4-7 NOVEMBER 2024
ROTTERDAM, THE NETHERLANDS

GET2024
GEOTHERMAL ENERGY
CONFERENCE

EXPLORING THE SHALLOW

Results of a data acquisition well in the Dutch Cenozoic succession

Milan Brussée, Marten ter Borgh & Henk van Lochem – EBN BV

Introduction to SCAN

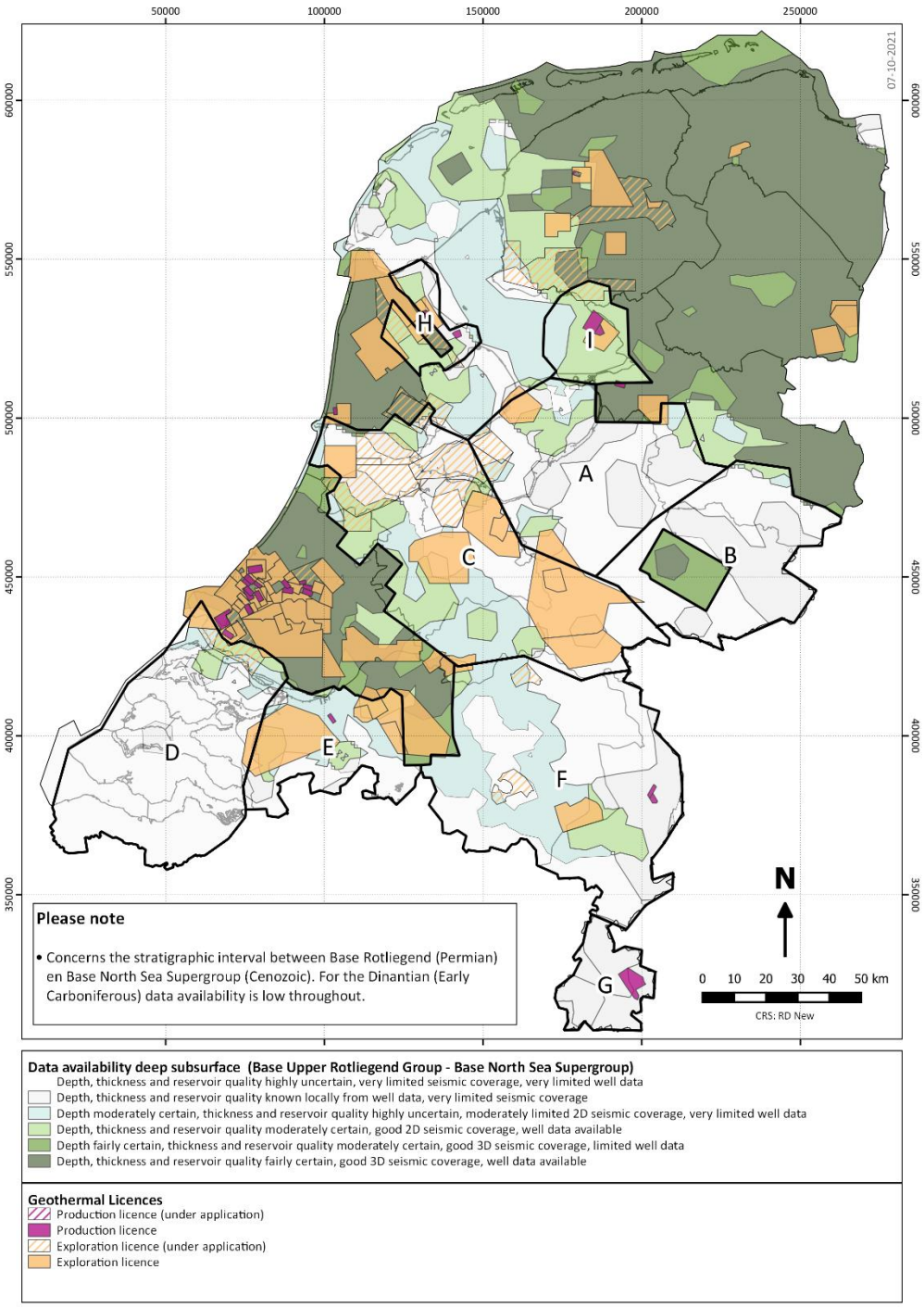
➜ SCAN stands for Seismische Campagne Aardwarmte Nederland

➜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.

