# Workshop SCAN wells
# De Bilt, Ede and Amsterdam
(BLT-01, EDE-01 and ASD-01)

Utrecht, 25-03-2025

Ministerie van Klimaat en Groene Groei

ebn

TNO

# Agenda

| | |
|---|---|
| Welcome, speakers & introduction | Gitta Zaalberg |
| Update on SCAN well campaign | Marten ter Borgh |
| Why De Bilt, Ede and Amsterdam? | Marten ter Borgh |
| Operational lessons | Adriaan Janszen |
| Data Acquisition related to operational constraints | Adriaan Janszen |
| Sedimentology: how was the reservoir deposited? | Sven McCarthy, PanTerra |
| What happened to the reservoir after deposition? | Dallyn Rodriguez, PanTerra |
| How does the reservoir perform? \| Core viewing | Pieter Bruijnen, Sanchita Ganguly & Adriaan Janszen |
| Ede-01 Vlieland Sandstone& Zechstein | Adriaan Janszen |
| Take-home messages& way forward | Marten ter Borgh |
| SCAN: a look back and going forward | Gitta Zaalberg |

# Introduction

Gitta Zaalberg

# EBN - State Energy Company of the Netherlands

To supply the Netherlands with reliable, affordable and sustainable energy

## Societal drivers

### Towards a sustainable energy system

We are working to create a CO2-neutral, integrated system.

### Security of energy Supply

Within the transition process, we want to ensure that the system can cope with any uncertainties that arise during the transition.

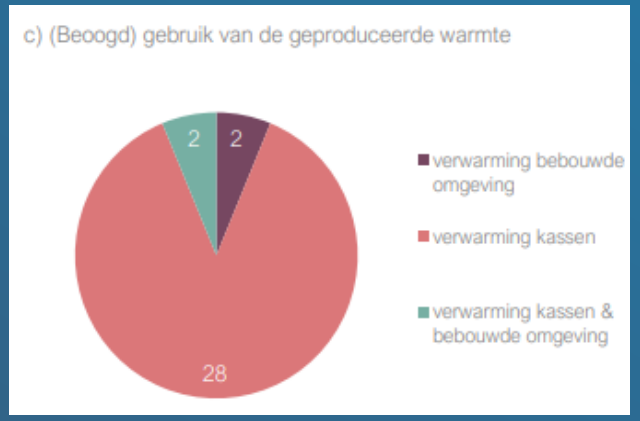
### Social value creation

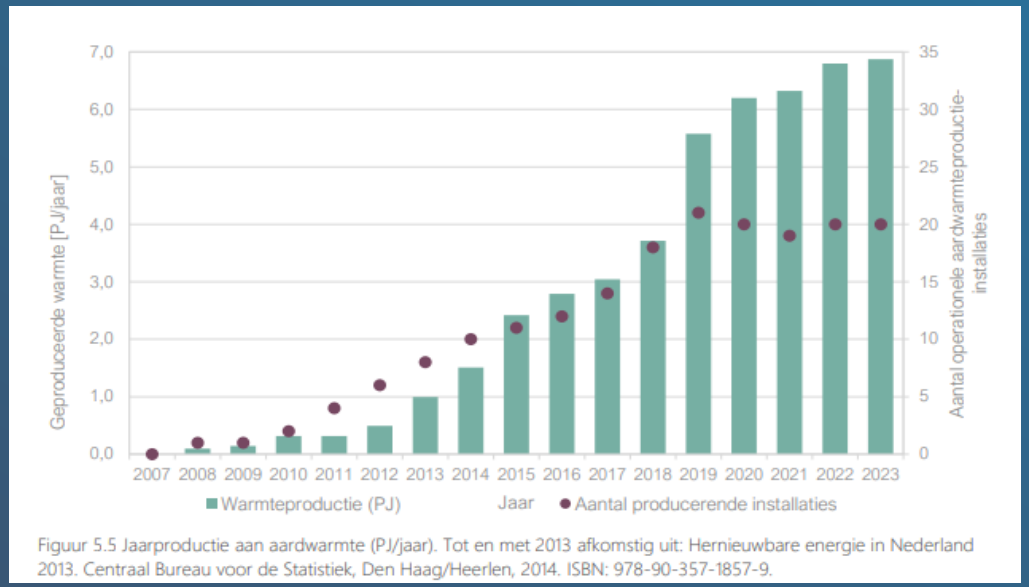
We want to contribute to a fair transition, together with and on behalf of society as a whole.

# Geothermal Energy

## High potential in The Netherlands

- Geothermal energy is a reliable and low-carbon emitting heat source with high COP
- Ambition of Ministry of KGG is connecting 3 mln households to district heating networks (currently 0,5 mln households)
- Geothermal energy for greenhouses is currently being developed quite successfully
- However the growth in geothermal projects has been stagnant for the last 4 years



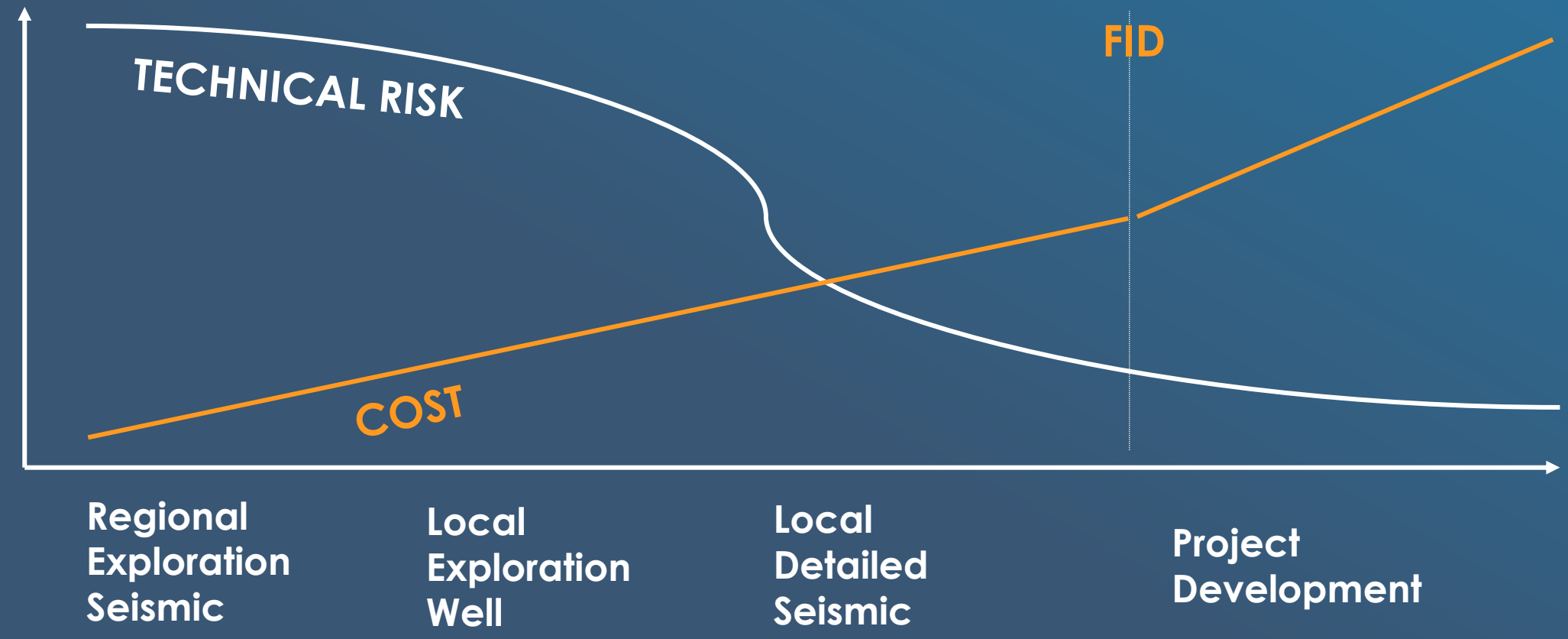




Figuur 5.5 Jaarproductie aan aardwarmte (PJ/jaar). Tot en met 2013 afkomstig uit: Hernieuwbare energie in Nederland 2013. Centraal Bureau voor de Statistiek, Den Haag/Heerlen, 2014. ISBN: 978-90-357-1857-9.

*Source: Voorpublicatie H5 Delfstoffen en aardwarmte in Nederland, Jaarverslag 2023, TNO-AGE voor KGG*

# Subsurface risks vs costs

In unknown areas ~50% of all project costs are spent during the exploration phase at de-risking the subsurface (and the outcome can be negative)

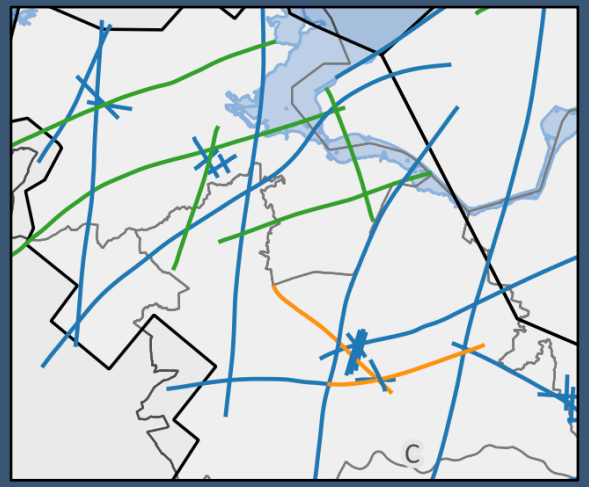


# The SCAN Program: de-risking the Subsurface

Objective: gather data and knowledge of the subsurface in areas with data-scarcity to accelerate development of geothermal heat in The Netherlands

## SCAN 1&2

**SCAN Regional 2D seismic surveys**

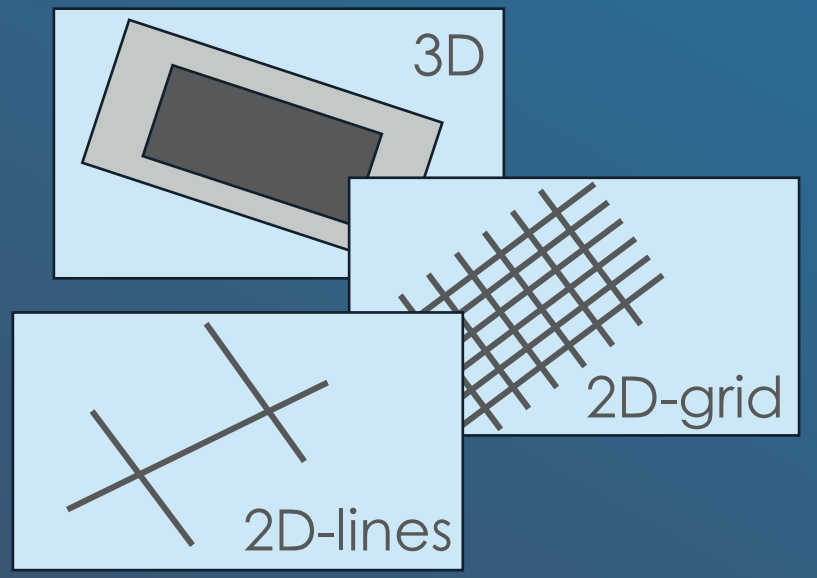


## SCAN 3

**SCAN Research & Exploration Drilling Campaign**

## SCAN 4

**SCAN detailed seismic surveys**

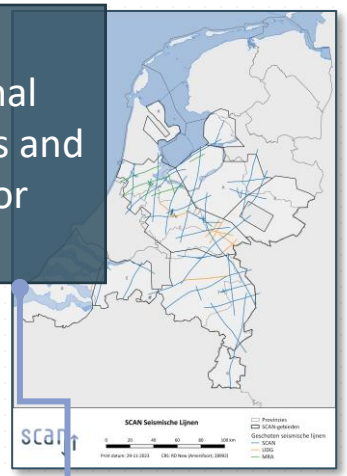


# SCAN project phases and activities

Project Proposal

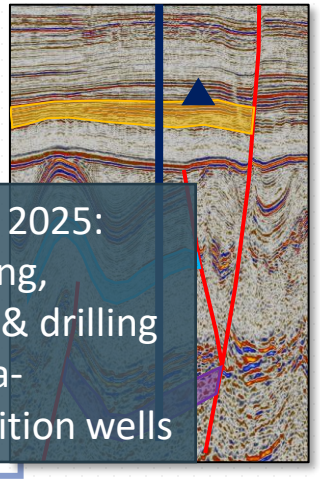
Seismic Funded

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



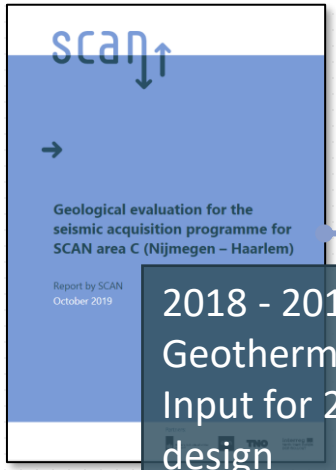

Wells Funded

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



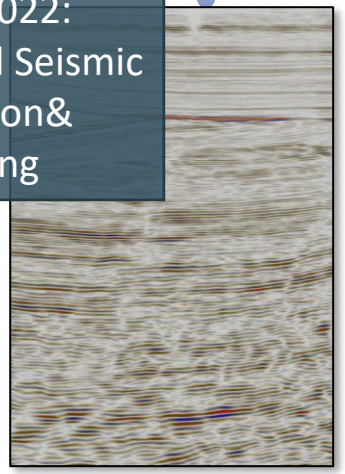
Additional 3D and 2D Seismic Acquisition Funded

2017 2018 2019 2020 2021 2022 2023 2024 2025 2026

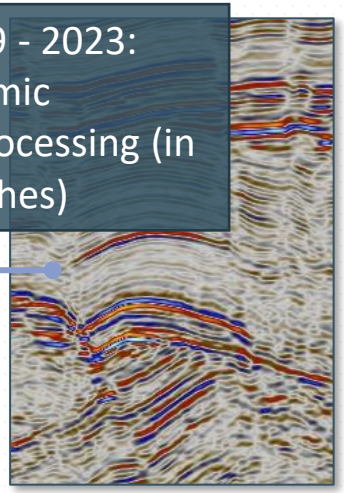



2018 - 2019: Geothermal play analysis. Input for 2D seismic survey design

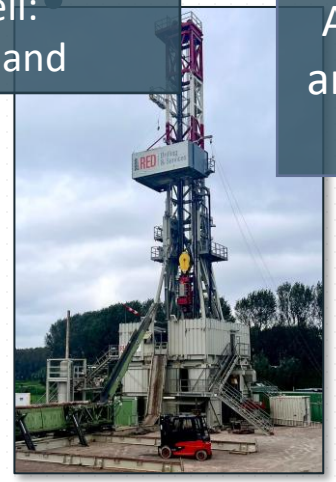
2019 - 2022: Regional Seismic acquisition& processing



2019 - 2023: Seismic reprocessing (in batches)



First well: Amstelland



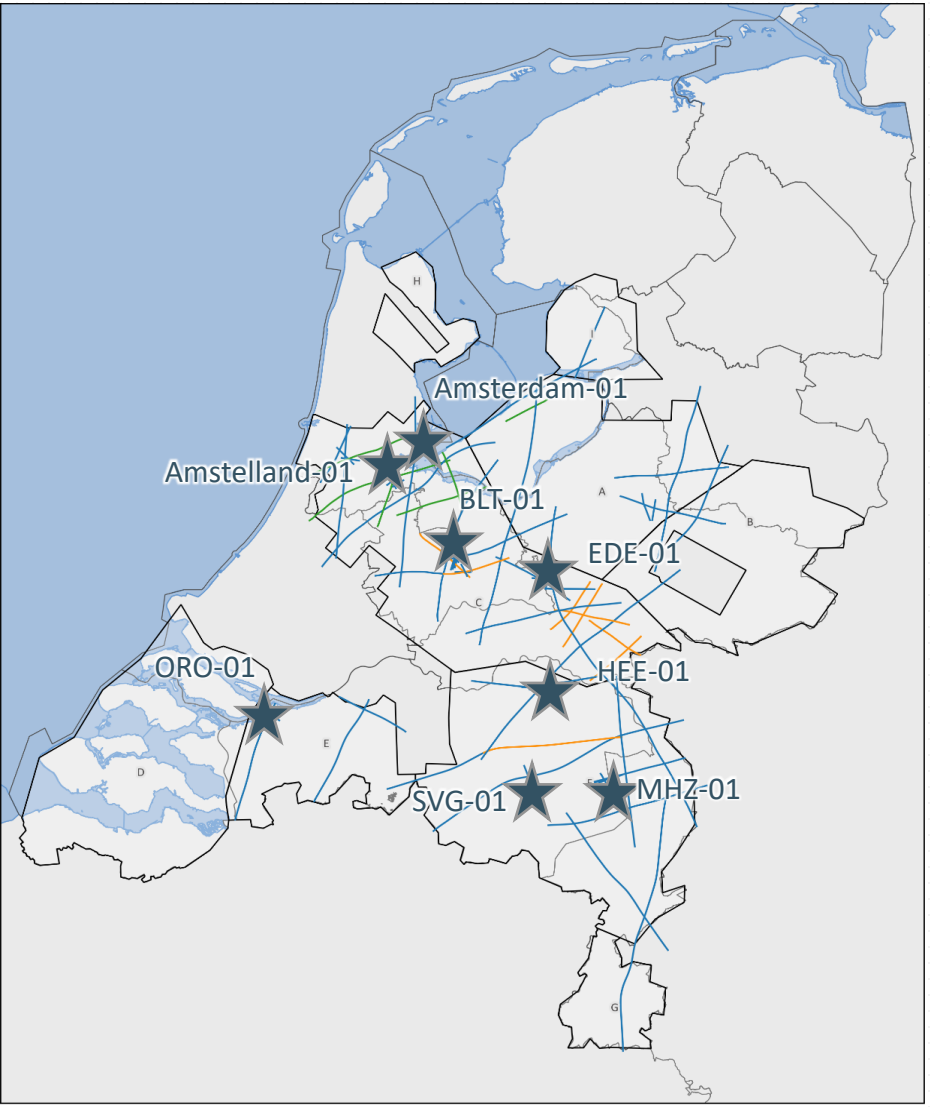
Additional 3D and 2D Seismic Acquisition

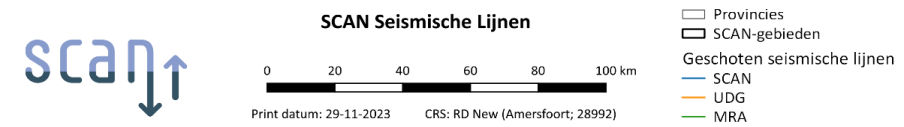
scan

# Update on SCAN well campaign

Marten ter Borgh

# SCAN Wells& Targets




| Well | SCAN Search Area (Well) | Primary objective | Secondary objective(s) |
|---|---|---|---|
| AMS-01 | Amstelland (Amstelland-01) | Rotliegend (Permian) | Chalk, Vlieland (E. Cret) |
| BLT-01 | Utrecht (De Bilt-01) | Rotliegend (Permian) | Triassic, Vlieland (E. Cret.), Chalk |
| EDE-01 | Ede-Veenendaal (Ede-01) | Rotliegend (Permian) | Vlieland (E. Cret), Zechstein (Permian) |
| ASD-01 | Amsterdam-Diemen-Almere (Amsterdam-01) | Rotliegend (Permian) | North Sea (Neogene) |
| HEE-01 | Oss (Heesch-01) | Triassic | Vlieland, Rotliegend, Cret. (Vaals Fm) |
| MHZ-01 | Deurne (Milheeze-01) | Triassic | Chalk Gp |
| SVG-01 | Eindhoven (Stad van Gerwen-01) | Breda Subgp (Neogene) | Middle North Sea Gp (Paleogene) |
| ORO-01 | West-Brabant Noord (Oranjeoord-01) | Lower North Sea (Paleogene) | Middle North Sea Gp (Paleogene) |

➜ SCAN Well Campaign Complete!

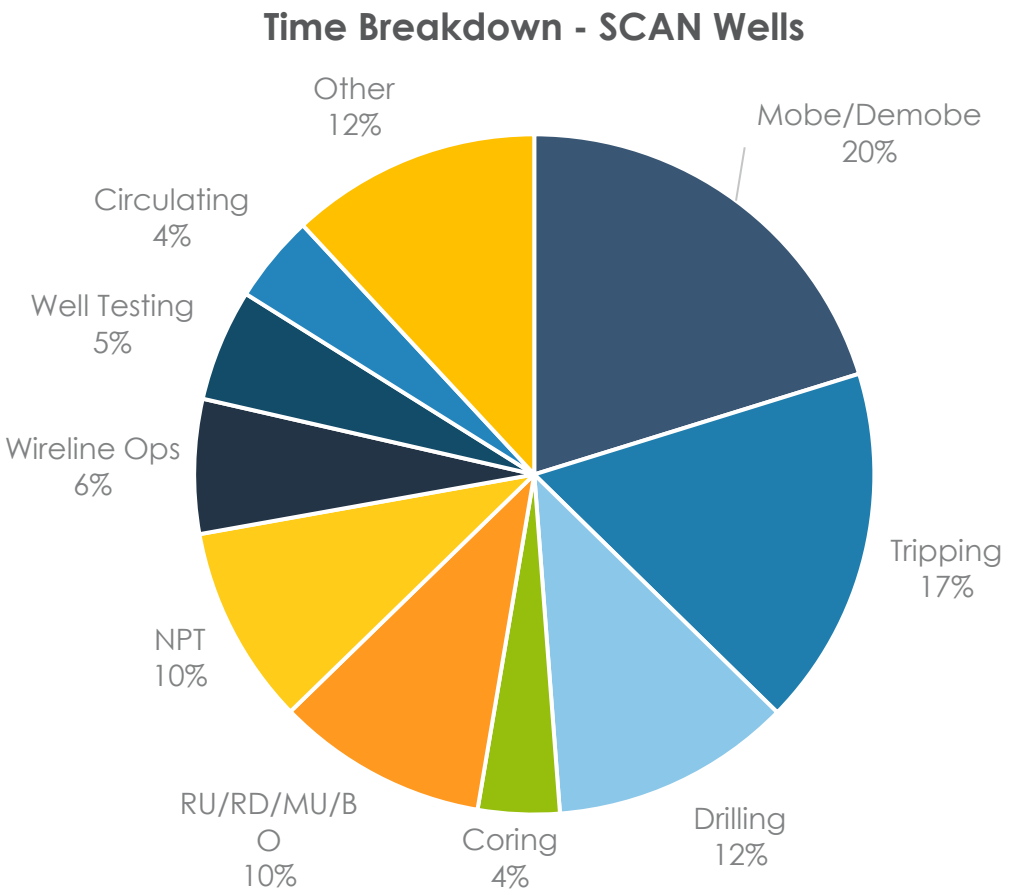
➜ 8 Wells drilled, logged& tested

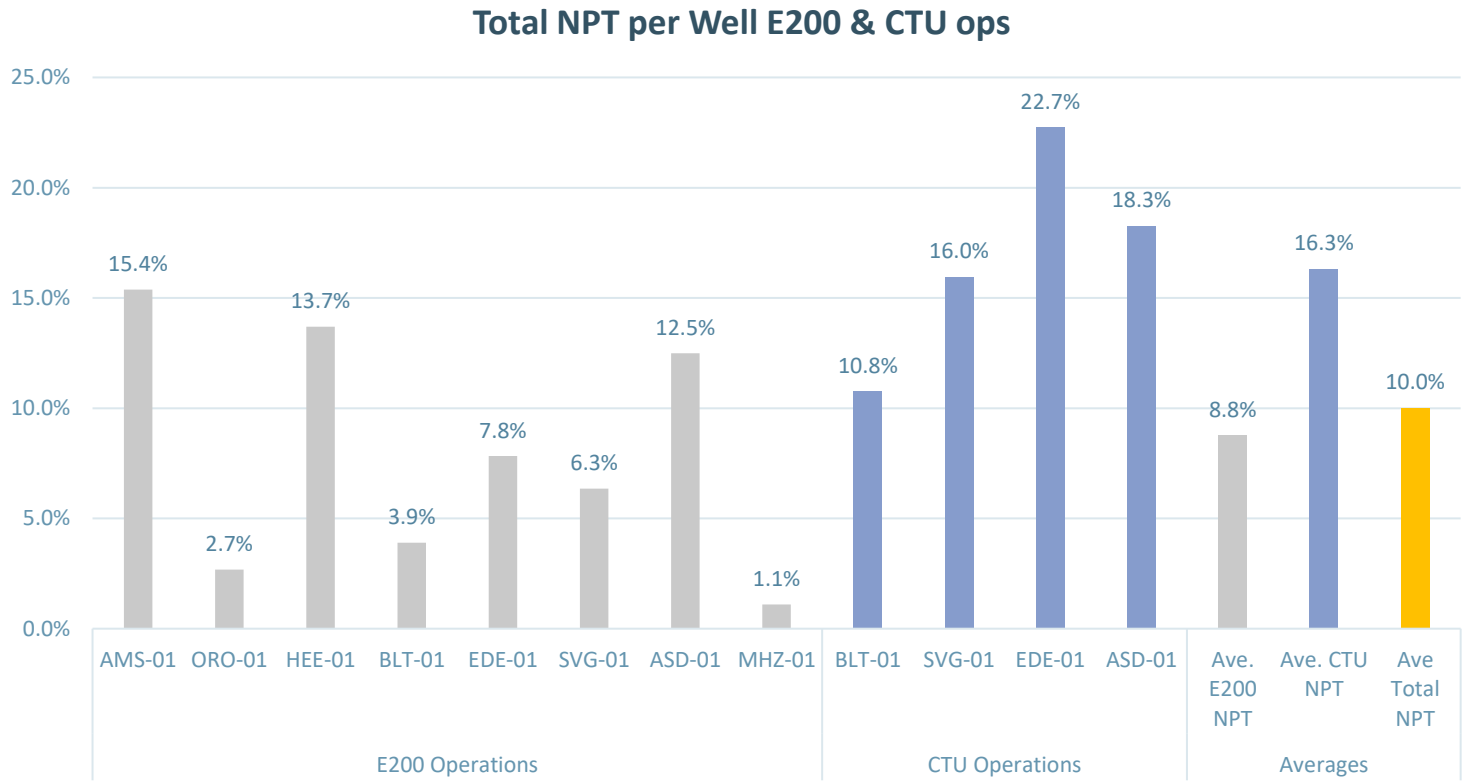
➜ **Please note: don't confuse Amstelland-01 (AMS-01, 2023) with Amsterdam-01 (ASD-01, 2025)**

# SCAN Well Campaign: Facts and Figures

➔0 LTIs, 503,4 days operational, 14.567 m drilled, only 10% NPT

➔Wireline, Well Testing& Coring together make up only 15% of time spent

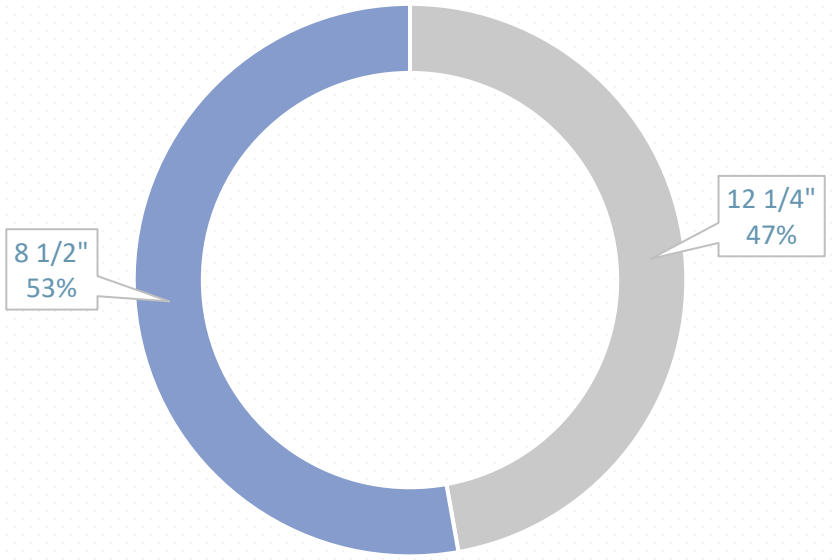


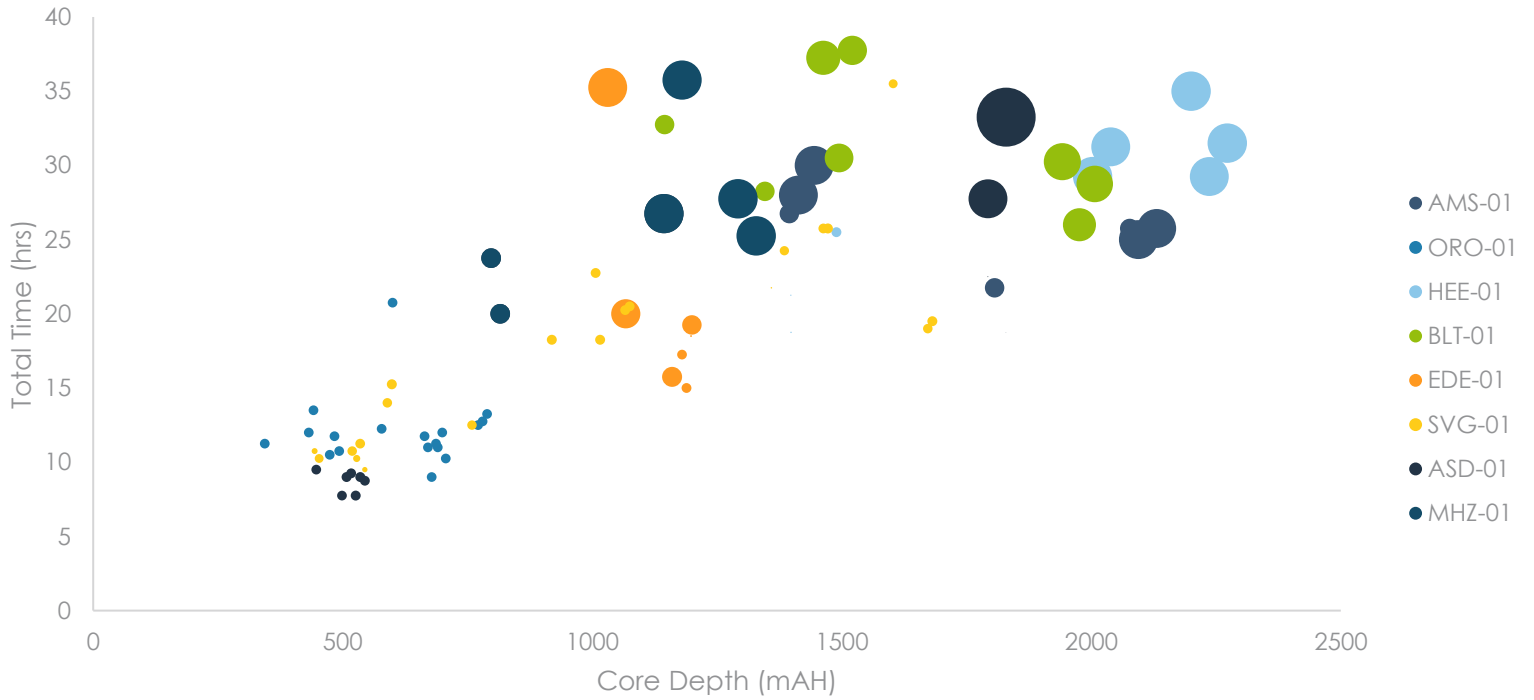
# Coring Summary

| No.of Coring Runs | Total Recovery | Best Recovery | Successful Runs | Stratigraphy |
|---|---|---|---|---|
| 89 | 1346m (95%) | 54.63m (ASD-01) | 82/89 | 25 different units |

Core Size Comparison by Runs




Coring Duration vs Depth vs Core Length



# How do results compare to pre-drill expectations?

➜For each geothermal target interval in a well, an estimate was made of the geological chance of success. Geological success is defined as the presence of a permeable layer. Geological success does not yet imply economic success.

➜An example: The Ede well had two targets: the Slochteren (76% chance of a permeable reservoir) and the Vlieland Sandstone (30% chance). The expected number of permeable layers to be encountered in this well is 0.76 + 0.30 = 1.06.

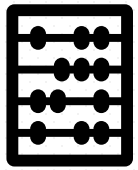
**8**

**SCAN wells drilled**

**29**

**Potentially permeable targets tested**

**15,3**



**Pre-drill expectation of permeable targets**

**16**

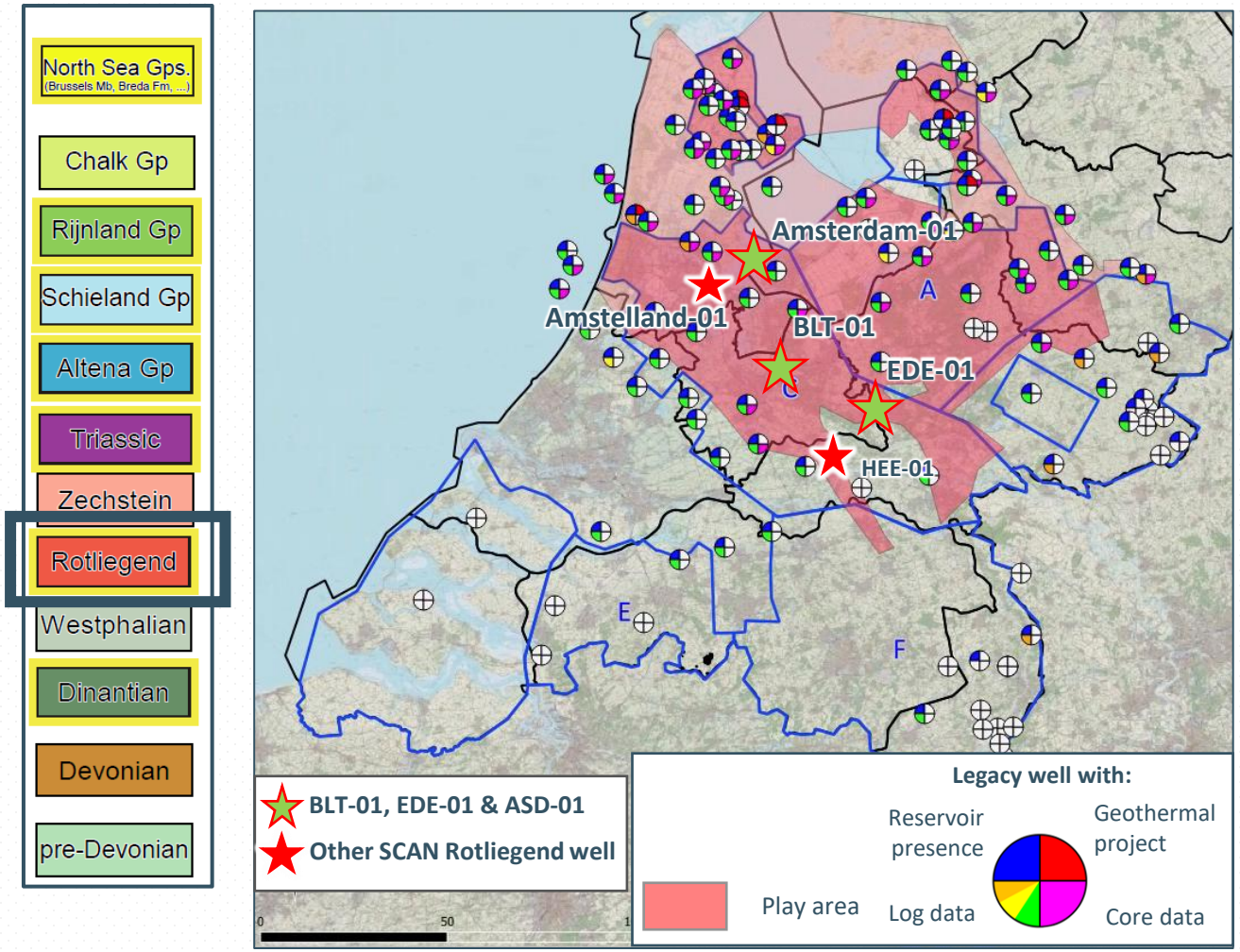
**Permeable targets found**

# Why De Bilt, Ede and Amsterdam?

Why drill wells here?

- Play analysis
- Well objectives
- Wells on seismic

# Play-Based Exploration for Geothermal




➜Central Netherlands is an area with major heat demand. Together, the SCAN wells discussed in this workshop help derisk southern North Holland, Utrecht, Flevoland and western Gelderland

➜Play-Based Exploration forms the basis for SCAN. All plays were mapped and assessed based on existing data and regional knowledge

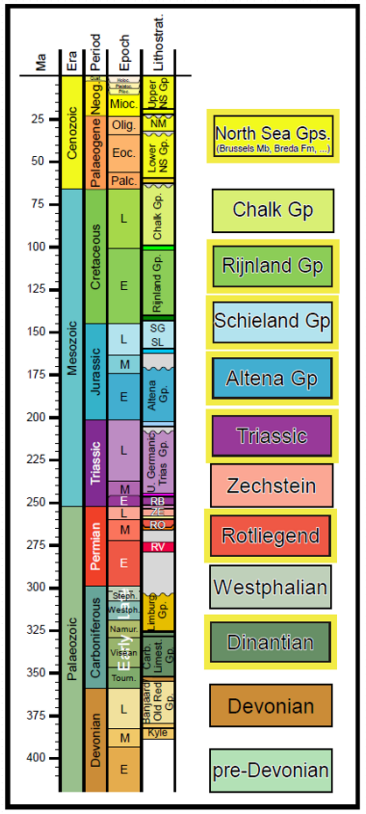
➜Conclusion for Central Netherlands: Rotliegend Slochteren Fm primary target

➜Data acquisition also focused on secondary geothermal targets: see next slide

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

# Objectives of De Bilt-01, Ede-01 & Amsterdam-01

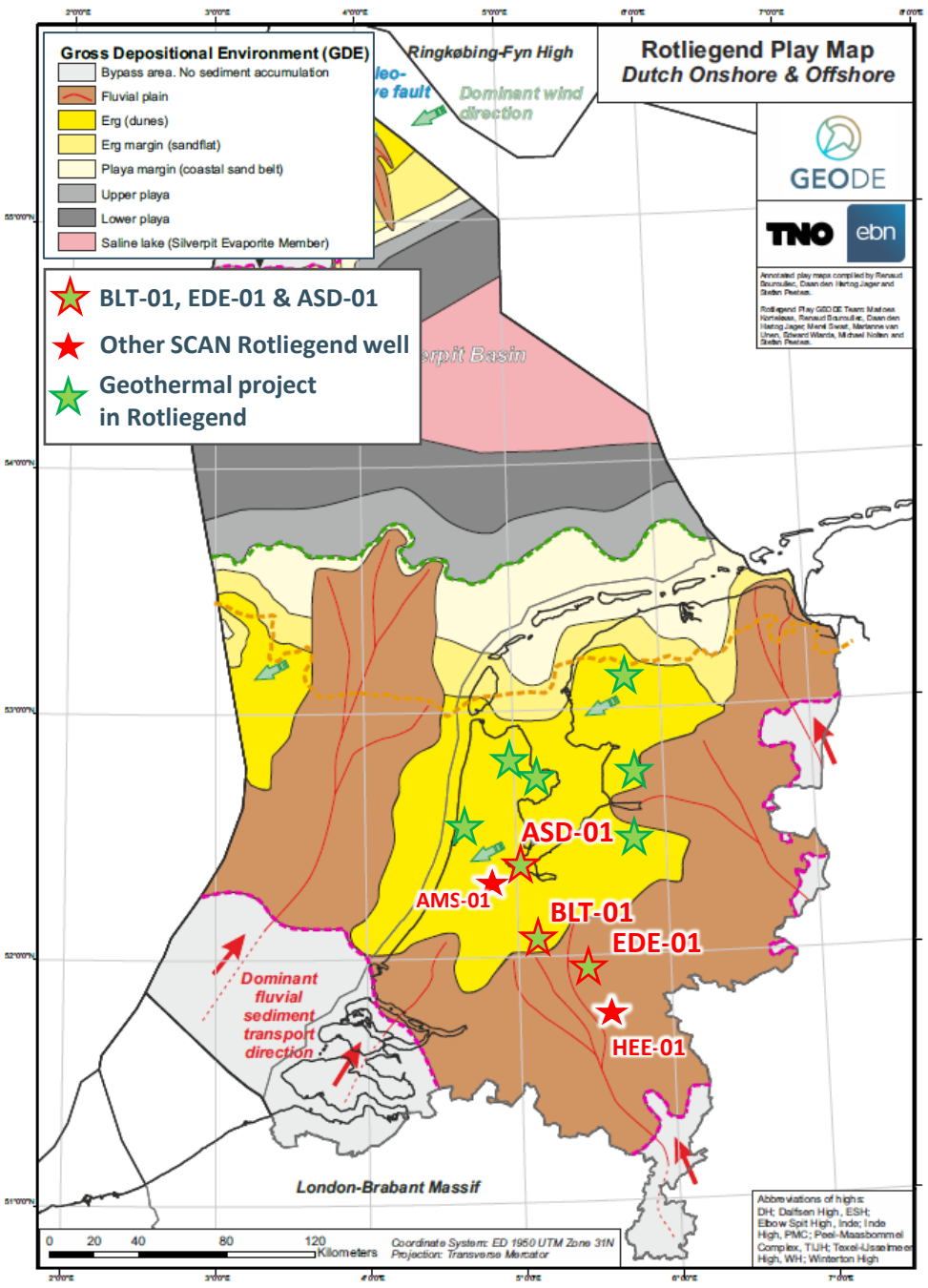
- ➜Determine geothermal reservoir properties of several intervals
- ➜Primary target: Upper Rotliegend Group – Slochteren Formation
- ➜Several secondary targets: Breda Subgp, Chalk, Vlieland Sst, Triassic. Please note: Triassic& Breda Subgp targets will be subject of future SCAN workshops
- ➜Determine geomechanical properties of the reservoirs, caprock and overburden
- ➜Determine formation fluid properties and temperature



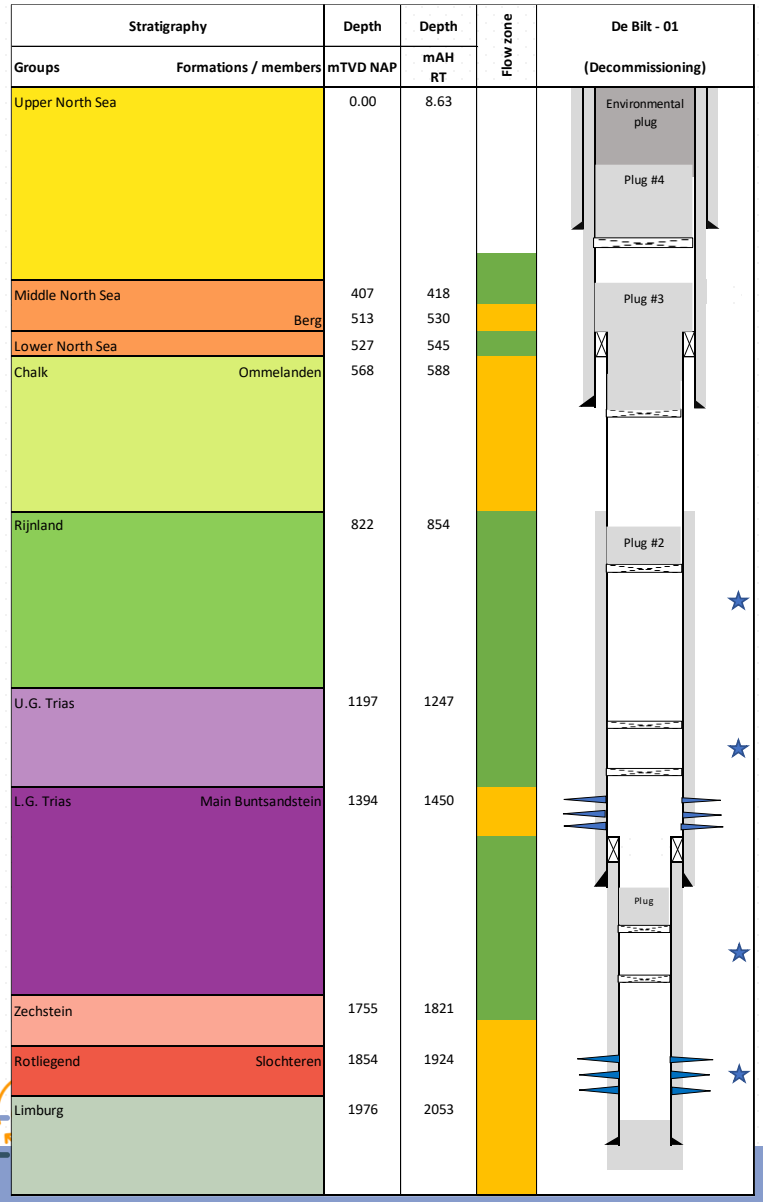

- ● ASD-01
- ● BLT-01
- ● BLT-01 & EDE-01

- ● BLT-01
- ● *EDE-01*
- ✓ BLT-01, EDE-01 & ASD-01

✓ Primary play
● Secondary play



# De Bilt-01 (BLT-01)



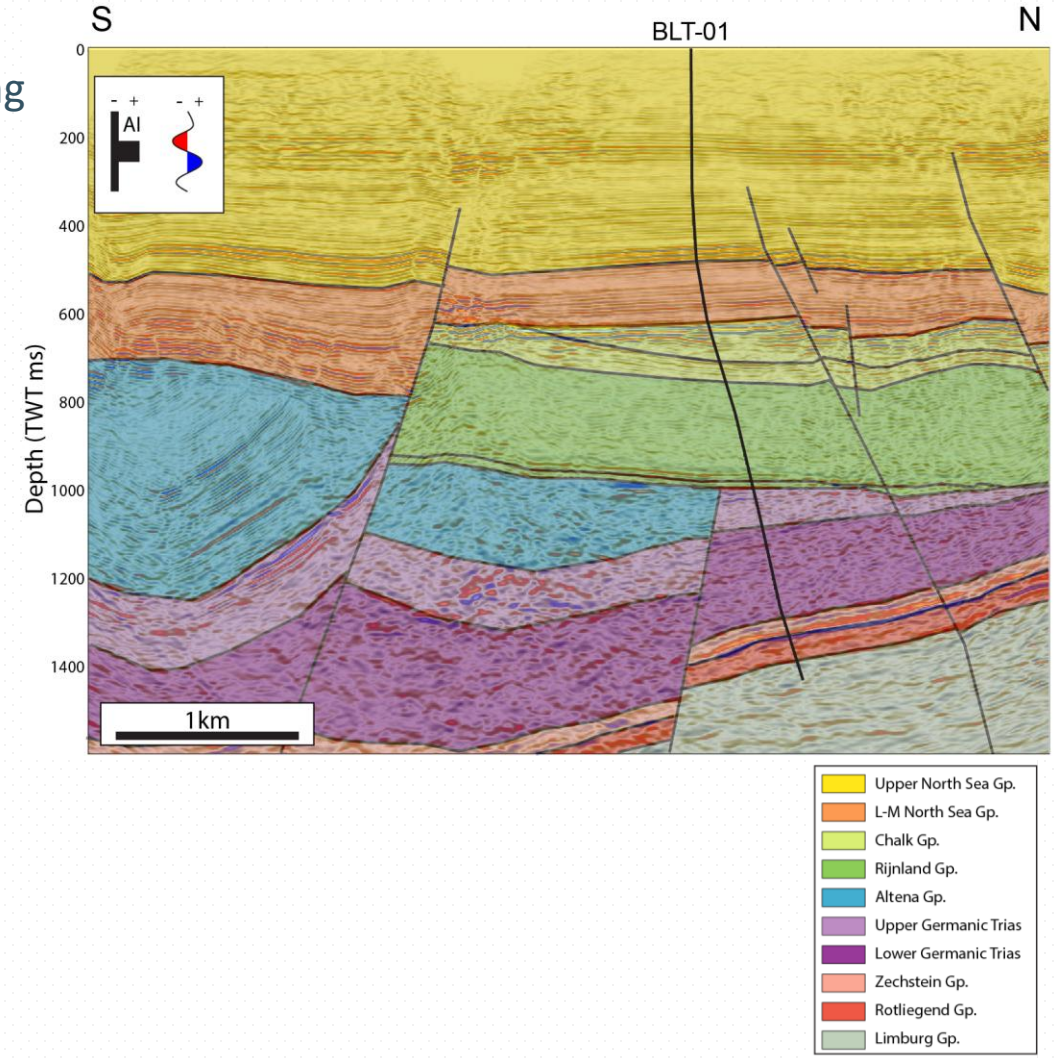

**Total Days:** 53 drilling + 27 testing

**Total Depth:** 2123 mMDRT

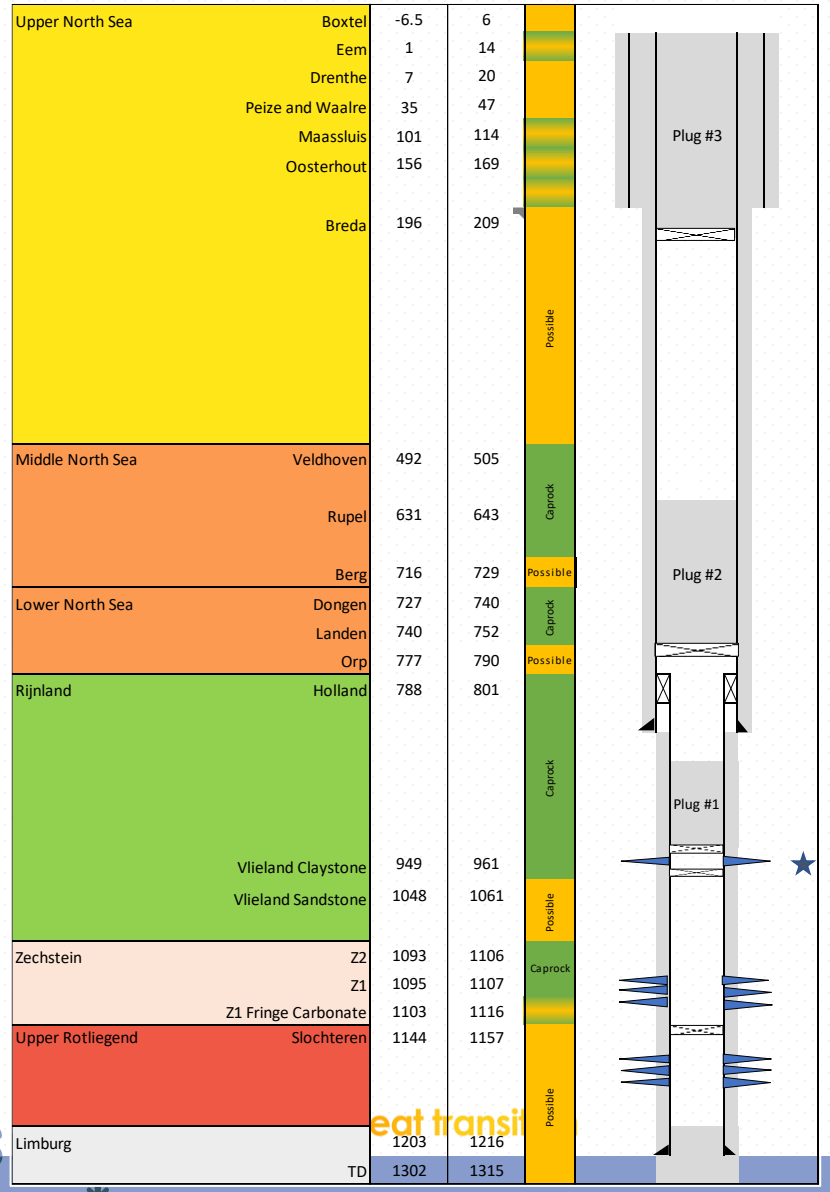
**Objectives: Slochteren, Main Buntsandstein, Vlieland Sandstone & Chalk**

**Data Acquired:**

- 6 OH WL Logs runs (5,1km)
- 8 Cores (220m cut, 99% recovery)
- 2 Well Tests
- 3 XLOTs



