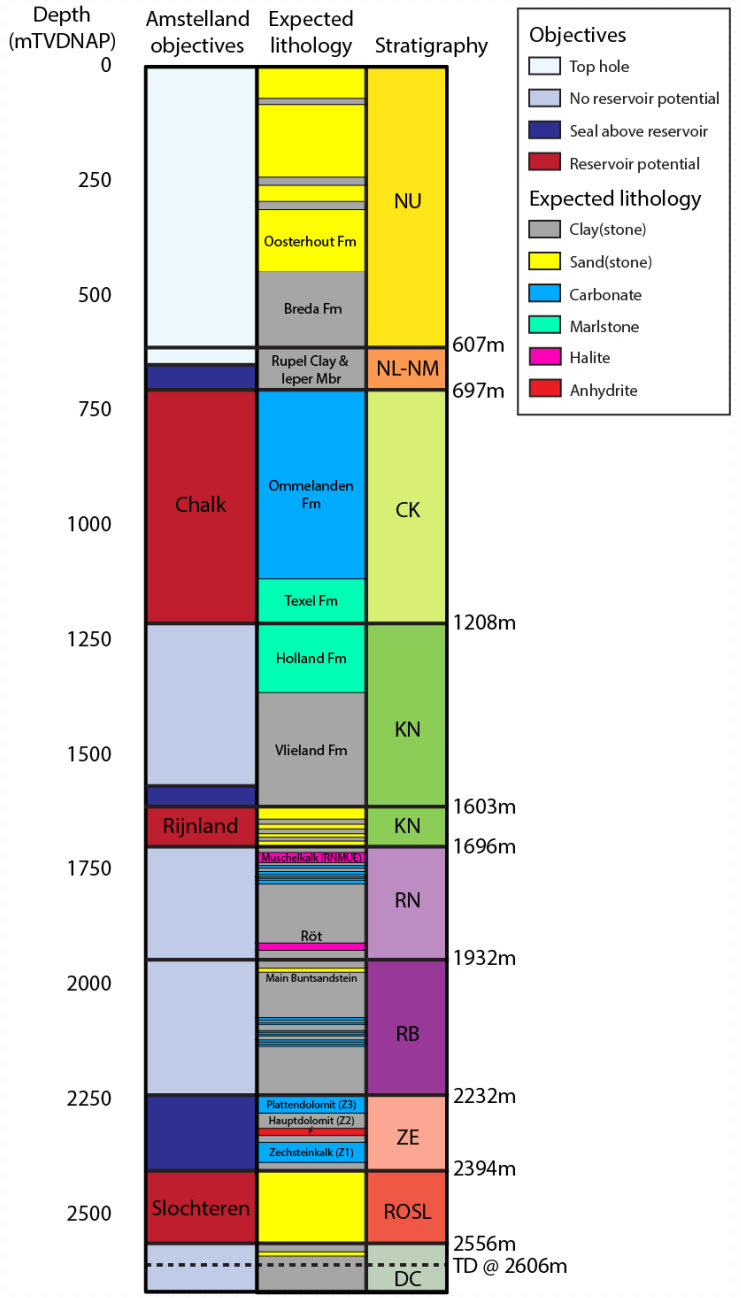

Daalsesingel 1
3511 SV Utrecht
info@scanaardwarmte.nl

www.scanaardwarmte.nl

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