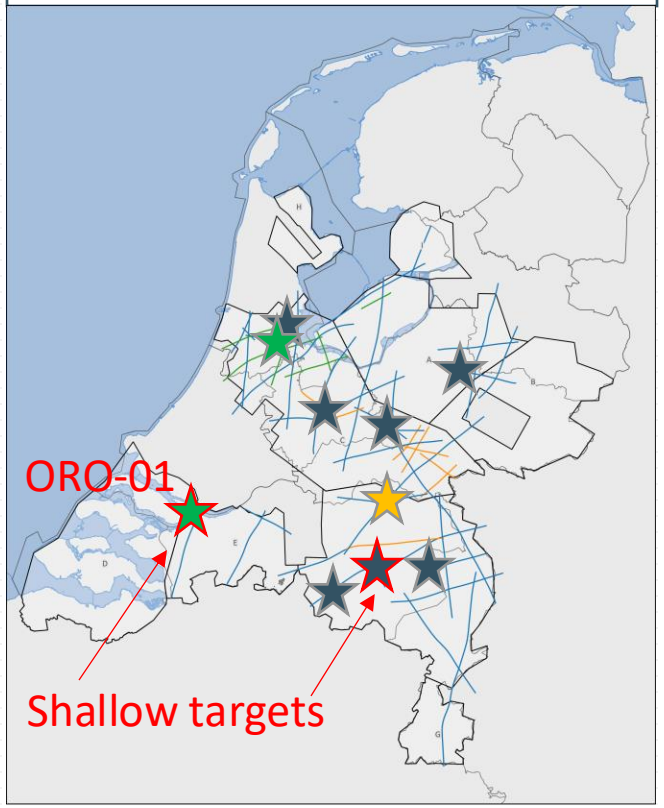


Components SCAN-program

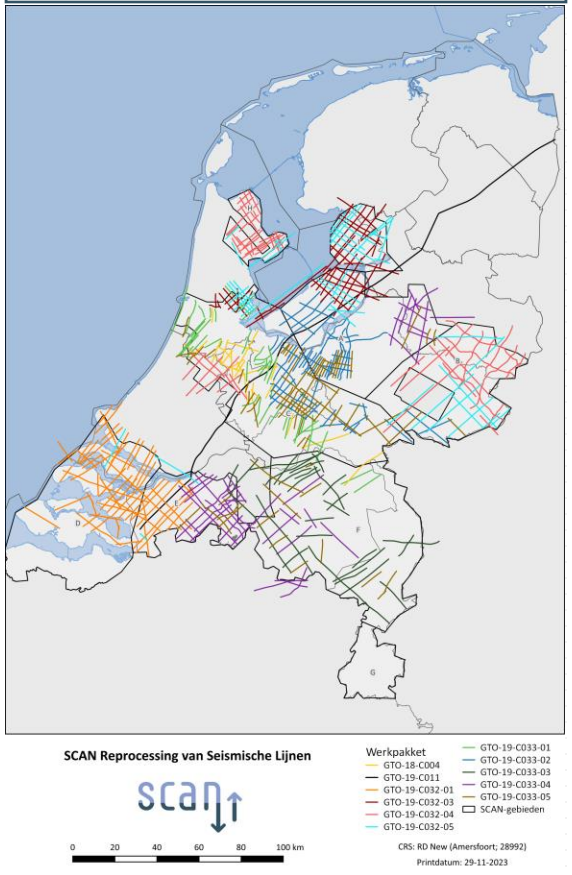
- **Acquisition 1950km new and 7500 km re-processing old 2D seismic data**
  - ✓ **Completed**
- **SCAN-drilling**
  - First two data-acquisition wells (Amstelland-01 & Oranjeoord-01) finalised and decommissioned, third well currently being drilled (Heesch-01)
  - In each of these wells extensive data acquisition on geothermal reservoirs, caprocks and overburden

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

New seismic lines



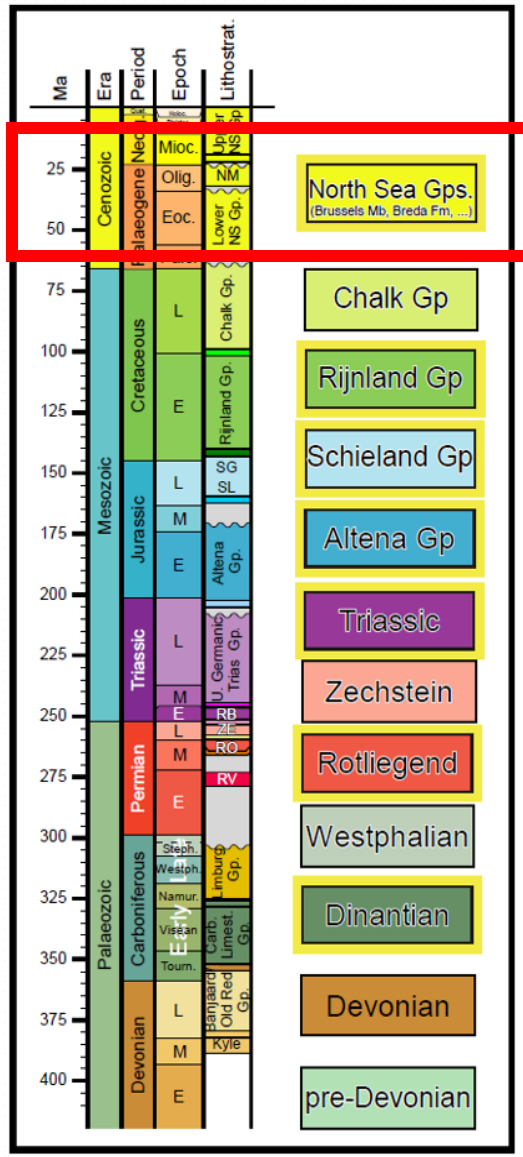
Re-processed seismic



★ Search area ★ Drilling completed ★ Drilling ongoing

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.)



✓ This presentation

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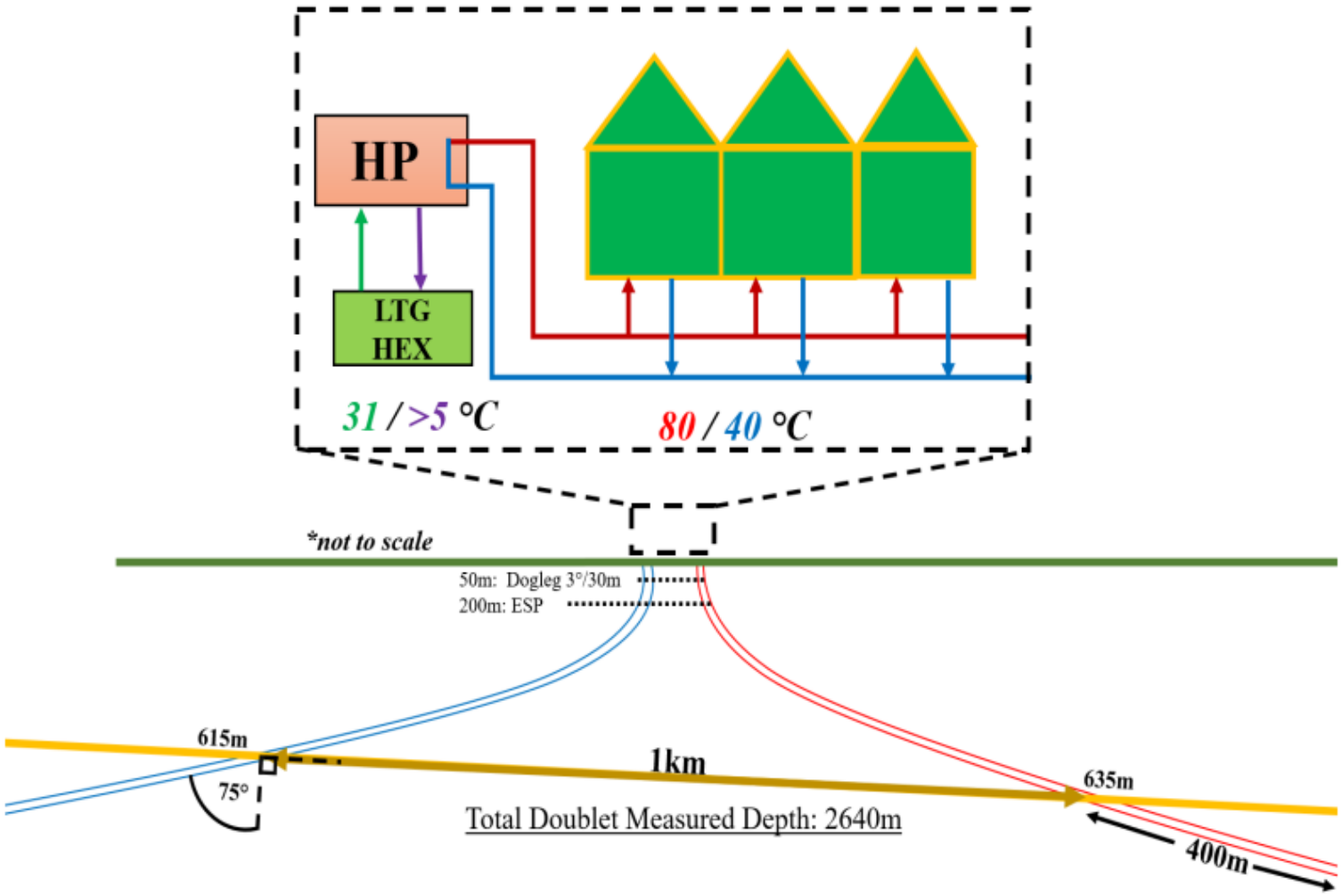
✓ Primary play