# Ede-01 (EDE-01)



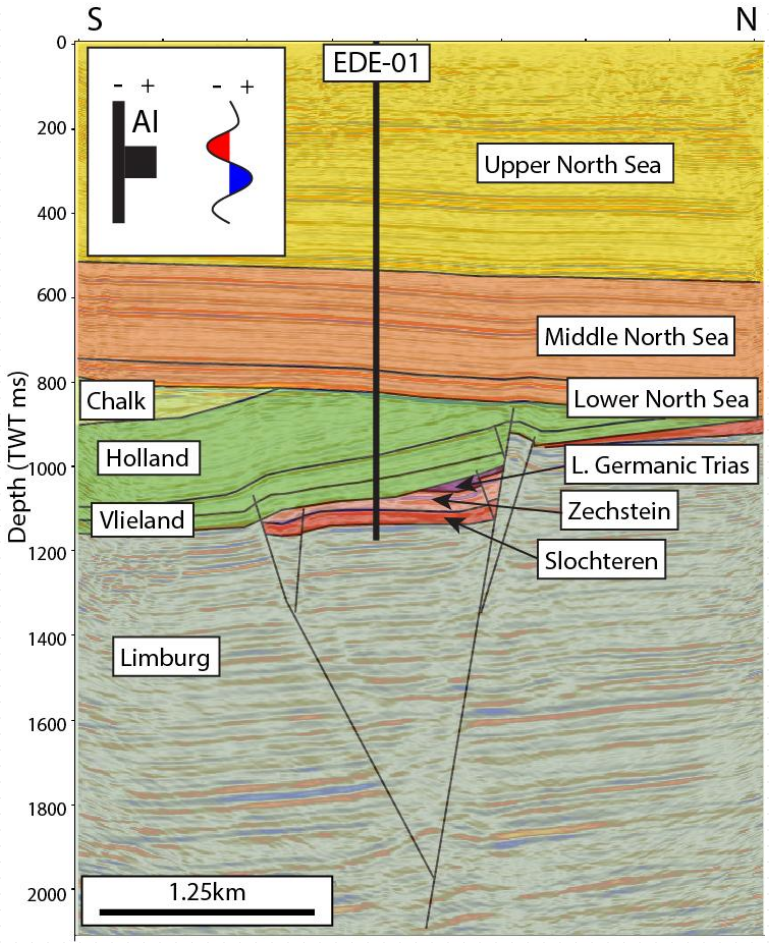

**Total Days:** 35 drilling + 18 testing

**Total Depth:** 1315 mMDRT

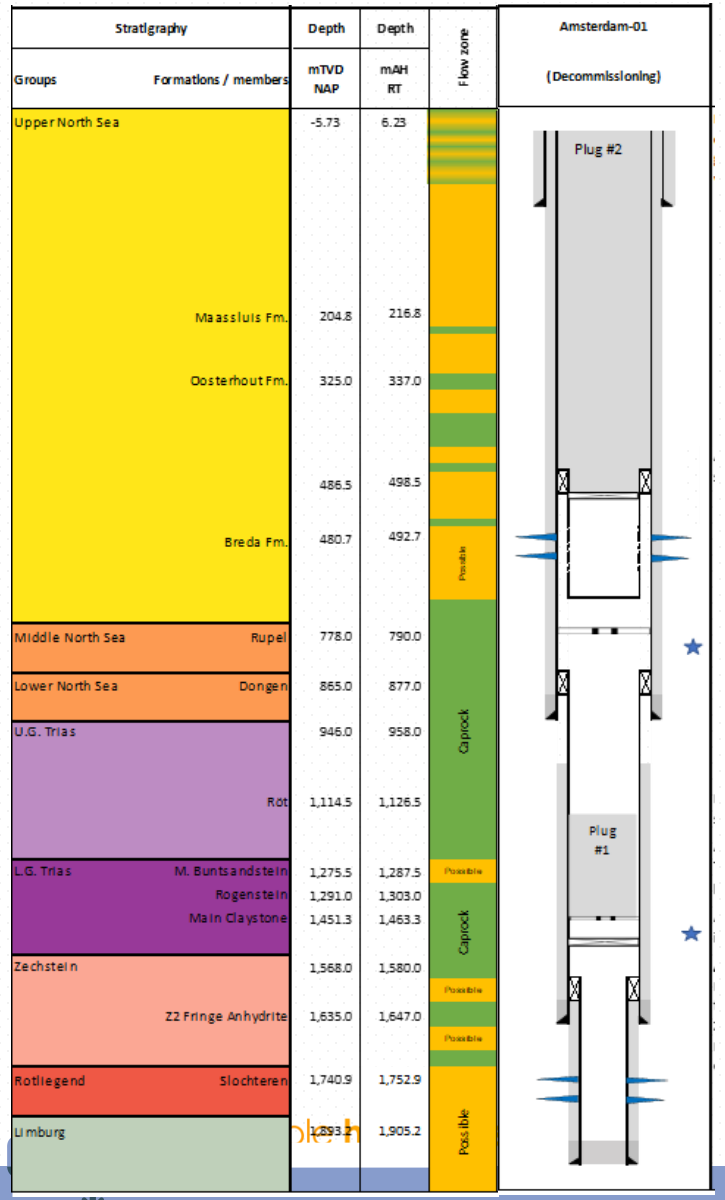
**Objectives: Slochteren & Vlieland Sandstone.** *Zechstein also found to have flow potential.*

**Data Acquired:**

- Conductor logging by Deltares
- 2 Measure-After-Drilling runs (1km)
- 2 CH WL Logs run (2,5km)
- 8 Cores (120m cut, 76% recovery)
- 2 Well Tests
- 1 XLOT



# Amsterdam-01 (ASD-01)




**Total Days:** 46 drilling + 33 testing

**Total Depth:** 1975 mMDRT

**Objectives:** Slochteren & Breda

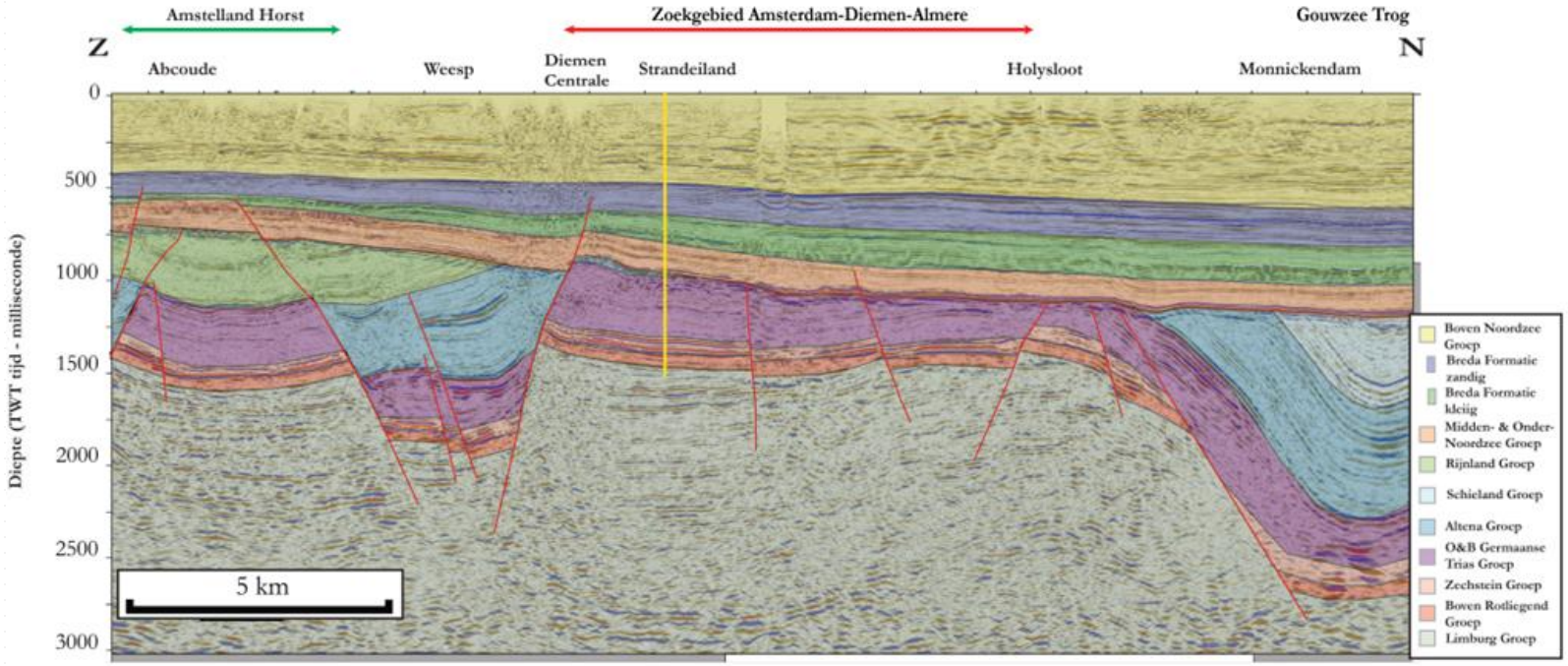
**Please note:**

A**SD**-01: Amsterdam-01 (2025)

A**MS**-01: Amstelland-01 (2023)

**Data Acquired:**

- 6 OH WL Logs run (5.3km)
- 11 Cores (155m cut, 98% recovery)
- 2 Well Tests & PLT's
- 2 XLOTs

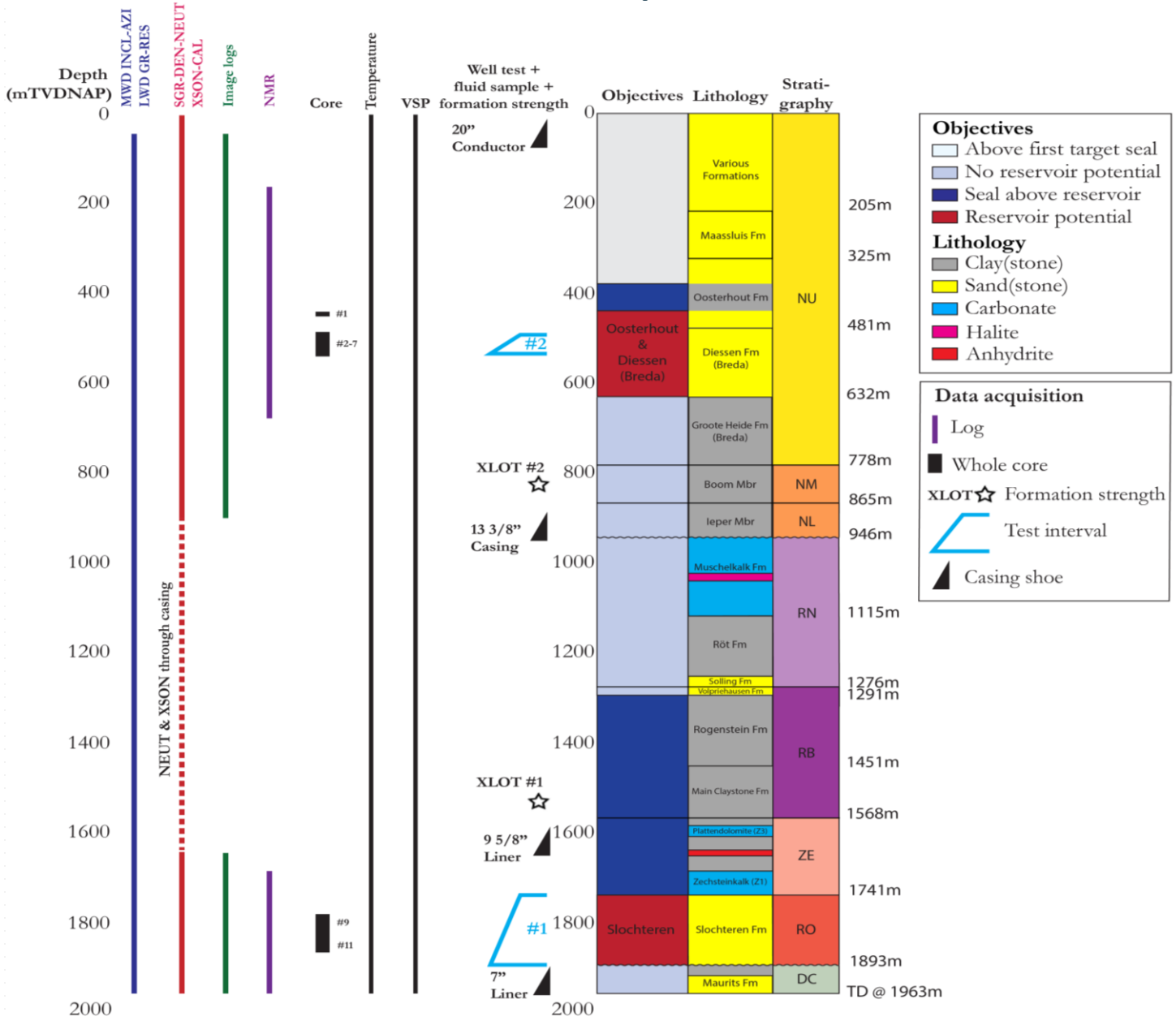


# Data Acquisition

**Comprehensive and state-of-the-art:**

- ➜LWD and (OH/CH) wireline log data
  - ➜(S)GR,RES,XSON,DEN,NEUT,IMAGE,NMR
  - ➜*No NMR in EDE-01*
- ➜VSP/Checkshot (*not in BLT-01*)
- ➜Core
  - ➜Screening analysis (CoreDNA)
  - ➜RCA, SCAL, core description
  - ➜Geomechanical tests
- ➜Production/Injection test
  - ➜Temperature
  - ➜PLT
  - ➜Fluid samples
- ➜Extended Leak off Tests (XLOT)

**ASD-01 data acquisition**



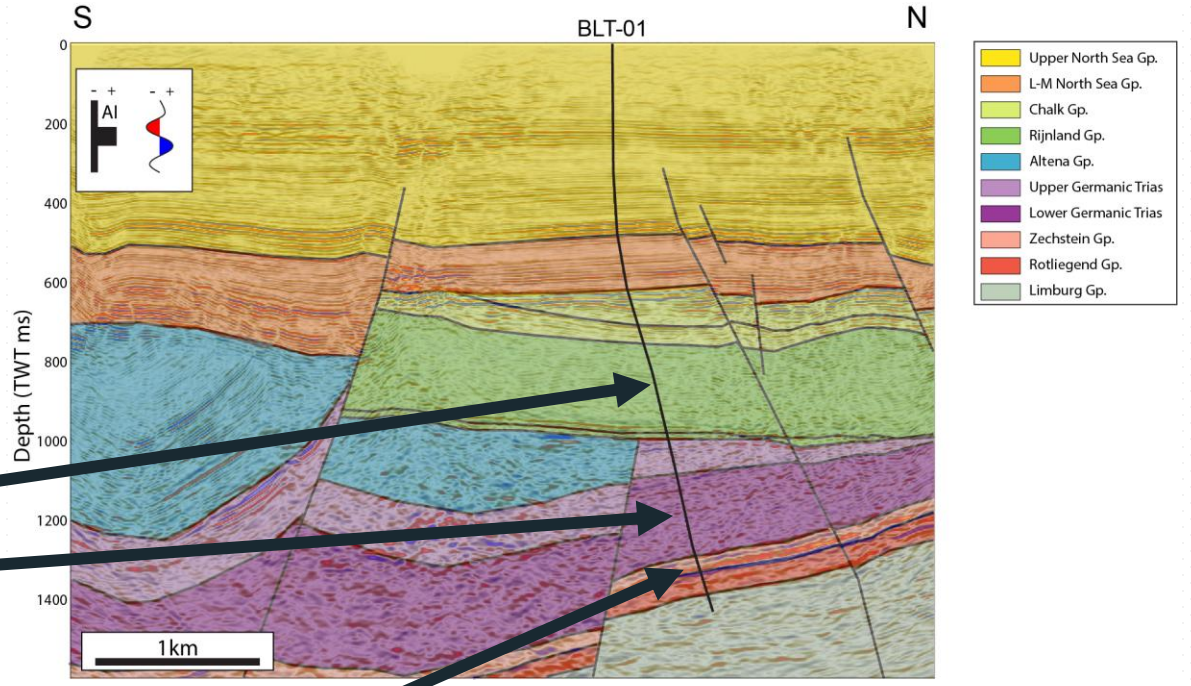
# Operational lessons

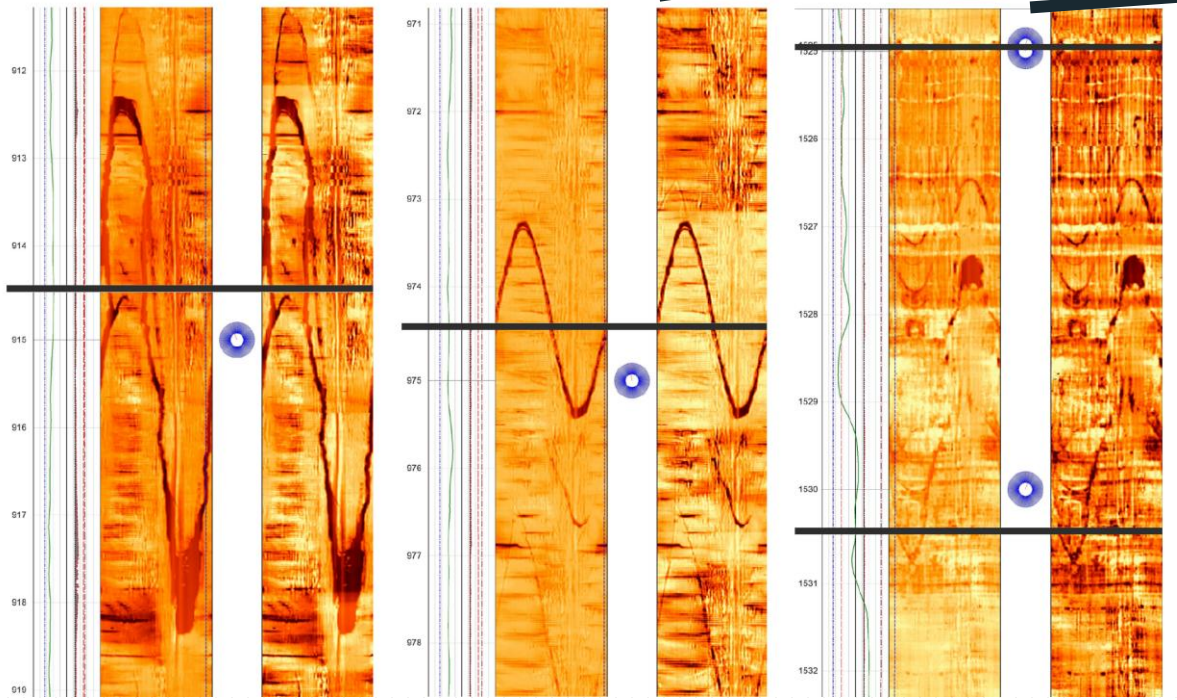
Adriaan Janszen

• Losses
• Wellbore stability
• Reservoir pressures
• Junk in hole
scanaardwarmte.nl

# BLT-01 - Loss zones

- ➜ Losses associated with fracture zones and dissolution holes
- ➜ Instantaneous loss rates up to 60 $m^3$/hour
- ➜ 124.4 $m^3$ of drilling fluid were lost while drilling 12 ¼” hole
- ➜ No losses in Chalk Group



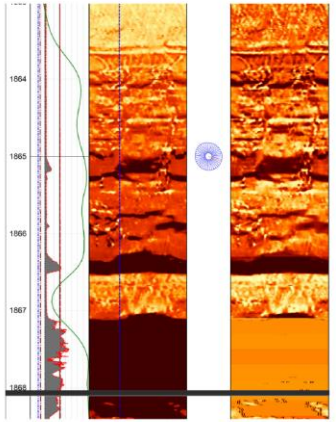
**Upper Holland Marl Mb**
**60 $m^3$/hr**



**1.6 $m^3$/hr**



**Lower Volpriehausen Sst**
**6.0 $m^3$/hr**



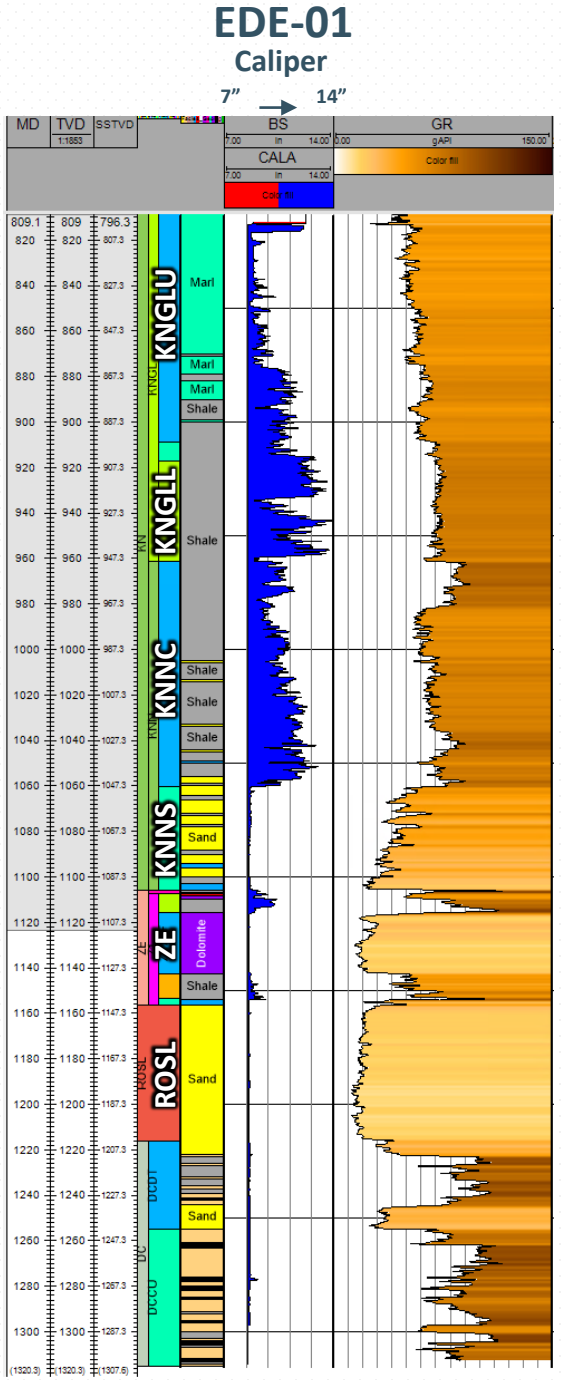

**Zechstein 2 Fringe**
**Anh. Mb**
**6.0 $m^3$/hr**

# EDE-01 – Wellbore stability

- ➜Wellbore stability issues in Vlieland Claystone and Holland Formation
- ➜Mechanical cavings up to 3cm started from 980 m m MDRT
- ➜Changed MW from 1.16 to 1.18sg
- ➜Collected core (KNNS & ROSL) and drilled to well TD
- ➜Decided to perform logging of 8.5” hole using LWD tools* and cased hole wireline* rather than open hole wireline. All logs planned were acquired, except for NMR

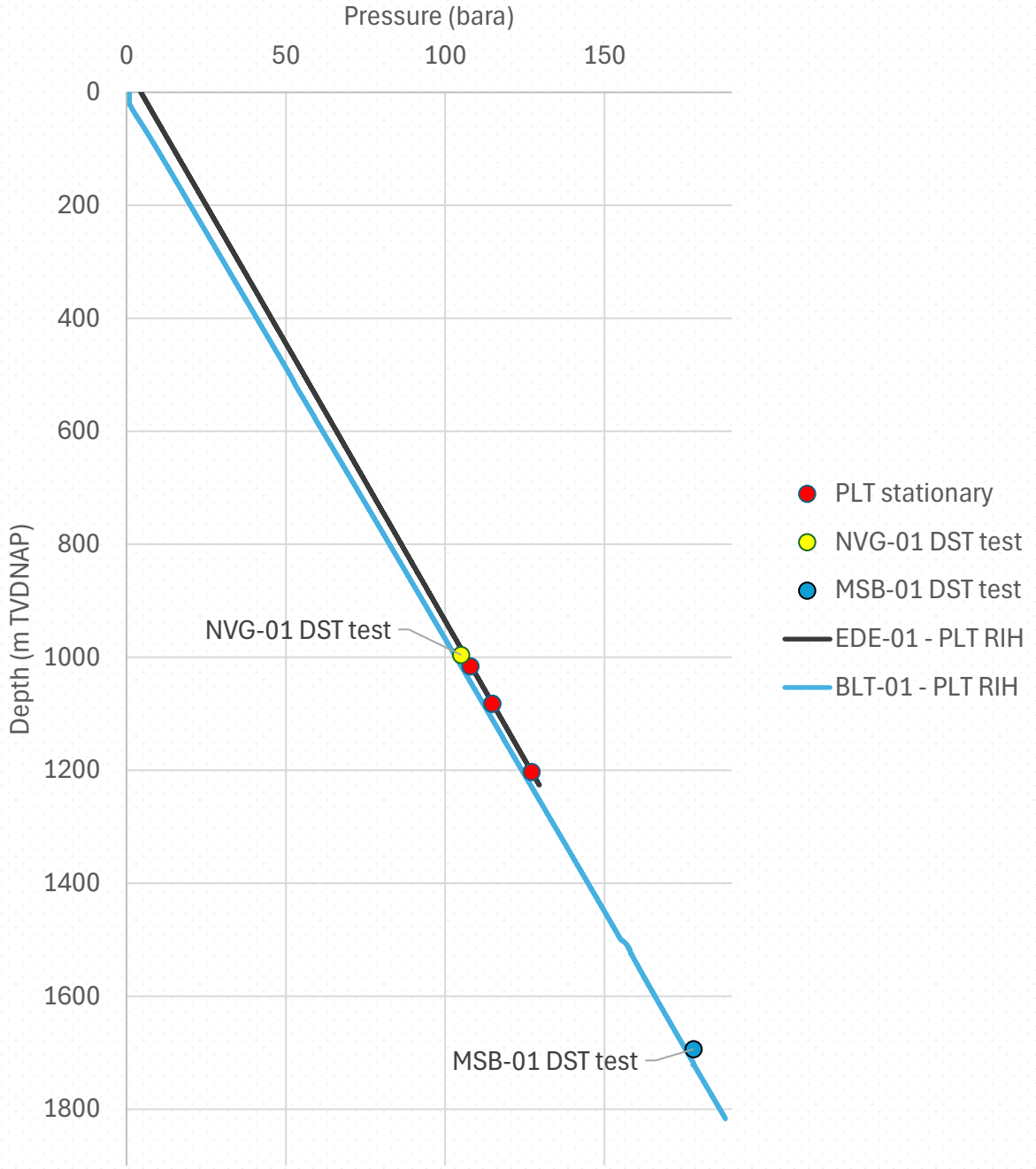
* LWD: image log, density, sonic

CH WL: neutron, spectral gamma ray, sonic (again)



# EDE-01 - Reservoir pressure

- ➜Hydrostatic water level geothermal wells in the Netherlands below ground level
- ➜During testing of Slochteren and Zechstein in EDE-01, static reservoir level proved to be above ground level
- ➜Slochteren was tested through natural flow (no pump required)
- ➜Static well-head pressure during shut-in approximately 3 bar(a)
- ➜Excess pressure is modest and was not observed during drilling
- ➜Legacy wells around Peel-Maasbommel High in similar pressure regime



# Junk in hole

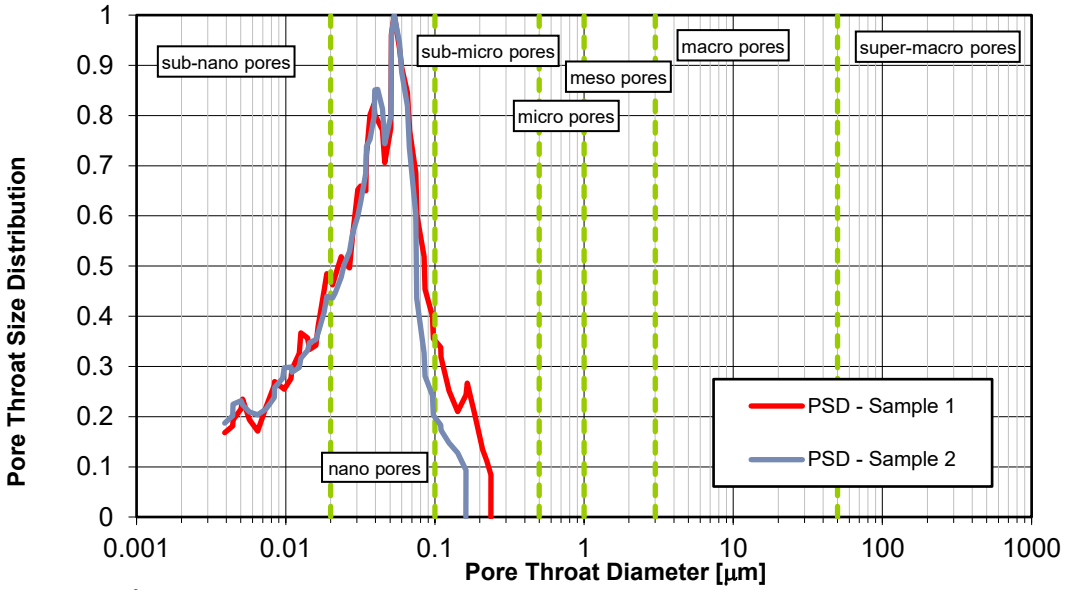
- ➜Aluminium parts from drilling out casing/liner shoes
- ➜Caused poor core recovery and some damage to Slochteren cores in Ede-01
- ➜Junk-basket run prior to coring helped
- ➜May have contributed to cancelled open hole wireline runs in 12 ¼” section Amsterdam-01 (Slochteren caprock)

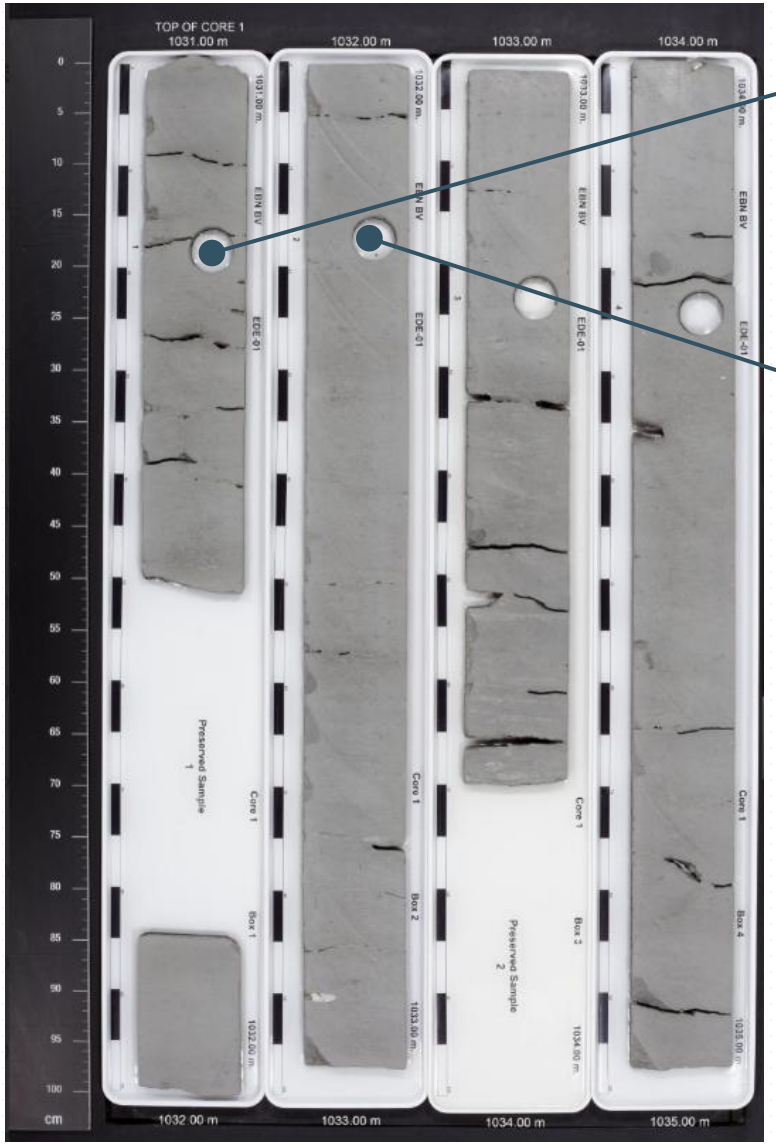
# What geomechanical data did we acquire?

- Caprock Characterisation
- Extended Leak-Off Tests (XLOTs)
- Additional Geomechanical Parameters

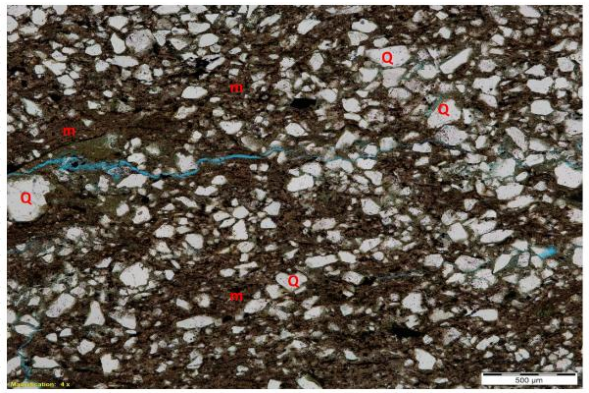
# Vlieland Claystone caprock

- 99m section overlying Vlieland Sandstone, Zechstein and Slochteren reservoir (EDE-01)
- Fine-grained silty claystones and siltstones deposited in marine distal offshore environment
- Small pore-throat diameters and low permeability => good capillary caprock
- Collected core and XLOT to determine mechanical caprock capacity




EDE-01 - Plug 1

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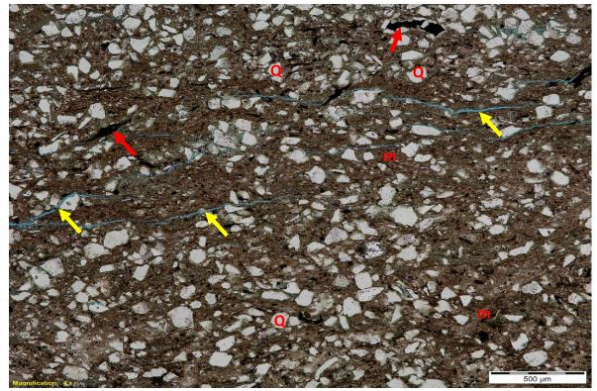
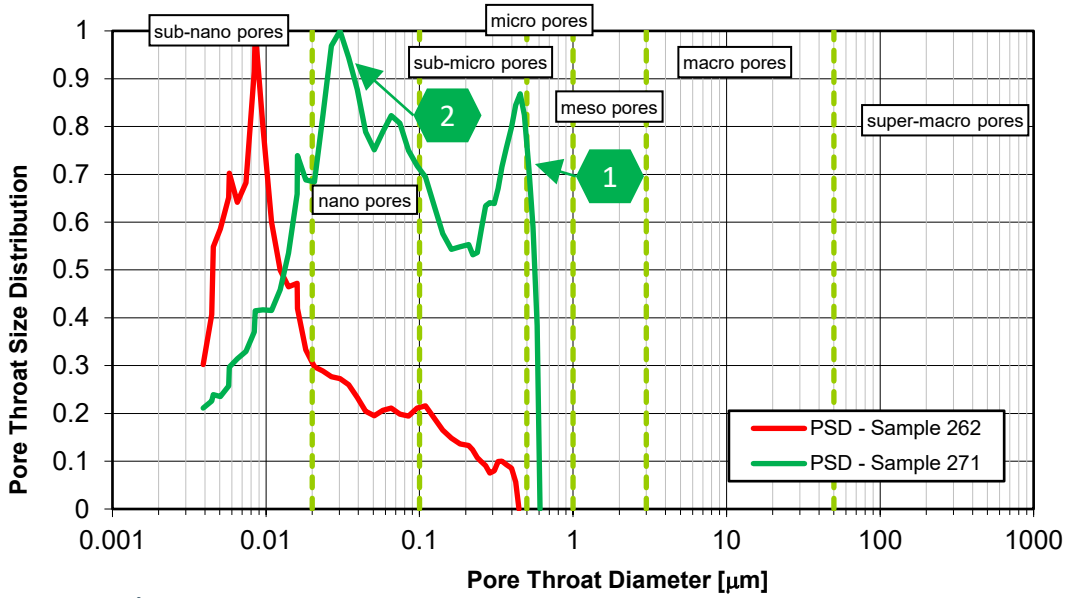
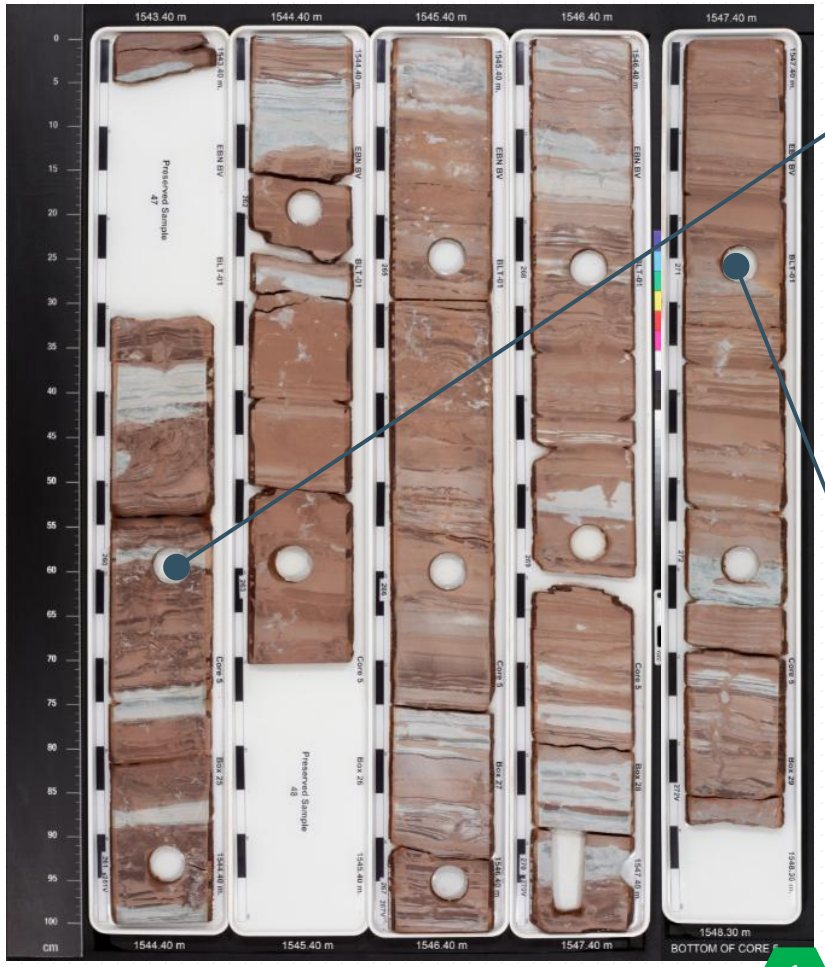


# Rogenstein and Main Claystone caprock

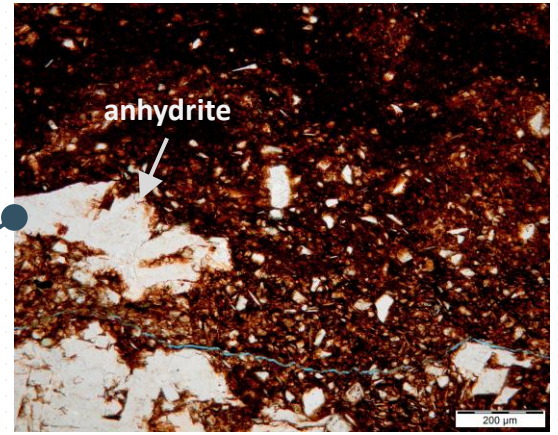
- ➜270-280m overlying Zechstein Group and Slochteren reservoir in BLT-01 and ASD-01
- ➜Fine-grained silty claystones and siltstones with anhydrite deposited in playa lake
- ➜Small pore-throat diameters and low permeability => good capillary caprock
- ➜Collected geomechanical data and XLOTs to determine mechanical caprock capacity



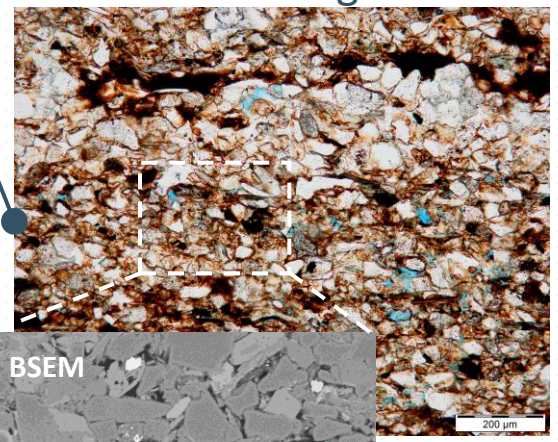

BLT-01 - Rogenstein Formation

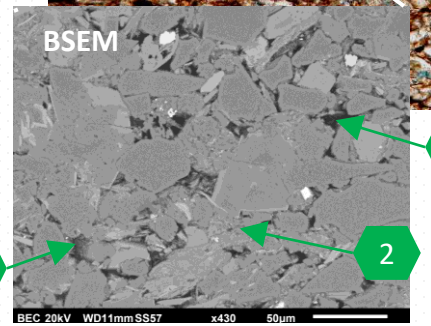



BLT-01 Plug 260




BLT-01 Plug 271

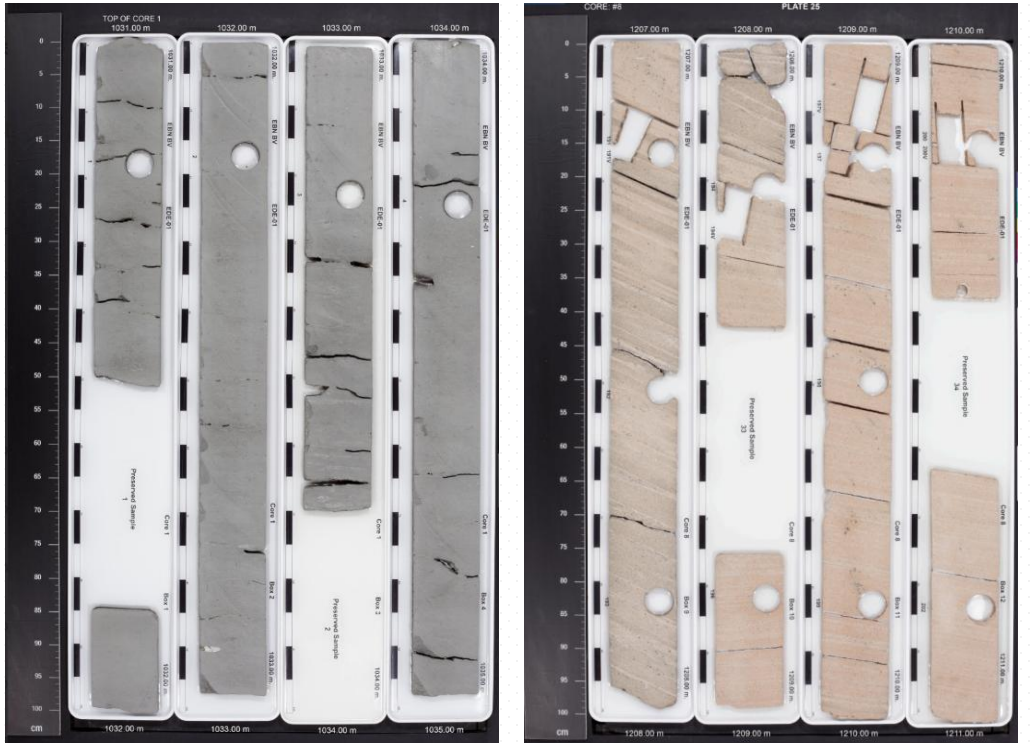


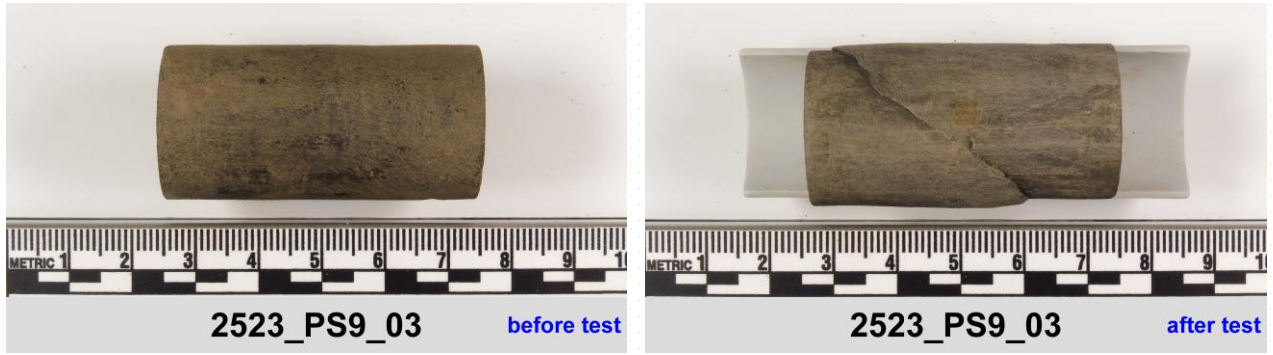
# Core laboratory testing

- ➜Measurements on Slochteren core and caprock
- ➜Scratch test to determine continuous record of the Unconfined Compressional Strength (UCS)
- ➜Strain-controlled tri-axial tests to determine elastic parameters, strength and post-failure slip
- ➜Linear thermal expansion coefficient and thermal conductivity measured

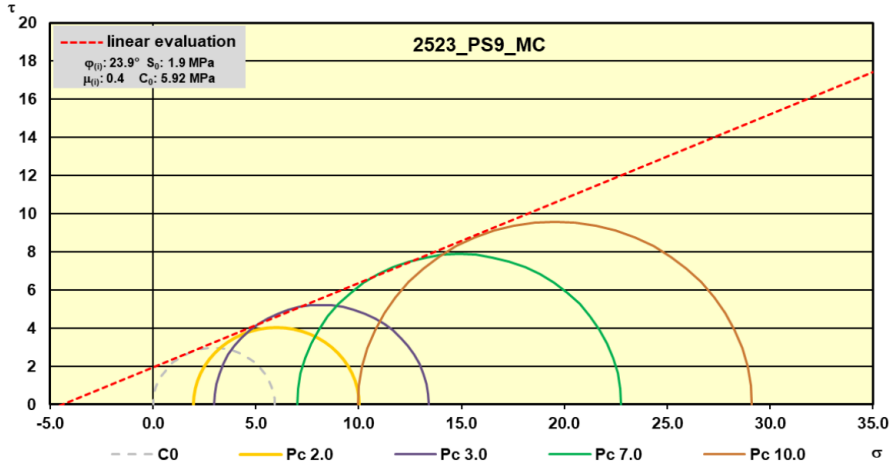
**Vlieland Claystone Fm - Caprock** **Slochteren Fm - Reservoir**



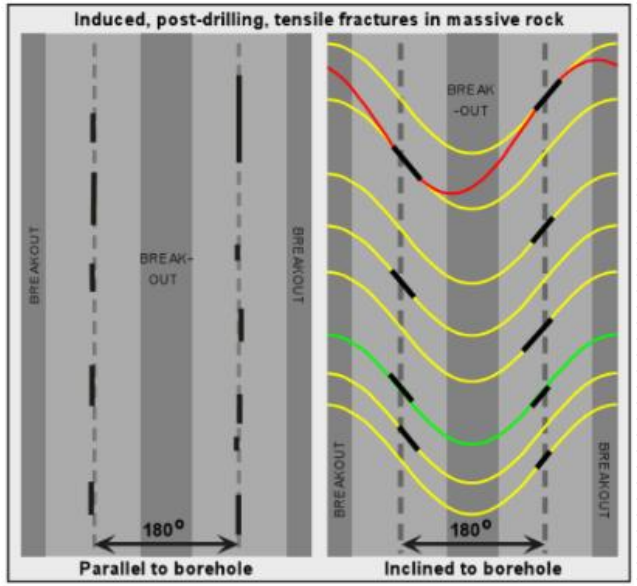
**Vlieland Claystone Fm – Caprock – EDE-01**

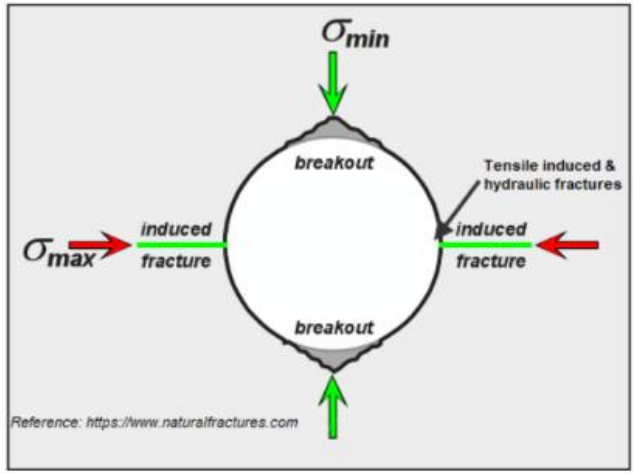



**2523_PS9**

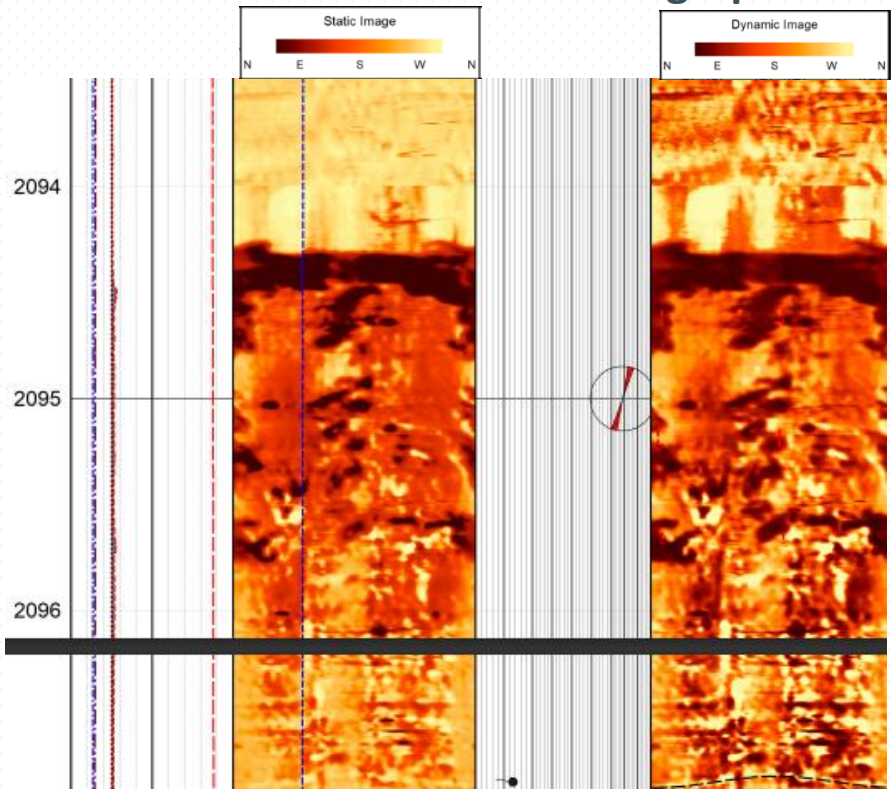


# Stress-field orientation - Breakouts

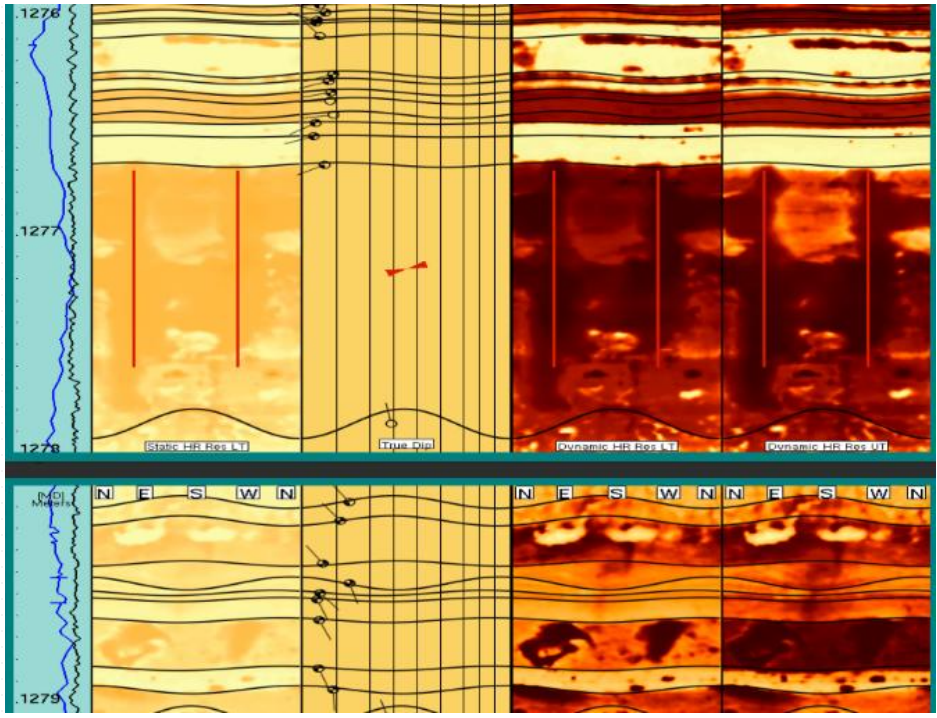



BLT-01 - Limburg Gp



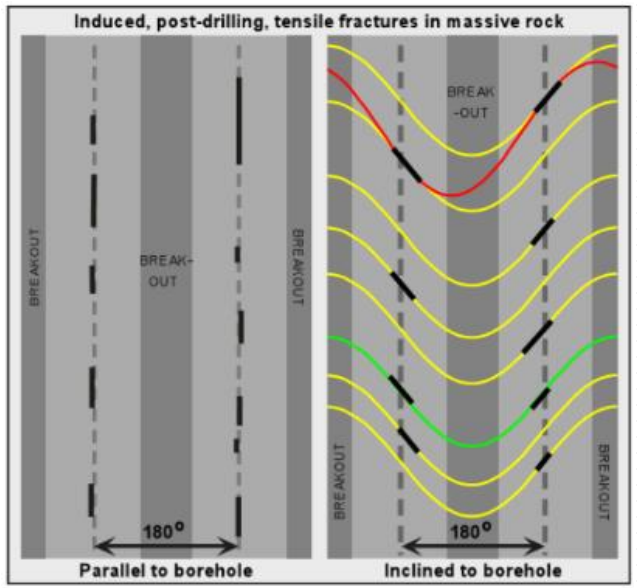

EDE-01 - Limburg Gp

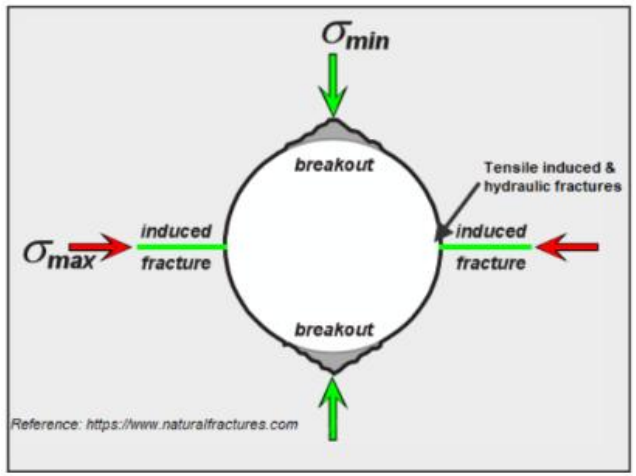



➜Borehole breakouts observed in image logs of all wells

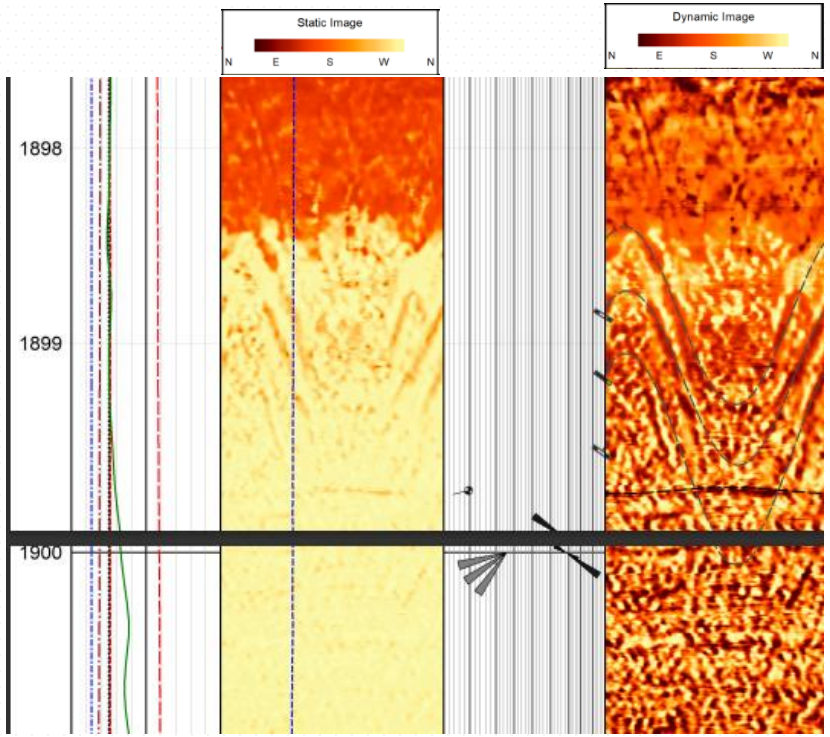
➜Breakouts NNE-SSW (BLT-01) and ENE-WSW (EDE-01)

# Stress-field orientation - DIFs




BLT-01 - Zechstein Gp

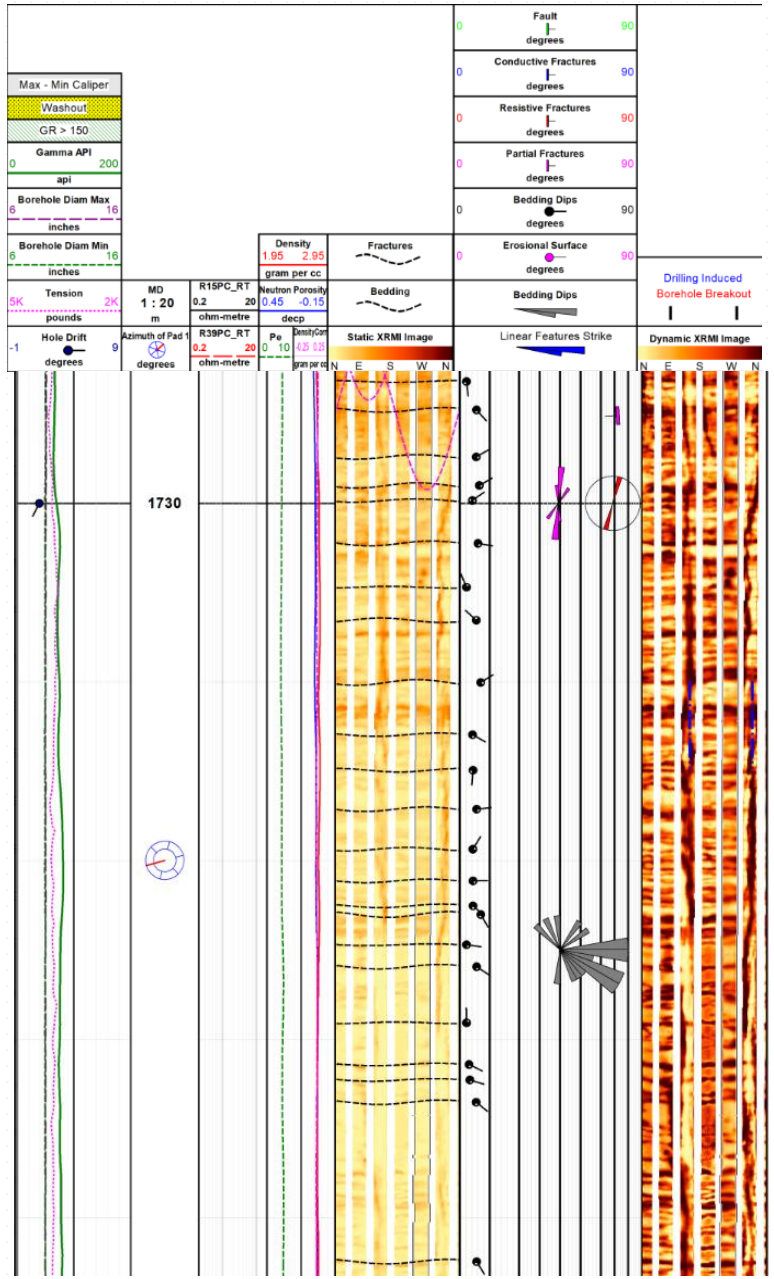



➜Tensile fractures WNW-ESE (BLT-01) and NW-SE (ASD-01)

➜**Shmin = NE-SW**

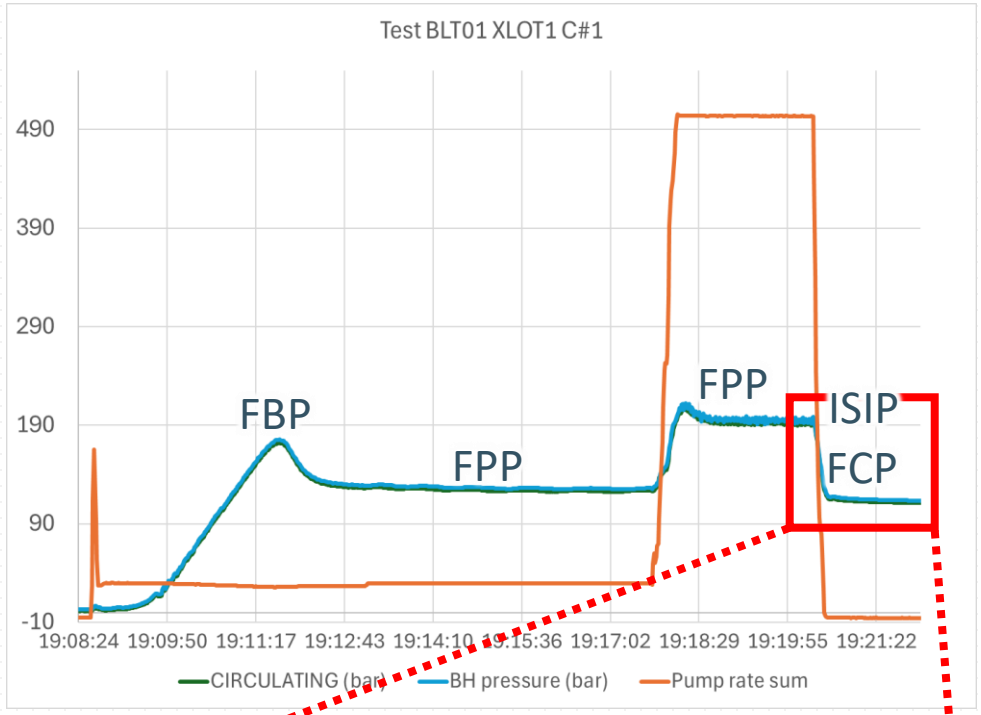
➜**Shmax = NW-SE**

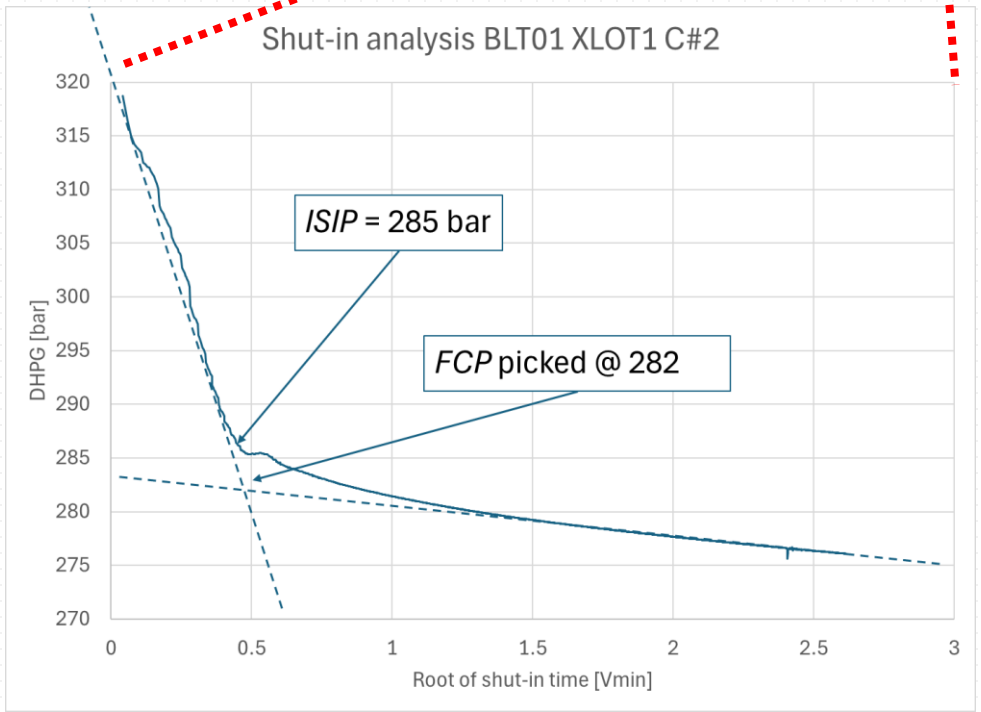
ASD-01 - Zechstein Gp



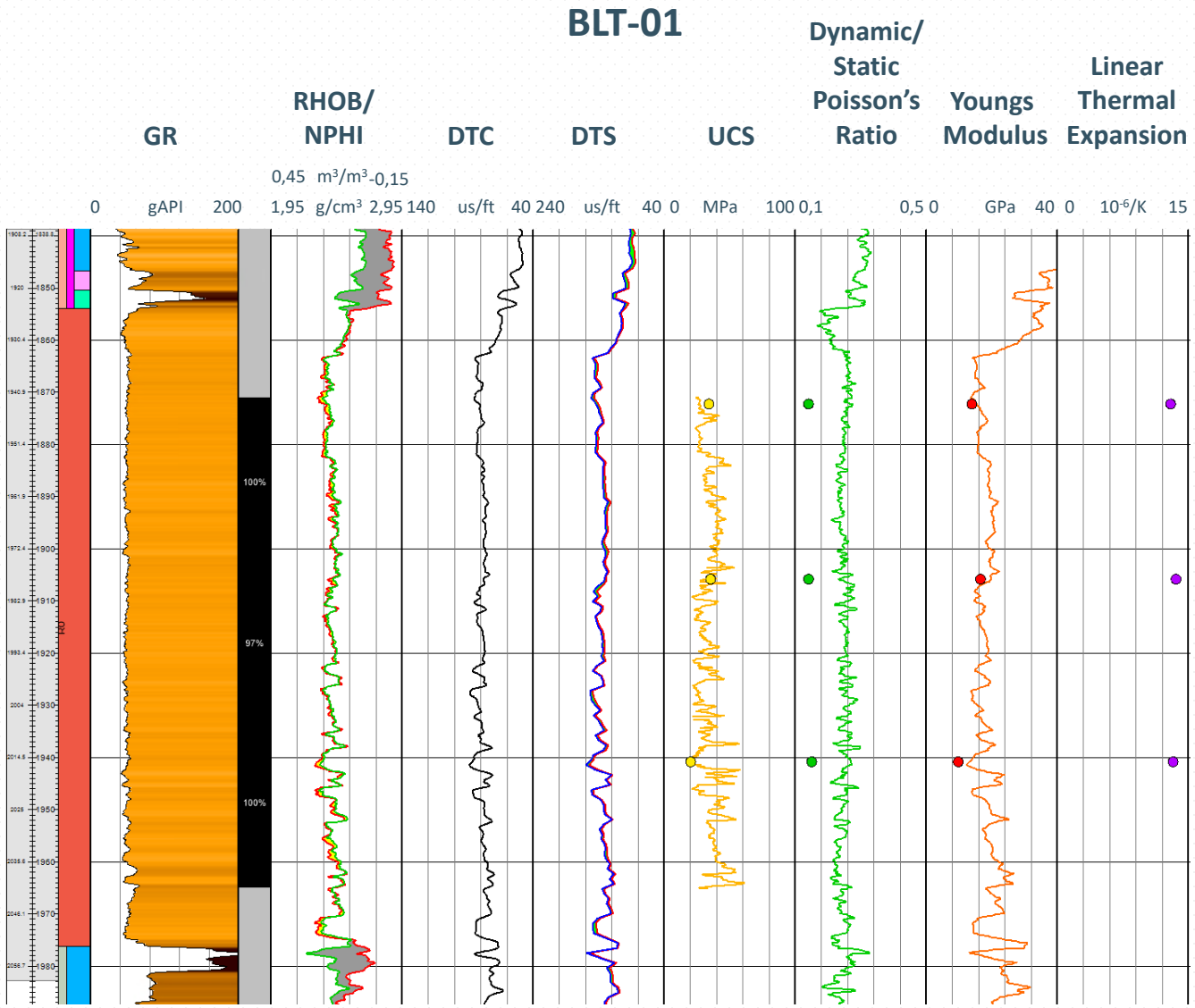
# Extended Leak-Off Tests (XLOT)

- Determine magnitude **minimum horizontal stress (Shmin)** in caprocks
- SCAN performs XLOTs through a 1.5m perforated interval before well decommissioning
- Main Claystone (BLT-01, ASD-01) and Vlieland Claystone (EDE-01) Slochteren caprocks tested
- Shmin determined from **fracture closure pressure (FCP)** + difference depth downhole pressure gauge->perforation

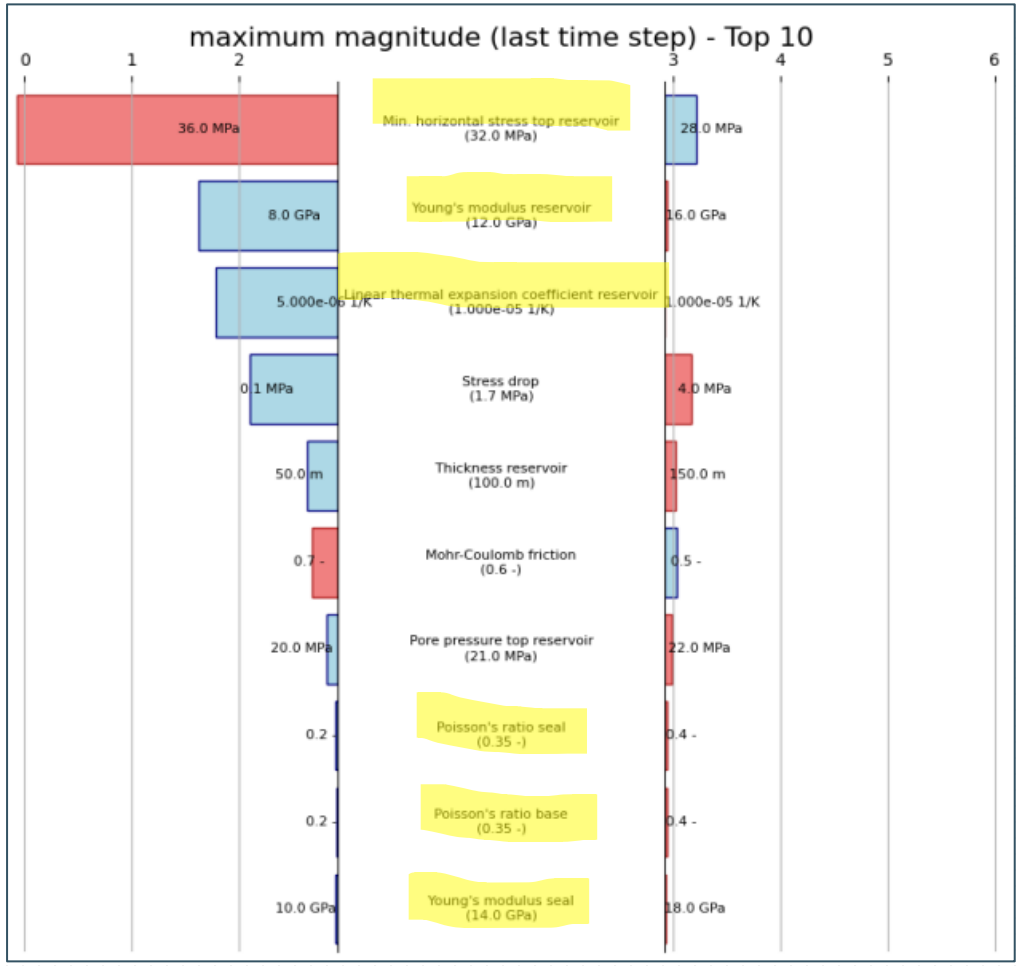


# Additional Geomechanical Parameters

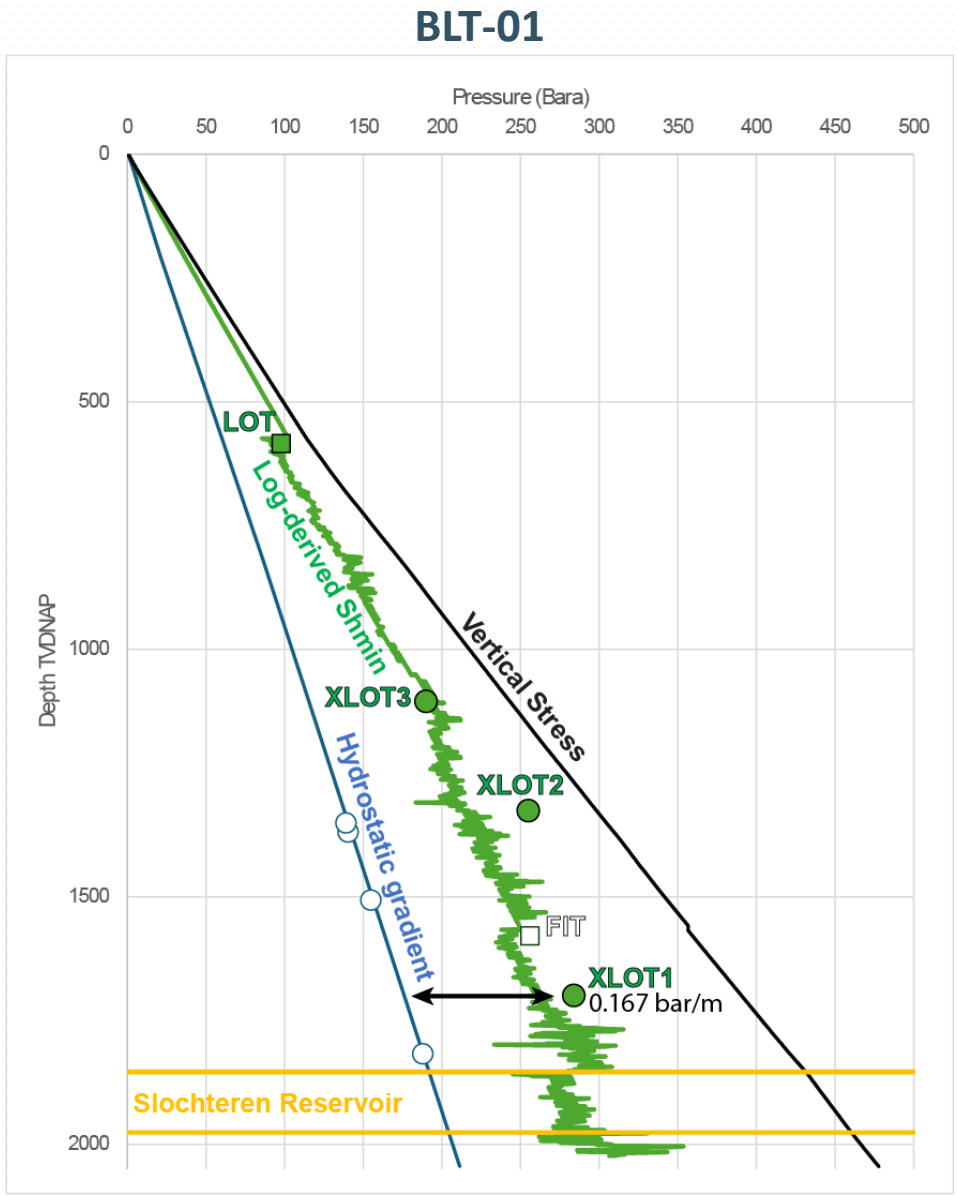



## Example SRIMA output, Mijnlieff et al., 2023



# Construction and Calibration of 1D geomechanical models

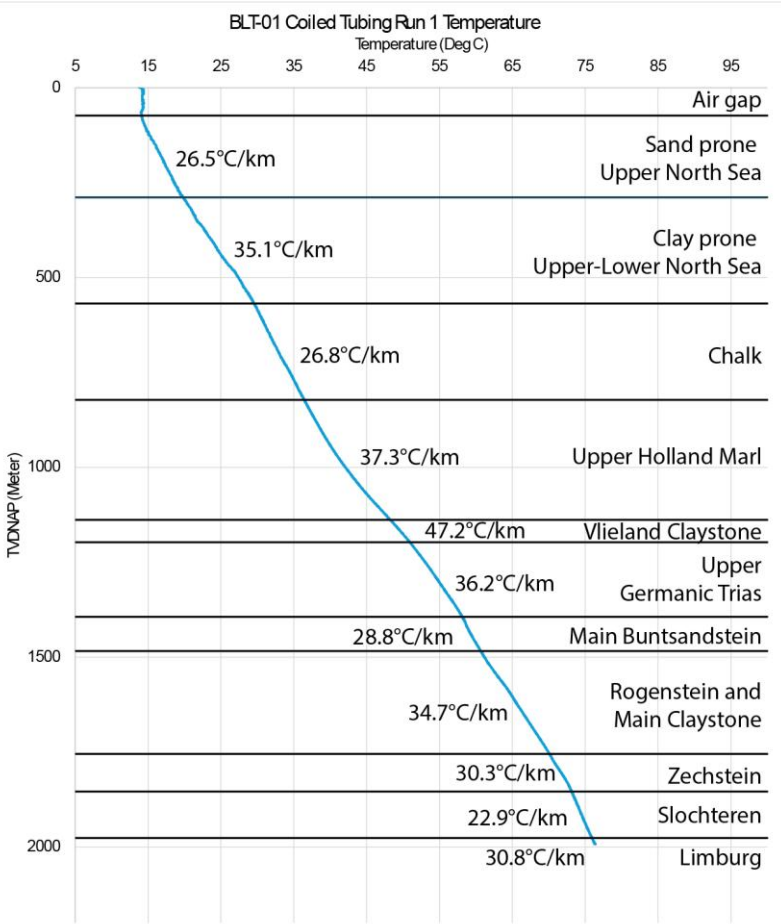
- ➜SCAN dataset provides abundance of geomechanical parameters
- ➜Allows use of local parameters, rather than generic conservative estimates
- ➜Provides input to induced seismicity and caprock integrity workflows (SRIMA-TAS)
- ➜XLOT-derived Shmin higher than log-derived Shmin from 1D geomechanical model for XLOT1&2 in BLT-01
- ➜See Hettema et al. (2025) EAGE-GET presentation available on scanaardwarmte.nl for a discussion of possible explanations

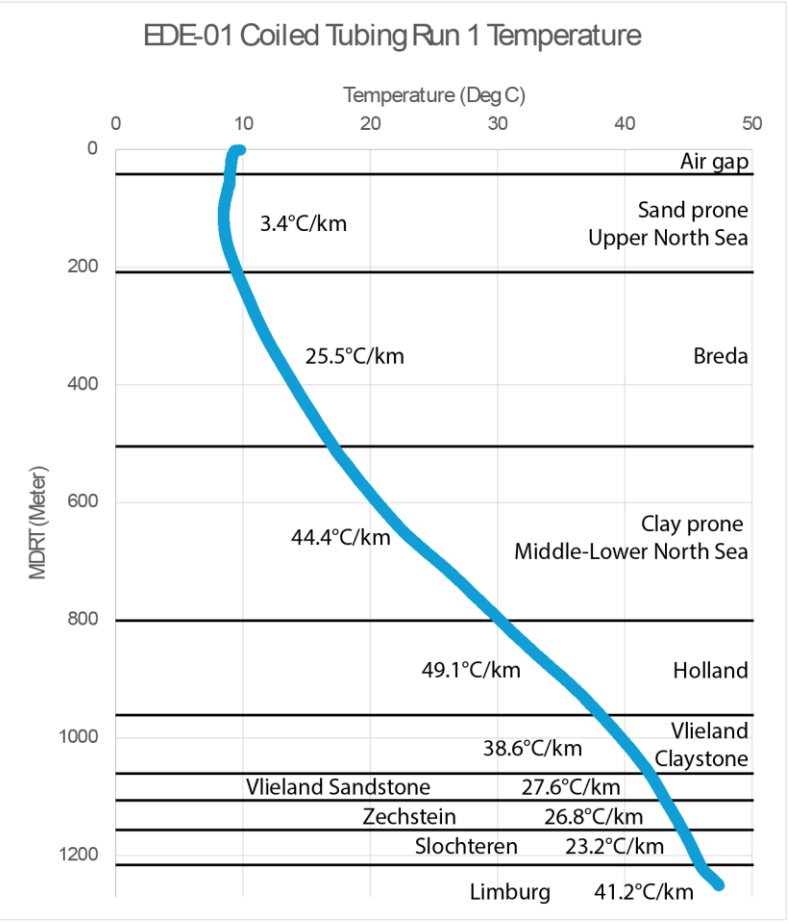


# What is the temperature and composition of the water in the Rotliegend aquifer?

# Temperature

- ➜Large amount of different temperature data acquired
- ➜Dedicated temperature log acquired prior to well test 3-14 weeks after drilling operations stopped => borehole in thermal equilibrium
- ➜Variations in geothermal gradient driven by lithology

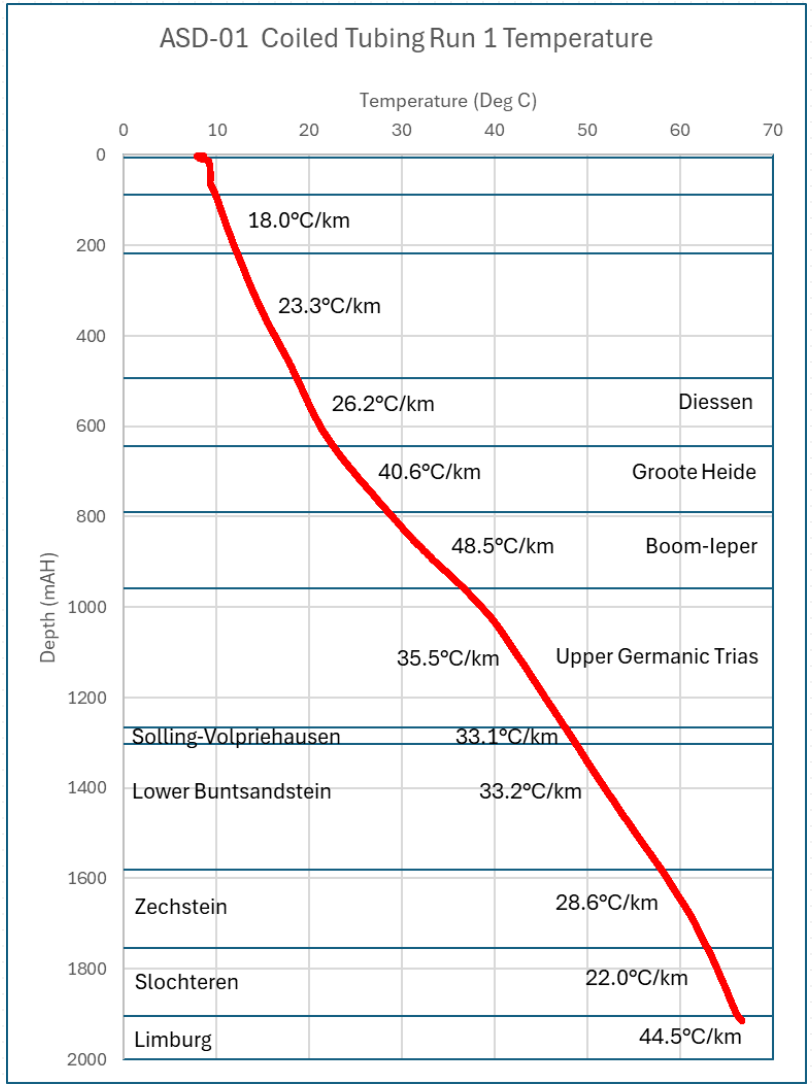


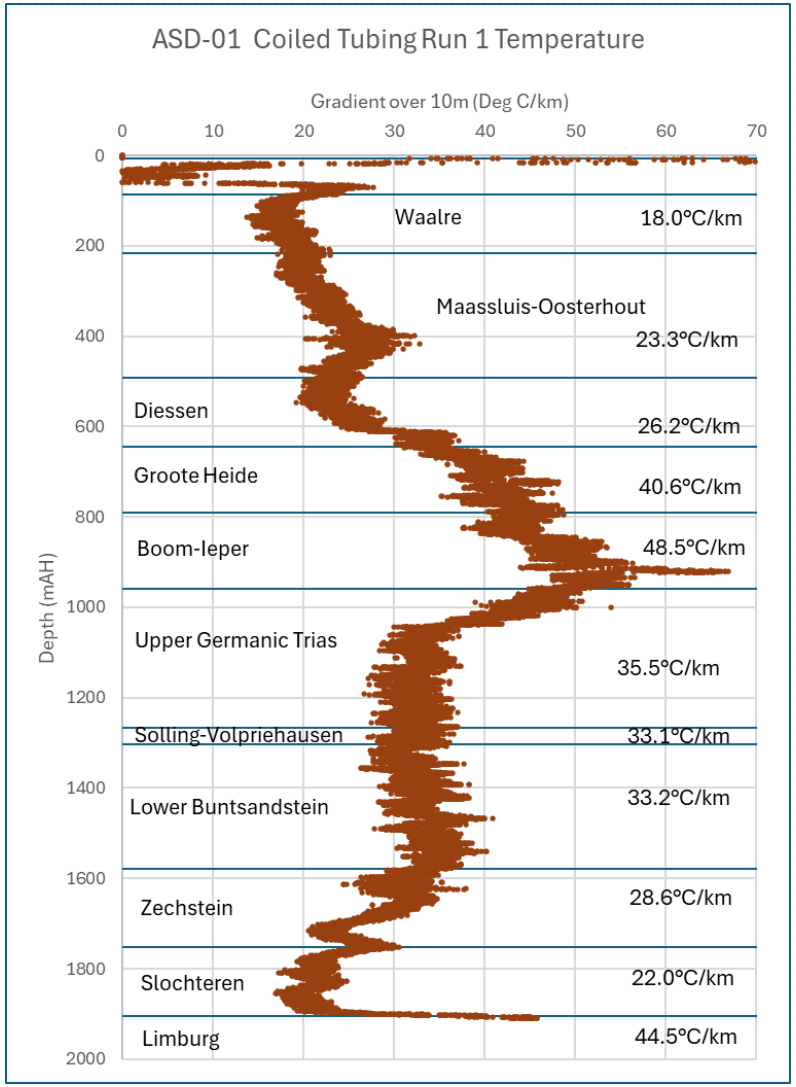




| | BLT-01 | EDE-01 | ASD-01 |
|---|---|---|---|
| Temperature Mid Slochteren reservoir [°C] | 75 | 48 | 66 |
| Compared to Bonté et al (2012) [°C] | +4 | +1 | -1 |
| Average temperature gradient to Mid Slochteren [°C/km] | 33.7 | 32.1 | 30.7 |

# Amsterdam-01 Temperature Gradient

- Low geothermal gradient in sandstone and carbonate intervals
- High gradient in claystones



# Slochteren Fluid Composition

- Slochteren Formation water sampled downhole and at surface
- Full compositional analysis of brine and dissolved gasses
- Predominantly methane (De Bilt-01, Amsterdam-01), $CO_2$ and $N_2$ (Ede-01), no $H_2S$ reported

| | BLT-01 | EDE-01 | ASD-01 |
|---|---|---|---|
| TDS [g/l] | 96.0 | 70.0 | 99.6 |
| Dissolved gas [$sm^3/m^3$] | 0.274 | 0.133 | 0.167 |
| Methane [weight%] | 41.6 | 0.1 | 53.7 |
| $CO_2$ [weight%] | 31.3 | 33.3 | 5.8 |
| $N_2$ [weight%] | 24.4 | 62.7 | 40.3 |

**Brine composition [mg/l]**

| Composition | ASD-01 | BLT-01 | EDE-01 |
|---|---|---|---|
| Cl | 68.300 | 63.000 | 42.000 |
| Na | 34.200 | 31.000 | 22.000 |
| Ca | 1.690 | 3.100 | 2.900 |
| $SO_4$ | 2.870 | 1.500 | 1.600 |
| Mg | 461 | 520 | 820 |
| K | 1.850 | 720 | 680 |
| Sr | 42 | 80 | 96 |
| Br | 100 | 84 | 84 |
| $HCO_3$ | 220 | 27 | 170 |
| Fe | 28 | 73 | 18 |
| Li | 6 | 22 | 8 |
| | | | |
| pH | 6,56 | 6,2 | 6,4 |

# Biological Threat Level

- Composition of microbiology in formation water can result in threats to geothermal systems:
  - Biofilm clogging
  - Microbially induced corrosion (MIC)
  - Acidification
- Formation water sampled at surface using sterile sampling equipment
- Quantification of bacteria and archaea (qPCR)
- Identification of bacteria and archaea (NGS)

| Well | Cells per ml | | Perceived threat level | | |
|---|---|---|---|---|---|
| | Bacteria | Archaea | Clogging | MIC | Acidification |
| De Bilt-01 | 3.00E+05 | 1.40E+04 | Moderate | High | High |
| Ede-01 | 1.50E+04 | N/A | Low | | |
| Amsterdam-01 | 4.80E+04 | 2.90E+02 | Moderate | | |

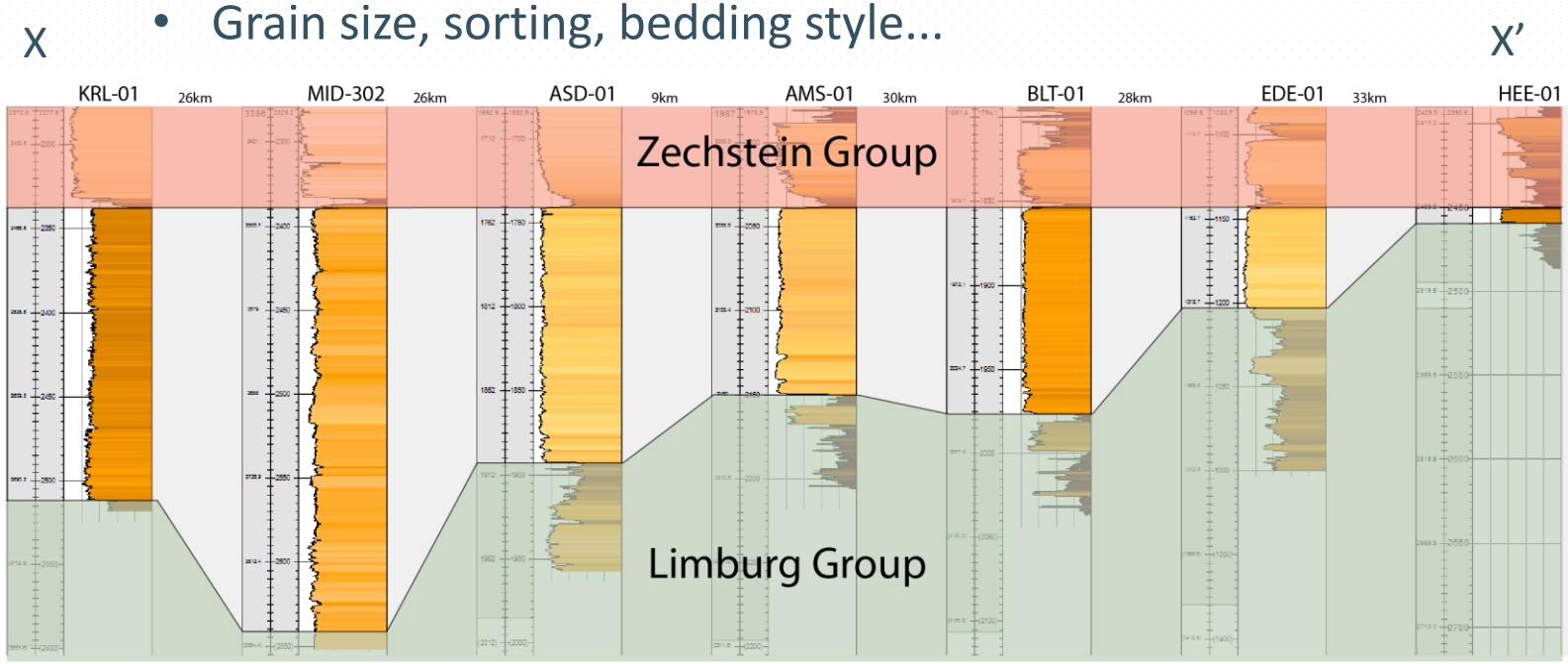
# How was the reservoir deposited

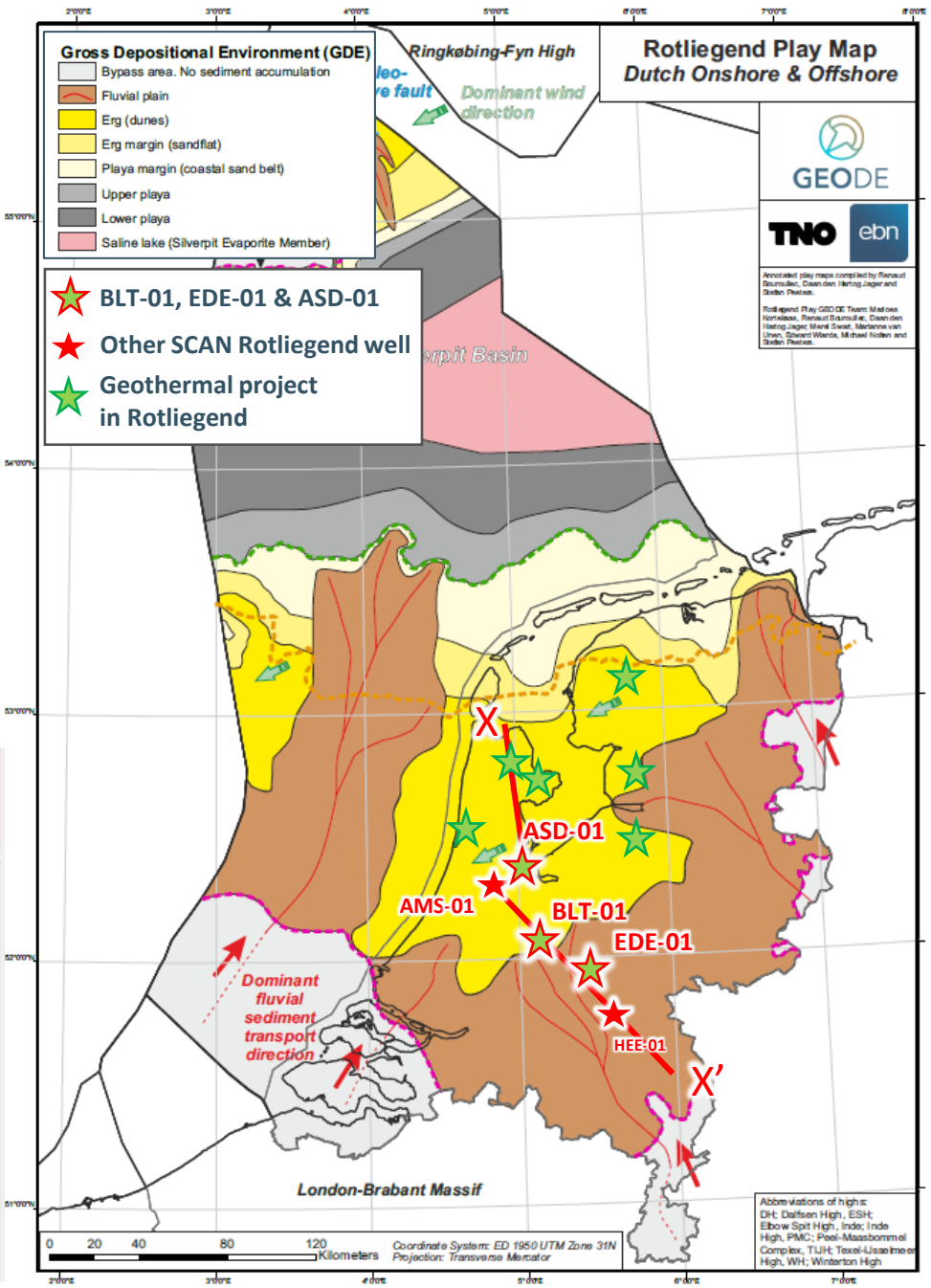
Sven McCarthy, PanTerra

- Palaeogeography
- Core Description
- Depositional Environments
- Reservoir Quality Controls

# Rotliegend Slochteren

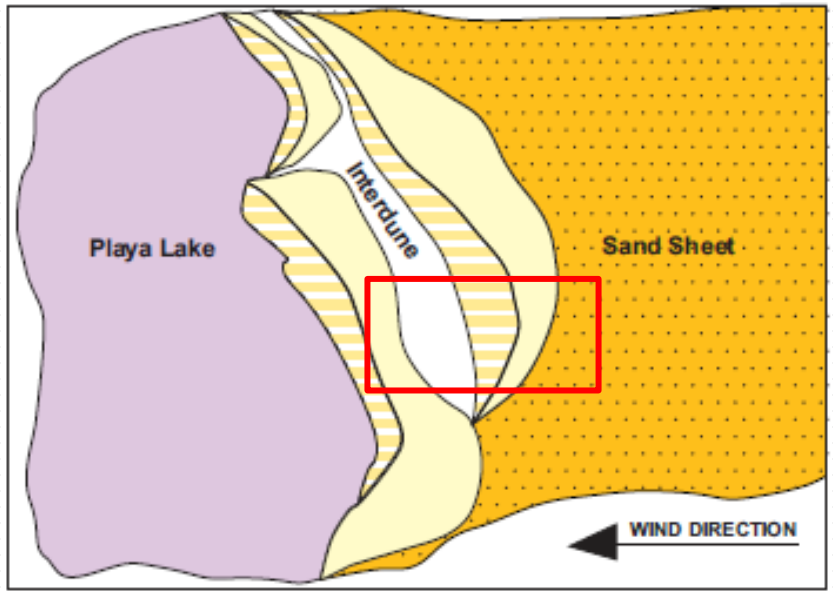
- Upper Rotliegend Group (Slochteren Formation)
- Permian epicontinental clastic deposits
- Aeolian dunes (erg) with greatest flow potential
- 50-250m thick, low clay content, little compositional variation
- Ede-01: 60 m; De Bilt-01: 118 m; Amsterdam-01 (ASD-01): 152 m TVT
- How to differentiate?
  - Grain size, sorting, bedding style...



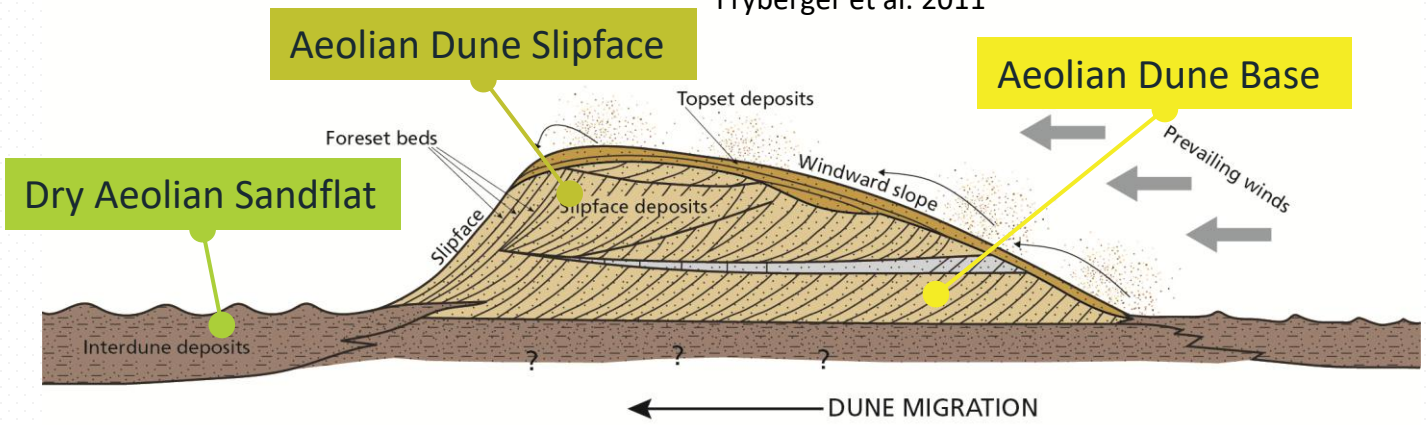



# Palaeogeography

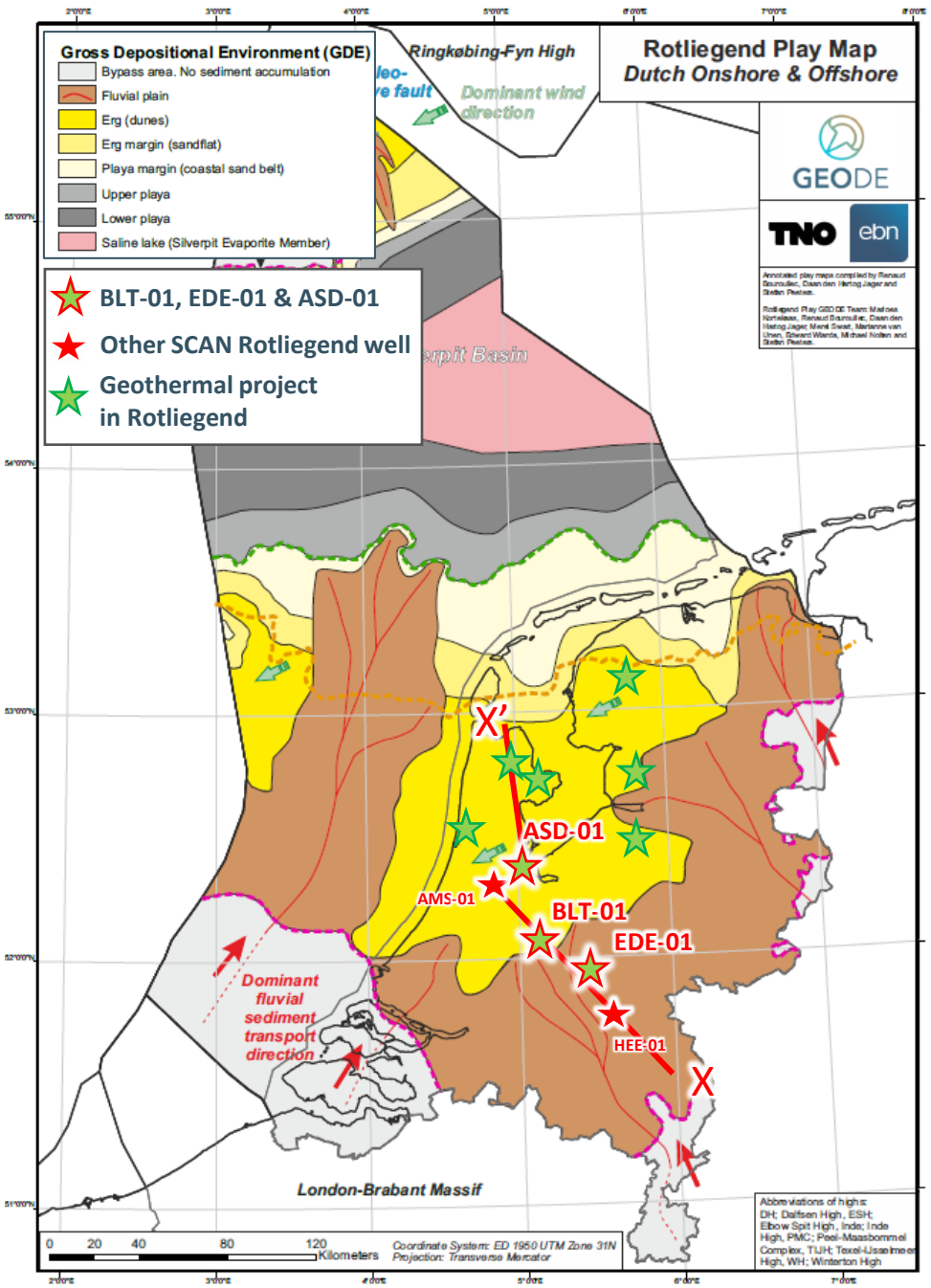
- Migrating aeolian dune forms and interdune areas
- Constant uniform wind direction
- Water table below sediment surface




Fryberger et al. 2011



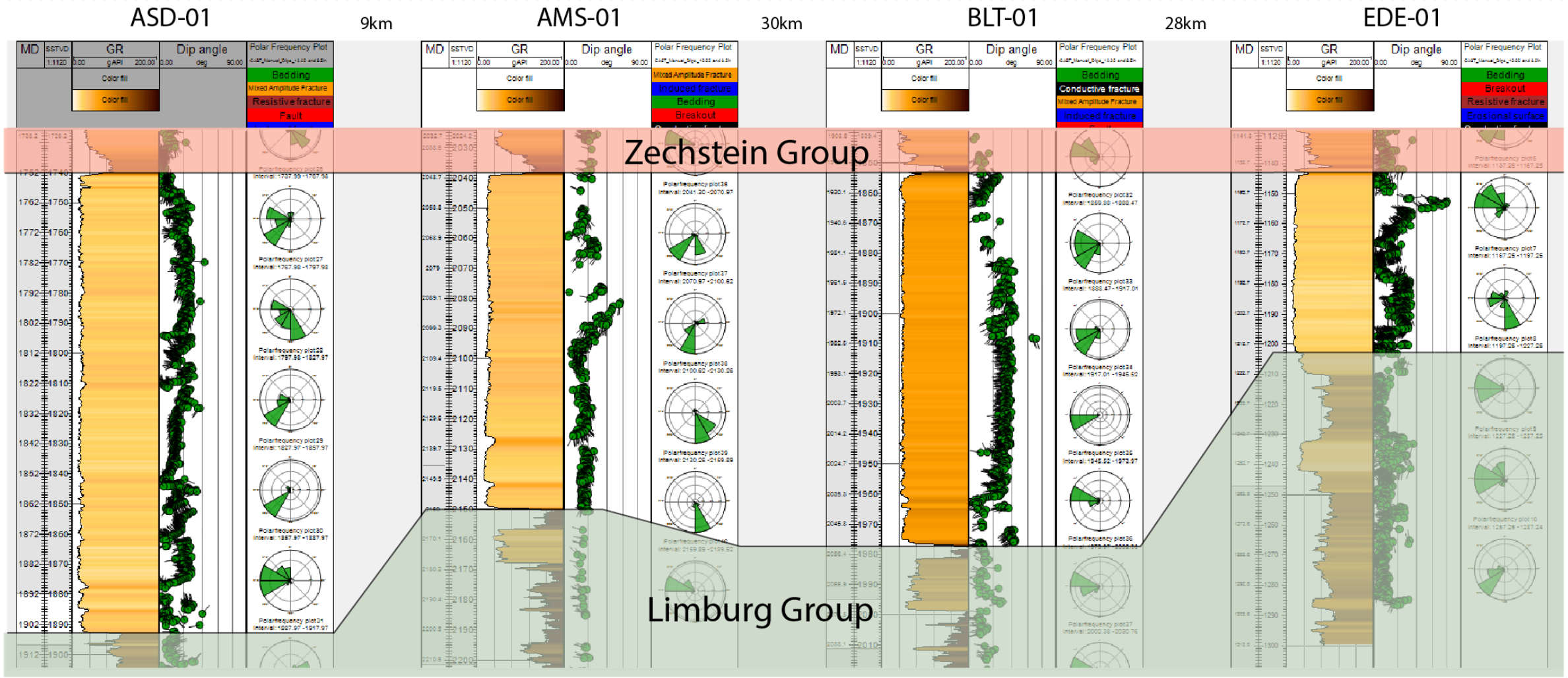

modified from Ahlbrandt and Fryberger (1982)






GEODE - Kortekaas et al., 2023

# Wind direction




**Dominant wind direction towards W-SW based on sedimentary dips, lower part of EDE-01 and AMS-01 towards S**

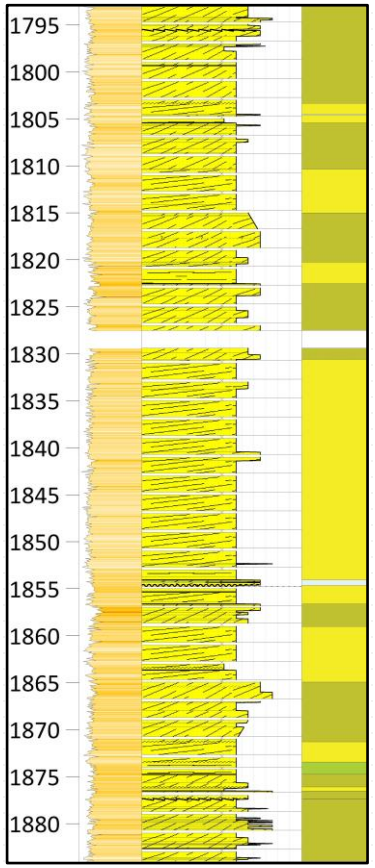
# Core sedimentology

*DSE=dep. sub-environment

| Depth | Core GR | Core Descr. | DSE* |
|---|---|---|---|

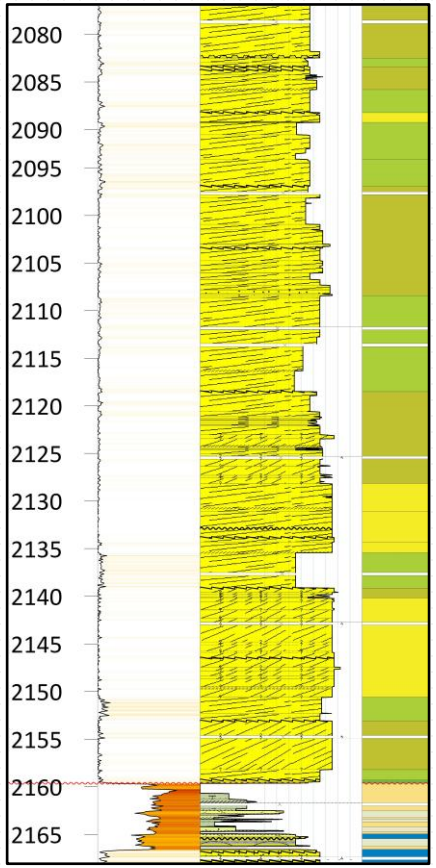
- Aeolian Dune Slipface
- Aeolian Dune Base
- Dry Aeolian Sandflat
- Homogenic Aeolian Sediment
- Fluvial Channel
- Damp Aeolian Sandflat