• Secondary play

Development concept shallow geothermal + heatpump



From: Rhodes, 2021

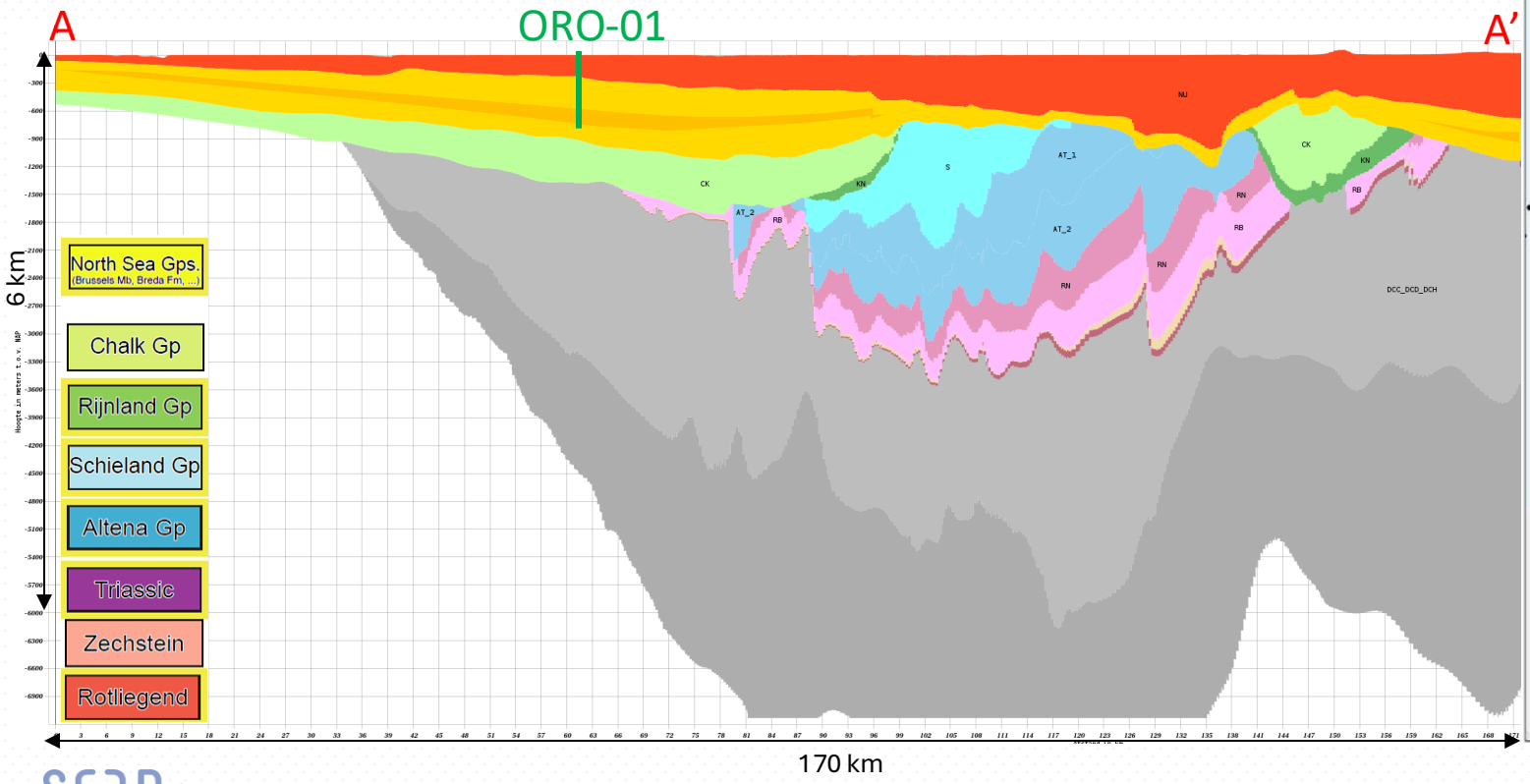
Brussels Sand Member in SW Netherlands

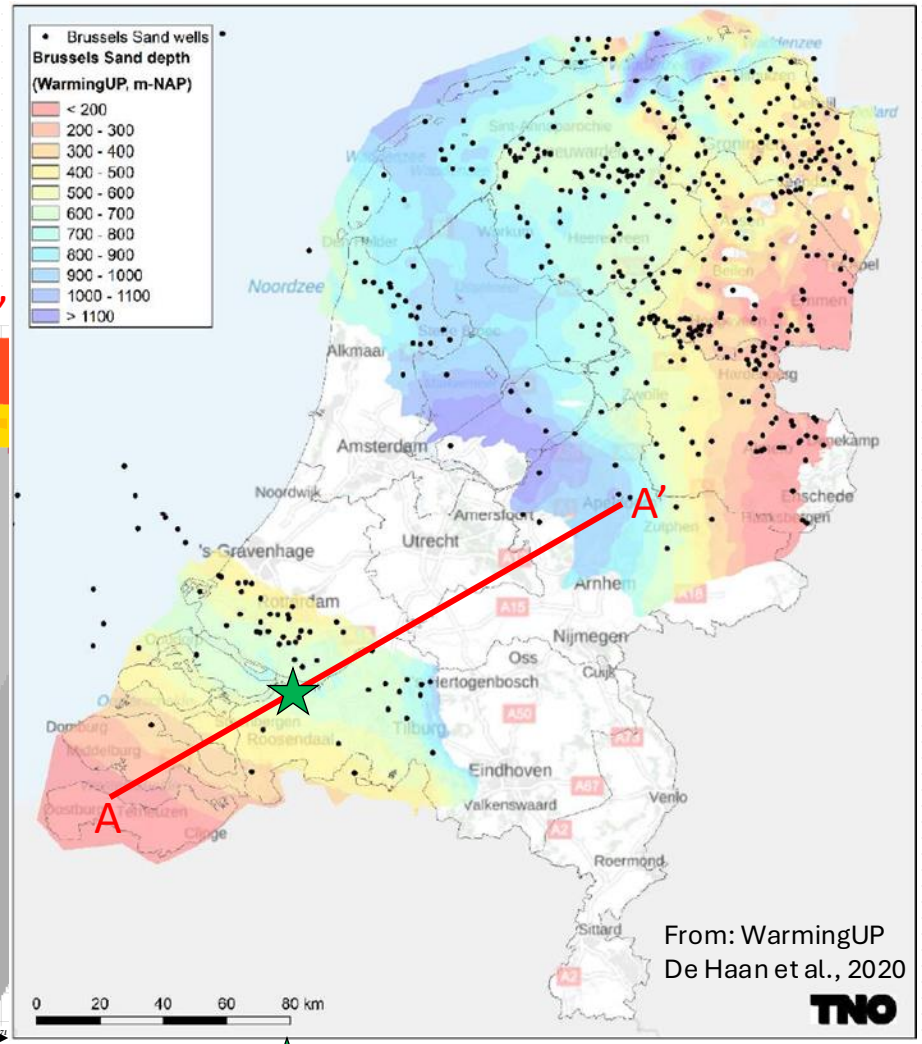
➔SCAN well Oranjeoord-01 targets Brussels Sand Member

➔In shallow subsurface <1200m in SW and NE of the Netherlands

➔One of few options for geothermal energy in SW of NL

➔Results SCAN well Oranjeoord-01 (ORO-01) relevant for large area





★ Location ORO-01

Primary target: Brussels Sand Member (NLDOBR)

➜Eocene shallow marine (poorly consolidated) sandstone

➜Interbedded with highly cemented banks

Large number of offset wells penetrate NLDOBR..

..but formation properties largely unknown/uncertain

➜Reservoir properties

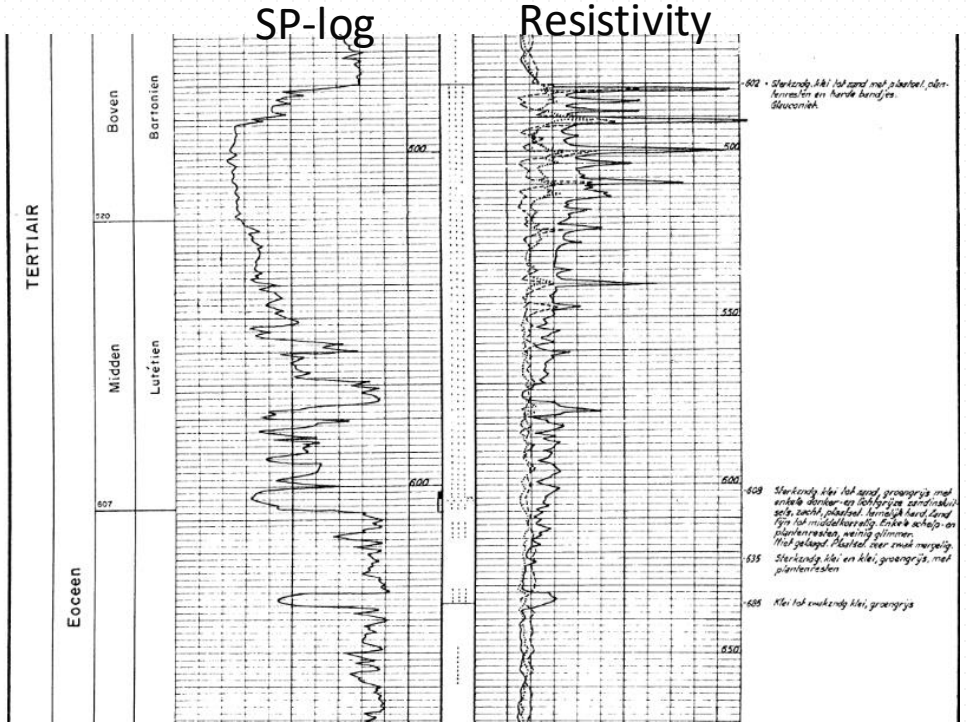
- ➜Porosity, (brine) permeability, N/G

➜Geomechanical properties

- ➜Poisson's ratio, UCS, E-modulus, thermal expansion coeff.,

➜Thermal properties

- ➜Temperature gradient, specific heat capacity, thermal conductivity



Composite Well Log of Steenbergen-01 (1949) with distinct peaks in resistivity log reflecting occurrence of cemented streaks