ASD-01

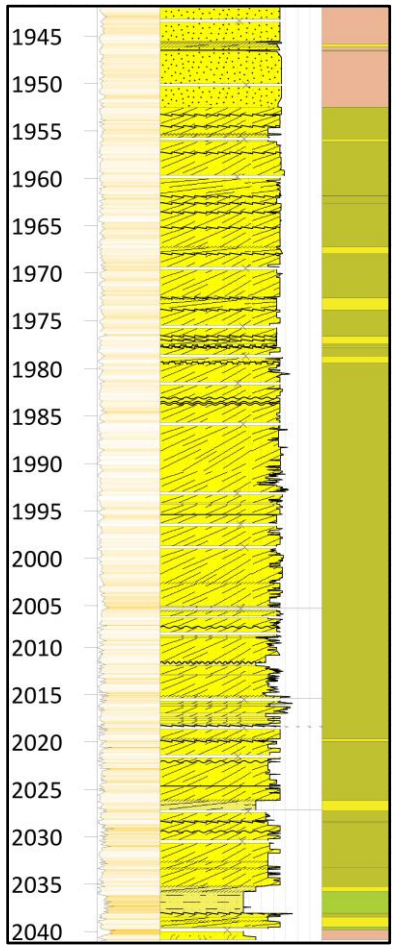



AMS-01

BPU

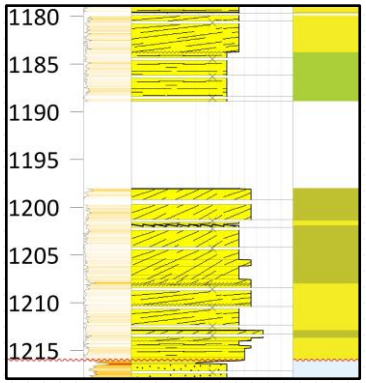



BLT-01




EDE-01

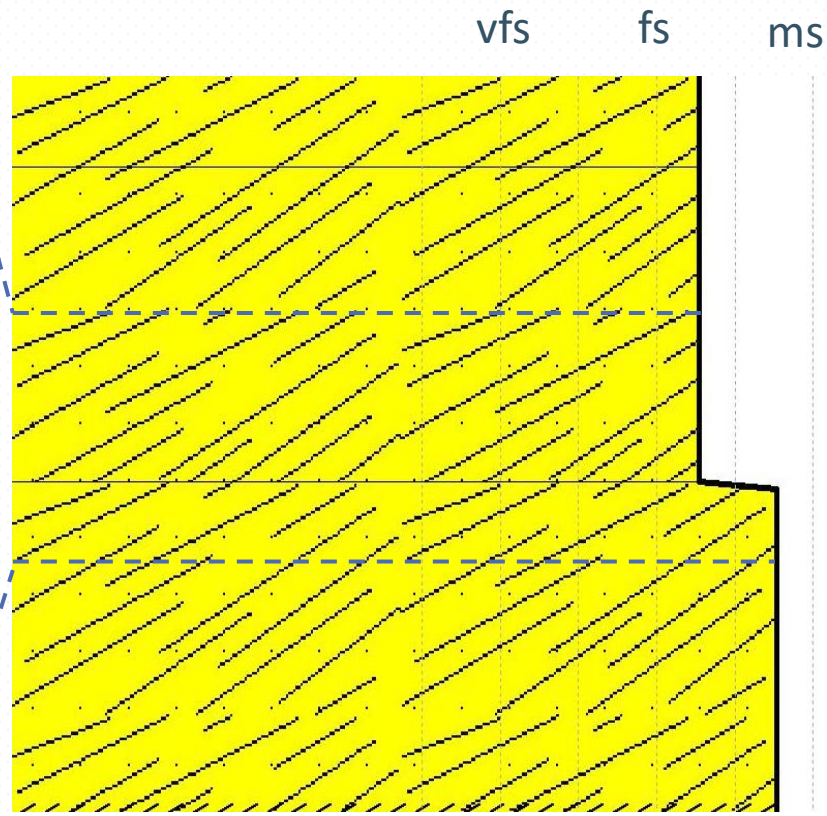
BPU



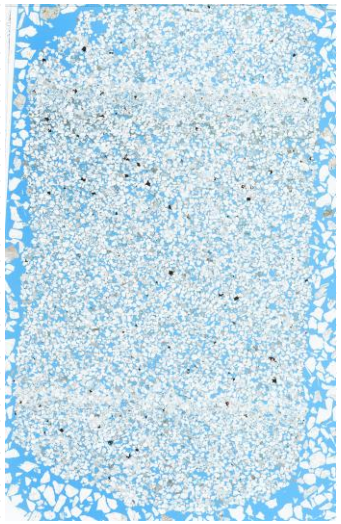

**Please note:** De Bilt& Ede will be compared to the Amstelland-01 well here (AMS-01, 2023), not to be confused with the Amsterdam-01 well (ASD-01, 2025)

# Depositional sub-environments - main

Aeolian Dune Slipface

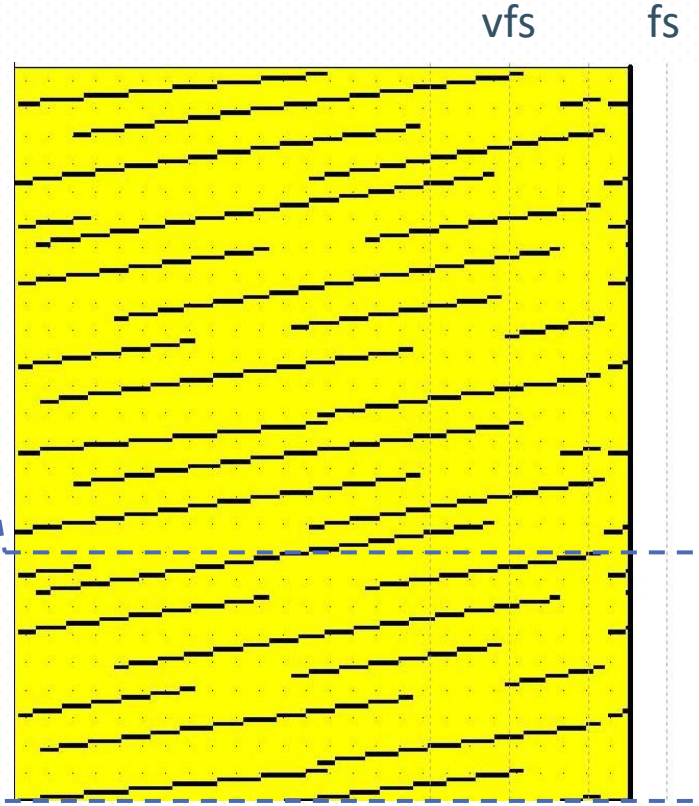



- Fine- to medium sand
- Bedded on mm- to cm-scale
- High-angle cross-bedding (based on BHI)
- Occasional fining-upward, tapered beds



# Depositional sub-environments - main

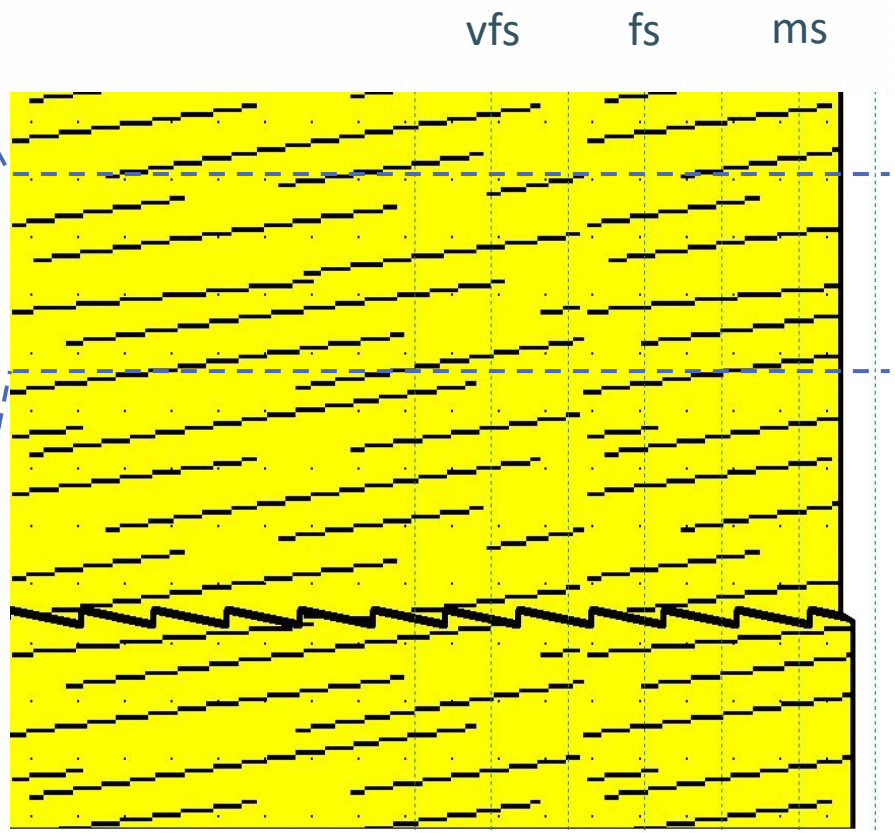
Aeolian Dune Base




- Grain-size lamination or thin-bedding
- Fine sand
- Planar, low-angle cross-stratification (<15°)
- Often gradational base contact to Dry Aeolian Sandflat

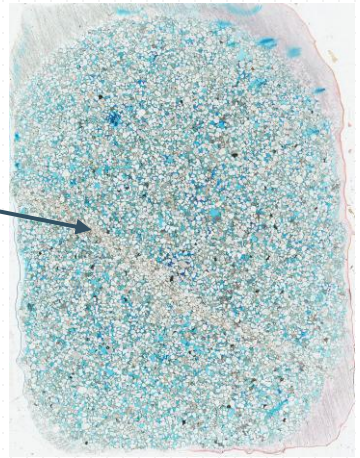
# Depositional sub-environments - main

Aeolian Dune Base – in AMS-01



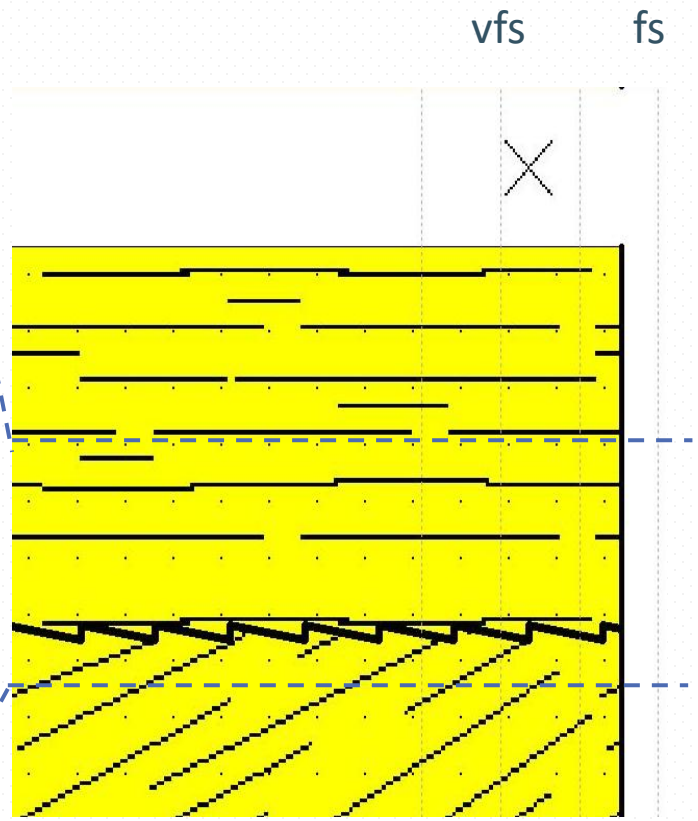

- Structureless cm-thick beds, thin silty laminae
- Medium (upper) sand
- Internally well sorted
- Apparent low-angle cross-stratification (<15°)
- Occur above Dry Aeolian Sandflat units

Deformation band

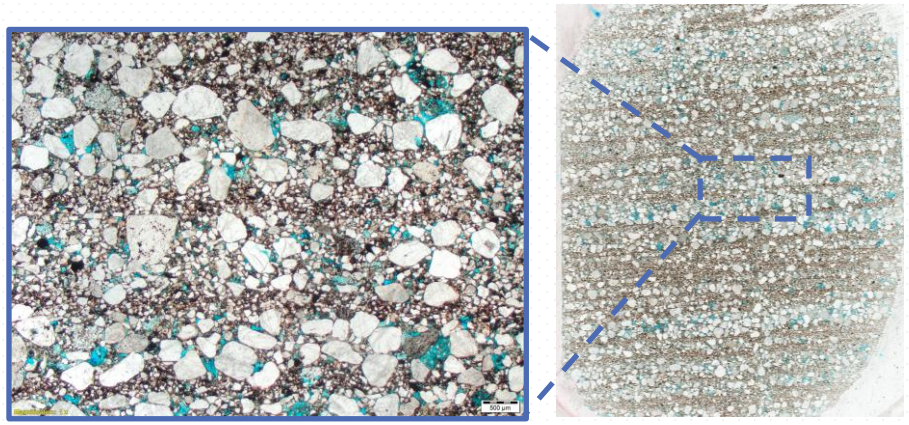


# Depositional sub-environments - main

Dry Aeolian Sandflat

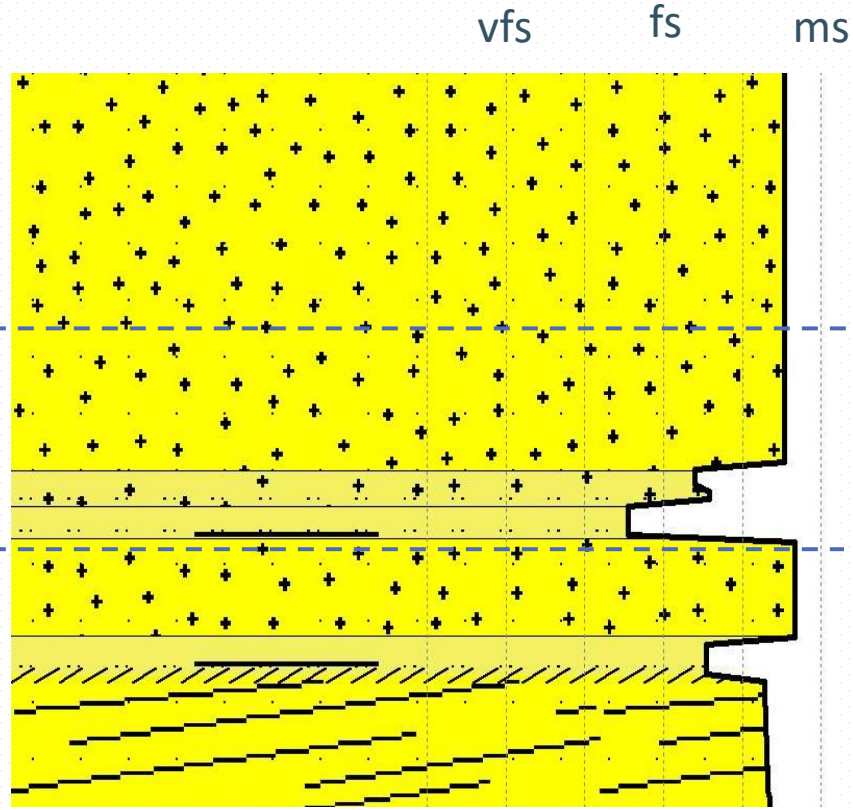



- Distinct bimodal (‘pin-stripe’) lamination
- Fine sand with up to coarse sand lags
- Horizontal to low-angle cross-bedding
- Often truncating aeolian dune slipface deposits



# Depositional sub-environments - minor

Homogenic Aeolian Sediment

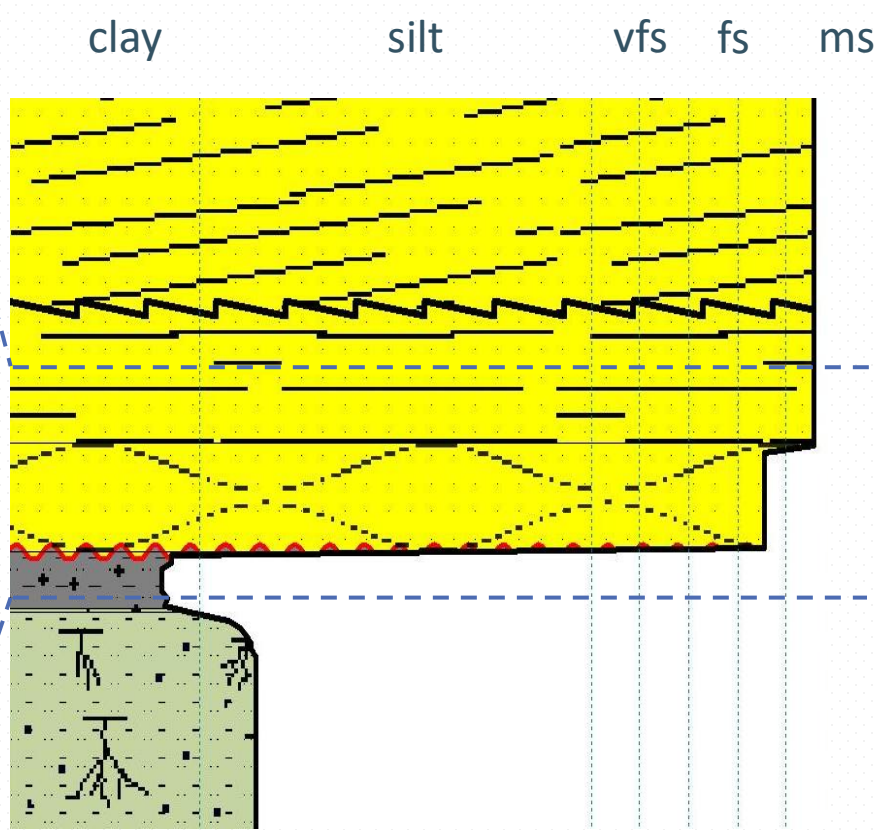



- BLT-01 only
- Structureless, occasionally faint lamination
- Medium sand, silty

- Interpretation: fluidisation by water escape

# Depositional sub-environments - minor

Damp Aeolian Sandflat

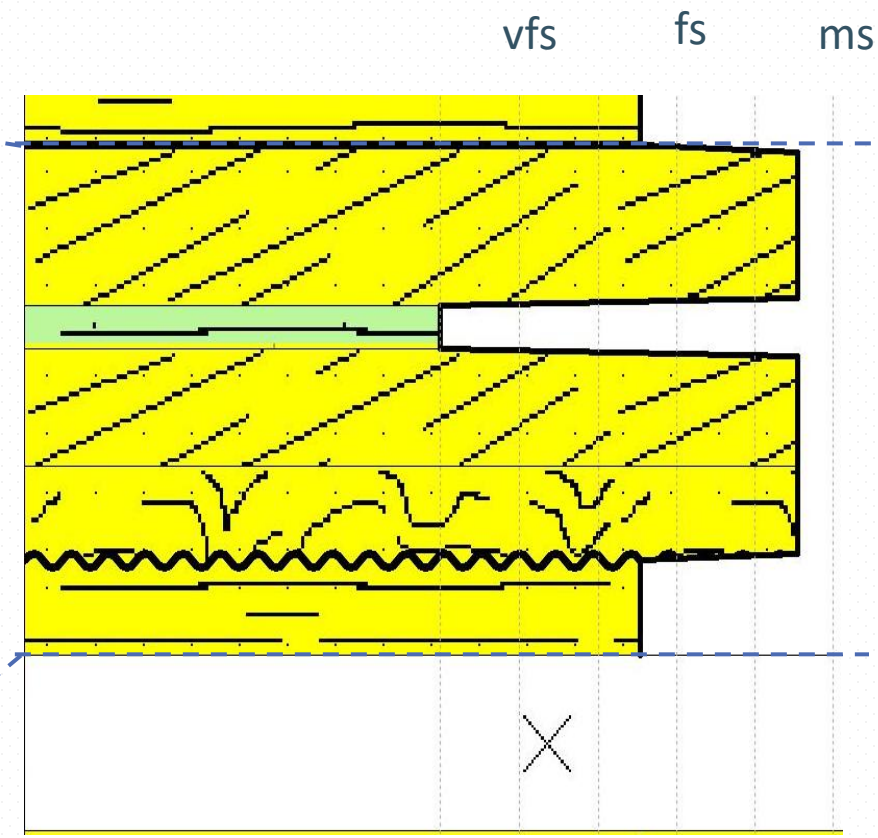



- AMS-01 only
- 30 cm thick interval above BPU
- Fine sand grading upwards to medium sand
- Horizontally wavy laminated (adhesion ripples)
- Extraclasts at base

- Interpretation: Development of sandflat at increasing sand input on initially adhesive, damp surface

# Depostional sub-environments - minor

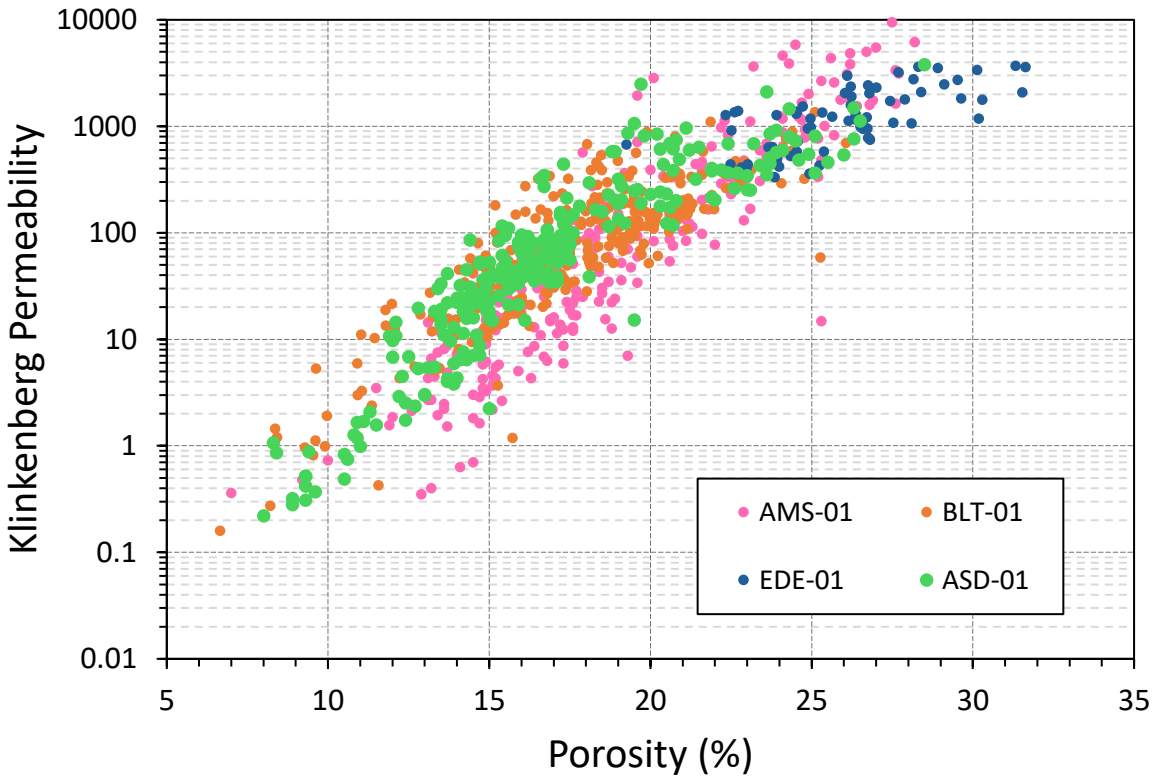
Fluvial Channel

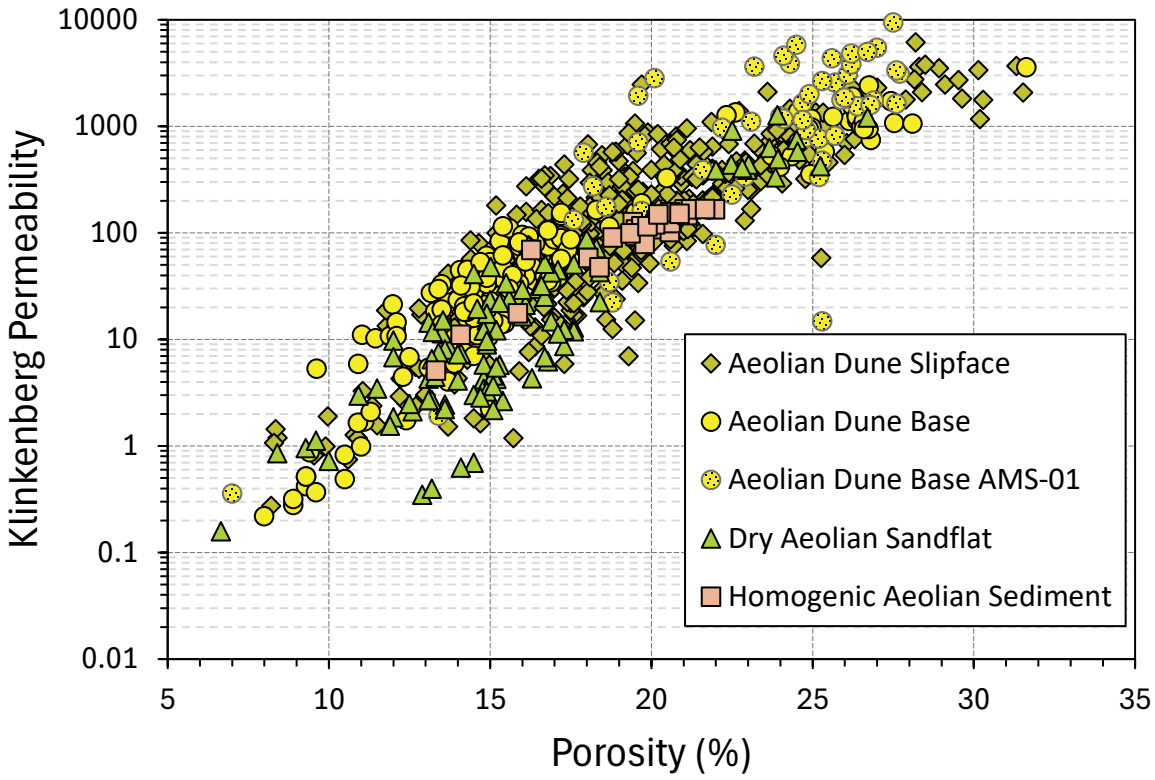



- ASD-01 only
- Structureless, occasionally faint lamination
- High-angle scour, base chaotic
- High-angle trough cross-stratification
- Encased in Aeolian Dune Base deposits

- Interpretation: remobilisation of aeolian dune base sands by flowing water

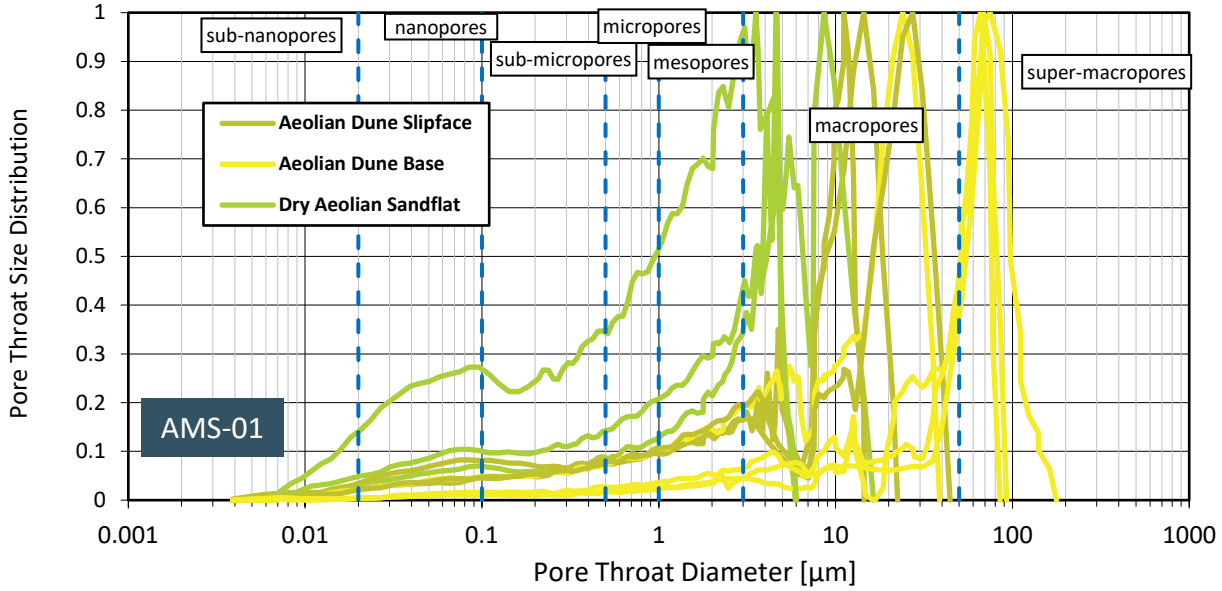
# Reservoir quality – well or facies influence?

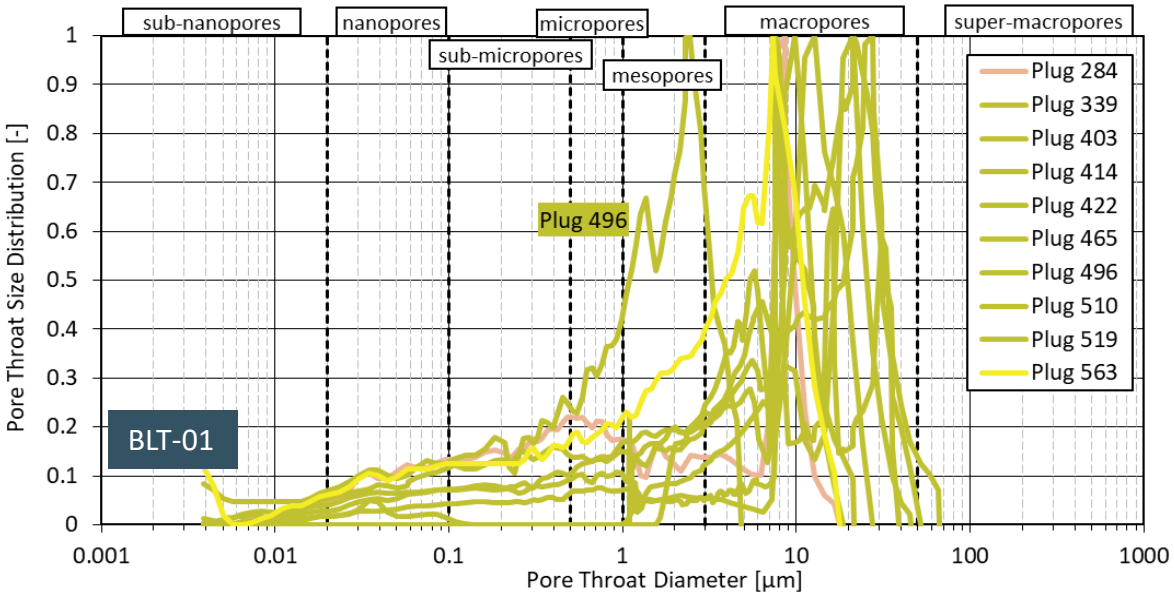


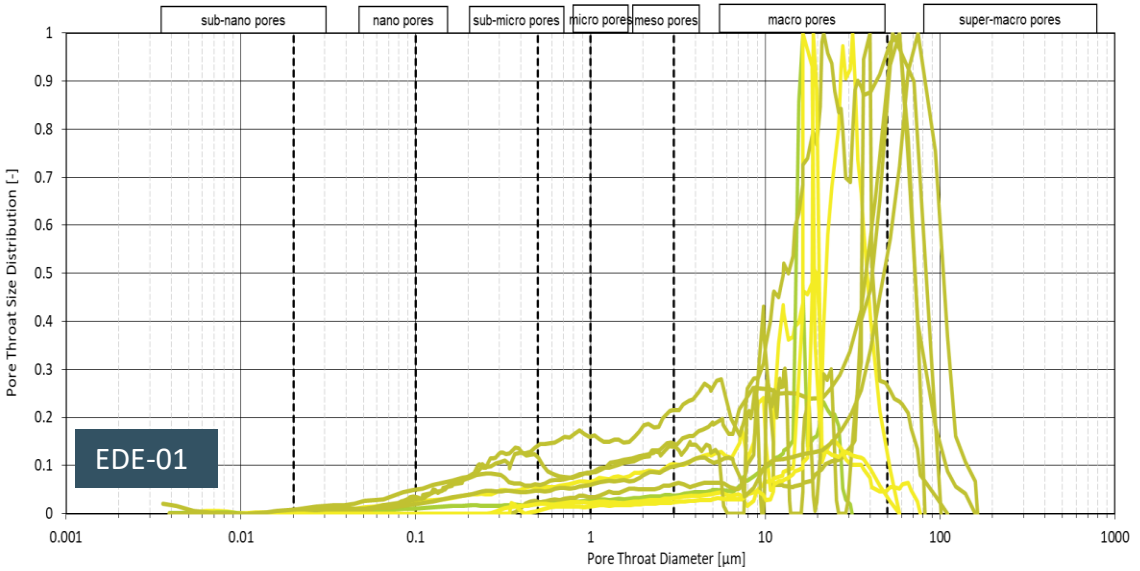




- Large differences between well locations
- Facies differences second order control

# Pore size distribution

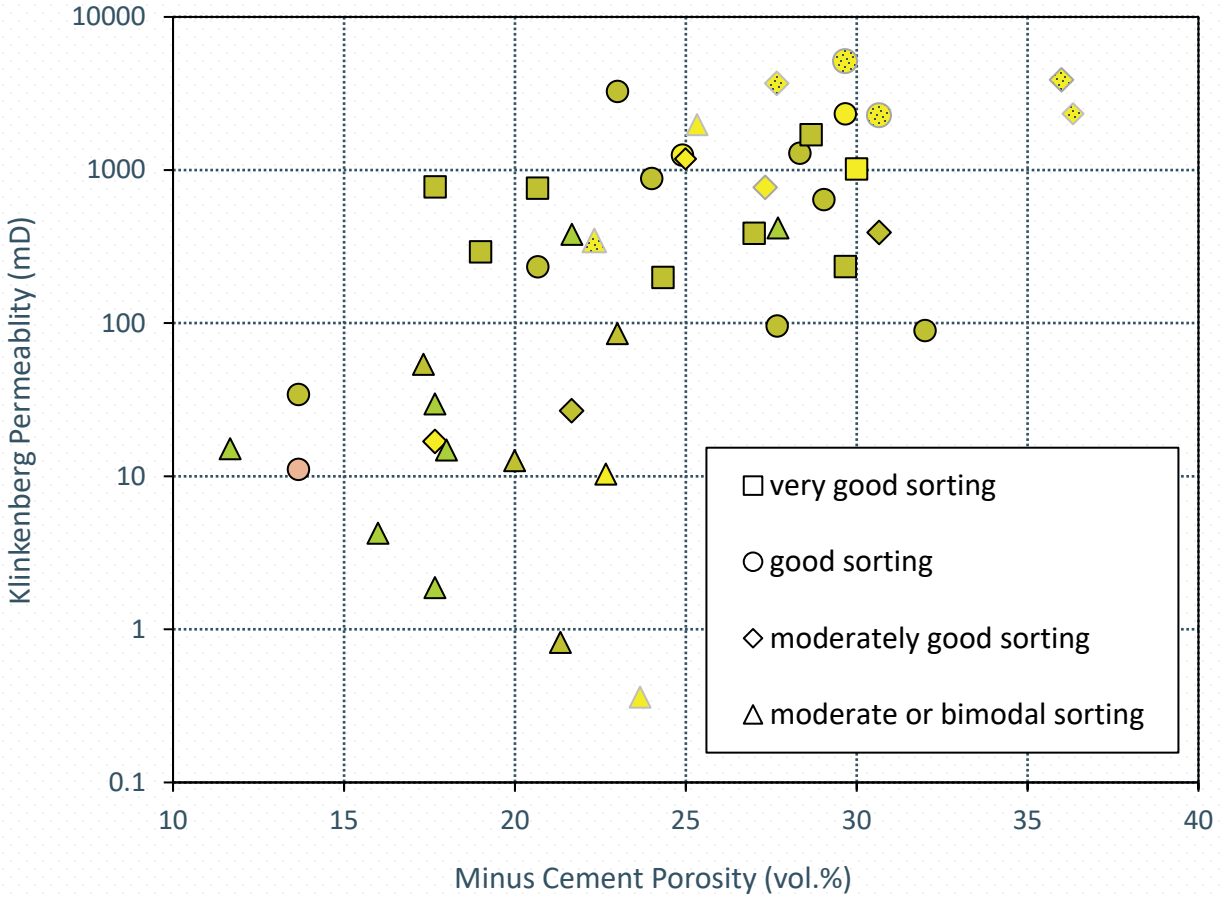



- AMS-01: high facies dependance of pore throat size distribution
- BLT-01: reduced intergranular pore throat sizes and influence of cements (e.g. 496)
- EDE-01: good to very good pore throat characteristics in all sub-environments, super-macro pores in Aeolian Dune Slipface

# The influence of sorting




Aeolian Dune Slipface

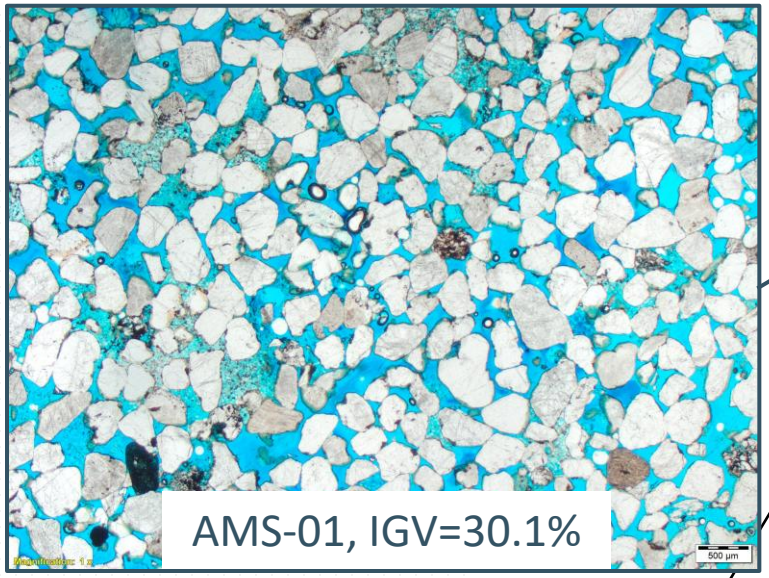
Aeolian Dune Base

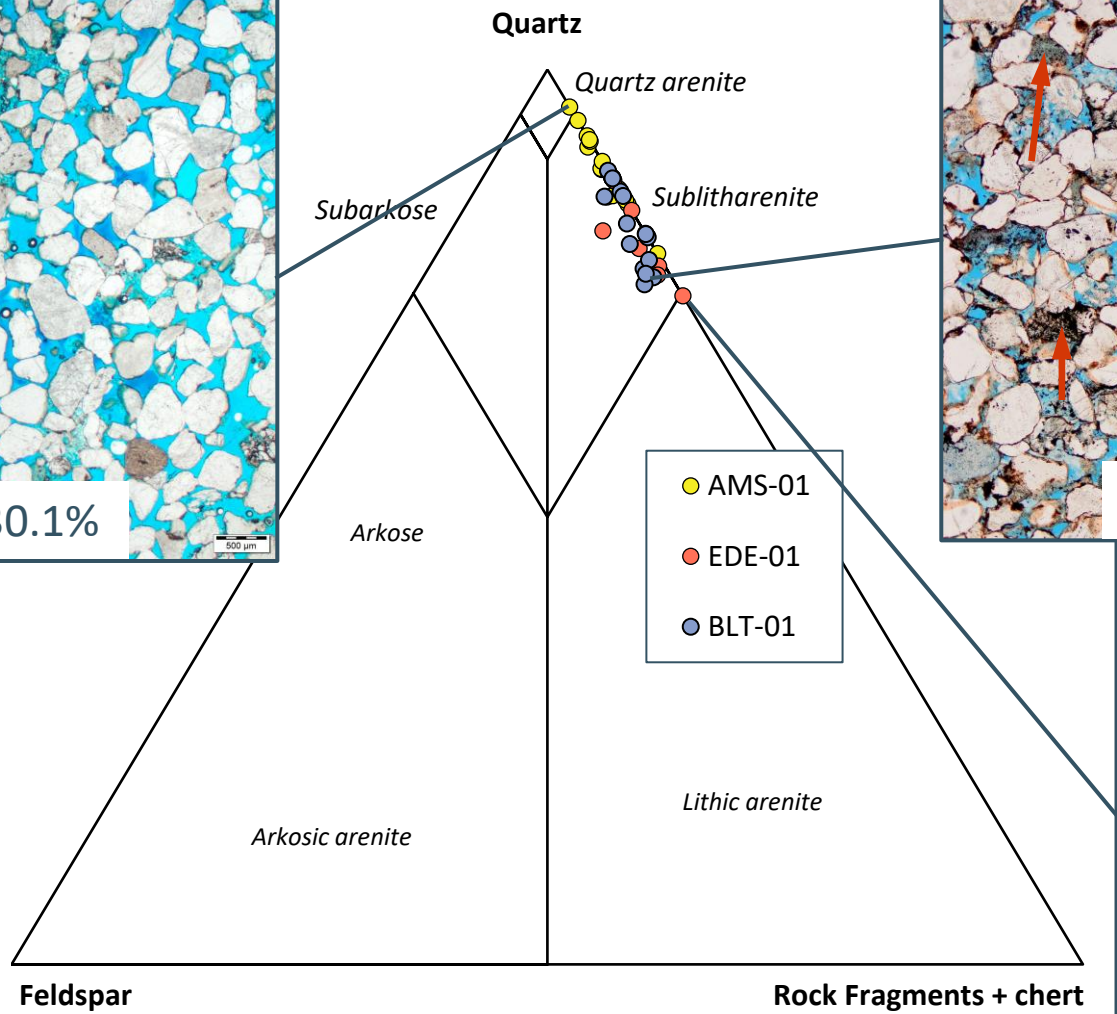
Aeolian Dune Base (AMS-01)

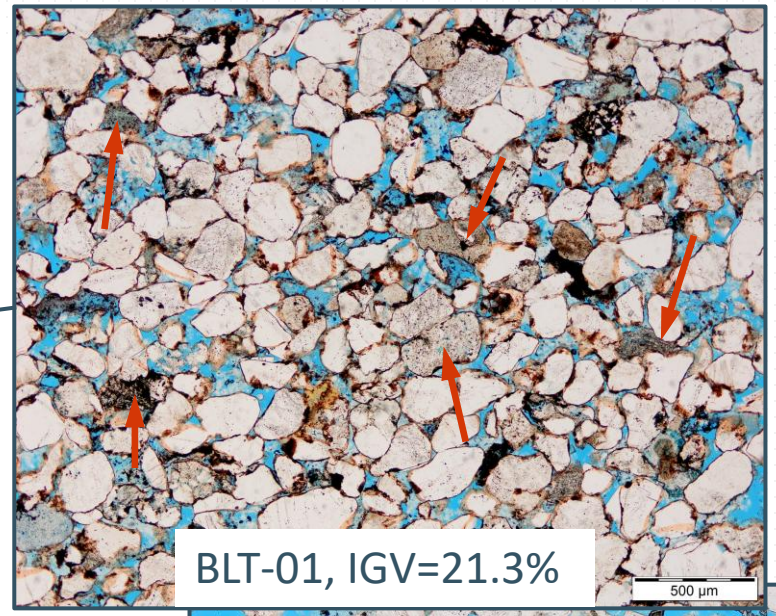
Dry Aeolian Sandflat

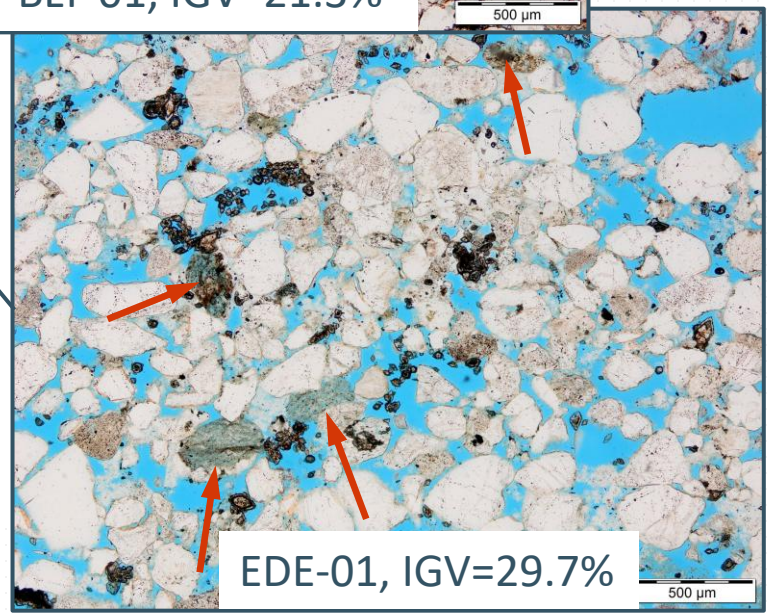
- Permeability and minus cement porosity both dependent on sorting
- Less good sorting or (bimodal) grain-size lamination reduces permeability
- Influence on pore throat size, associated with detrital compostion

# How does the deposition affect flow?



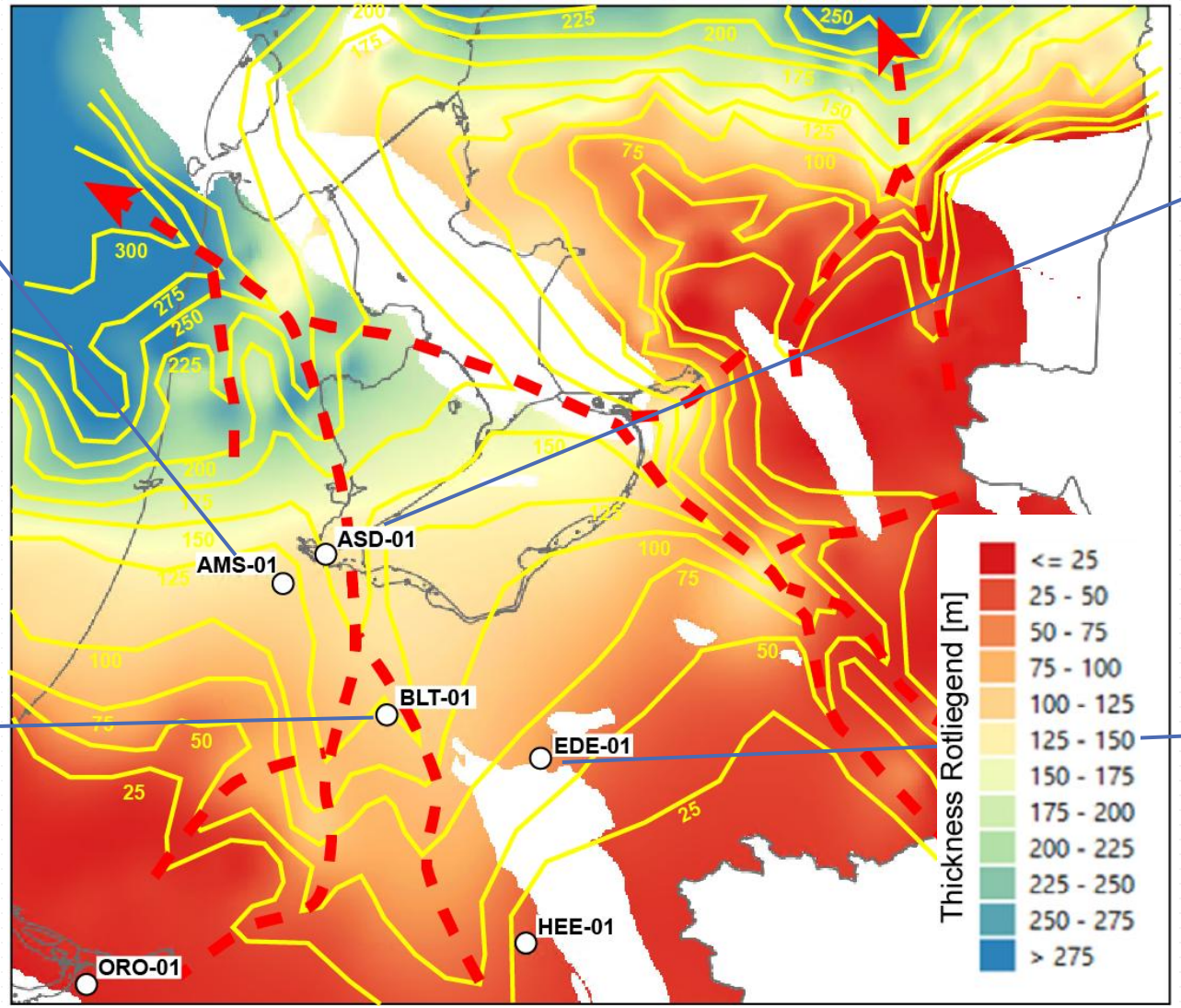




- Content of unstable grains increases compaction
- EDE-01 deviates – less overburden?

# Conclusions – differences between wells

AMS-01 (111 m)
- Multiple aeolian dune sequences
- Distinct Aeolian Dune Base facies with very good reservoir quality (quartz-rich, well sorted)
- strong control of sub-environment

BLT-01 (118 m)
- Dominant Aeolian Dune Slipface
- Aggradational succession
- Varied detrital composition – higher compaction
- Homogenic Aeolian Slipface at top



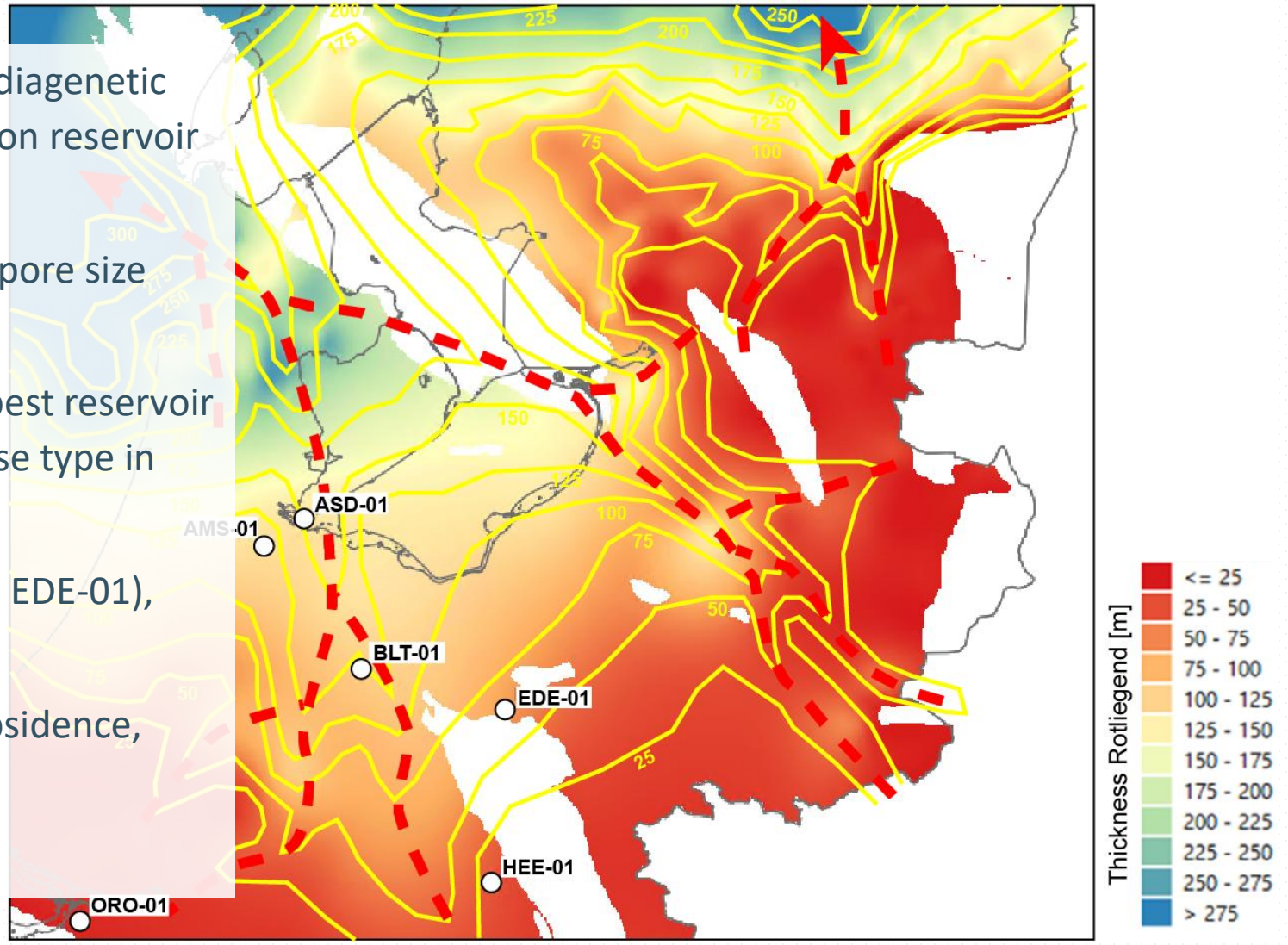

ASD-01 (152 m)
- Aeolian Dune Base very prominent
- Thick aggradational units
- Evidence of (minor) episodic fluvial reworking
- Good reservoir quality in Aeolian Dune Slipface

EDE-01 (60 m)
- Significant Aeolian Dune Base
- Good to very good reservoir quality in all sub-environments
- High intergranular porosity related to low compaction

# Overall conclusions

- Despite differences between wells and in diagenetic overprint, significant depositional control on reservoir quality
- Sorting and detrital composition relate to pore size distribution
- Aeolian Dune Slipface deposits generally best reservoir quality; unique excellent Aeolian Dune Base type in AMS-01
- Compaction varies by well location (low in EDE-01), also by detrital composition

➢ Complex interplay of sediment supply, subsidence, sub-environment and diagenesis

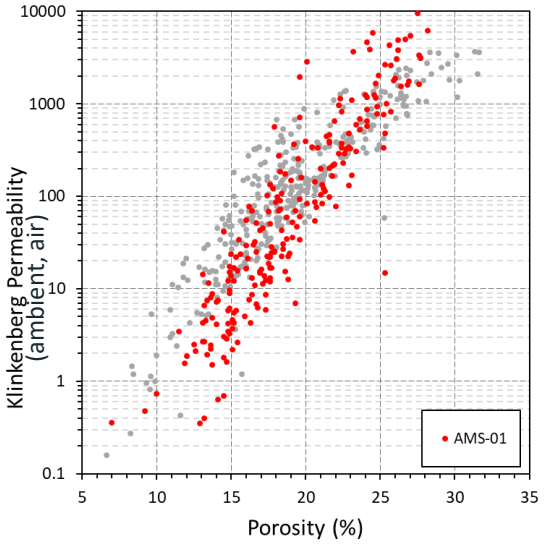


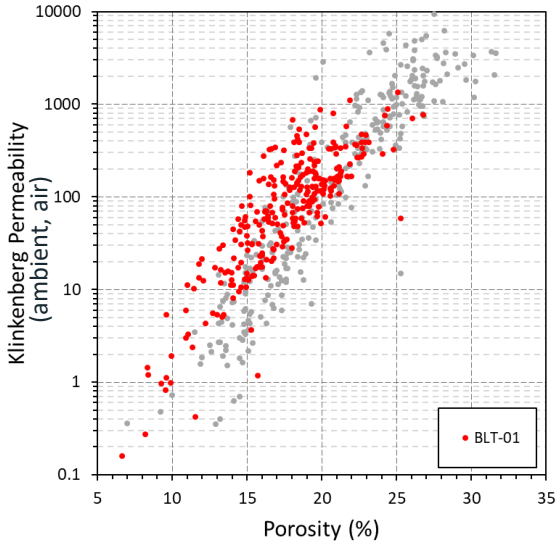
# What happened to the reservoir after deposition?