From: Geel et al.,2021; WarmingUP

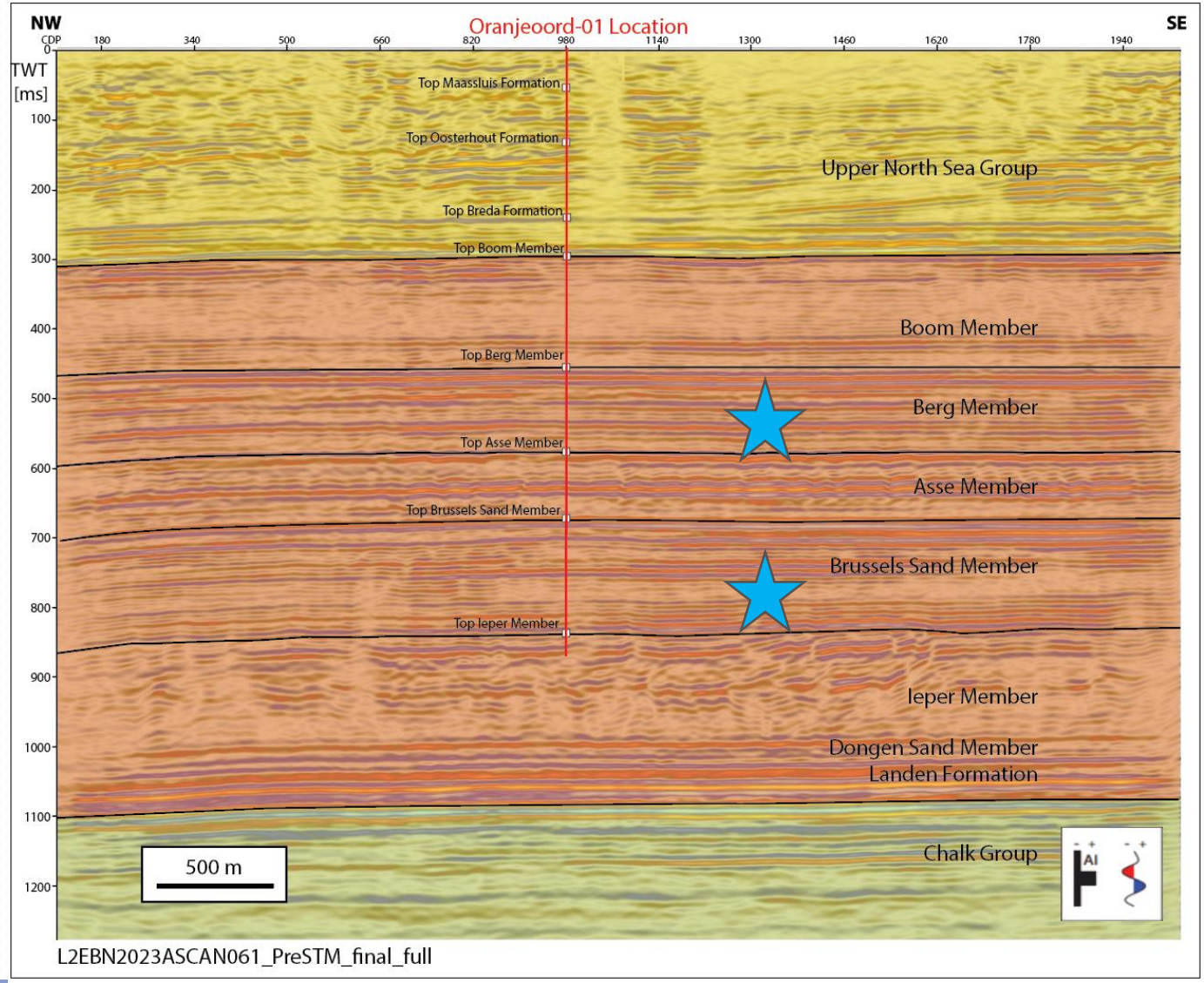
SCAN well Oranjeoord-01

www.scanaardwarmte.nl

SCAN Well Oranjeoord-01 (ORO-01)

- ➜Second SCAN data-acquisition well
- ➜Location: Heijningen, Moerdijk
- ➜Total depth: 844 mMD
- ➜Geothermal targets:
  - ➜**Primary: Eocene Brussels Sand Member**
  - ➜Secondary: Oligocene Berg Member
  - ➜Each target includes the caprock above

Oranjeoord-01
well location



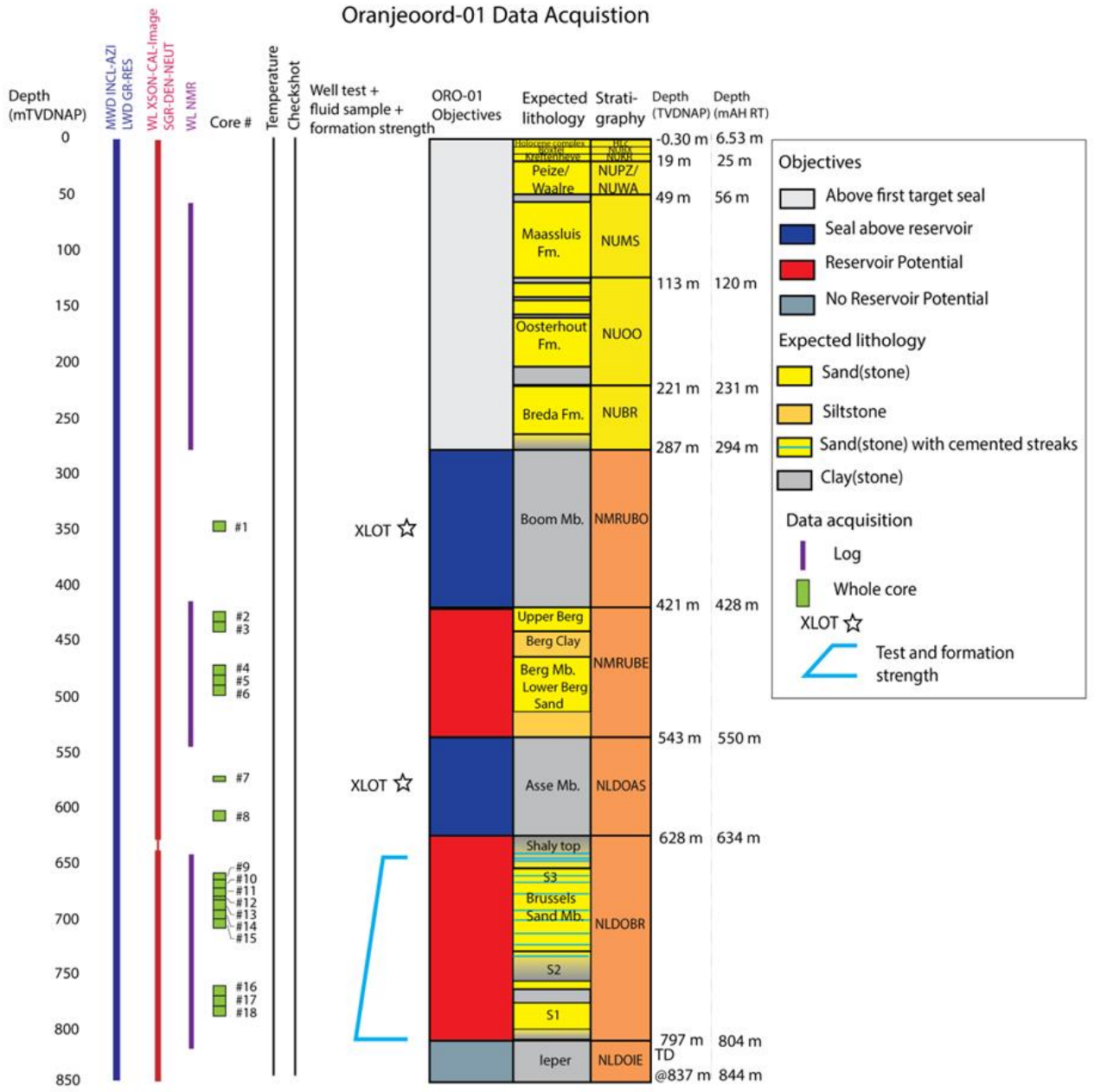
SCAN Well Oranjeoord-01 (ORO-01)

- All planned data-acquisition performed successfully:
  - All logging performed according to plan with good results.
  - 18 cores, total 133,8 m cored, recovered 122,9 m
  - Production-& injection test with 1000m^3 formation water
  - 2 Extended Leak-off Tests (XLOT) for in-situ stress conditions successfully concluded.
  - Checkshot survey performed
- Operations (including decommissioning) concluded on 20 May. Rig off location on 25 May.
- First data publicly available.

Key results

- ➔Primary target Brussels Sand Member
  - ➔159 mAH thickness
  - ➔Average porosity ~35%
  - ➔Pre-liminary results core analysis on 16 plugs show high permeabilities
    - ➔ 700 – 3000 mD Gas permeabilities
    - ➔ 200 – 1700 mD Brine permeabilities
  - ➔Permeable reservoir:

  Transmissivity (K*H) from well test ~ 22 Dm
  - ➔Formation temperature ~ 31°C
- ➔Secondary target Berg Member:
  - ➔119 mAH thickness
  - ➔High porosities, but first indications core plug measurements show low to medium permeabilities



Core analysis (1/2)

- ➜122.9 meter core recovered
  - ➜ Boom Mb (Seal - 9m)
  - ➜ Berg Mb (reservoir - 45 m)
  - ➜ Asse Mb(seal – 11m)
  - ➜ Brussels Sand Mb (reservoir – 58m)
- ➜ Preserved sections selected for future analysis
- ➜ Core Analysis [In progress]
  - ➜ RCA: Ambient helium poro-perm (H and V); Klinkenberg poro-perm @ overburden stress
  - ➜ SCAL: FRF and "m", brine permeability, HPMI, NMR
  - ➜ Geomechanics: single-stage tri-axial tests, thermal expansion coefficients
  - ➜ Sedimentology, petrography, SEM, BSEM
- ➜All core material to be stored at TNO after analysis finalised

Brussels Sand Member
(Cemented bank)

Brussels Sand Member

Core analysis (2/2)

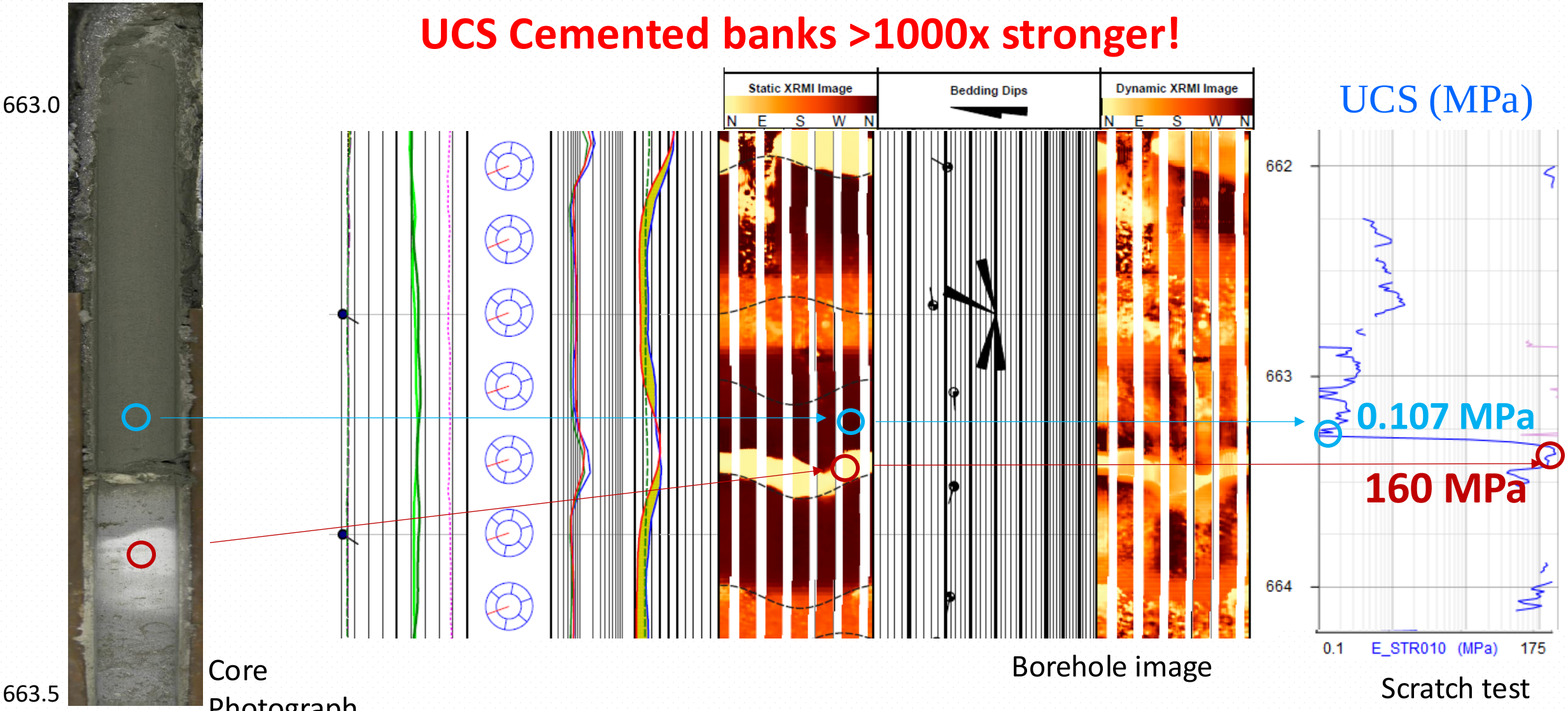
[Finished]