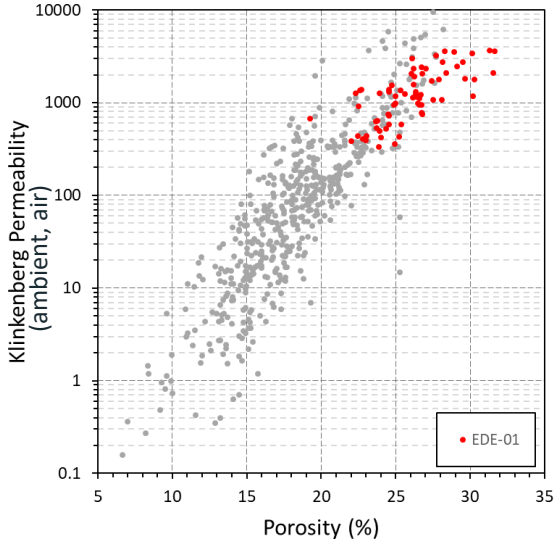
Dallyn Rodriguez, PanTerra

PANterra
GEOCONSULTANTS
WHAT HAPPENED
AFTER DEPOSITION?
Burial & Compaction
Deformation Bands
Freshwater Flow
Connate Waters
Marine Invasion
Faults
500 µm
AI-Generated Image

# Key diagenetic controls




## Amstelland-01

- Moderate compaction.
- Varying effect of authigenic cements.
- Kaolinite & quartz exert a negative influence.

## De Bilt-01

- Greater mechanical compaction.
- Post-compactional, late authigenic cements (dolomite & anhydrite).

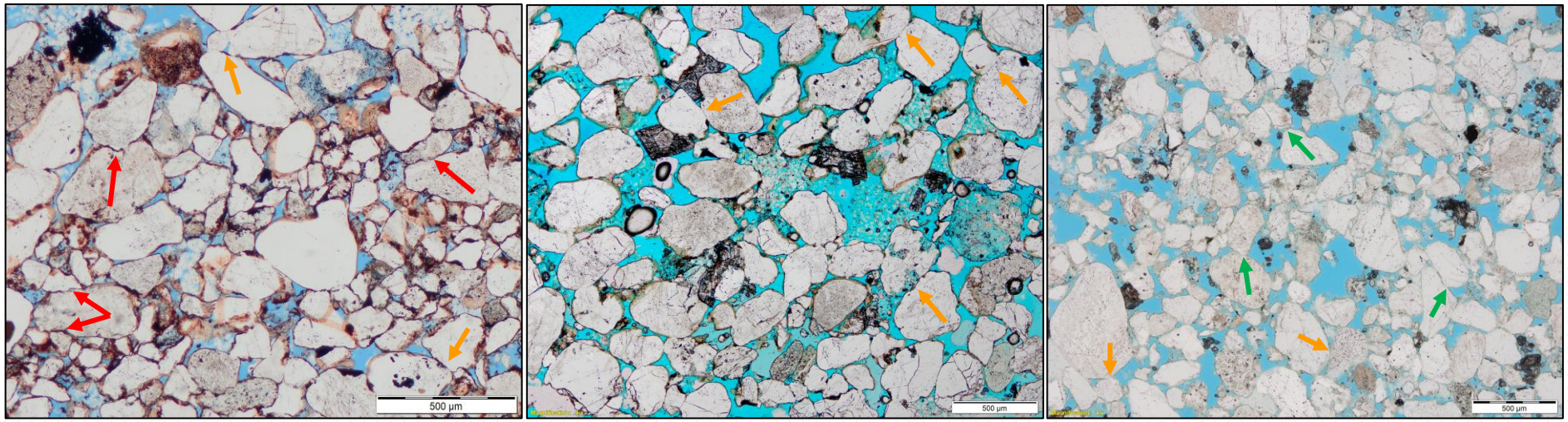
## Ede-01

- Lower mechanical compaction.
- Extensive grain dissolution.
- Sparse pore-filling cements.

**Please note:** **De Bilt& Ede will be compared to the Amstelland-01 well here (AMS-01, 2023), not to be confused with the Amsterdam-01 well (ASD-01, 2025)**

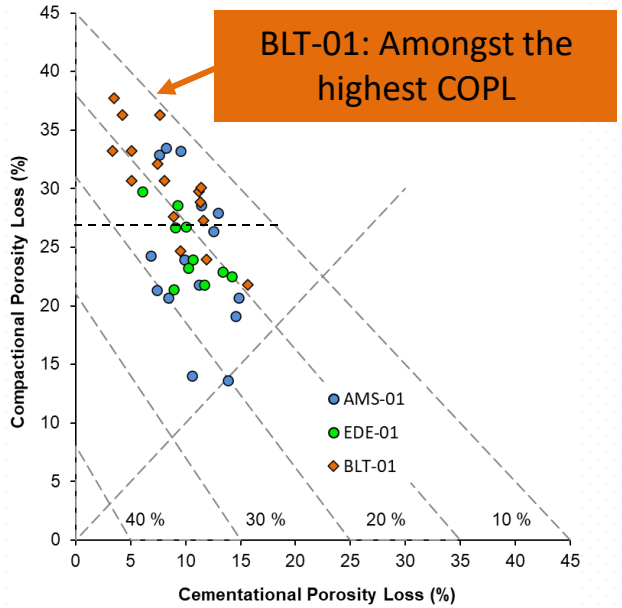
# The role of compaction

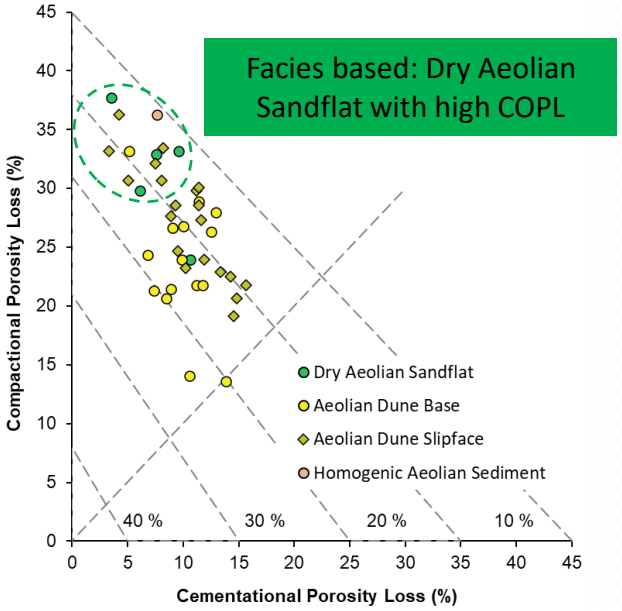
- A majority of the porosity loss is attributed to compaction across all wells.
- Compaction is highest in BLT-01. Role of clay coatings- promoted compaction through localised early pressure dissolution (?)
- Depositional facies-based variability. The Dry Aeolian Sandflat contains common ductile rock fragments, silt grains and detrital clays, thus enhancing the compaction effect.




Avg. COPL – 30.3% | Avg. COPL – 24.1% | Avg. COPL – 24.8%

Red arrow = Concavo-convex / sutured
Orange arrow = Long contact
Green arrow = point contact



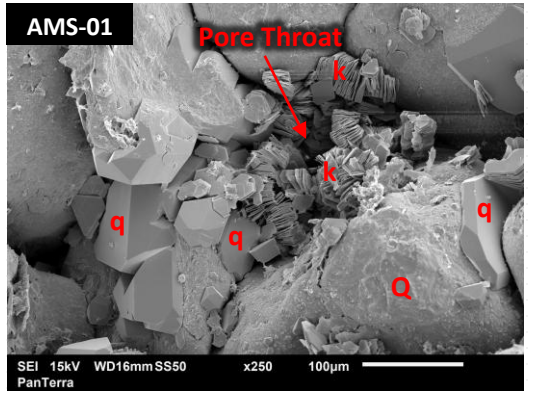
# Impact of authigenic cements

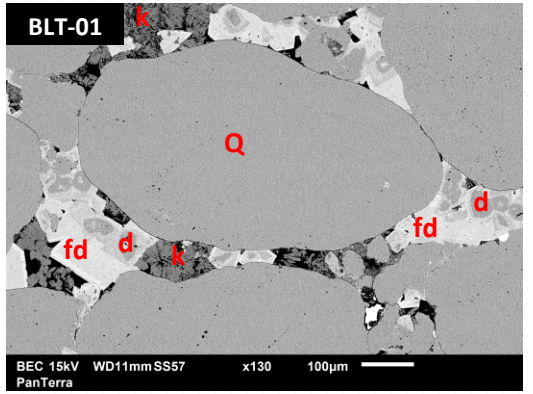
- Early pore-filling blocky cements are not observed in BLT-01 and EDE-01. Presumably related to the low regional water table. Helps preserve primary porosity.
- Quartz & kaolinite exert a moderate influence in Amstelland-01.
- Cementation has a relatively minor influence in EDE-01 (kaolinite & siderite).
- Post-compactional cements (red fill) often have a strong negative and varying influence on reservoir properties. **Particularly in BLT-01!**

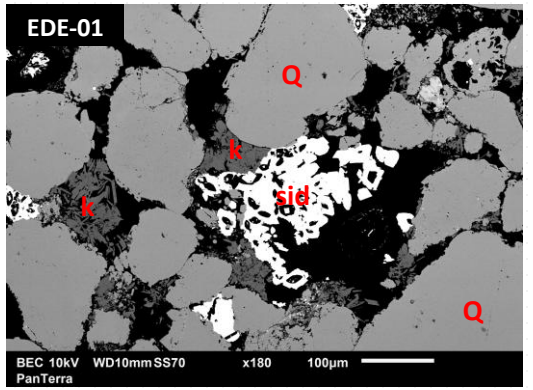
| | Well | AMS-01 | BLT-01 | EDE-01 |
|---|---|---|---|---|
| Authigenic Blocky Cements | Dolomite | ↓ | | |
| | Ferroan Dolomite | ↓ | ↓↓ | |
| | Siderite | | | ↓↓ |
| | Quartz | ↓↓ | | |
| | Anhydrite | | ↓↓ | |
| | Pyrite | | | |
| | Barite | | | |
| Authigenic Clays | Kaolinite | ↓↓ | ↓ | ↓ |
| | Illite | | | |

↓↓ = Major RQ Factor
↓ = Moderate RQ Factor

Blue = Early/Syn-compaction
Orange = Syn-compaction/Late Cement
Red= Post-compaction/Late Cement

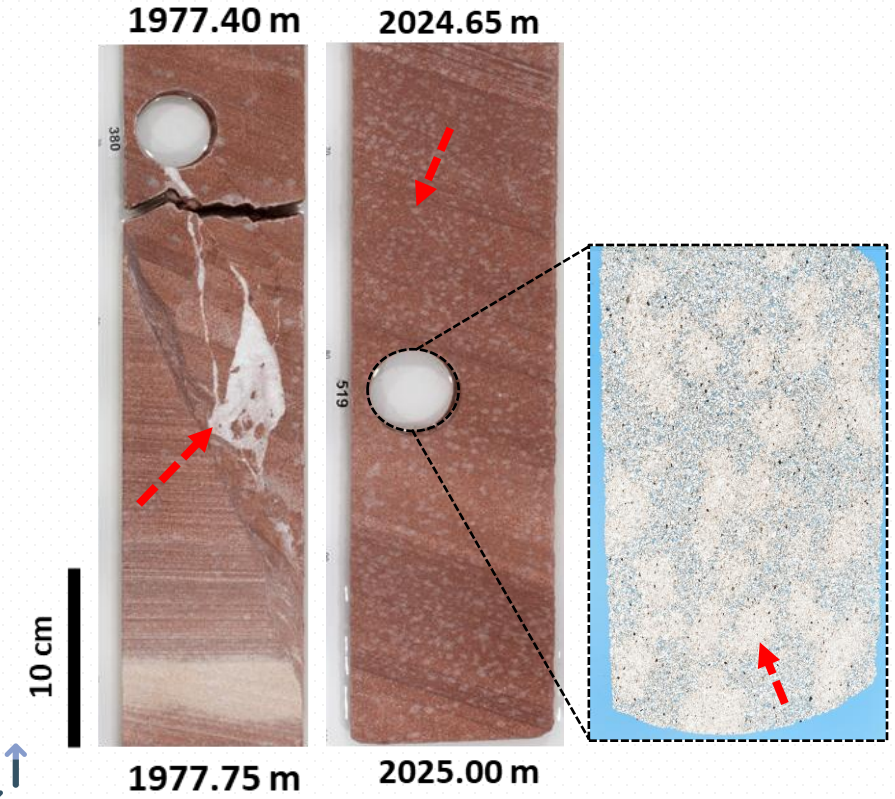


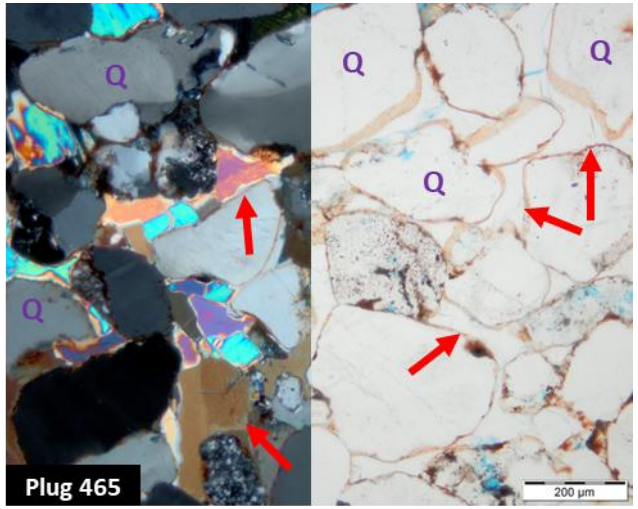



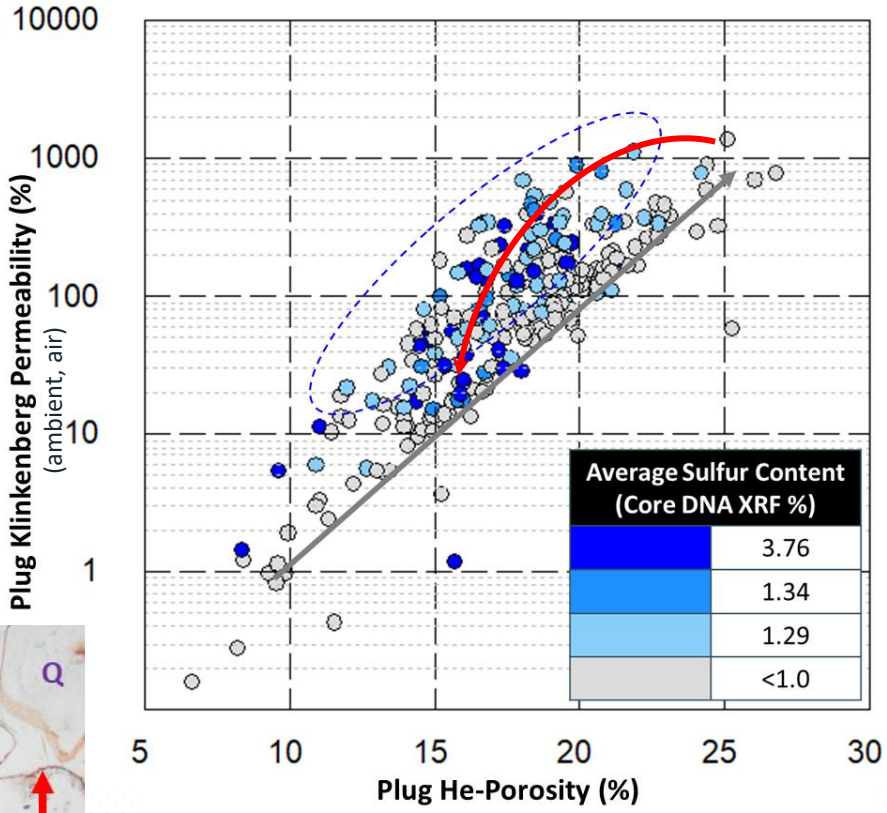
# Diagenetic influence of faults & fractures (De Bilt-01)

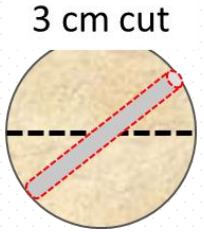
- ➜ Post-compactional anhydrite cement attributed to fault-related fluid flow.
- ➜ Patchy, poikilotopic habit exerts a strong negative control on porosity, but a milder effect on permeability.
- ➜ Locally restricts pore-scale fluid flow while increasing flow tortuosity.
- ➜ Ingress of overlying Zechstein fluids?




Red arrow = anhydrite cement
Q = Detrital quartz grain



# Fracture distribution

**Amstelland-01**

More deformation features than other wells

Open& cemented fractures, deformation bands & cm-scale faults

**Amsterdam-01**

Negligible deformation

4 cm-scale fractures across the cored interval

**De Bilt-01**

Moderate to sparse amount of deformation features

Open& cemented fractures. Cm – scale faults

**Ede-01**

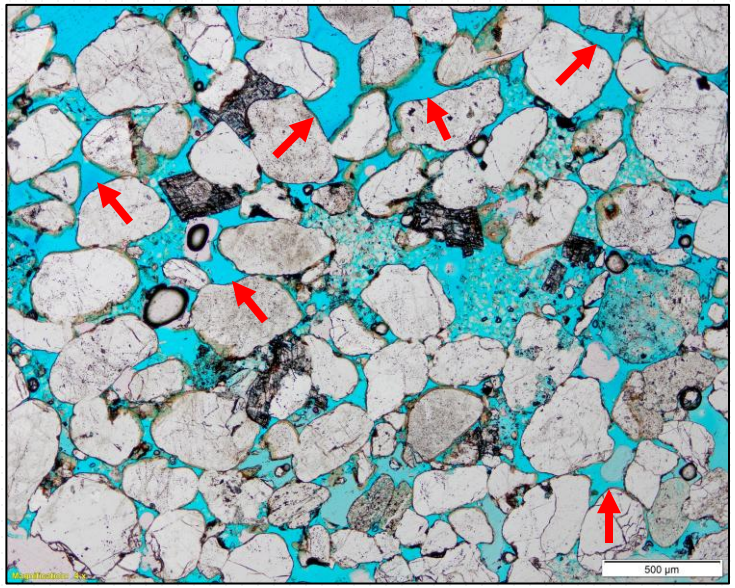
Rare deformation features

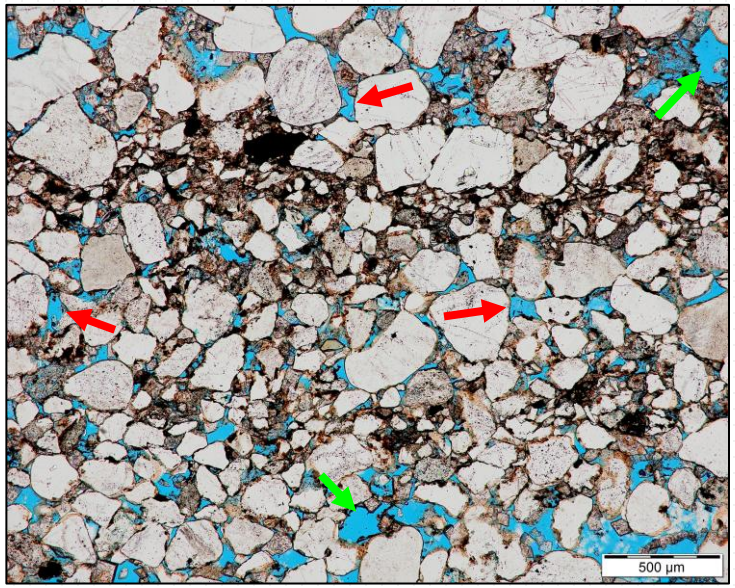
Cemented fractures.

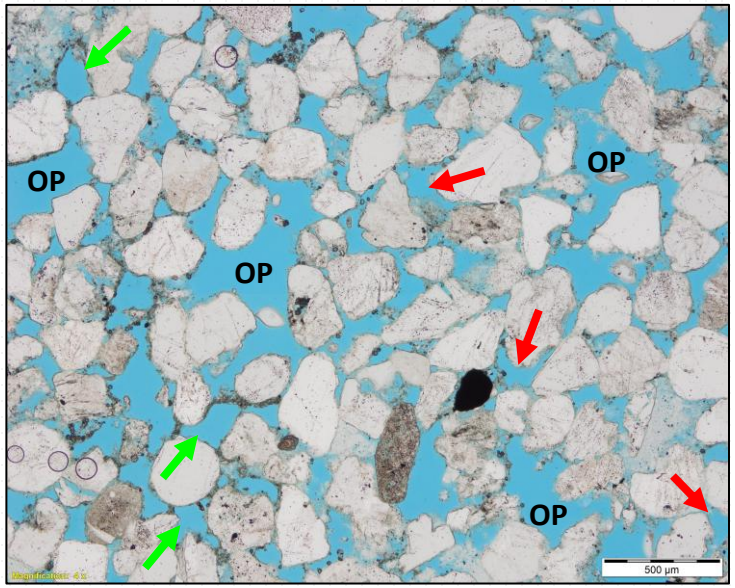
# Porosity enhancement due to grain dissolution

- ➜ Amstelland-01 porosity is largely governed by primary pores.
- ➜ De Bilt-01 exhibits contributions of secondary pores, dominantly the mouldic variety.
- ➜ Extensive grain dissolution in Ede-01, primarily oversized pores (locally up to 11.7%).

**Red arrow = Primary Pore**
**Green Arrow = Mouldic Pore**
**OP = Oversized Pore**
**Impregnated Pore Space**



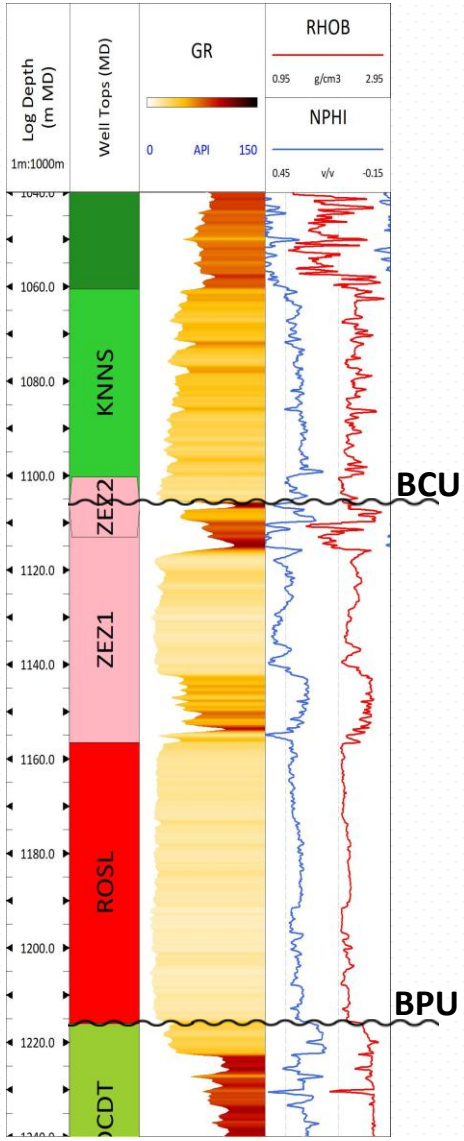



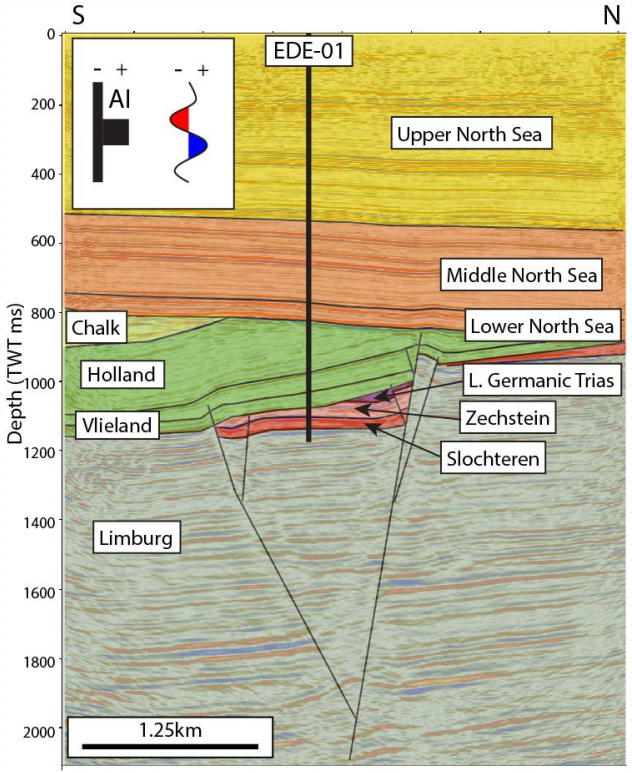

**Amstelland-01**
Primary pores: 11.3%
Oversized+Mouldic pores: 0.4%
(Mouldic Pores: 0.2%)

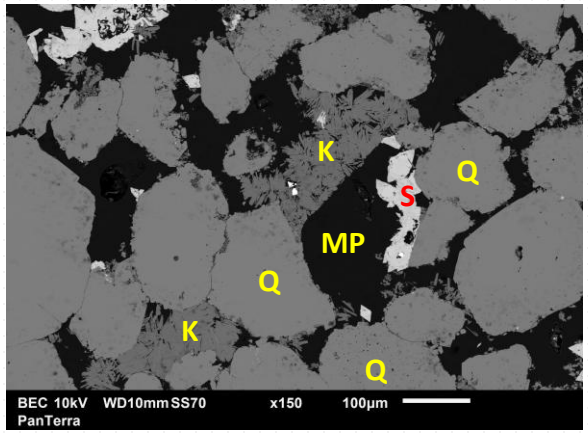
**De Bilt-01**
Primary pores: 8.8%
Oversized+Mouldic pores: 2.0%
(Mouldic Pores: 1.5%)

**Ede-01**
Primary pores: 13.1%
Oversized+Mouldic pores: 5.5%
(Oversized pores: 4.8%)

# Porosity enhancement due to grain dissolution (Ede-01)




- Absence of Triassic and Jurassic strata is attributed to significant uplift and erosion.
- 50 meters of Zechstein Group (ZE) along-hole, unconformably overlain by the Vlieland Sandstone Formation (KNNS).
- The ingress of meteoric and marine waters during uplift is proposed to have driven extensive grain dissolution.
- Late Jurassic to Early Cretaceous uplift phases (?)

**Influence of Uplift and Vlieland Transgression**

↓ Pre/syn-compaction kaolinite

↓ Burial

↓ Uplift – meteoric/marine fluids

↓ Grain dissolution

↓ Fully marine – siderite

**Influence of Acidic Carboniferous Fluids**

↓ Burial

↓ Expulsion of acidic and reducing Carboniferous fluids

↓ Grain dissolution + kaolinite + siderite

# Well specific trends

## Amstelland-01

- Moderate mechanical compaction.
- Abundant pore-filling cements, but do not show a strong systematic correlation with reservoir properties.
- Kaolinite & quartz exhibit a negative influence on reservoir quality.
- Strong permeability decrease measured at the plug scale across deformation bands.

## De Bilt-01

- Mechanical compaction during burial is the main driver for porosity loss and permeability reduction. Clay coatings promoted compaction?
- Post-compactional pore-filling cements exert varying negative controls on reservoir properties.
- Dolomite decreases permeability significantly when abundant, whereas anhydrite causes widespread impairment of porosity, with less pronounced permeability reduction.

## Ede-01

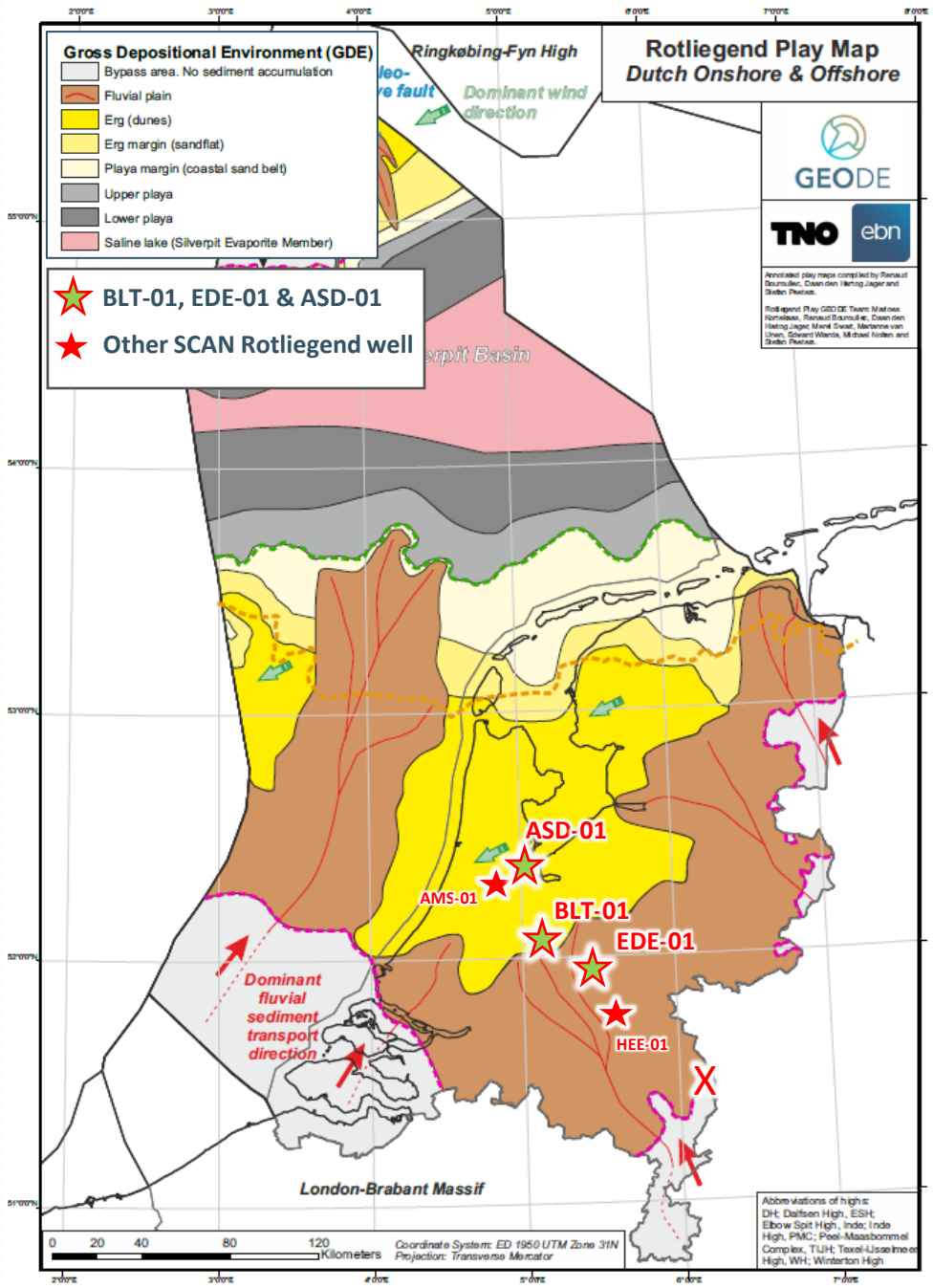
- Limited compaction and sparse early pore-filling cements helped preserve intergranular pore space.
- Extensive grain dissolution associated with the exposure to meteoric and marine fluids during uplift is proposed to have had a strong positive impact on reservoir quality.
- Authigenic siderite (associated with marine fluids during the Vlieland transgression) exerts a systematic (negative) yet minor control on reservoir properties.

# General features

- Compaction exerts a strong negative influence on reservoir quality and differs between facies. Depositional facies containing higher ductile rock fragments and detrital clays exhibit increased compaction (e.g. the Dry Aeolian Sandflat).

- The low position of the water table and location away from the lake margin do not favour reservoir impairment by early blocky cements (particularly dolomite and anhydrite).

- Post-compactional cements, especially those related to fractures often have a strong negative overprint on reservoir properties, making it challenging to determine the governing factor on reservoir quality.




GEODE - Kortekaas et al., 2023

# scan

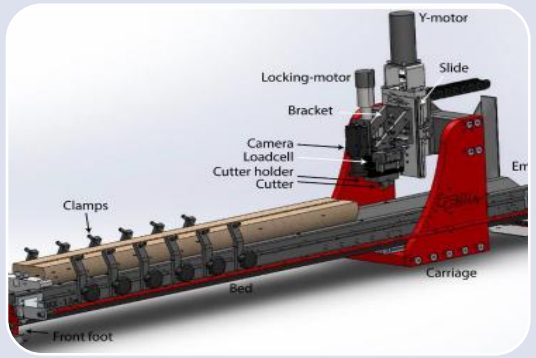
## How does the reservoir perform?

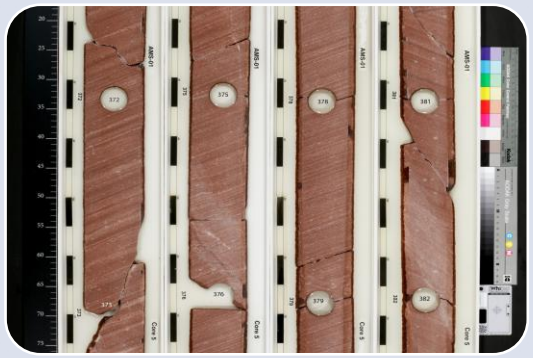
Pieter Bruijnen, Sanchita Ganguly,
Adriaan Janszen

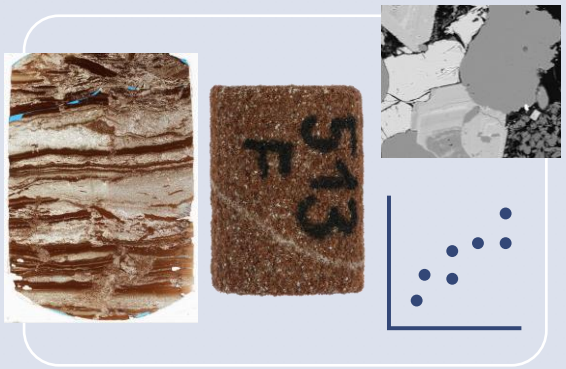
To core viewing

• Core Analysis
• Petrophysical Integration
• Well Test Interpretation
• Integration

# Core Analysis Program






## Screening

- Core GR
- CoreDNA

## Core Description

- Digital recording in WellCAD
- Lithology, texture, contacts, fractures, …
- White light photography

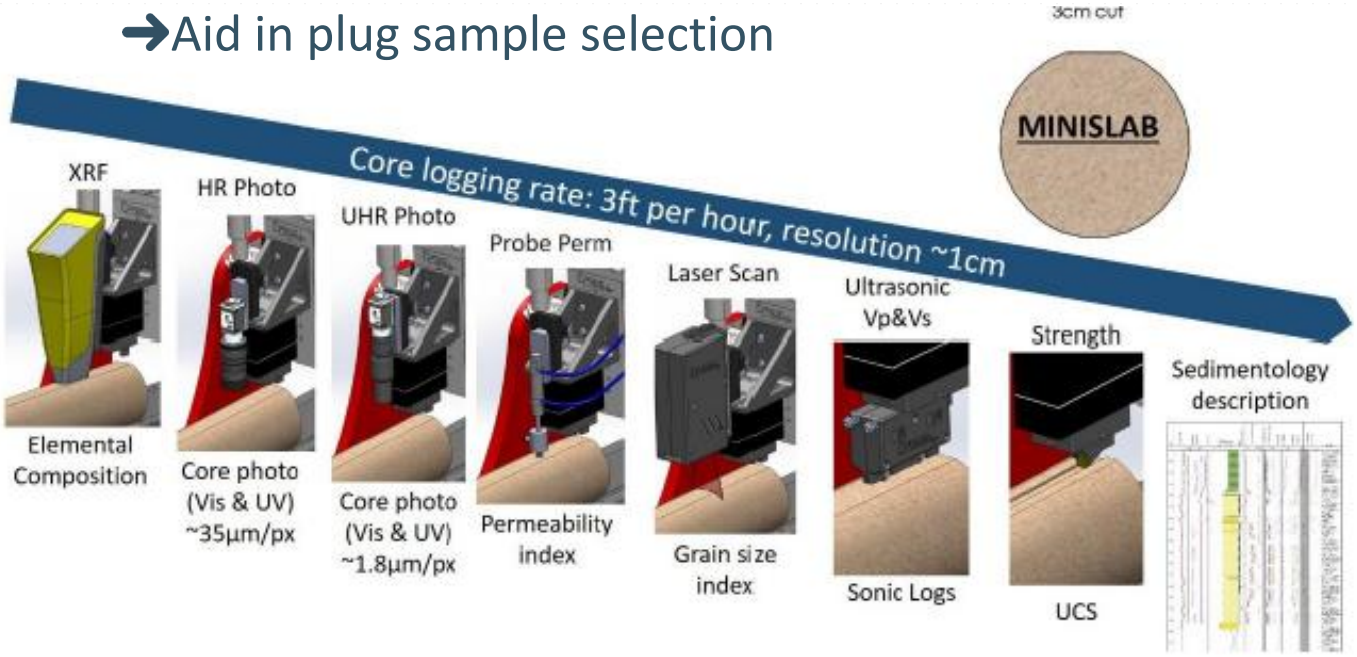
## Sample Analysis

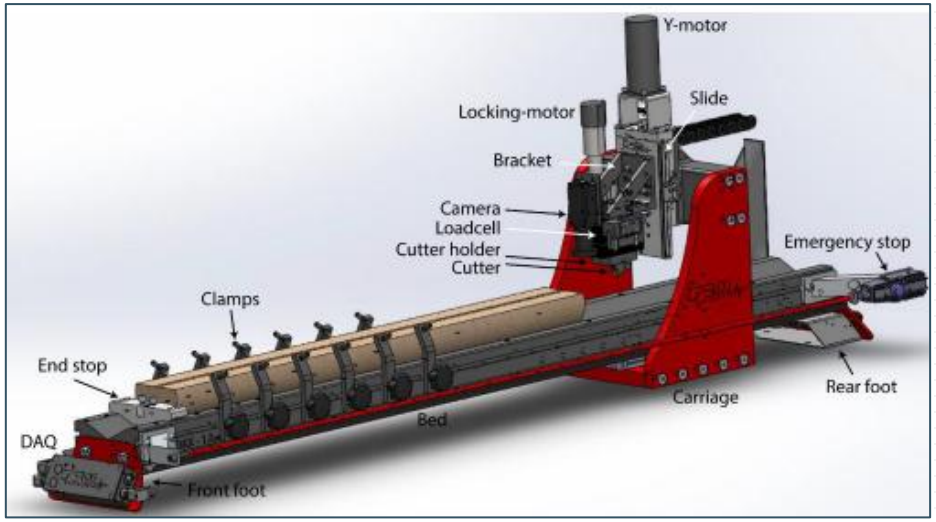
- RCA (Ø, $k_{air}$, $k_v$)
- SCAL (brine permeability, NMR, FRF)
- MICP/HPMI
- Petrography (THS, SEM, XRD)
- Geomechanics
- Thermal properties

# Core Screening

- ➜Screening along entire length of cores at cm scale:
  - ➜Spectral core gamma ray
  - ➜CoreDNA (multi-sensor)
- ➜CoreDNA probe selection varies (seal/reservoir)
- ➜Is useful for:
  - ➜Core to log calibration
  - ➜Indication of facies early in the program
  - ➜Aid in plug sample selection

Gamma ray instrument

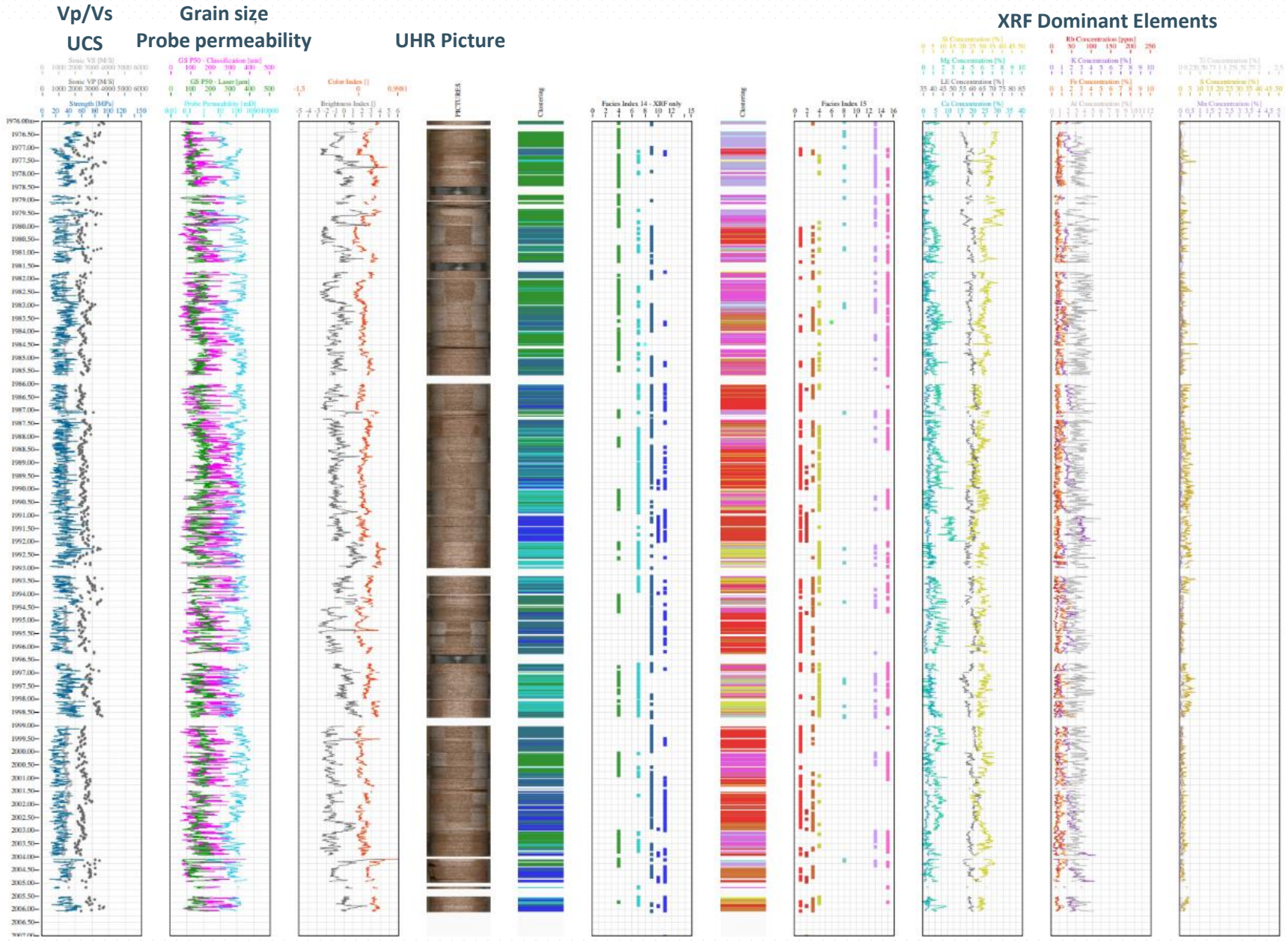



CoreDNA (from EPSLog)

# CoreDNA example – BLT-01 – Core 7 – 1976-2007 m MDRT

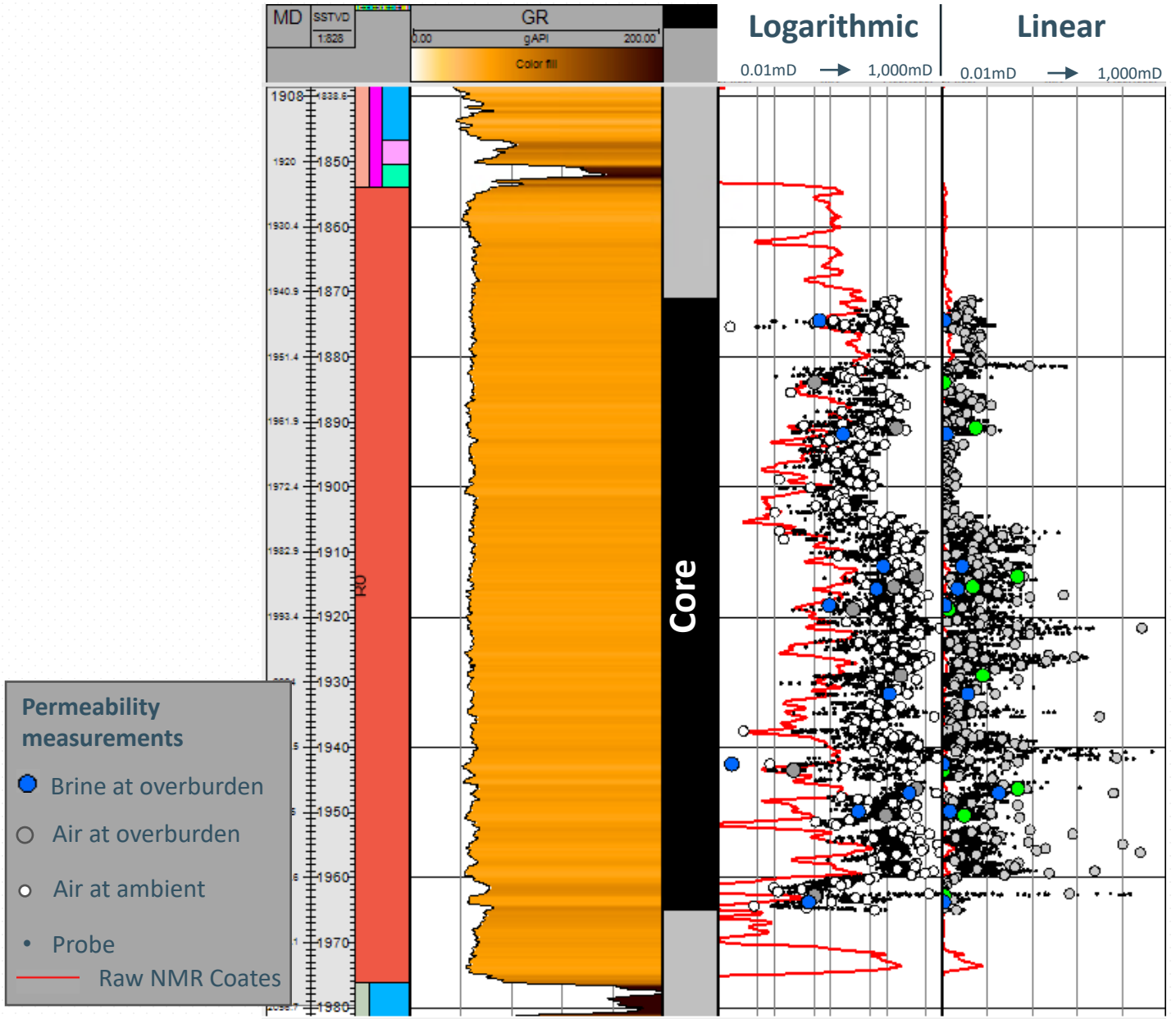
Vp/Vs
UCS
Grain size
Probe permeability
UHR Picture
XRF Dominant Elements



# Permeability Measurements

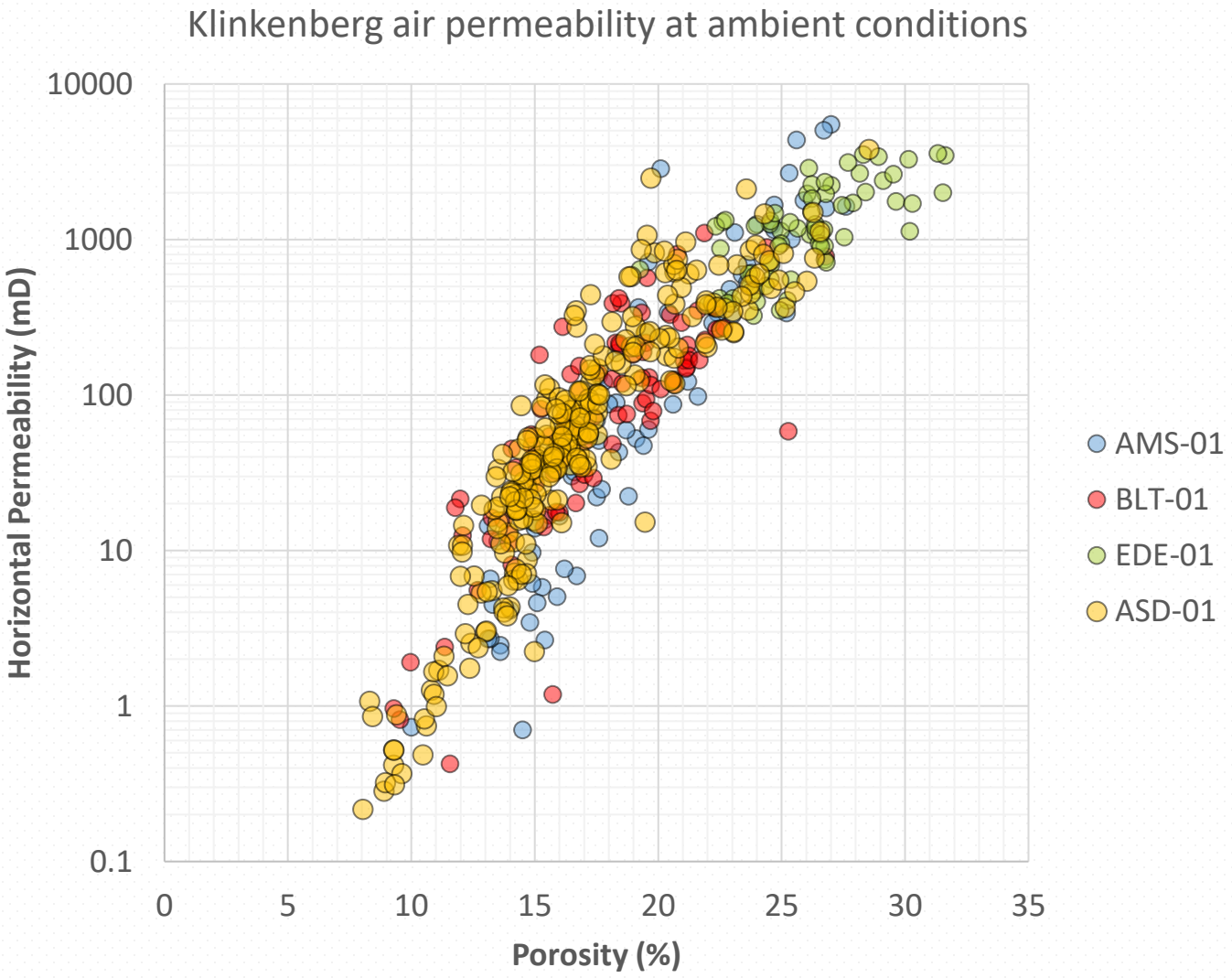
**Permeability is the key geothermal reservoir property!**