- ➜CoreDNA results available
  - ➜Probe permeability
  - ➜Grain size analysis
  - ➜Core photographs
  - ➜Rock strength measurement (scratch test)
  - ➜XRF
- ➜Thermal properties
  - ➜Thermal conductivity
  - ➜Specific Heat capacity
- ➜Microbial and formation water analysis
  - ➜Microbial analysis
  - ➜Formation fluid analysis

Scratch test

Example Scratch test: *Cemented Bank in Brussels*

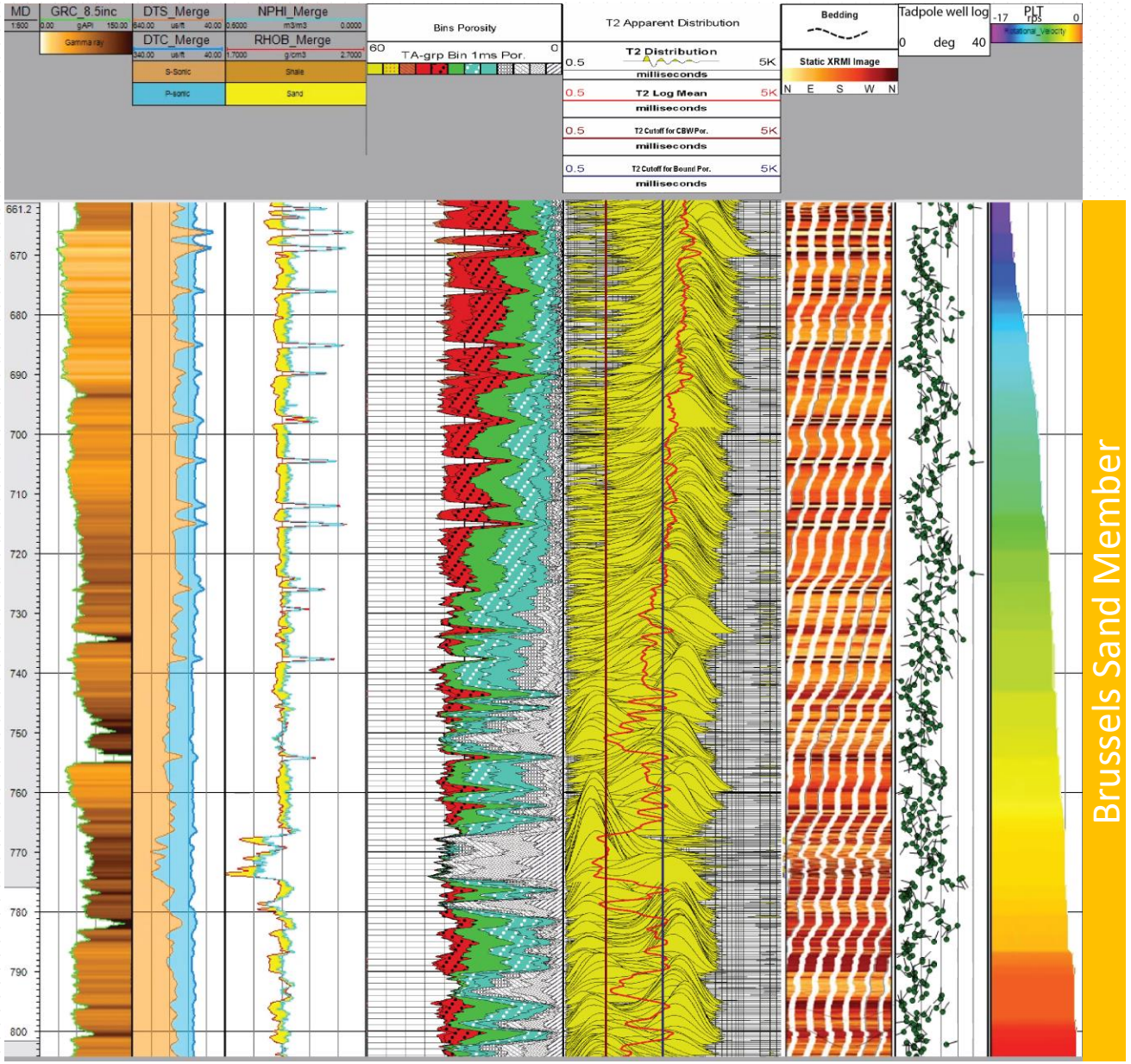
UCS Cemented banks >1000x stronger!