- ➜ CoreDNA probe permeability
  - ➜ Every 3cm, interpolated to 1 cm, performed on uncleaned core
- ➜ Routine air permeability
  - ➜ Horizontal plugs every 33cm, vertical every 100 cm
- ➜ Klinkenberg air and brine permeability at reservoir conditions
  - ➜ 10 horizontal plugs for each per well
- ➜ Mercury-Injection Capillary Pressure (MICP/HPMI)
  - ➜ Pore-throat diameter => Theoretical permeability
- ➜ NMR logs (*not in EDE-01*)
  - ➜ Timur-Coates model yields permeability
- ➜ Well test
  - ➜ Transmissivity (permeability * reservoir height)



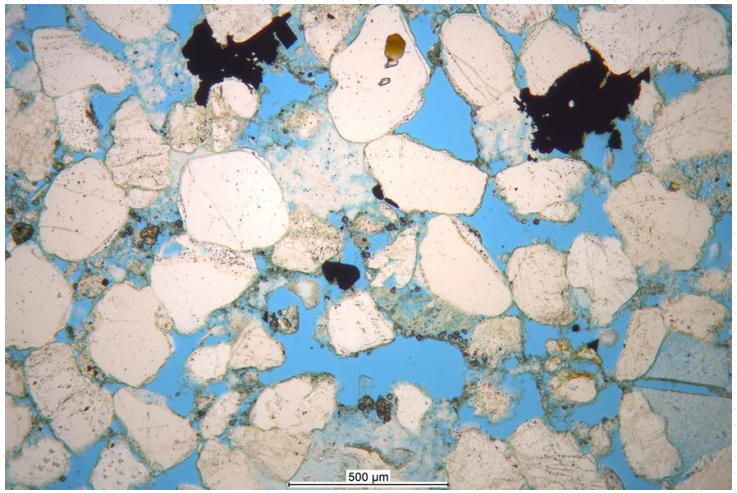
# Routine Air Permeability

- 837 horizontal air permeability measurements at ambient conditions in Rotliegend
  - AMS-01
  - BLT-01
  - EDE-01
  - ASD-01
- Increase of permeability with increasing porosity
- Differences in porosity-permeability trends

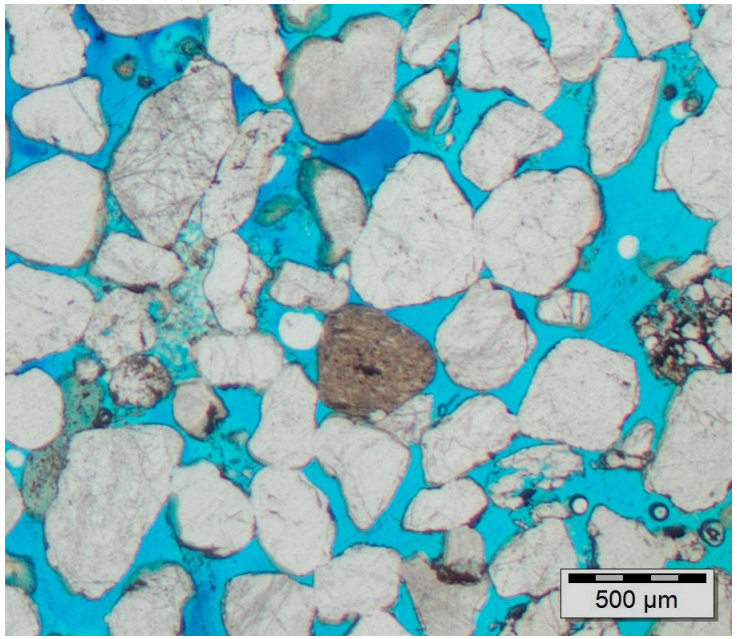


# Air Permeability

- ➜Pore-throat diameter controls permeability
- ➜Dissolution in EDE-01 resulted in large oversized and mouldic pores but pore throats clogged with diagenetic products
- ➜Differences in porosity-permeability trend

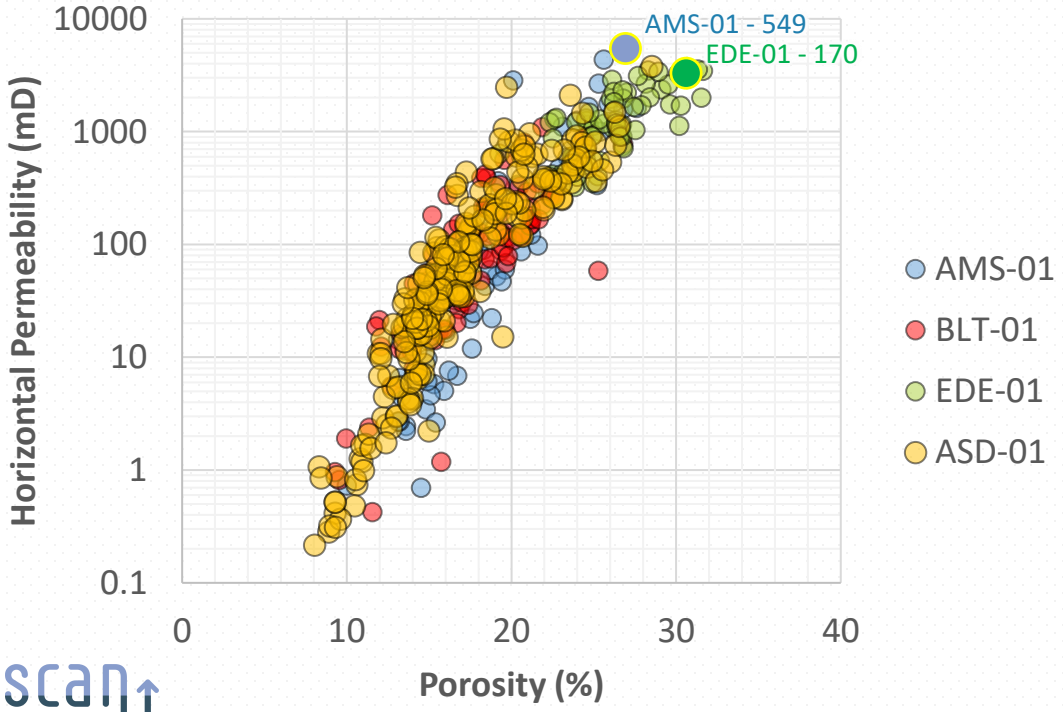


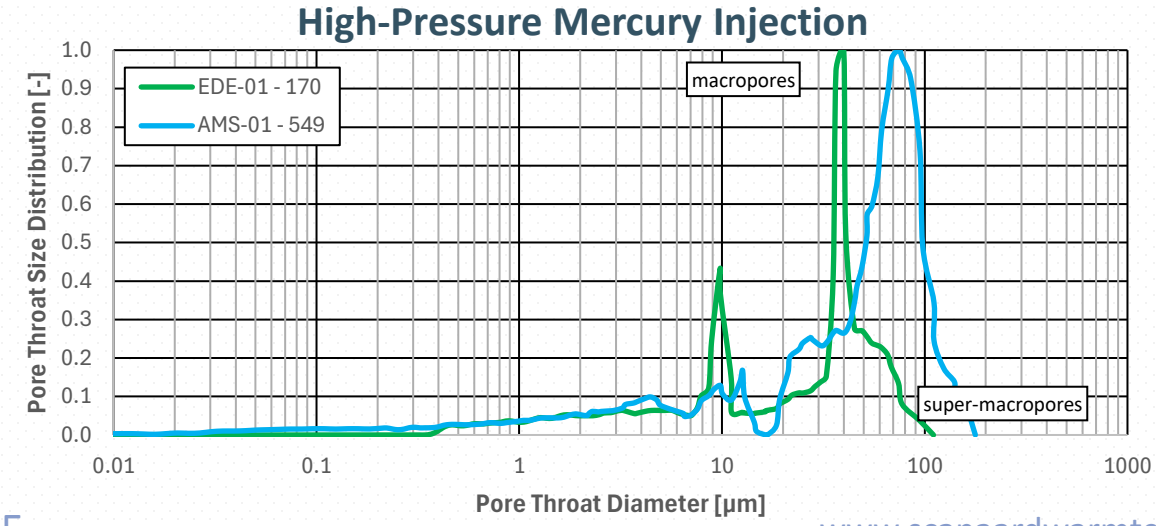

**EDE-01** – 170 - 1200.22 mAH
Porosity: 30.1%
Air Permeability: 3270 mD
**Aeolian dune slipface**




**AMS-01** – 549 – 2145.33 mAH
Porosity: 28.5%
Air Permeability: 10883 mD
**Aeolian dune base**

Klinkenberg air permeability at ambient conditions

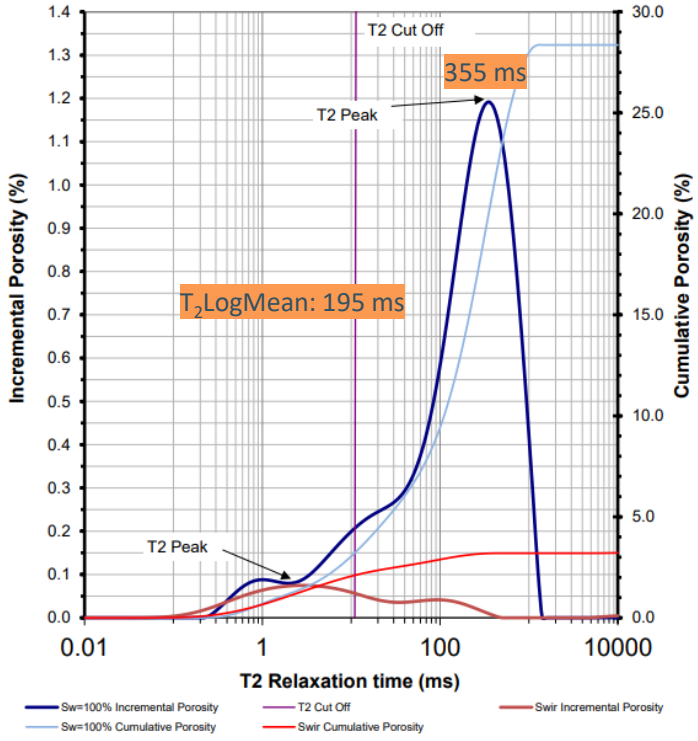


# NMR Experiments

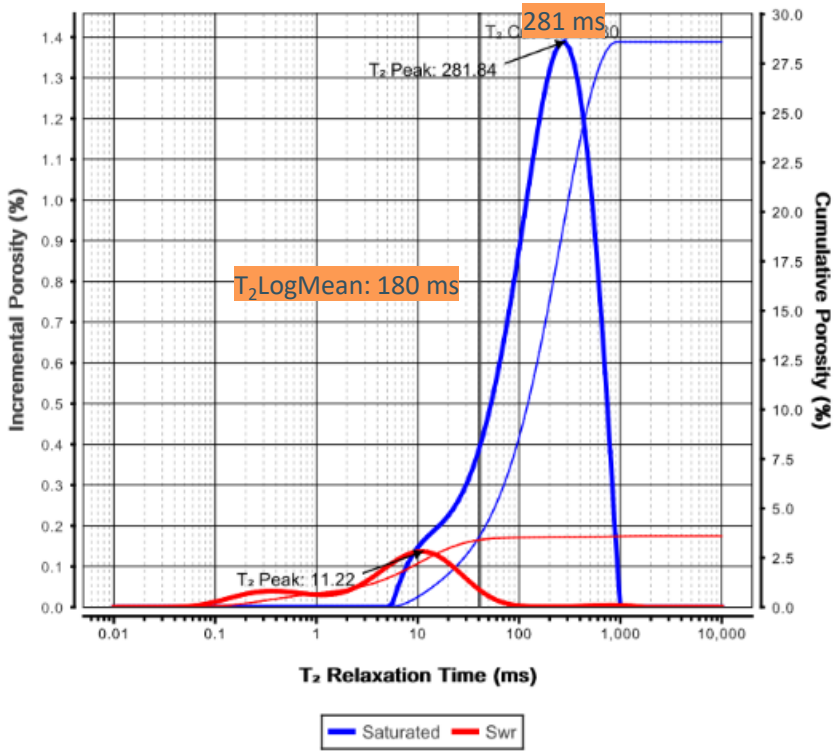
- ➜Also, NMR experiments reveal differences in pore size
- ➜Amstelland-01 plug associated with very high permeability
- ➜Ede-01 plug with higher total porosity but lower $T_2$ peak and $T_2$logmean than Amstelland-01 plug
- ➜Pore size distribution recorded by NMR logs (particularly after calibration with core)
- ➜Yields Timur-Coates permeability

## Amstelland-01




**AMS-0**1 – 549 – 2145.33 mAH
Porosity: 28.5%
Air Permeability: 10883 mD
**Aeolian dune base**

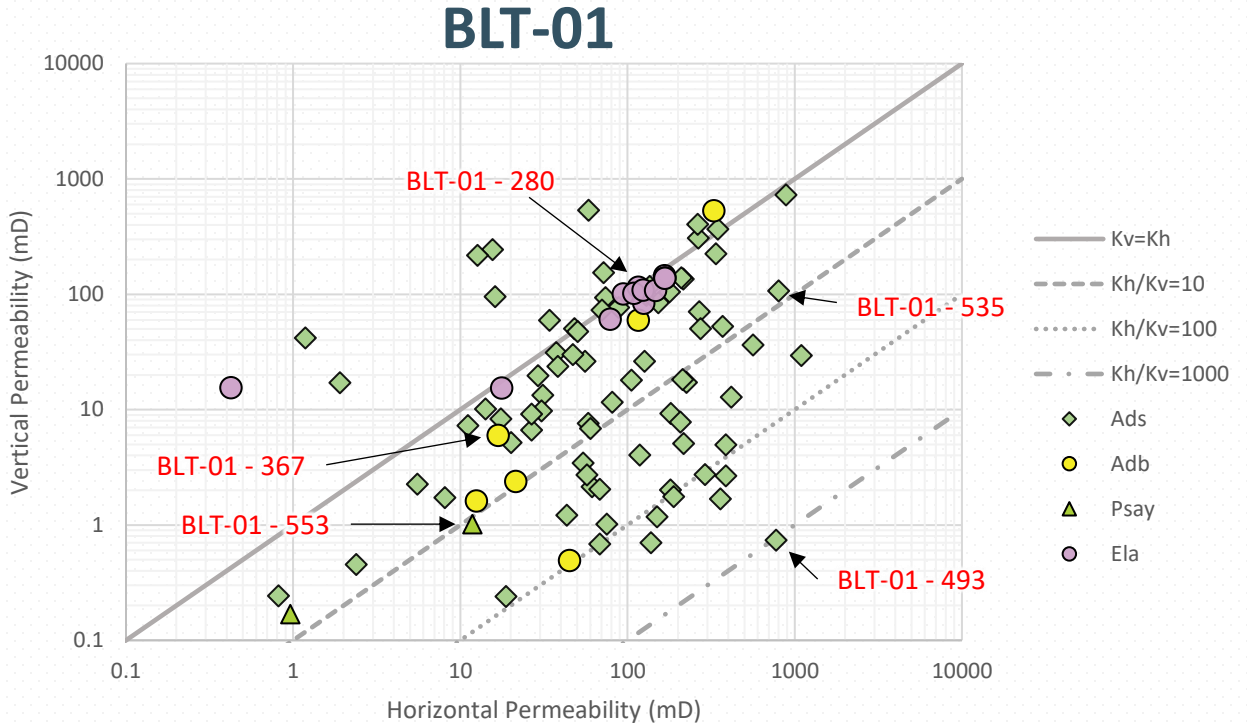
## Ede-01




EDE-01 – 170 - 1200.22 mAH
Porosity: 30.1%
Air Permeability: 3270 mD
**Aeolian dune slipface**

# Vertical Permeability

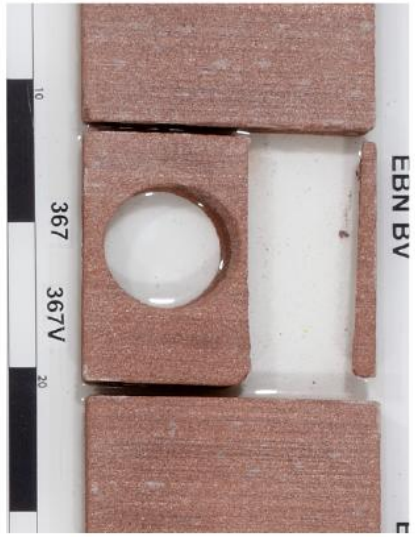
- Vertical permeability important for evaluating the performance of horizontal/highly deviated producer and injector wells
- 282 air vertical plugs from Rotliegend
- High variability on plug-scale:
  - Depositional sub-environment
  - "Artefacts"




Plug 535
Depositional sub-environment: Ads
Horizontal Permeability: 803 mD
Vertical Permeability: 107 mD
Kh/Kv: 7.53

Plug 493
Depositional sub-environment: Ads
Horizontal Permeability: 775 mD
Vertical Permeability: 0.74 mD
Kh/Kv: 1047.88

Plug 367
Depositional sub-environment: Adb
Horizontal Permeability: 16.8
Vertical Permeability: 6.0
Kh/Kv: 2.81

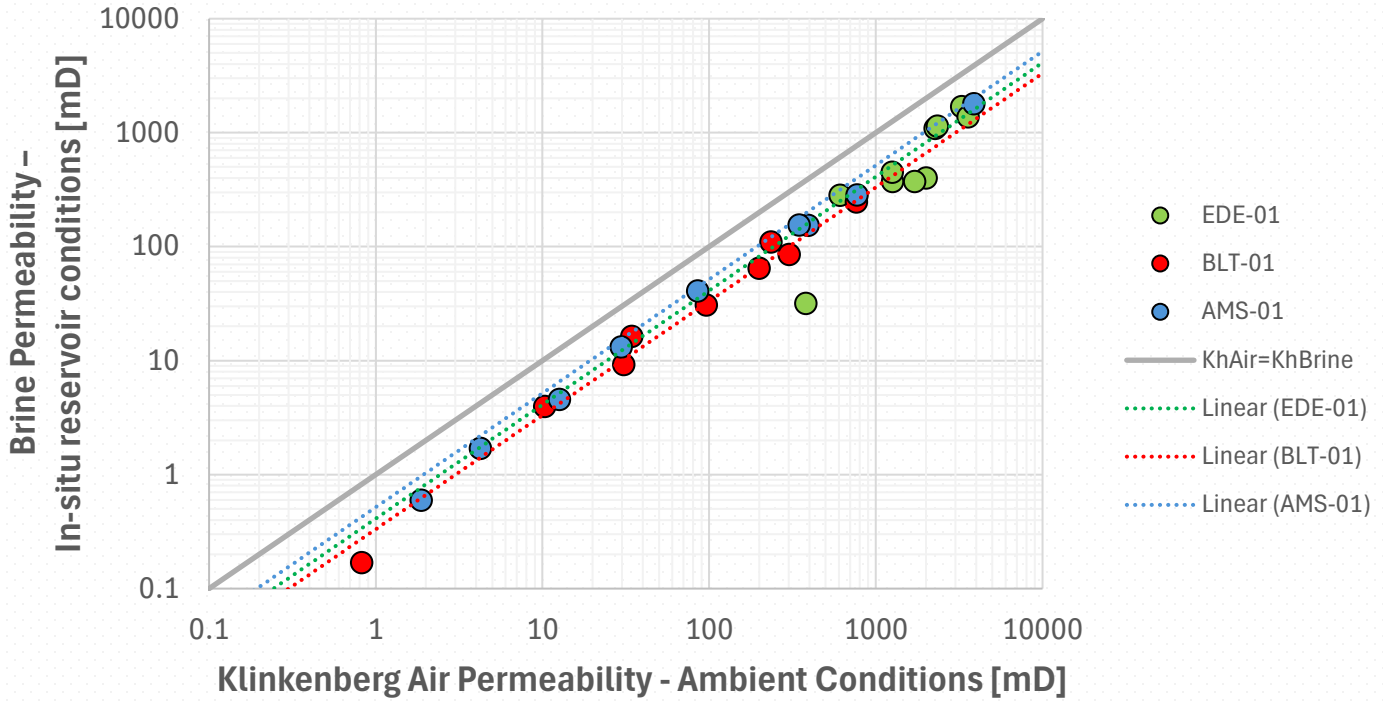


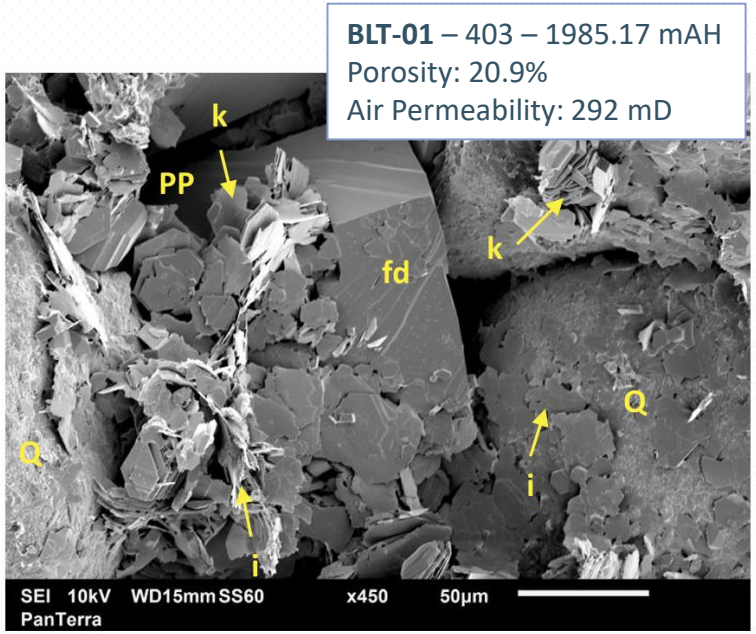

Plug 553
Depositional sub-environment: Psay
Horizontal Permeability: 11.8 mD
Vertical Permeability: 1.02 mD
Kh/Kv: 11.64

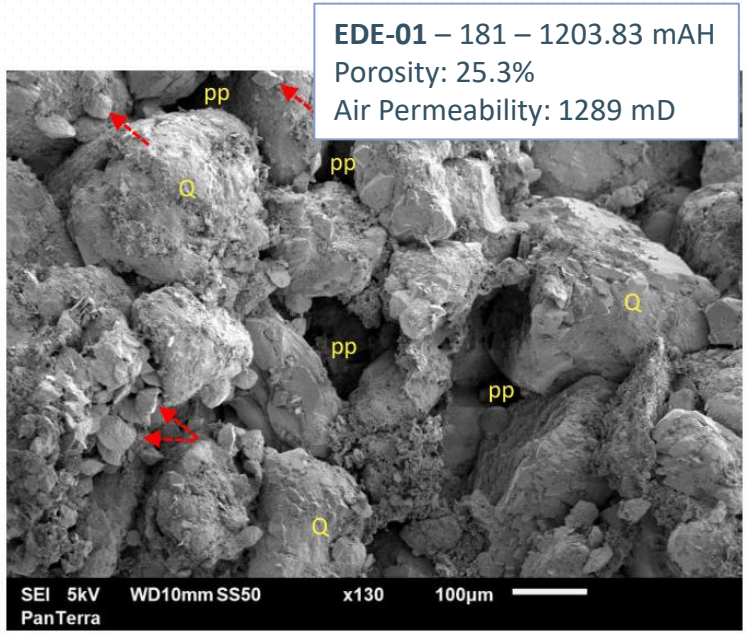
Plug 280
Depositional sub-environment: Ela
Horizontal Permeability: 115.7 mD
Vertical Permeability: 115.2 mD
Kh/Kv: 1.00

# Brine Permeability

- ➜Brine permeability at reservoir conditions consistently lower than air permeability at ambient conditions
- ➜Brine permeability (reservoir) ≈ 30-50% of air permeability (ambient)
- ➜Water adsorption on rough surface and tortuous pores reduces effective radius or completely restricts access to water (Heap et al., 2018)
- ➜Legacy permeability datasets are typically air permeabilities at ambient conditions…



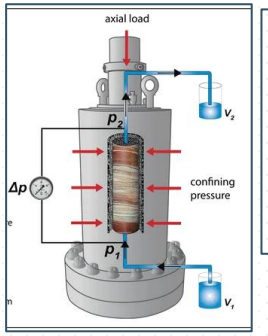



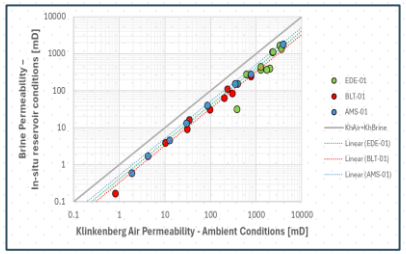



# Core Permeability and Productivity

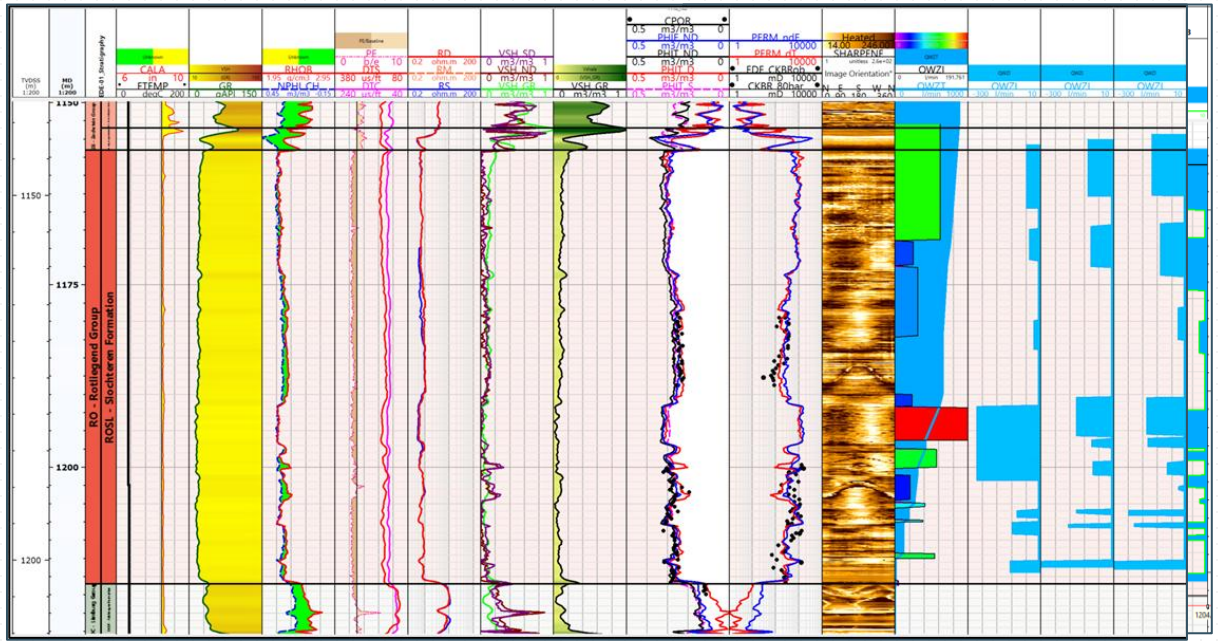
- Core data is high resolution spot data at **1 – 1.5 cm** scale
- Corrected for reservoir PT & fluid
- Well tests (Production / Injection) are from **10s to 100s** of meter perforated reservoir section
- The “gap” can be filled by the log data
  - Acquired at reservoir condition
  - At intermediate continuous **15 - 30cm** scale
  - Calibrated to core data
  - Adjusted to Well Test / PLT data

Core Plugs: 1 – 1.5 cm scale




Core Plugs @ rese P & fluid




Well Logs: 15-30cm scale at reservoir PT condition

Well Test: 10s – 100s m scale

Core domain

# Core Poro-Perm Workflow

Routine core analysis (RCA):

- Ambient conditions plugs
- Helium porosity and gas/air permeability

Core porosity

Stressed core porosity

Stress correction for core porosity

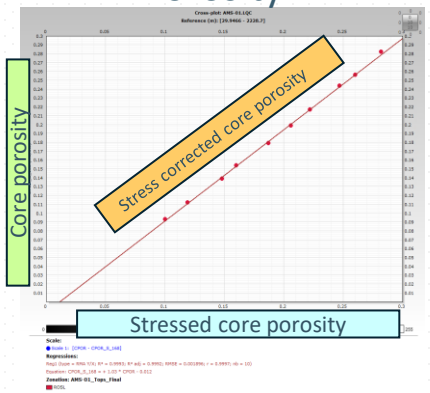
Core gas/air permeability

Stressed core brine perm

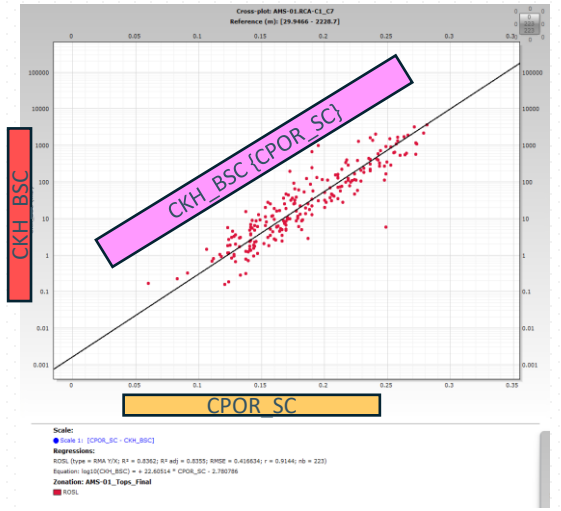
Stress & brine correction for core air permeability

Stress & brine corrected poro-perm relationship

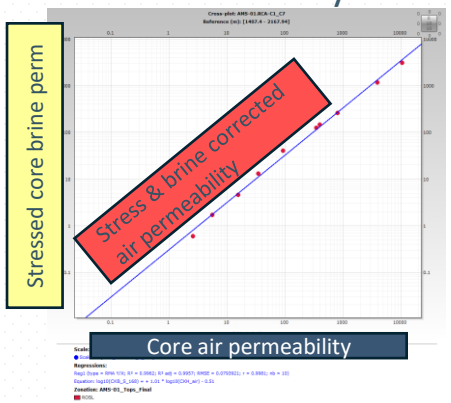
Porosity




Poro-perm




Permeability




$PERM = f(Porosity)$

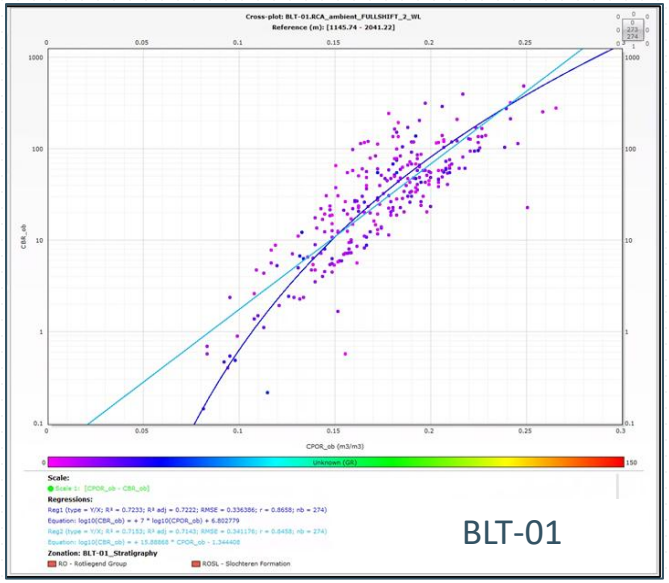
Special Core Analysis (SCAL):

- Stressed core porosity (at res pressure)
- Stressed core brine permeability (at res. pressure)

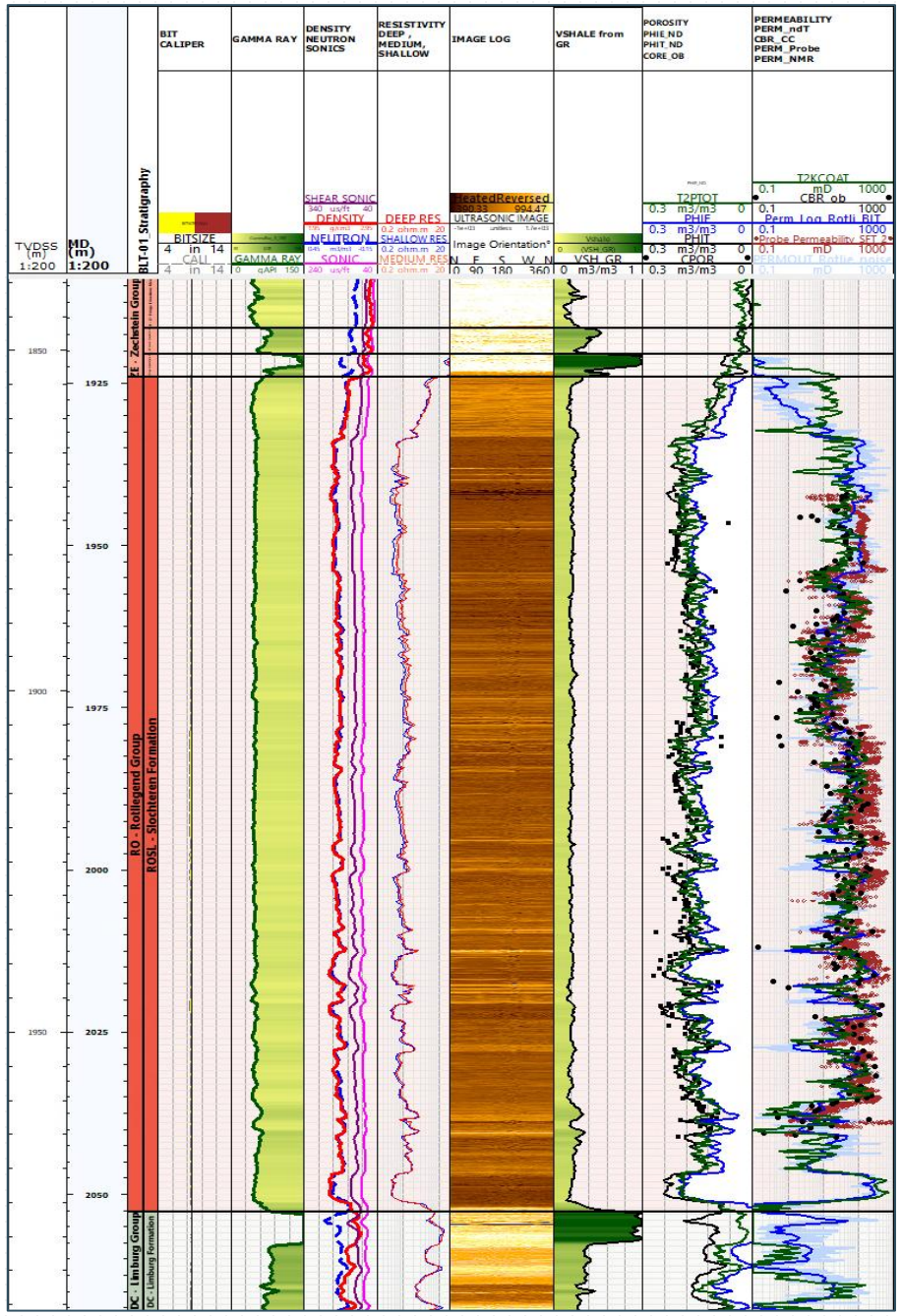
# Core to Log Calibration

## BLT -01

- Corrected core Porosity, Permeability and Grain density used
  - ➢ Calibrate porosity log (Density, Neutron-Density, & Sonic)
  - ➢ Poro-Perm transform per well
- Perm_logs from Poro-Perm transform on porosity logs
- Other data for QC:
  - ➢ Probe permeability
  - ➢ Core calibrated NMR Permeability



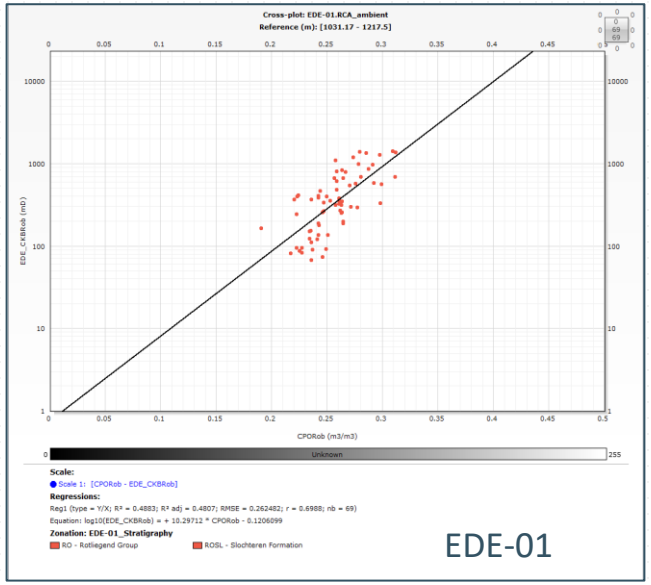
BLT-01



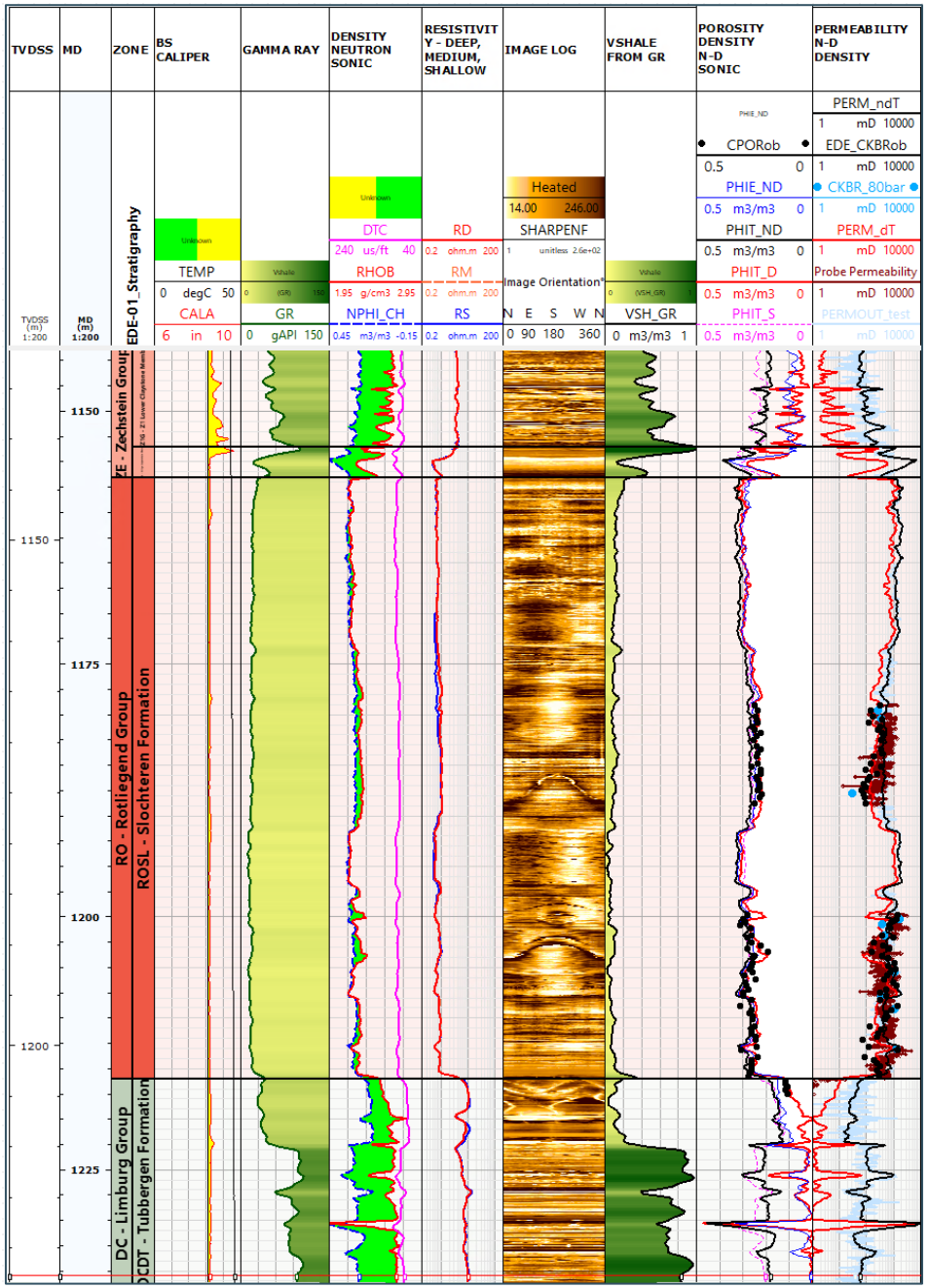
# Core to Log Calibration

## Ede -01

- Corrected core Porosity, Permeability and Grain density used
  - ➢ Calibrate porosity log (Density, Neutron-Density, & Sonic)
  - ➢ Poro-Perm transform per well
- Perm_logs from Poro-Perm transform on porosity logs
- Note that core from the best reservoir sections was not recovered resulting in some uncertainty of porosity-permeability transform at high end: <u>to be refined further</u>
- Other data for QC:
  - ➢ Probe permeability



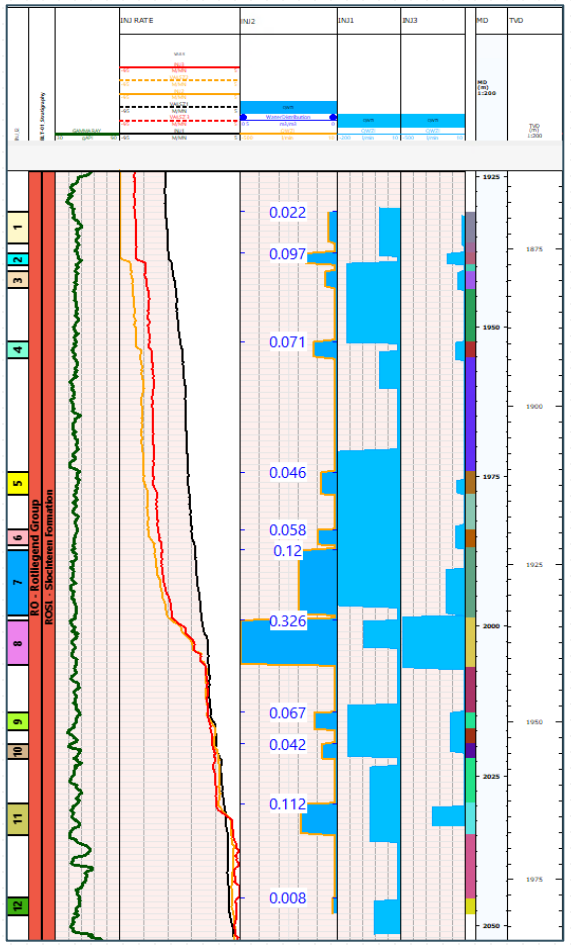

EDE-01



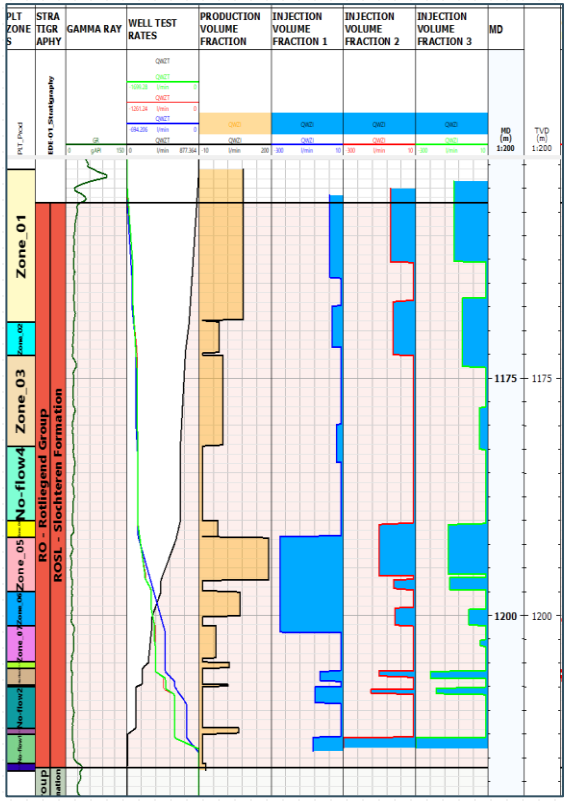
# Log to Well Test Comparison

- Production logging tool (PLT) data acquired while producing / injecting water provided:
  - Volume of production per flow zone
  - Rate of production / injection per flow zone
- Average Perm per flow zone vs flow volume fractions compared
  - BLT-01 : Injection PLT vs Avg PERM_log
  - EDE-01: Production PLT vs Avg PERM_log
- Comparisons discussed in next slides

BLT-01



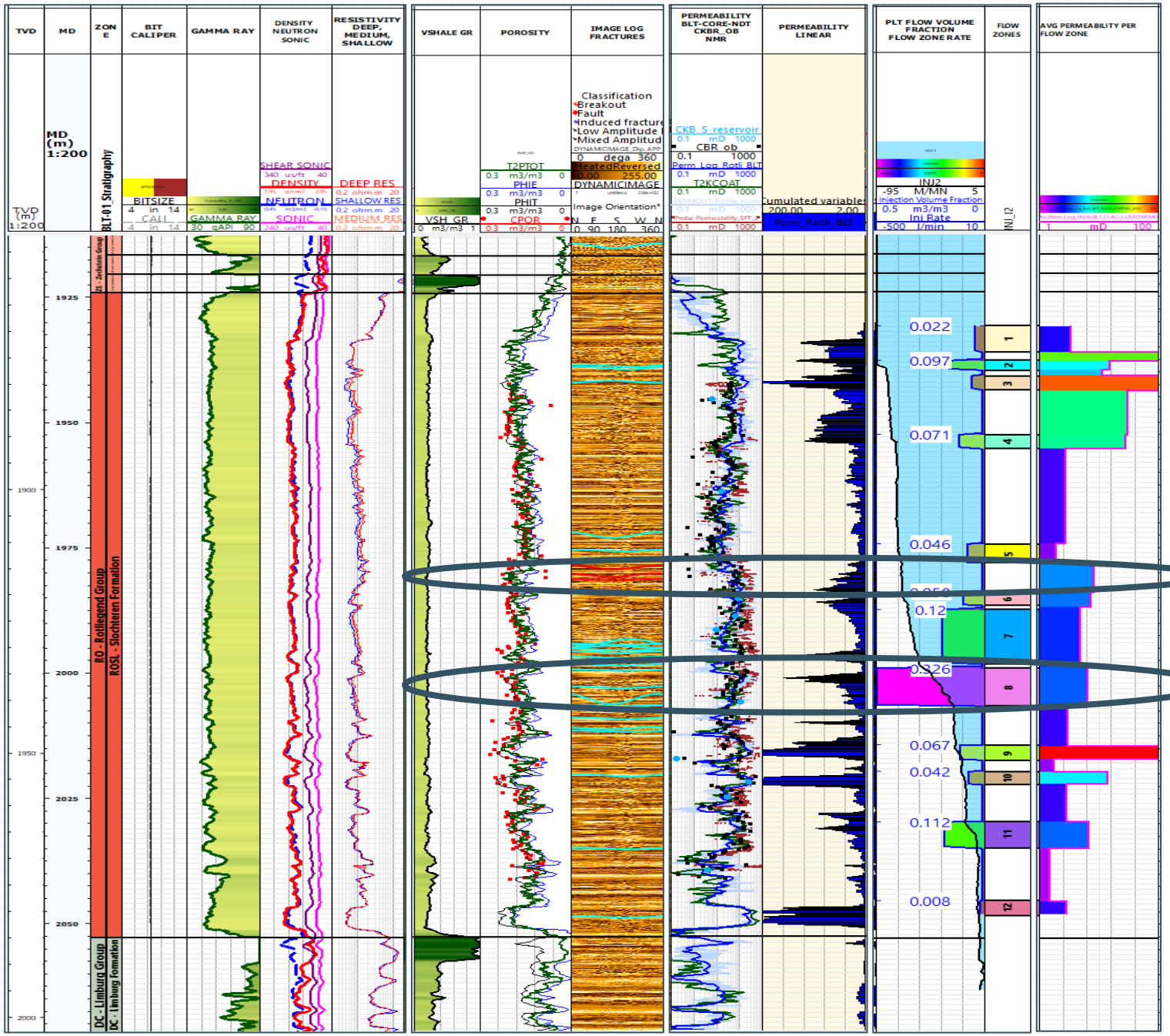

EDE-01



# BLT-01

All available well data integrated and calibrated to core

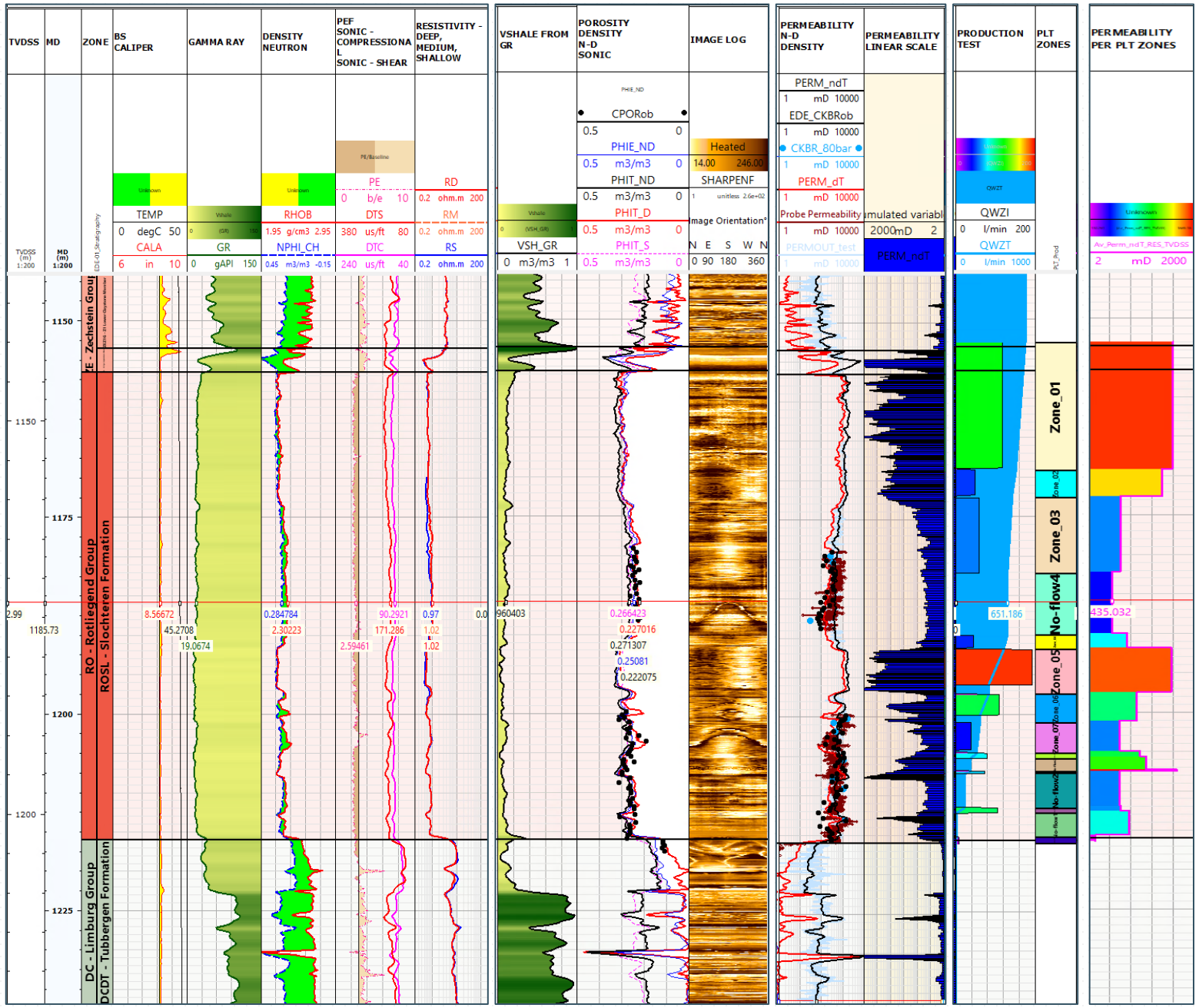
- Average Porosity
  - 15.4% (13.9 – 17.3%)
- Average Perm
  - 45 mD (low) - 55mD (high)
- Qualitative variation per flow zone
  - Matches in most zones
  - Exceptions – fractures / cemented micro faults
- Matrix flow dominant with minor exceptions



# EDE-01

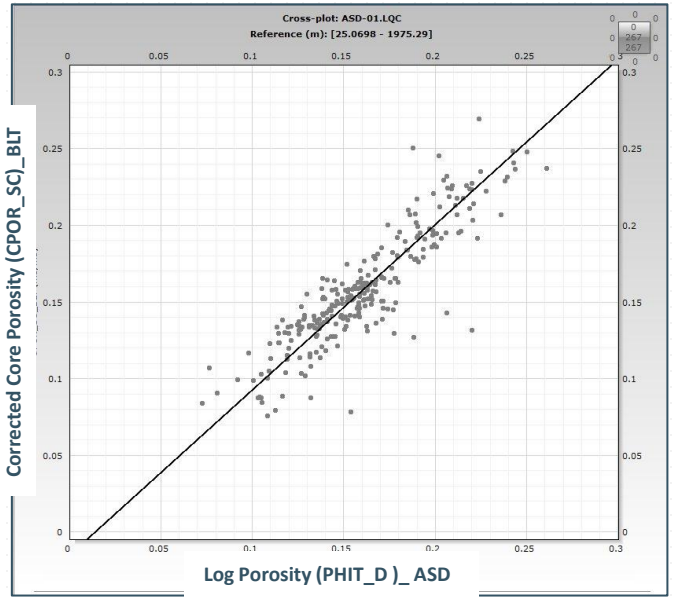
All available log data integrated and calibrated to core

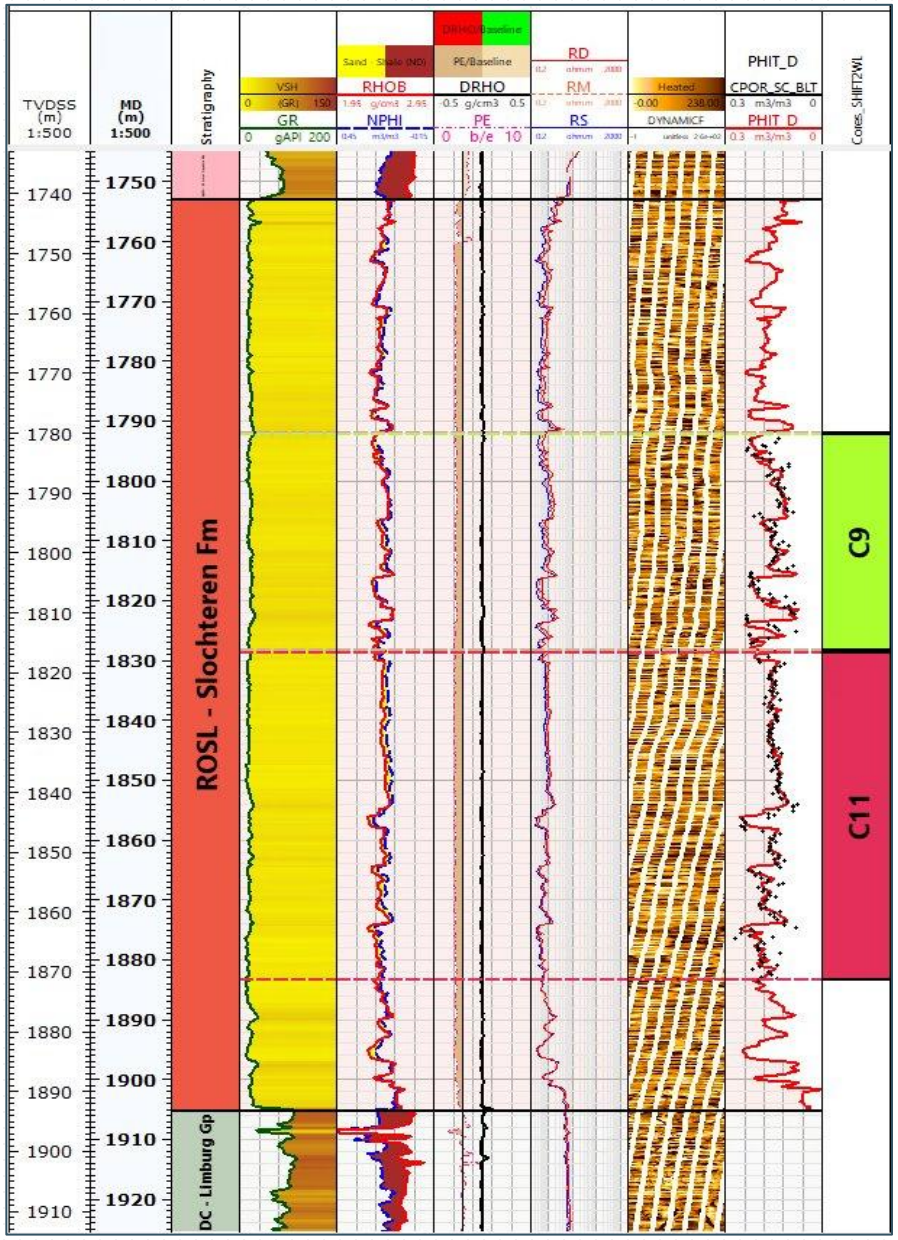
- Note that core from the best reservoir sections was not recovered resulting in some uncertainty in the porosity-permeability in these units
- Preliminary results:
  - Average Porosity
    - 27% (26.6 – 29.4%)
  - Average Permeability
    - 537mD (low) – 957mD (high)
- Qualitative variation per flow zone matches very well
- Matrix flow dominant



# Amsterdam-01: Ongoing

- Routine Core data - available
- Special core analysis (brine permeability, reservoir conditions) ongoing
- Average porosity = 16%, based on preliminary stress correction using other SCAN wells



# SCAN well test objectives

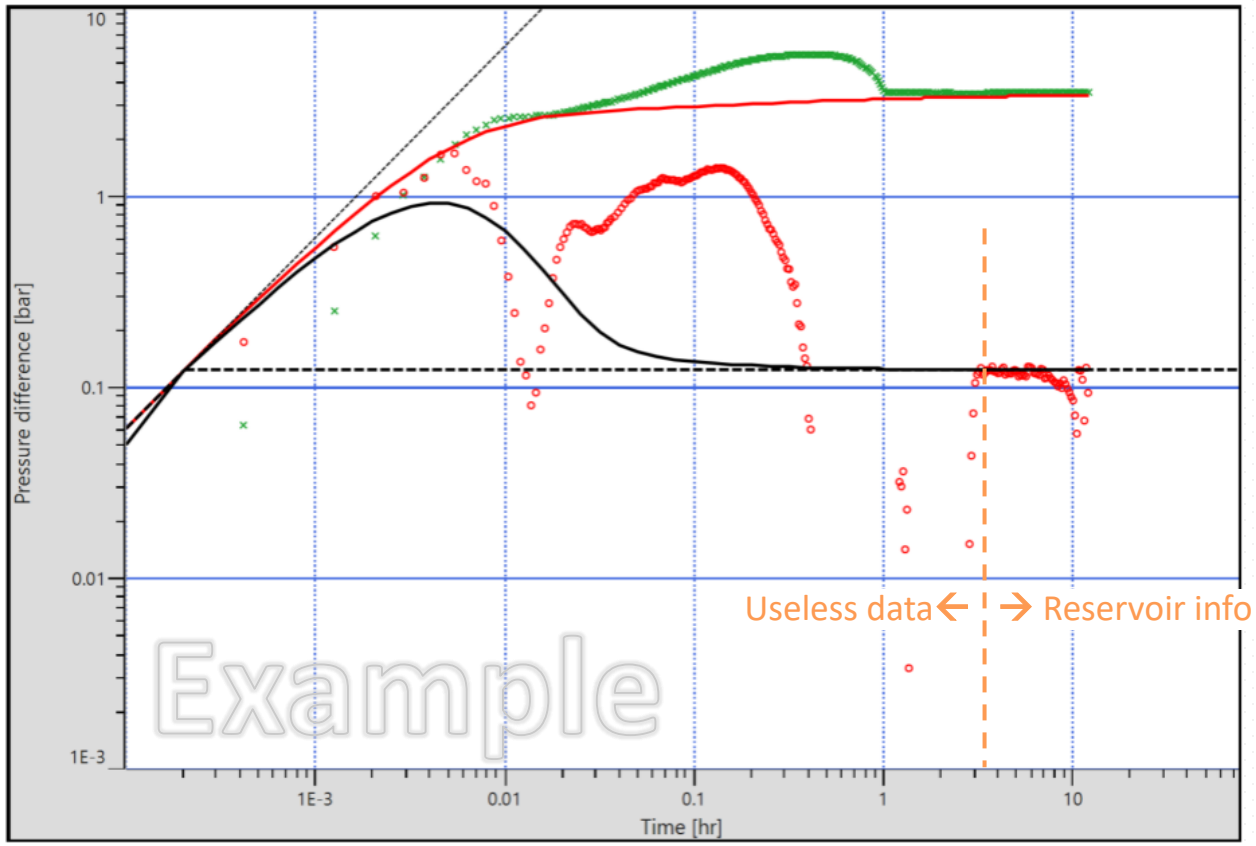
1. Evaluation of reservoir characteristics:

- Transmissivity, permeability, porosity, Productivity Index
- Reservoir architecture, faults (within reasonable distance)
- Fluid properties
- Skin (*minimizing* the skin was no objective)

2. Data & costs:

- Maximising data *quantity* and *quality* (logs, cores, PLT, downhole shutin, etc.)
- Minimizing costs (cheaper artificial lift, less production, smaller welltest spread)

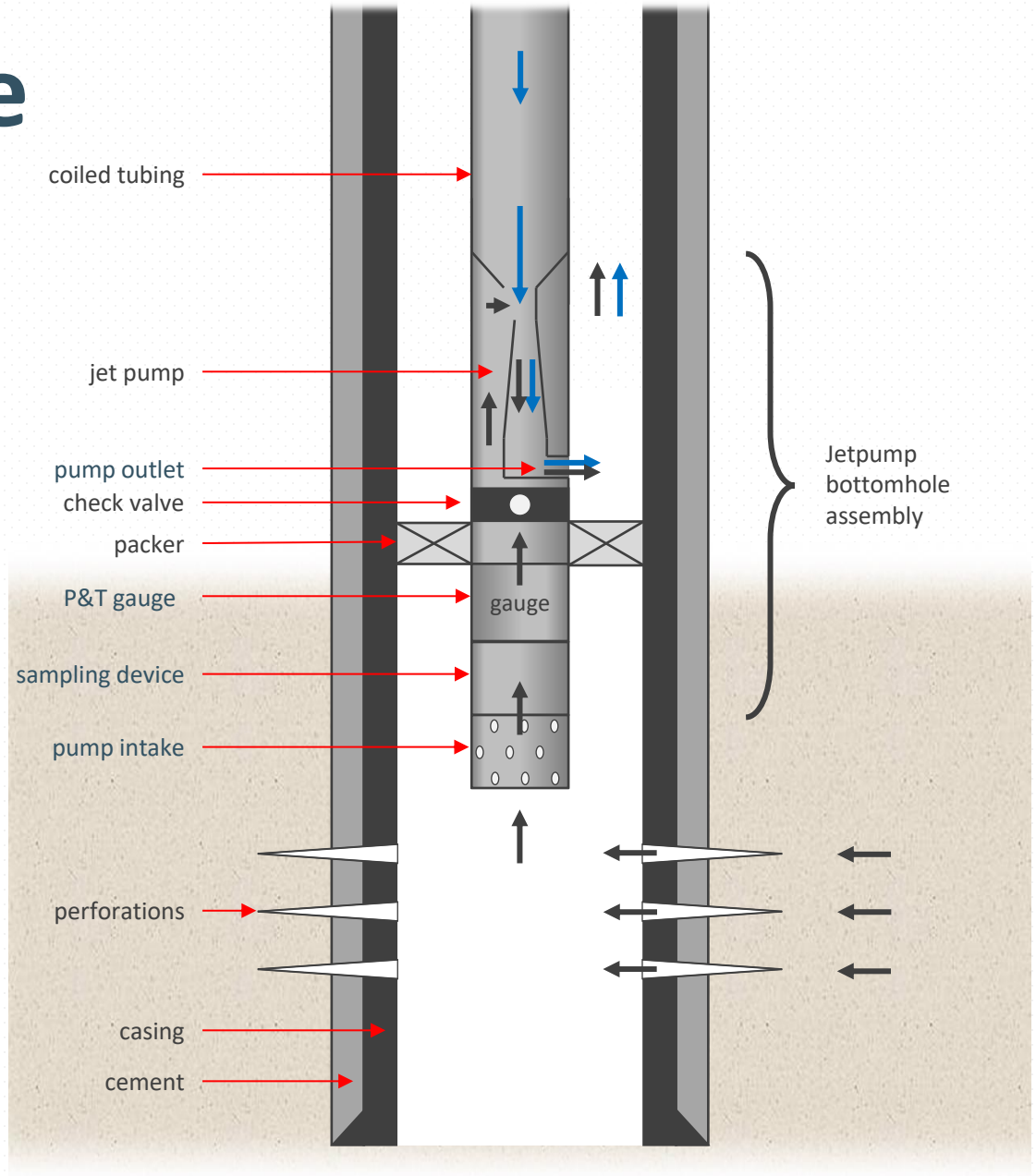
*Example of a buildup without downhole shutin: highly undesirable (uninterpretable) well test*



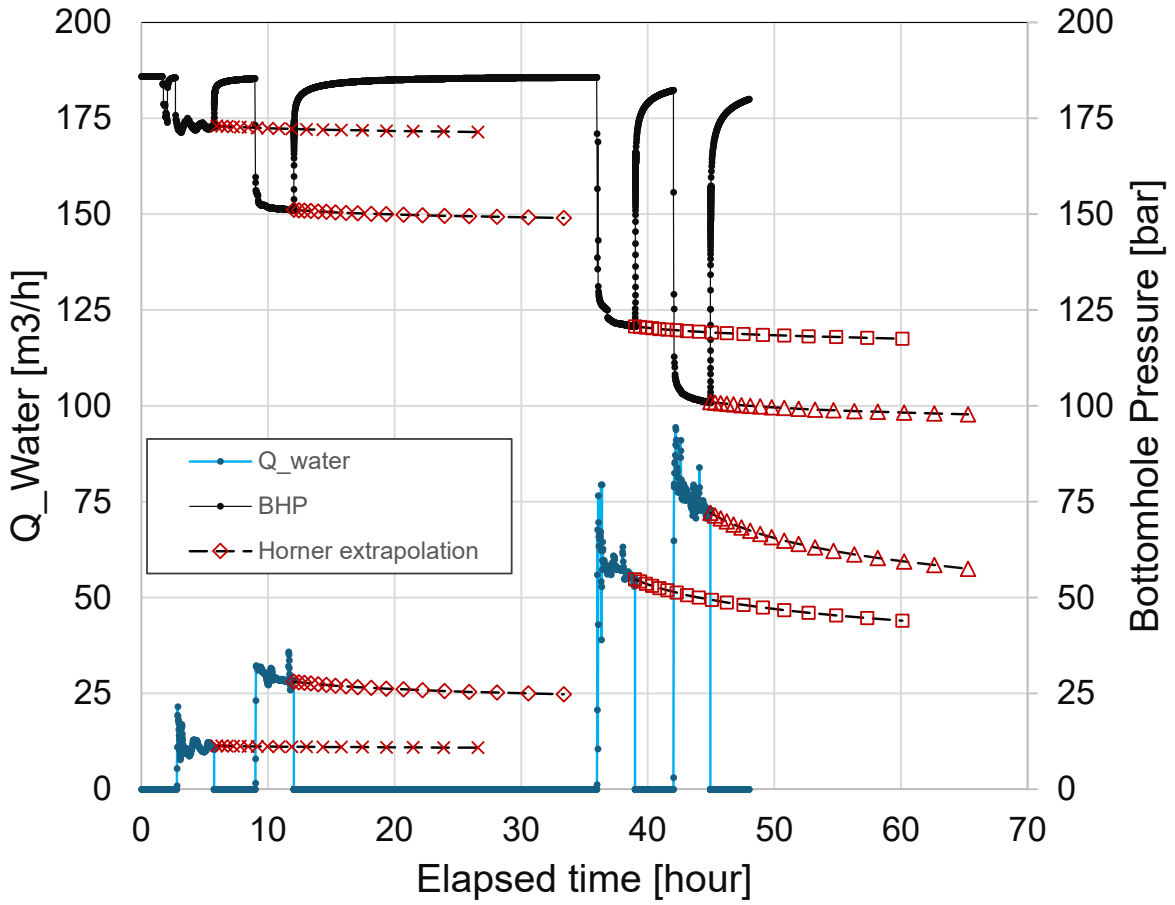
# Generic well test sequence

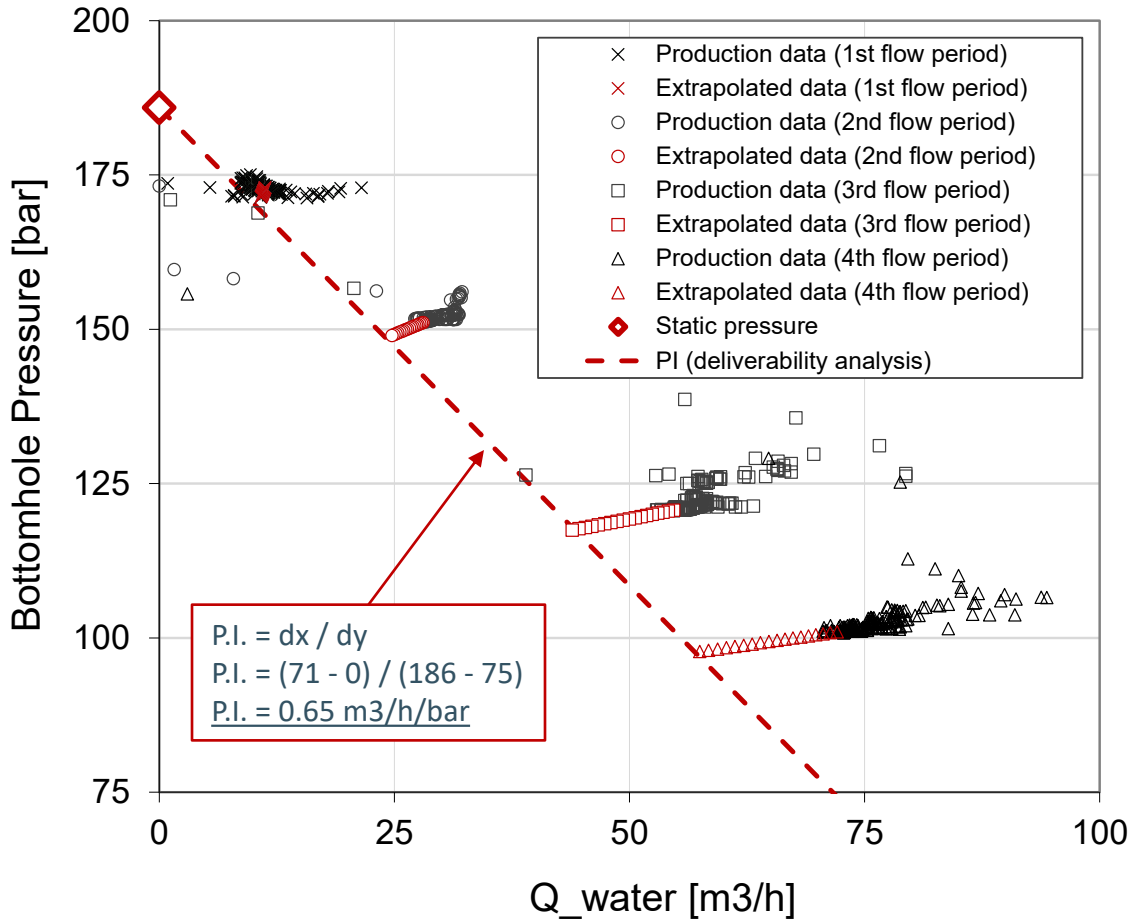
Generic operational well test steps for all SCAN wells starting from ORO-01:

1. Perforate casing underbalanced
2. Run Jetpump BHA on coiled tubing
3. Set packer
4. Injection via coiled tubing through jetpump = start production test
   - ❑ Production period #1 — 3 hours
   - ❑ Buildup #1 (downhole shutin) — 3 hours
   - ❑ Production period #2 — 3 hours
   - ❑ Buildup #2 (downhole shutin) — 24 hours
5. POOH Jetpump BHA
6. RIH wireline PLT
7. Re-inject produced water & PLT passes



# Deliverability analysis HEE-01 example

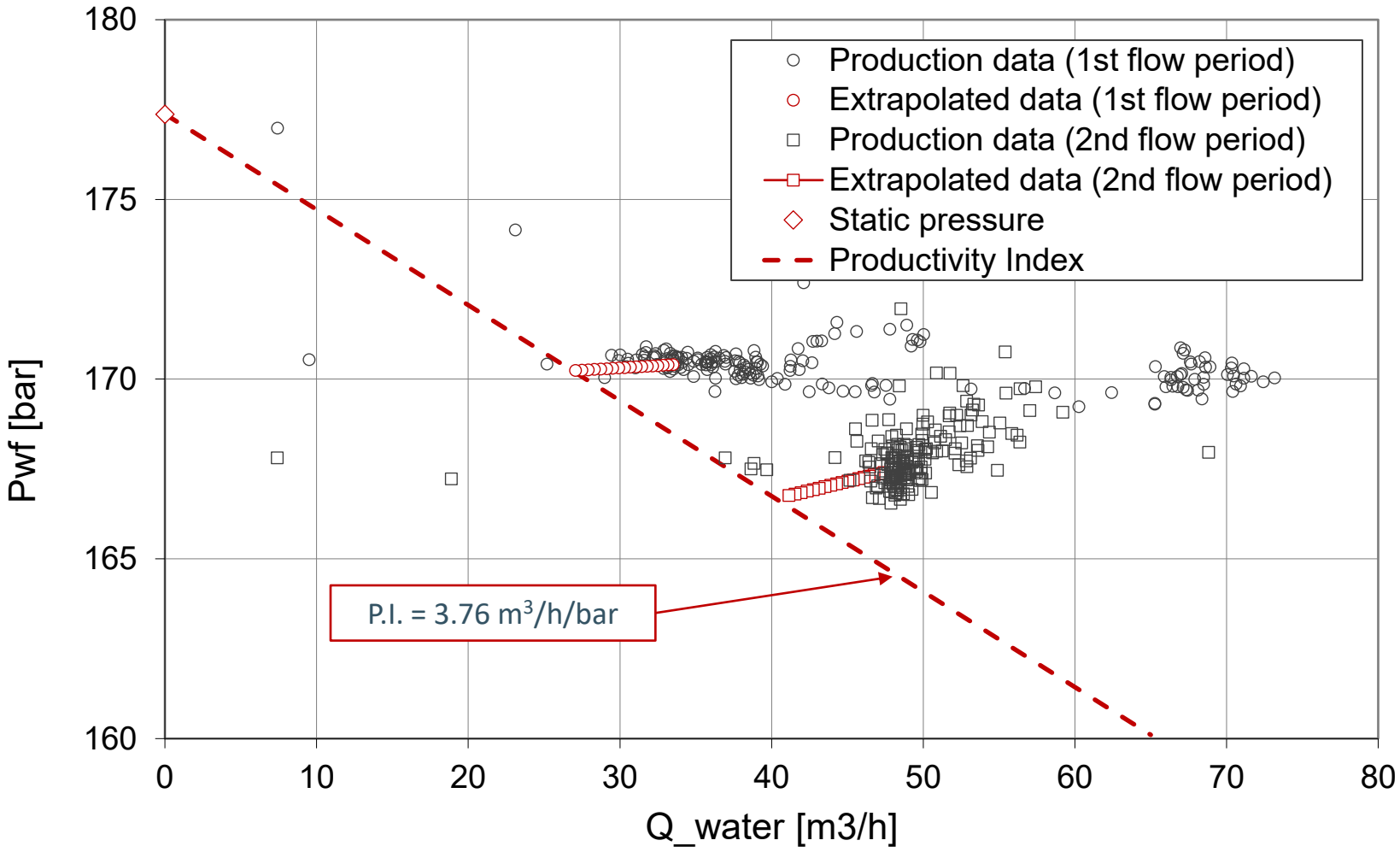



We *extrapolate* to steady state; no need to *flow* until steady state (€ ↓)

Two points (1 static & 1 dynamic) are sufficient to draw a straight line (€ ↓)

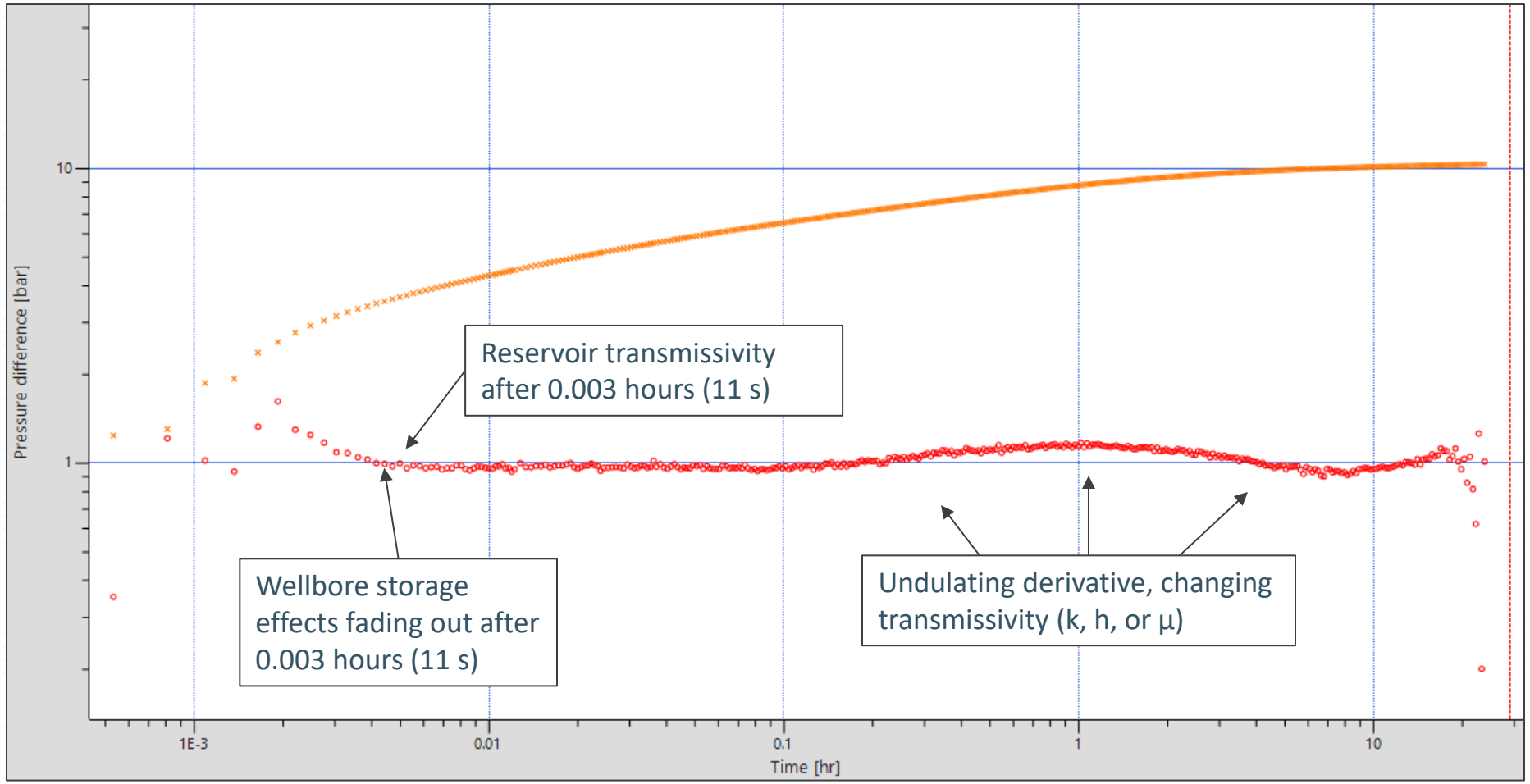
# Amsterdam-01 Deliverability results




Deliverability analysis:

- Extrapolation of transient data to steady state data
- Single (short) flow rate sufficient to determine Productivity Index
- P.I. = 3.76 m³/h/bar

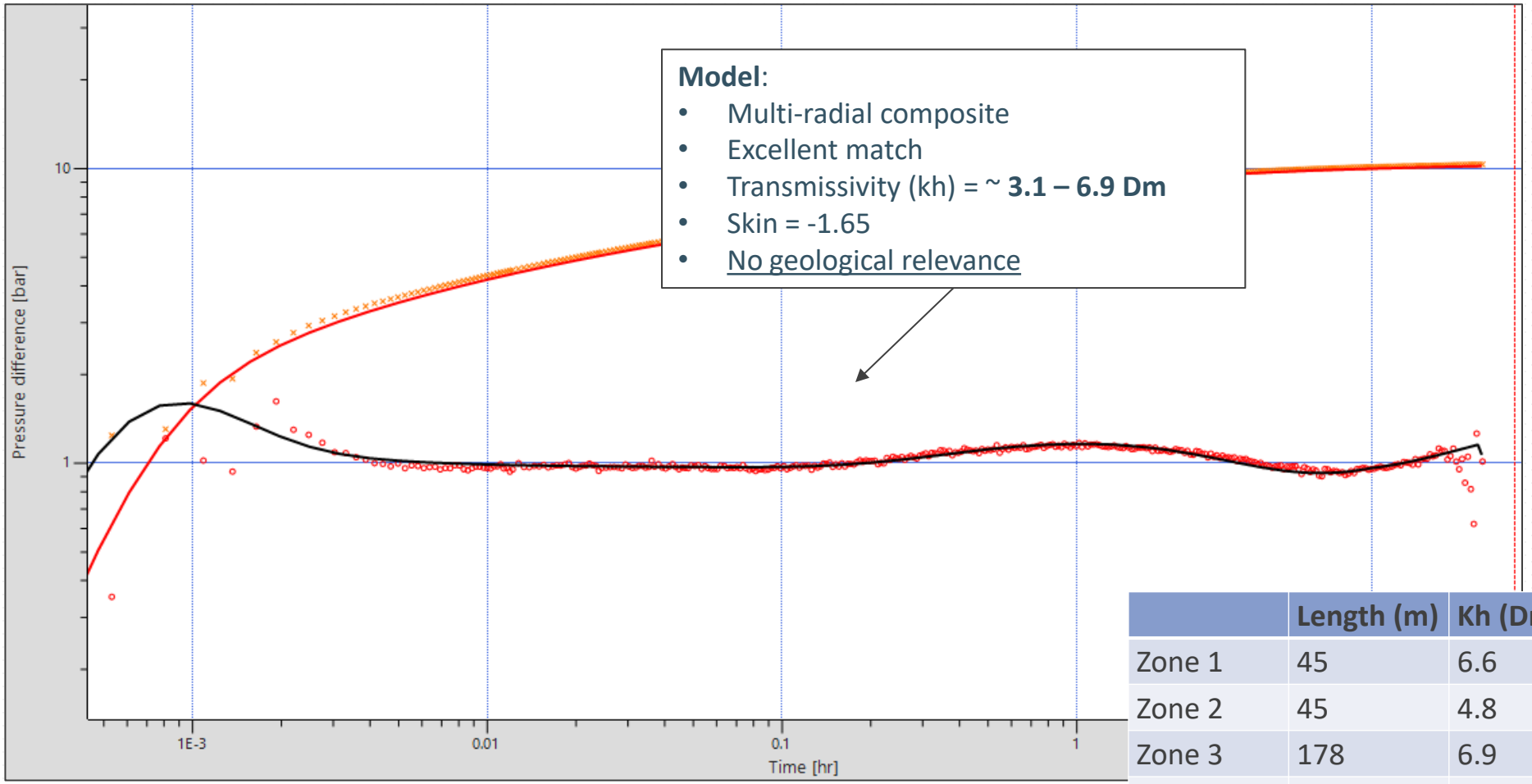
# Amsterdam-01 PTA data



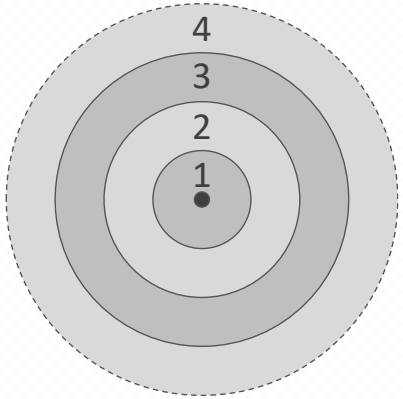

Buildup analysis:

- Very clear and smooth data set (due to downhole shutin)
- 'easy' to interpret the reservoir properties

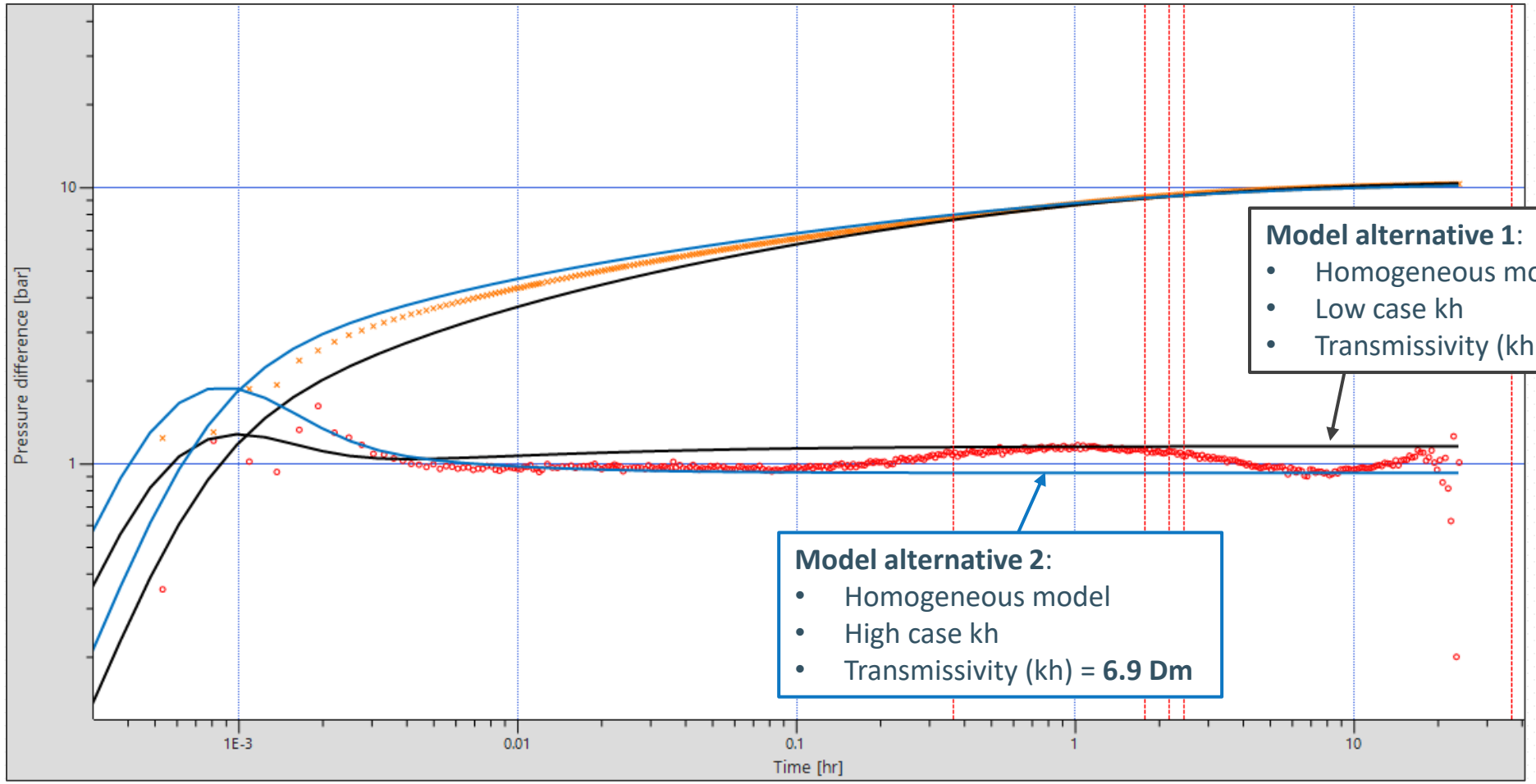
# Amsterdam-01 PTA model




| | Length (m) | Kh (Dm) |
|---|---|---|
| Zone 1 | 45 | 6.6 |
| Zone 2 | 45 | 4.8 |
| Zone 3 | 178 | 6.9 |
| Zone 4 | infinite | 3.1 |



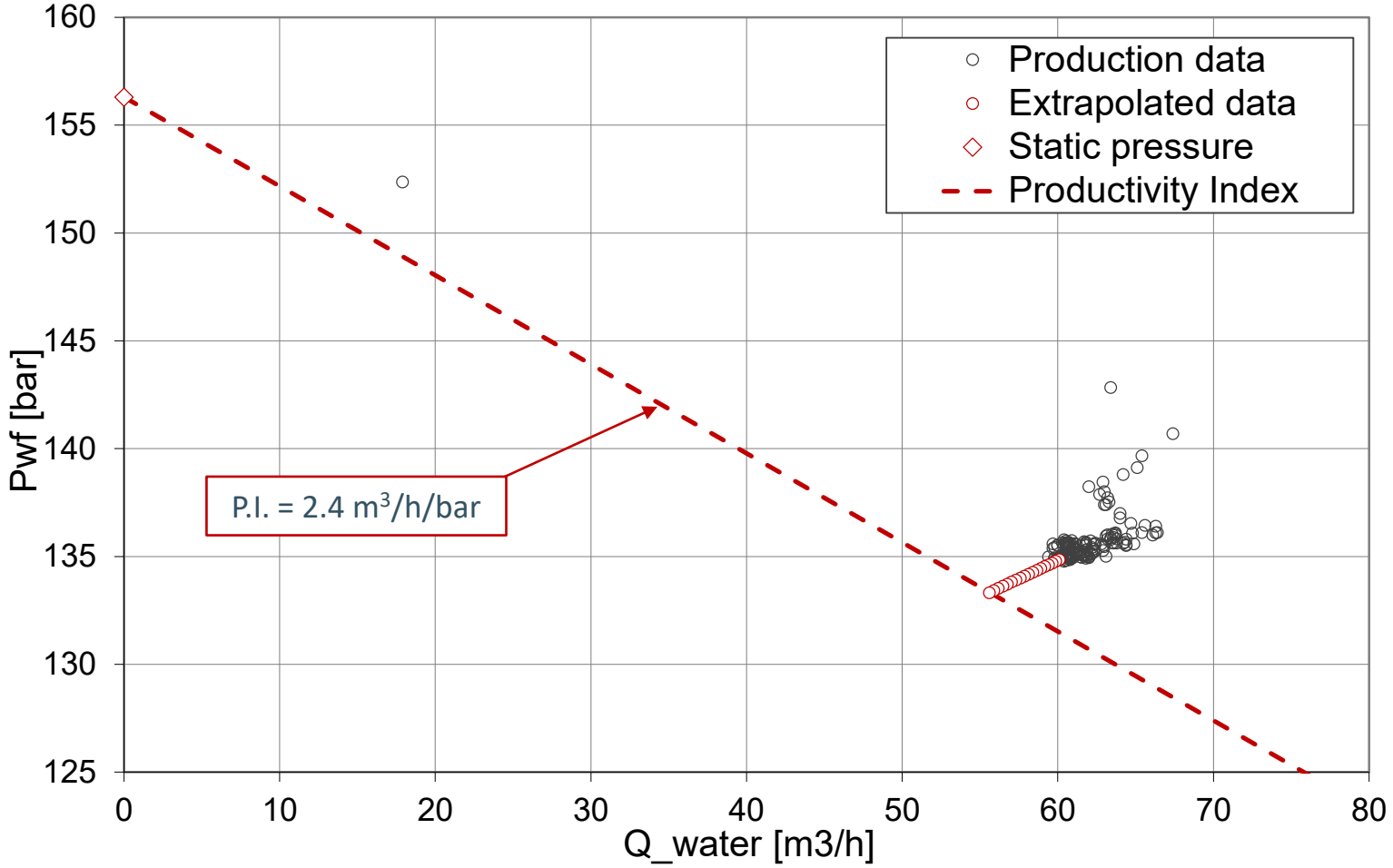
# Amsterdam-01 PTA model - alternative




**Model alternative 1**:
- Homogeneous model
- Low case kh
- Transmissivity (kh) = **5.7 Dm**

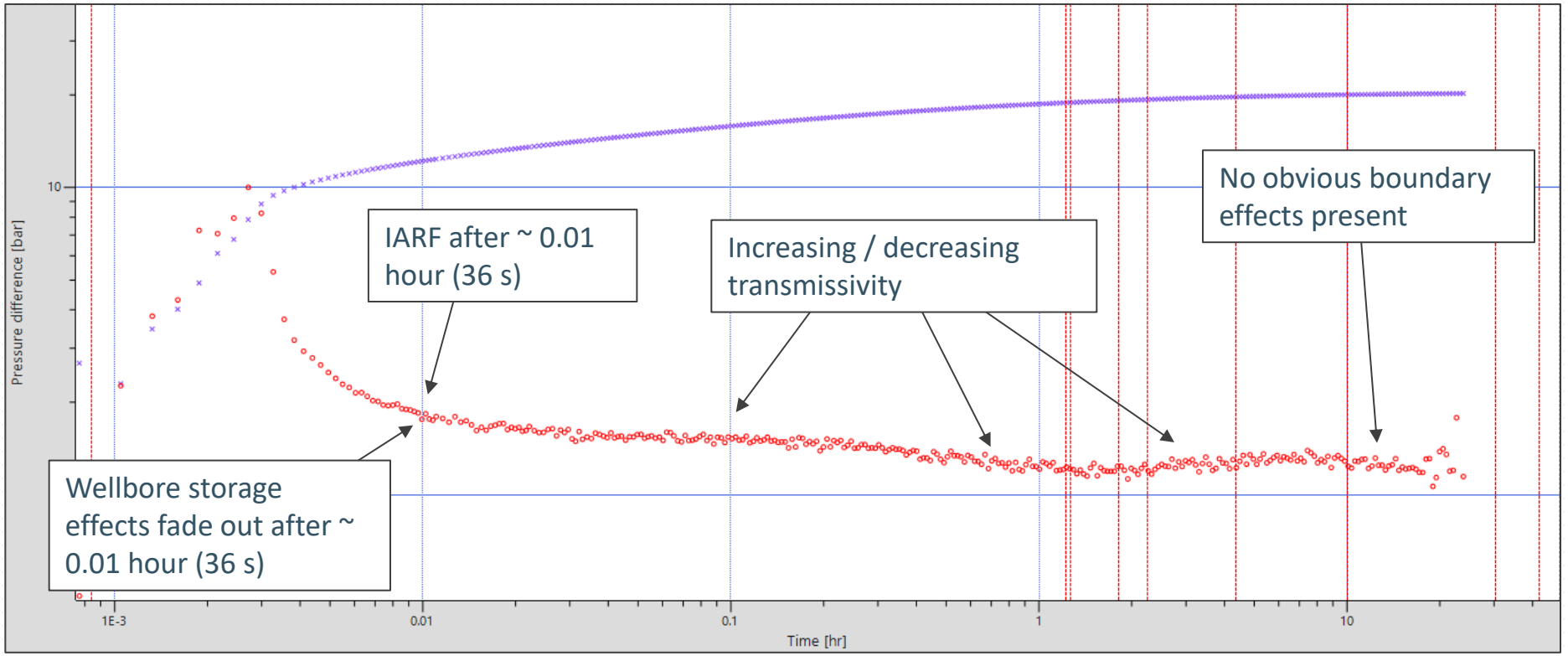
**Model alternative 2**:
- Homogeneous model
- High case kh
- Transmissivity (kh) = **6.9 Dm**

# De Bilt-01 results




- Extrapolation of transient data to steady state data
- Single (short) flow rate sufficient to determine Productivity Index
- Productivity Index = 2.4 $m^3$/h/bar

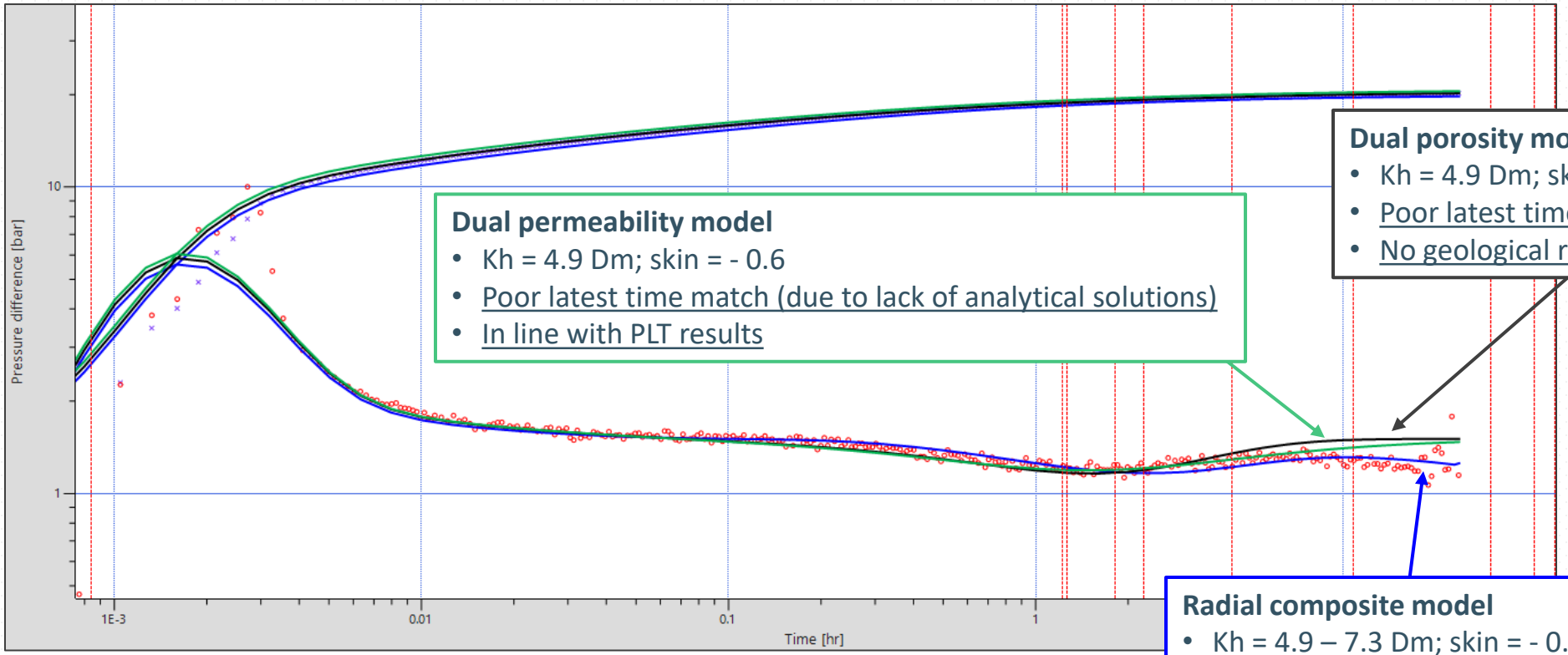
# De Bilt-01 PTA data




Buildup analysis:

- Very clear and smooth data set (due to downhole shutin)
- ‘easy’ to interpret the reservoir properties

# BLT-01 PTA model

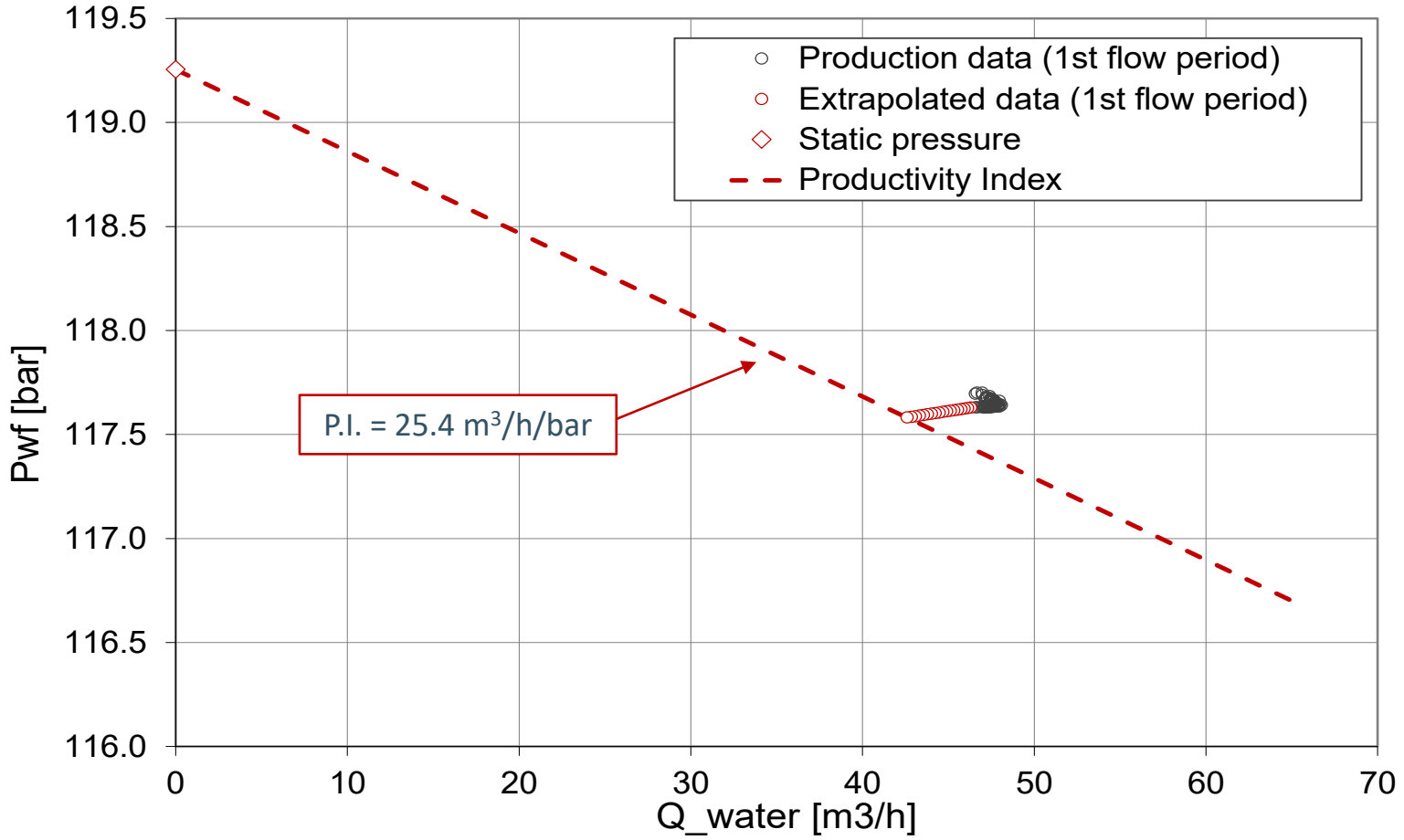



**Dual permeability model**
- Kh = 4.9 Dm; skin = - 0.6
- Poor latest time match (due to lack of analytical solutions)
- In line with PLT results

**Dual porosity model**
- Kh = 4.9 Dm; skin = - 0.4
- Poor latest time match
- No geological realism (fractures = 62 volume%)

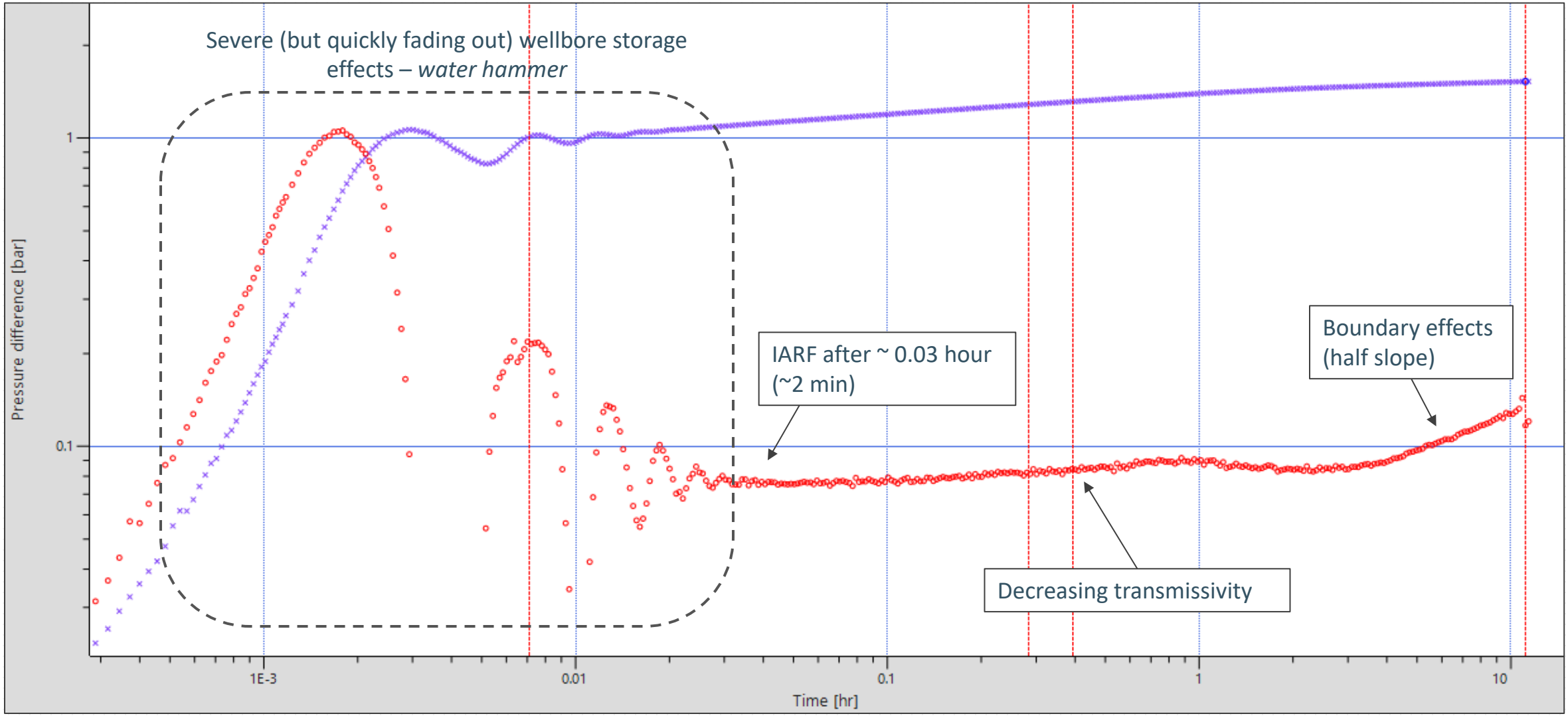
**Radial composite model**
- Kh = 4.9 – 7.3 Dm; skin = - 0.6
- Good match
- No geological realism