Well log data

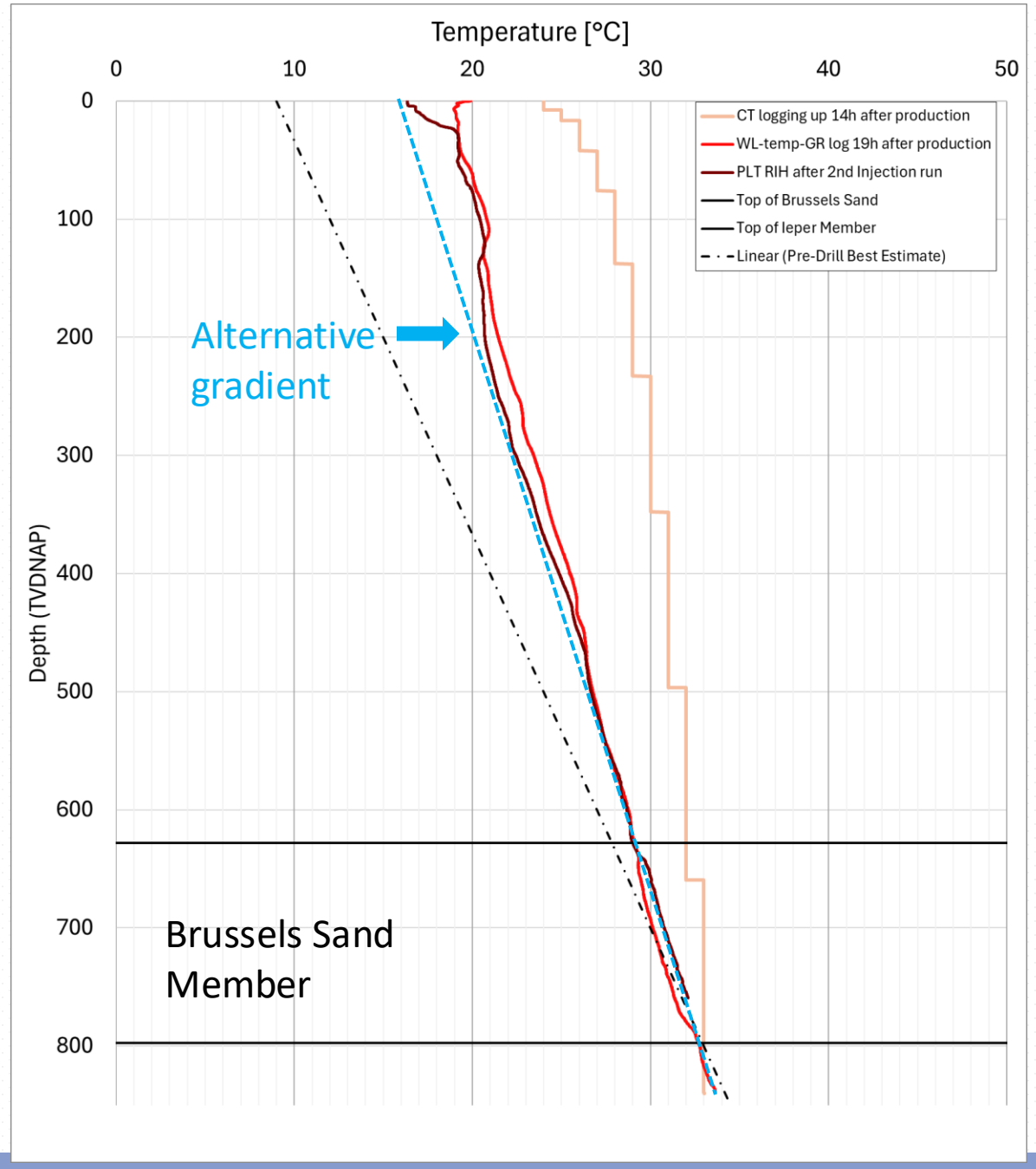
Extensive well log dataset available

- ➜Whole well
  - ➜Spectral Gamma ray
  - ➜Shear & compressional sonic
  - ➜Bulk density & Neutron log
  - ➜Borehole Image
- ➜Reservoirs
  - ➜NMR [calibration on core in progress]
- ➜Tested reservoir
  - ➜Production logging tool



Temperature

- ➜31°C mid reservoir temperature Brussels Sand Member
- ➜Temperature gradient in reservoir ~30°C /km
- ➜Measured temperature gradient in overburden lower (~20°C /km)
- ➜But… measured borehole temperature strongly dependent on well operations:
  - ➜E.g. heated by produced formation water
  - ➜e.g. cooled by mud circulation or cold pipe



Data on NLOG.nl

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Boring ORANJEOORD-01

Identificatie:	ORO-01
Locatie:	51.66392107, 4.41983567 (WGS84)
Aangeleverde locatie:	88072.966, 408789.714 (RD)

Basisgegevens | Deviatie | Documenten | Lithostratigrafie | Monsters | Kernmetingen | Productiecijfers | Logs LIS/LAS

Boring ORANJEOORD-01

Categorie	Document
Boorgat/Put - Eindrapport	SodM EOWR(27 Jun 2024)
Documenten met boorgatmetingen	12.25in_Run1.1.1_AST_SemblanceAnalysis(25-837)(23 Apr 2024) 12.25in_Run1.1.1_XRMI_DIP_INTERPRETATION(63-636)(10 May 2024) 12.25in_Run1.2.1_DSN-SDLT(13-637)(23 Apr 2024) 8.5in_Run2.1.2_AST_SemblanceAnalysis(48-829)(05 Jul 2024) 8.5in_Run2.1.2_AST(640-828)(04 May 2024) 8.5in_Run2.1.2_CALIPER(640-839)(04 May 2024) 8.5in_Run2.1.2_XRMI_PROC_STAT_DYNAM_IMAGE(639-841)(12 May 2024) 8.5in_Run2.2.1_CSNG(640-834)(05 May 2024) CH_Run3.1.1_GR-TEMP-PROFILE LOG(0-839)(11 May 2024) CH_Run3.3.1_INJECTION_PLT(640-820)(11 May 2024) Daily Time Logs zip(06 May 2024) Drilling Evaluation Log(65-844)(24 May 2024) Formation Evaluation Log(65-844)(24 May 2024) Gas Evaluation Log(65-844)(24 May 2024) Pressure Evaluation Log(65-844)(24 May 2024)

Link naar deze pagina: https://www.nlog.nl/nlog-mapviewer/brh/3910793071?lang=nl

Overview of status of deliverables at https://scanaardwarmte.nl/locatie-heijningen/

Take home messages

Brussels Sand Member shows high potential for geothermal energy

Large dataset available for shallow geothermal reservoirs and caprocks

More data to be published soon

THANK YOU