# Ede-01 results

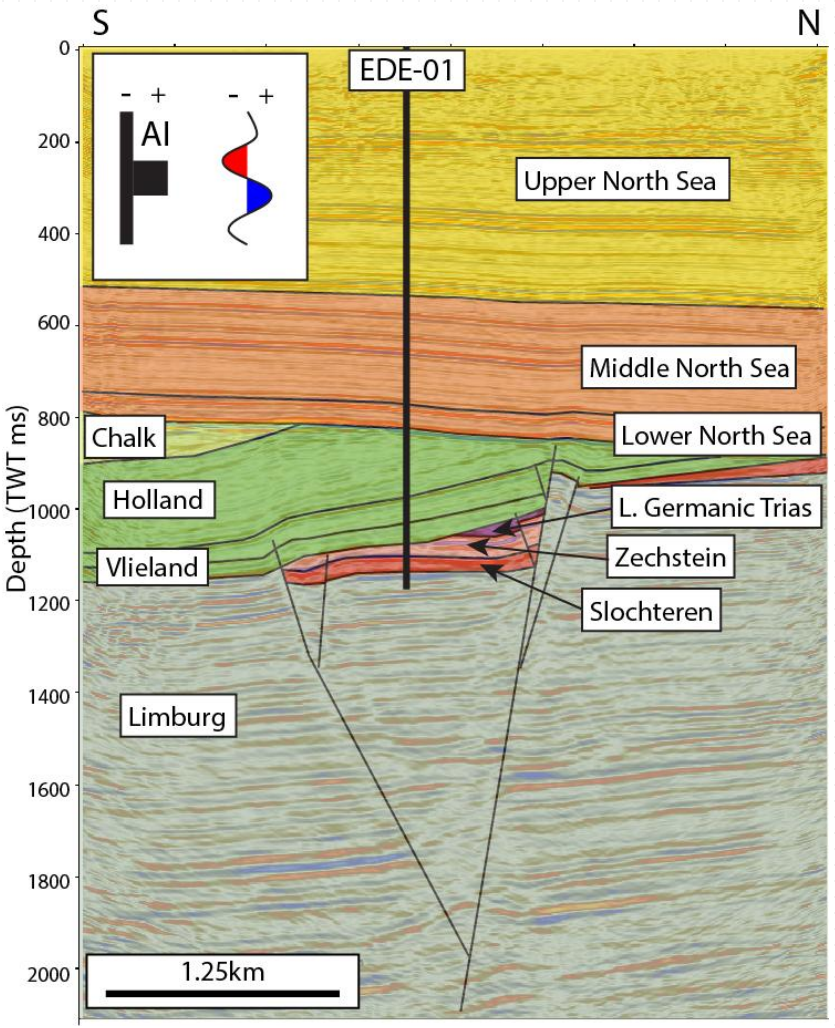


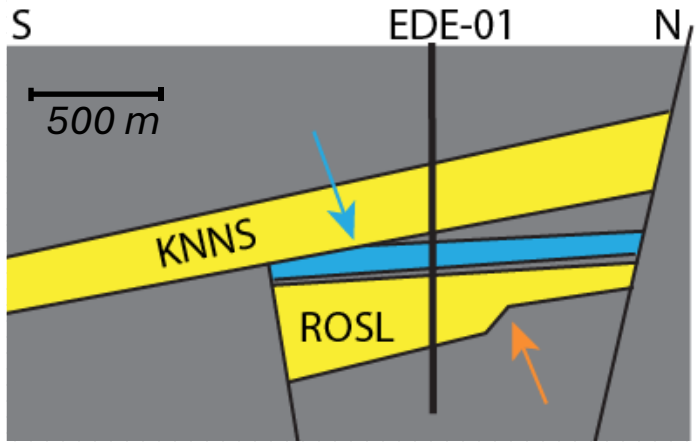

- A slight (3 bar) overpressure was observed and the well was naturally flowing → decided to leave out the artificial lift and perform the production test by natural flow:
  - Single flow period
  - No downhole shutin device
  - PLT during production period (including downhole P&T gauge)
- Extrapolation of transient data to steady state data
- Single (short) flow rate sufficient to determine Productivity Index
- P.I. = 25.4 m3/h/bar

# Ede-01 PTA data

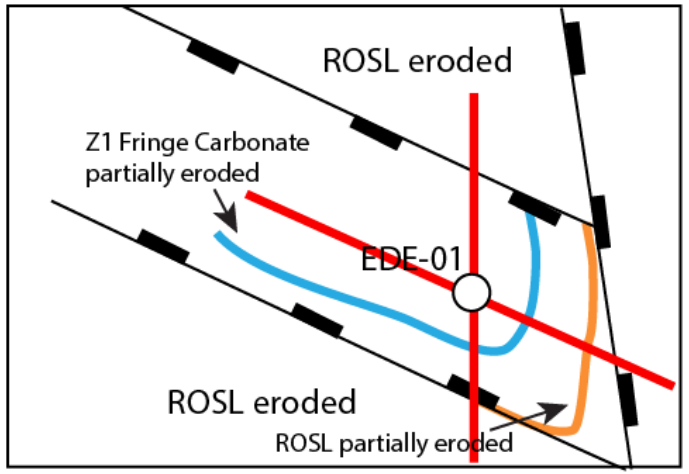


# Ede-01 PTA conceptual model



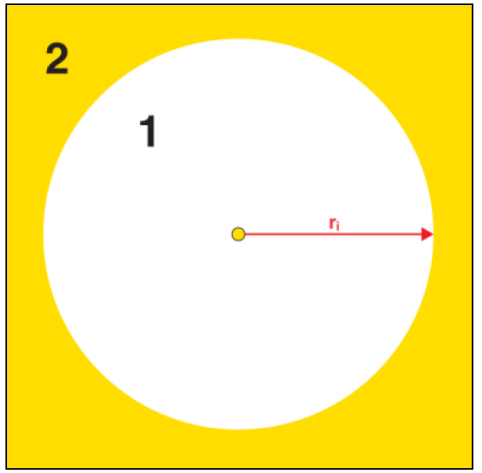




thickness reduction @ ~ 140 m



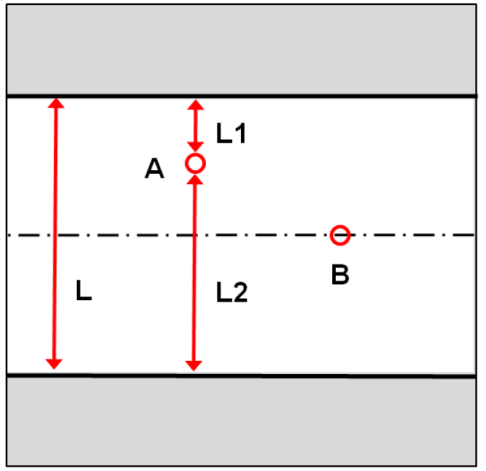

2 parallel faults @ ~ 550 m

PTA reservoir model



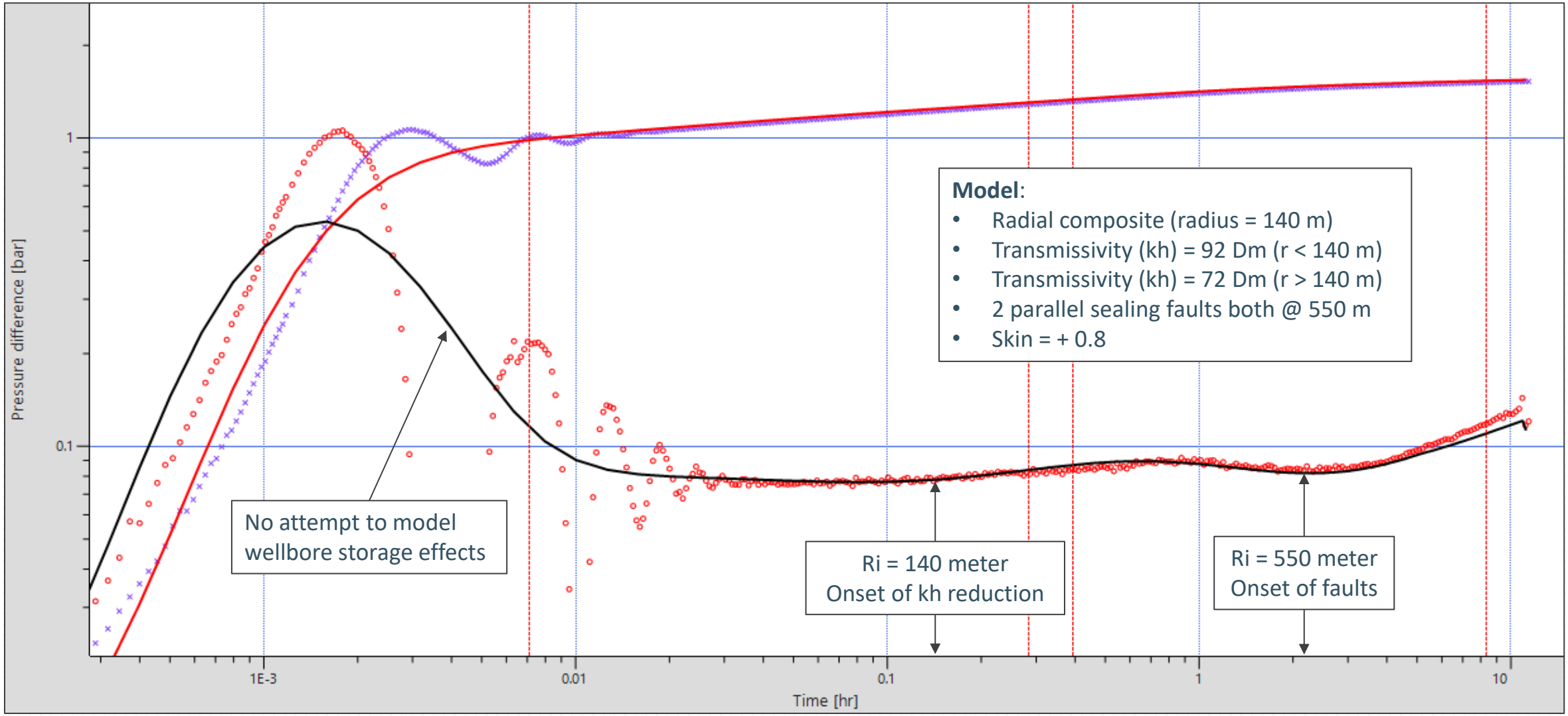

Radial composite model

PTA boundary model




Parallel faults

# Ede-01 PTA model



# Reservoir Performance Summary

| Well | kh [Dm] Well Test | Kh [Dm] Petrophysics | Skin [-] | P.I. [$m^3$/h/bar] | Reservoir | Boundary | Cumulative production [$m^3$] | Other |
|---|---|---|---|---|---|---|---|---|
| Amsterdam-01 | 5,7 – 6,9 | * | -1,65 | 3,8 | Homogenous, some lateral variation in reservoir quality (k, h or μ) | No | 329 | - |
| De Bilt-01 | 4,9 | 5,3 – 6,5 | -0,6 | 2,4 | Dual permeability (two zones); no extensive fracture network | No | 140 | - |
| Ede-01 | 72 (far) – 92 (near) | 32 – 57** (near) | +0,8 | 25,4 | Reduction in reservoir quality (thinning) | 2 parallel sealing faults @ 550 m | 260 | Slight overpressure |

* Special Core Analysis for Amsterdam-01 ongoing
** Preliminary results. Porosity-permeability transform to be refined

## Conclusion:

- kh from well test& petrophysics in the same ballpark. Evaluation on remaining gap ongoing

## Data improvement:

- Downhole shutin eliminates wellbore storage effects

## Cost reduction:

- Jetpump perfect for SCAN well testing purposes
- Multirate testing not needed to determine P.I.: single rate & brief (3 hours) production period suffices for SCAN
- Pressure Transient Analysis: single rate & brief (3 hours) production period suffices for SCAN (it's the buildup that counts)
- For our purposes, steady state flow is not a necessity, transient flow is sufficient (and shorter and hence cheaper)

# Ede-01 Vlieland Sandstone & Zechstein

Adriaan Janszen

# Vlieland Sandstone reservoir in EDE-01

- Palaeogeography
- Depositional Environments
- Reservoir Quality Controls

scanaardwarmte.nl

Jeremiah et al., 2010

# Vlieland Sandstone - Palaeogeography

**EDE-01:**

➔45.5 m fine-medium argillaceous sandstone and pebbly sandstones

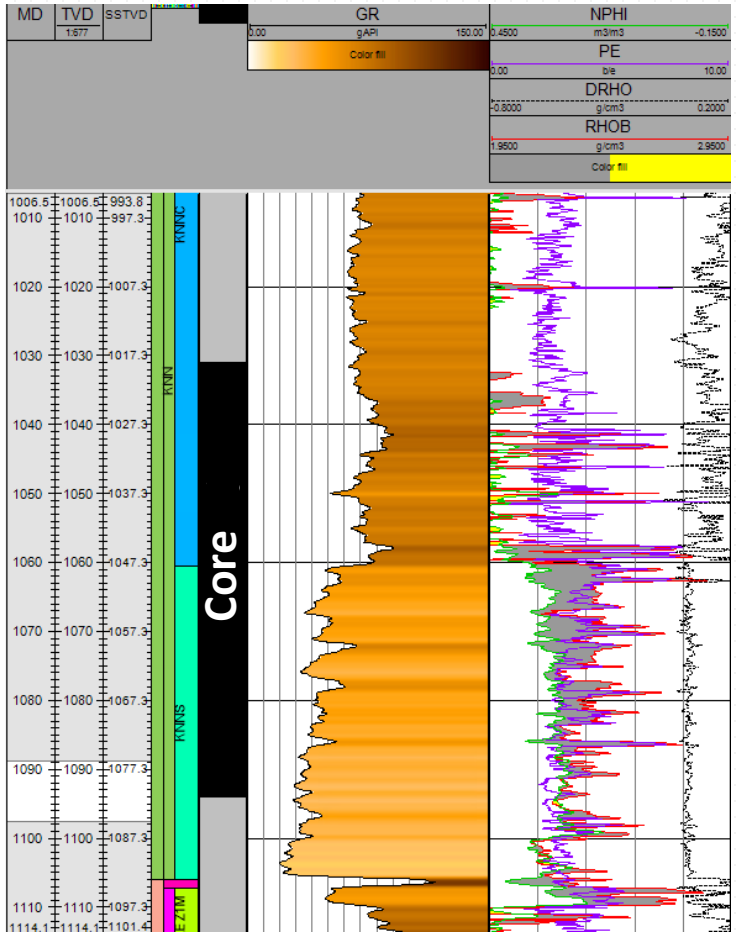
➔Early-Late Barremian age

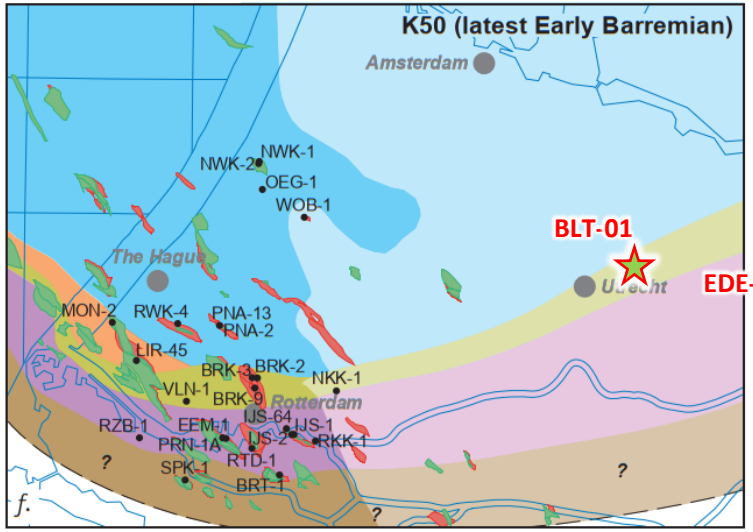
➔Well-oxygenated marine conditions

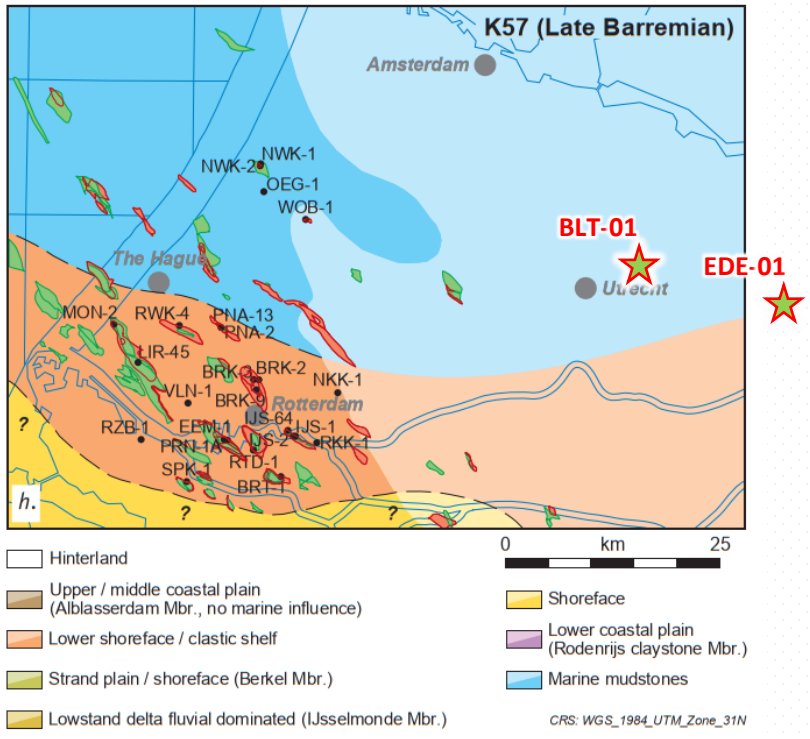
**BLT-01:**

Not deposited, deposition started in Late Barremian with Vlieland Claystone

**EDE-01**



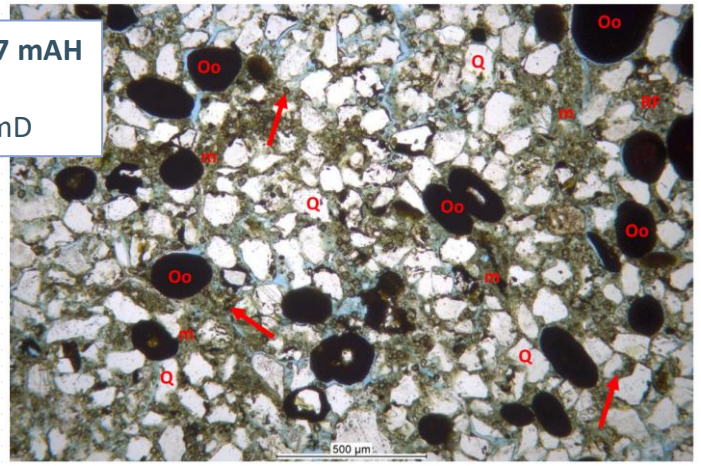



# Depositional environments

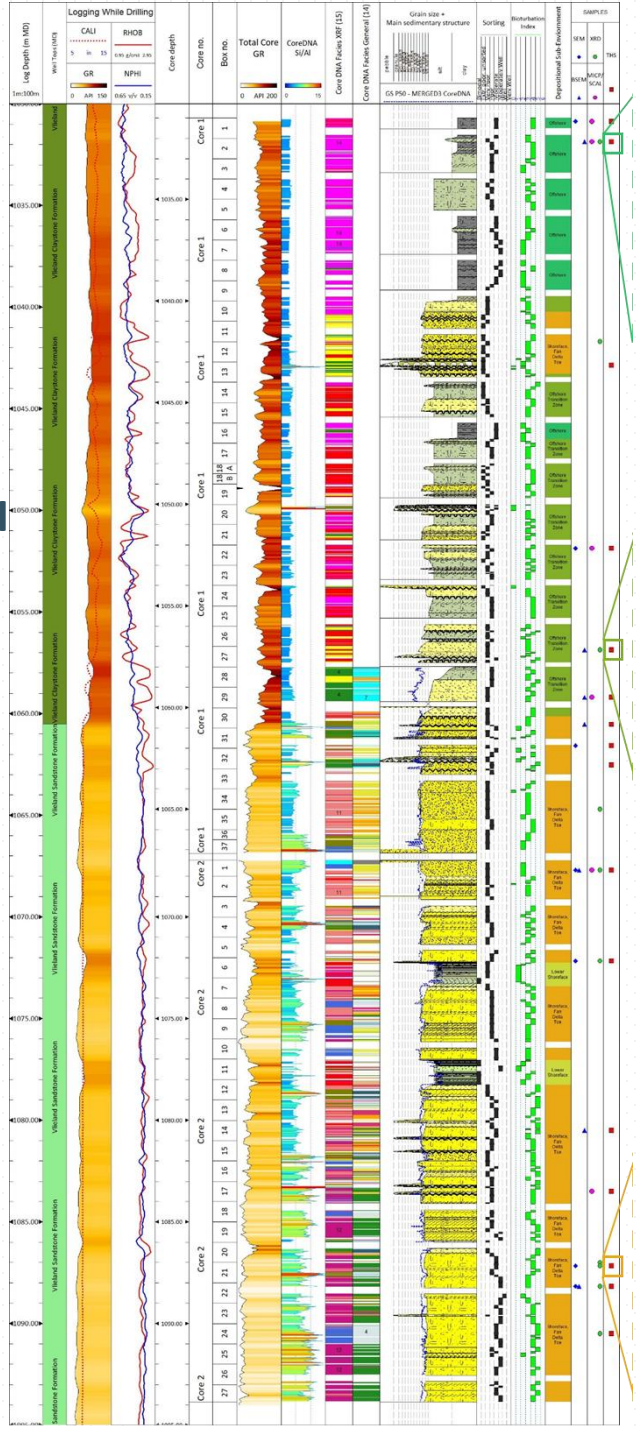
- ➜Highly bioturbated sandstones interbedded with pebbly sandstone
- ➜Grading into lenticular-bedded heterolithics
- ➜Coal/wood fragments
- ➜Lithic extraclasts
- ➜Iron ooids and bioclasts
- ➜Three transgressive cycles cored
- ➜Deposited in fan delta toe and upper- to lower-shoreface

**EDE-01 – 70 – 1072.17 mAH**
Porosity: 22.2%
Air Permeability: 1.9 mD



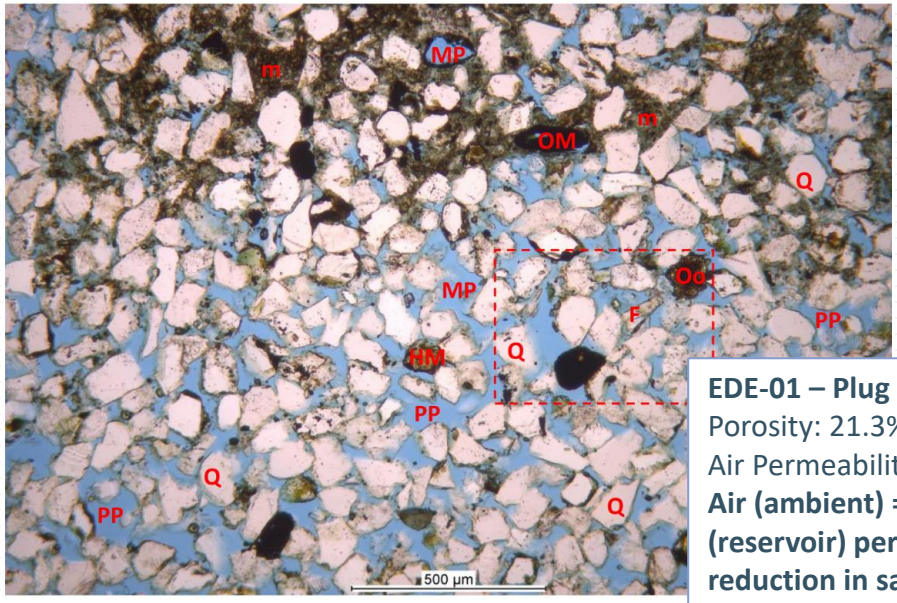

**EDE-01 – 1062 mAH**

**EDE-01 – 1072 mAH**

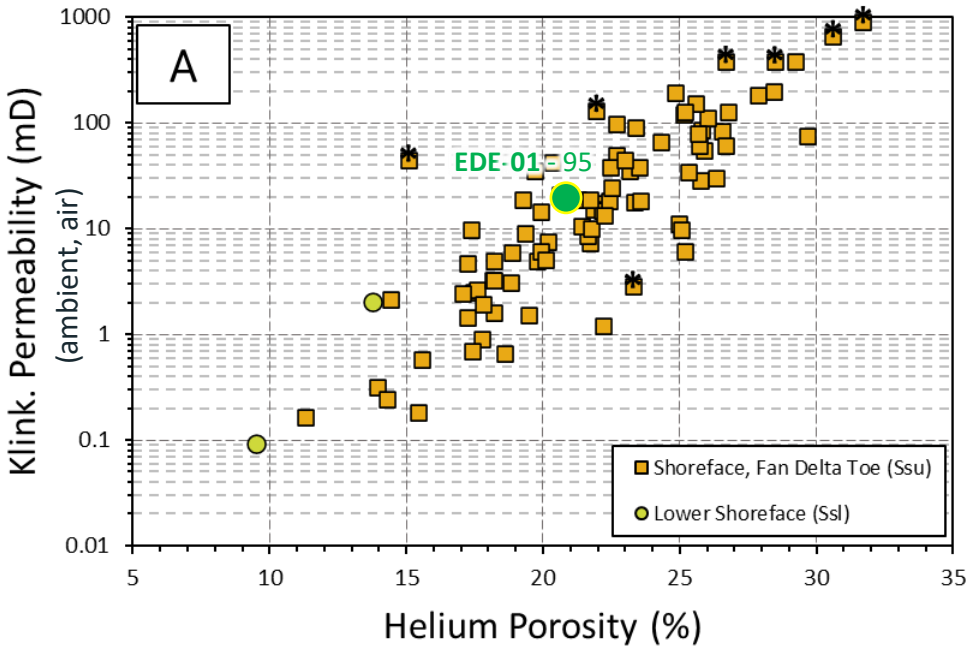


# Reservoir quality controls

- ➜Bioturbation resulted in poor sorting and high detrital clay content (illite and chlorite)
- ➜Siderite cements
- ➜Based on quick-look core screening and petrophysical analysis decided not to perform well test
- ➜SCAL showed significantly lower brine permeability than air permeability
- ➜Reservoir quality of shallow-marine sandstones is regionally highly variable




**EDE-01 – Plug 95 – 1080.5 mAH**
Porosity: 21.3%
Air Permeability: 18.5 mD
**Air (ambient) => Brine (reservoir) permeability reduction in sample 98: 18.6 mD => 0.26 mD**




* Fractured or friable plugs – permeability likely overestimated

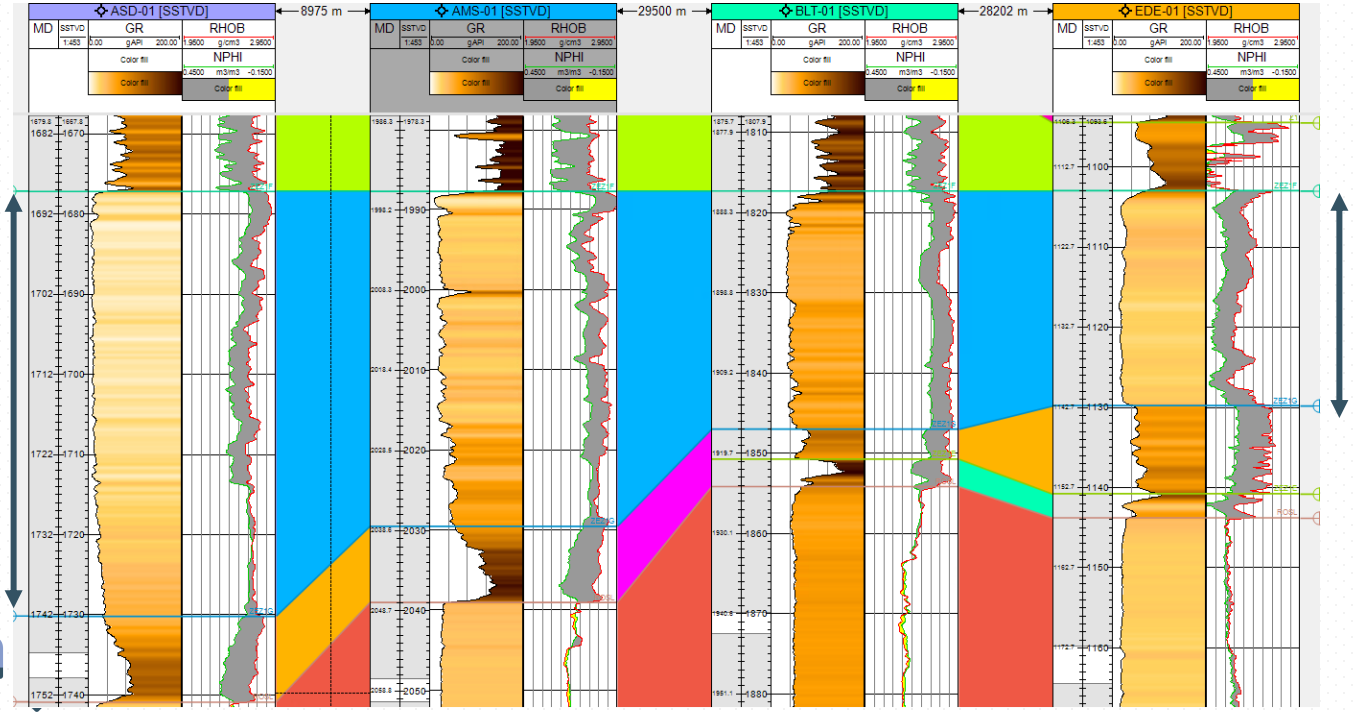
# Z1 Fringe Carbonate reservoir in EDE-01

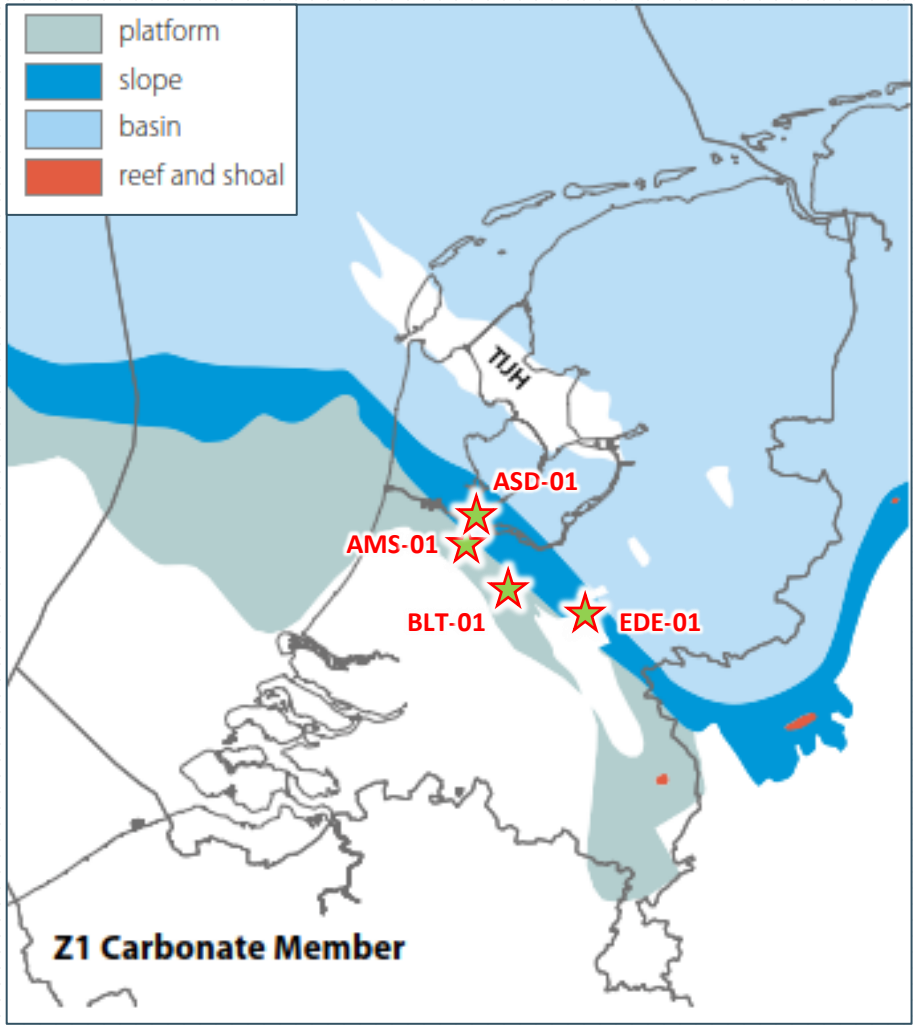
- Palaeogeography
- Reservoir Quality and Flow

scanaardwarmte.nl

# Zechstein – Z1 Fringe Carbonate Member

- ➜Not cored, calcareous dolomite deposited on platform-slope (including bryozoan and stromatolite bioherms) according to published paleogeographic maps
- ➜Tight in ASD-01, AMS-01 and BLT-01
- ➜Highly porous in EDE-01
- ➜Porosity probably associated with exposure and dissolution below the Base Cretaceous Unconformity

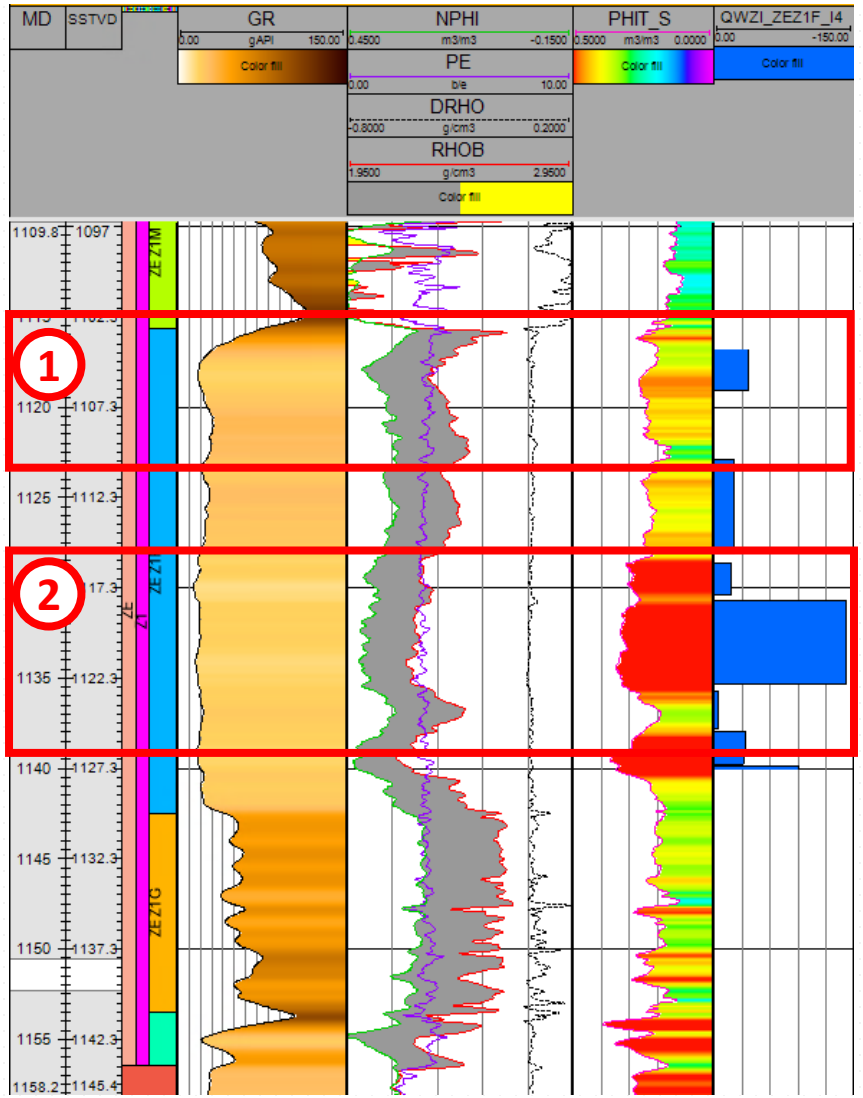


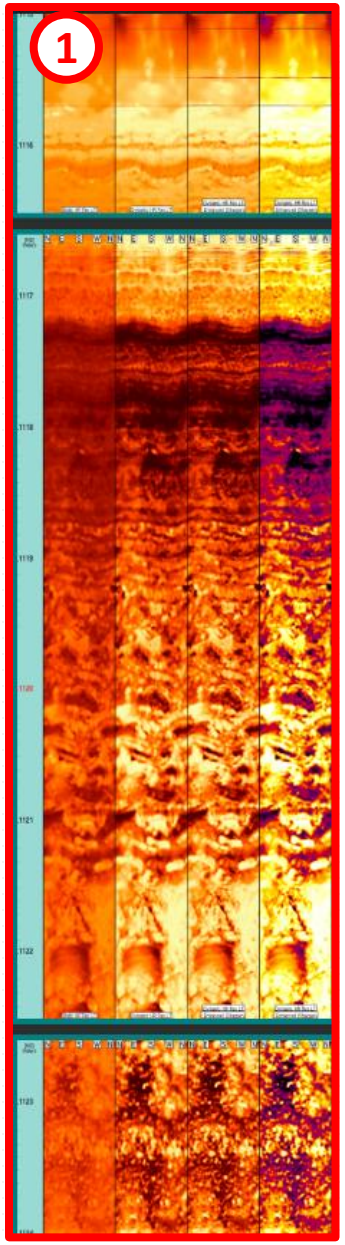



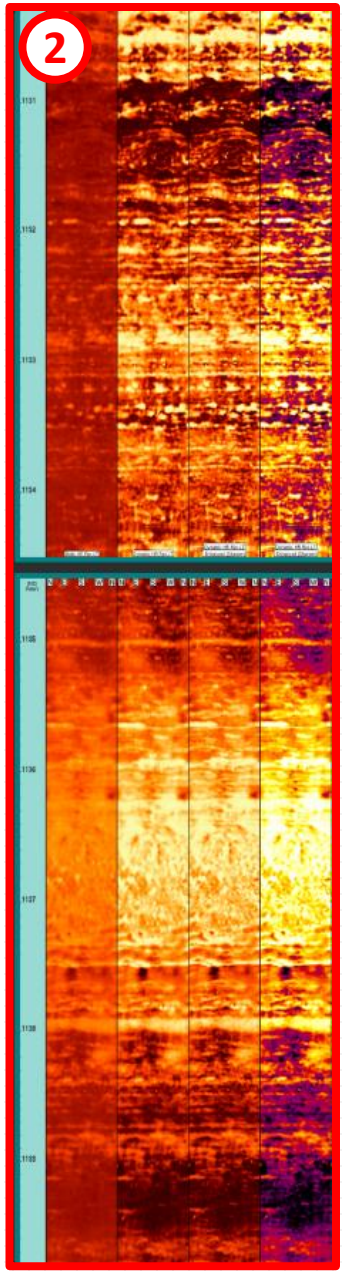

Bouroullec and Geel, 2025

# Zechstein – Z1 Fringe Carbonate Member

- EDE-01: 26.8 m TVT with average porosity 26.3%
- No fractures
- No losses
- Dissolution features in image log
- Flow tested:
  - Transmissivity: 5.3 Dm
  - Average permeability: 200mD
- Potential upside to underlying Slochteren reservoir



# Take-home messages& way forward

Marten ter Borgh

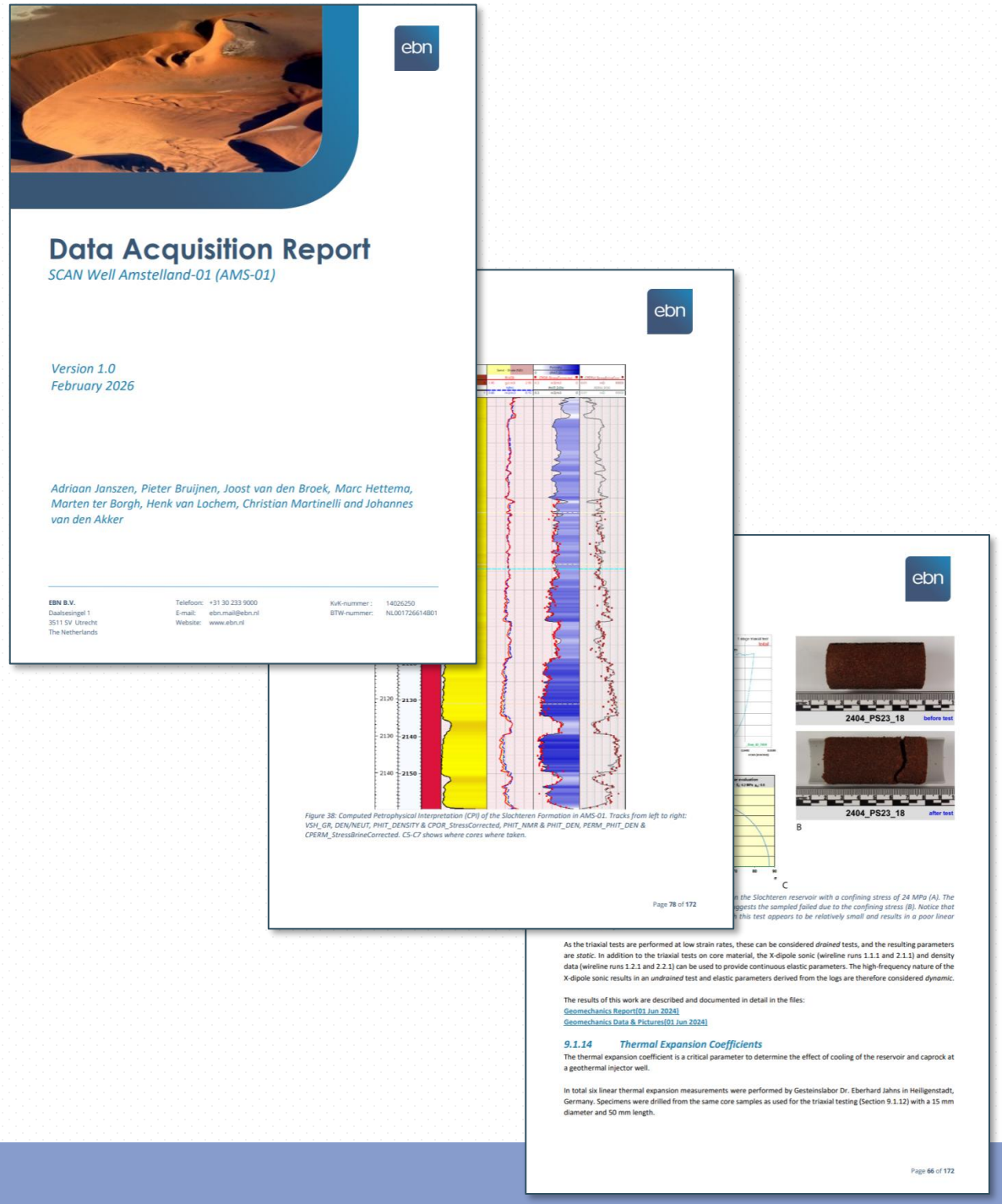
# Take-home messages

- ➔Successful Operations with zero Lost Time Injuries
- ➔Robust dataset to evaluate geothermal potential and impact of heat extraction
- ➔Well tests performed with downhole shut-in giving robust estimates of reservoir transmissivity
- ➔Well test transmissivity generally consistent with petrophysically-derived permeability
- ➔High quality temperature data acquired including geothermal gradients

# Data Acquisition Reports

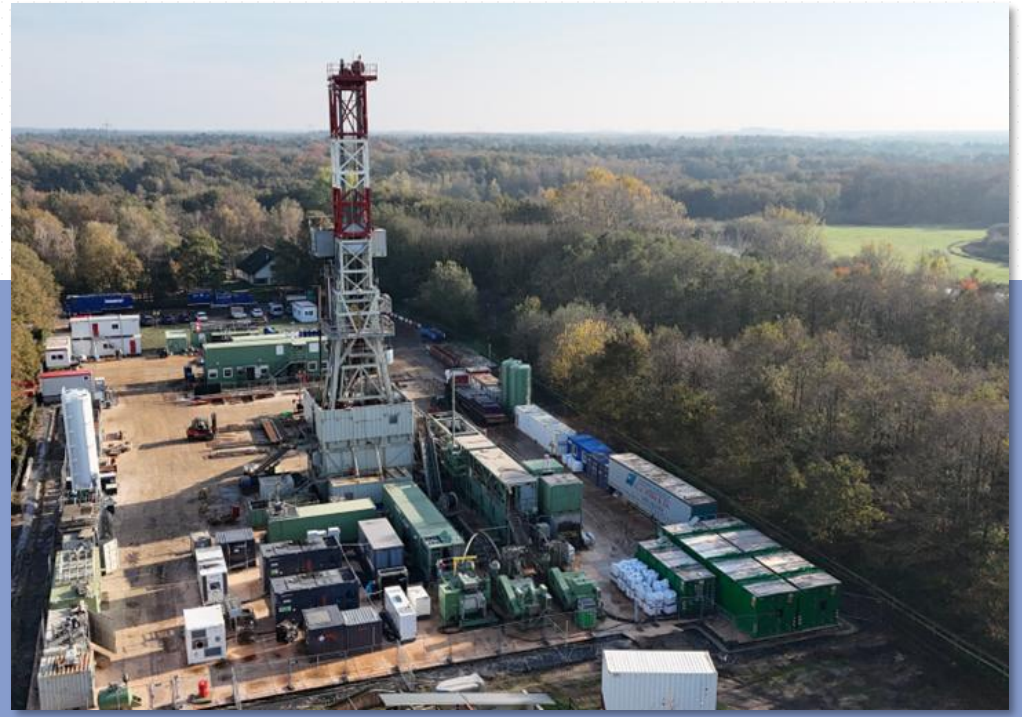
- ➜Data Acquisition Reports:
  - ➜Describe acquired data, suggested workflows and data limitations
  - ➜High-level overview of what was encountered in the well
  - ➜Well Test Interpretation& Petrophysical Evaluation
  - ➜Remaining uncertainties and recommendations for future work

- ➜**Amstelland-01 data acquisition report published on NLOG (172 pages)**



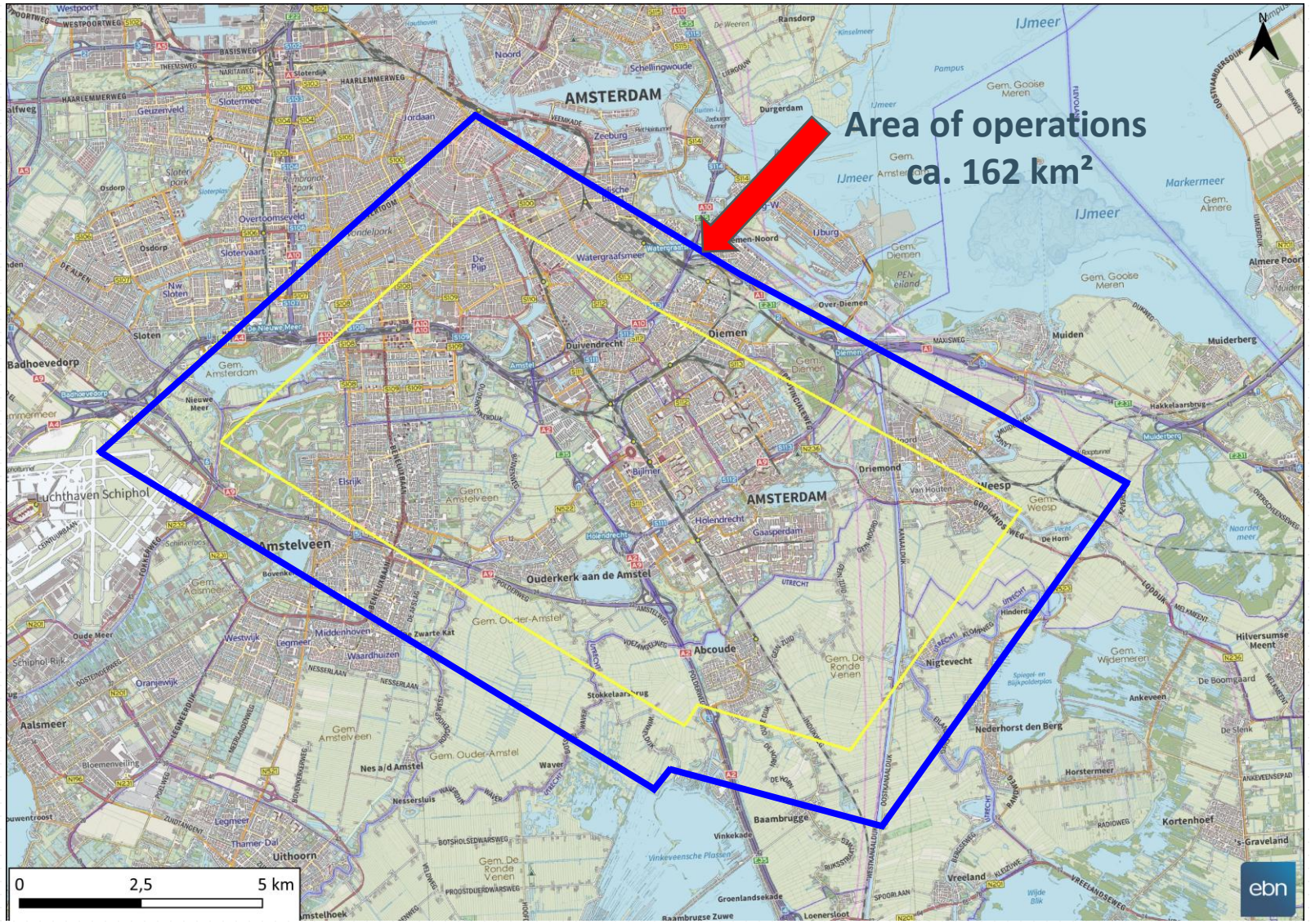
# SCAN: a look back and going forward

Gitta Zaalberg



# SCAN Seismic Survey Metropolitan Region Amsterdam

- Ca. 500.000 inhabitants
- ~135.000 letters distributed
- 9 Municipalities
- >600 Land users permitted
- 2 Water boards, Schiphol etc.
- Completed end of December
- ~20.000 source points
- ~7.5 TB Data recorded
- Processing ongoing




Provincie Noord-Holland

info@scanaardwarmte.nl
www.scanaardwarmte.nl

# Onderzoek in de ondergrond – op zoek naar mogelijkheden voor aardwarmte

Beste bewoner/ betrokkene,

U ontvangt deze brief omdat er binnen nu en 2 weken in uw omgeving seismisch onderzoek plaatsvindt. Dat wordt uitgevoerd door SCAN in samenwerking met Smart Seismic Solutions (SP). Dit onderzoek brengt de diepe ondergrond (aardlagen) in beeld. Met de resultaten kan worden bepaald waar aardwarmte productielocaties geplaatst zouden kunnen worden. In deze brief leest u meer over het onderzoek en wat u hiervan kunt merken.

**Over het seismisch onderzoek**
De twee onderzoeksmethodes die gebruikt worden heten 'vibroseismiek' en 'schotgatseismiek'. De eerste techniek werkt met een vibrosels voertuig dat geluidsgolven de ondergrond in stuurt. Het voertuig lijkt op een vuilniswagen en heeft onderaan, op straatniveau, een triplaat die geluidsgolven opwekt. Om de 20 meter stopt het vibrosels voertuig om geluidsgolven de ondergrond in te sturen om vervolgens door te rijden naar het volgende meetpunt.

Daarnaast vindt er ook schotgatseismiek plaats in het veld/ park. Een landbouwtractor, met daarop een kleine boorinstallatie, plaatst seismische ladingen in de grond op een diepte van ongeveer 20 meter. Daarna worden één voor één de seismische ladingen ontstoken. Grondmicrofoons (geofoons) worden aan het aardoppervlak geplaatst. Die vangen de geluidsgolven op die terugkaatsen op de onderliggende aardlagen.

Scan de QR-code op het einde van deze brief voor de uitlegvideo en meer informatie.

**Laat de wit-oranje grondmicrofoons liggen**
Een grote hoeveelheid grondmicrofoons ligt gedurende het onderzoek in het gras, veld of op de stoep (naast de looproute). Deze kleine wit-oranje meetkastjes verzamelen onderzoeksgegevens om de structuur van de aardlagen in kaart te brengen. Ziet u er een of meer liggen? Laat die daar alstublieft liggen. Als het onderzoek is afgelopen (na enkele weken), worden de microfoons opgerumd.

**Wat u kunt opmerken**
Als het vibrosels voertuig geluidsgolven de ondergrond in stuurt is er flink wat geluid te horen. Het kan zijn dat u daar wakker van wordt. Tegelijkertijd voelt dit als het voorbijrijden van een tram of zware vrachtwagen die over een drempel rijdt. Bij het ontsteken van de seismische ladingen in het veld/ park kunt u, met name dichtbij, een zware, doffe plof horen. De trillingen van beide typen onderzoek zijn voelbaar in de directe omgeving maar kunnen ook verderop voelbaar zijn. Hoe sterk de trillingen zijn, hangt af van de ondergrond en plaatselijke omstandigheden. Bij sommige gevels wordt een sensor geplaatst om te controleren of de trillingen binnen de norm blijven. Wij vragen hiervoor uw begrip.

**Planning van het onderzoek**
De werkzaamheden met het vibrosels voertuig worden een of twee keer in de komende weken (op werkdagen) in uw omgeving uitgevoerd en vinden plaats in de avond en nacht tussen 21:00 en 7:00 uur. Het voertuig heeft 15 minuten nodig om precies op het meetpunt te parkeren. Het opwekken van geluidsgolven duurt vervolgens 1 minuut per meetpunt. Daarna rijdt het voertuig naar het volgende punt, 20 meter verderop in de straat, en herhaalt het proces zich.

Het ontsteken van de seismische ladingen in het veld/ park vindt plaats op werkdagen tussen 7:00 en 23:00 uur en neemt in uw directe omgeving enkele uren in beslag, verspreid over verschillende dagen.

In de avond/ nacht worden de geluidsgolven opgewekt omdat er dan minder omgevingsgeluid is, en hoe stiller de omgeving hoe beter de onderzoeksresultaten.

**Meer informatie en contact**
Het SCAN-programma wordt uitgevoerd door EBN en TNO, en wordt gefinancierd door het Ministerie van Klimaat en Groene Groei. Kijk voor meer informatie op de pagina 'Seismisch onderzoek Metropoolregio Amsterdam' op scanaardwarmte.nl. Stel uw vragen gerust via info@scanaardwarmte.nl of bel met 085-3327900 als u specifieke vragen heeft die met de uitvoering van het onderzoek te maken hebben of als u hinder ondervindt.

Met vriendelijke groet,
Het team van SCAN & SP

Scan de QR-code voor de uitlegvideo en meer informatie:
Deze brief is in het Arabisch en Turks te vinden onder het kopje 'Veelgestelde vragen'.

scanaardwarmte.nl

Onderzoek in de ondergrond naar aardwarmte

Onderzoek in de ondergrond naar aardwarmte

PostNL
Port Betaald

Daalsesingel 1 | 3511 SV Utrecht

## Belangrijke informatie

→ Kijk op scanaardwarmte.nl

Onderzoek in de ondergrond naar aardwarmte

Seismisch onderzoek

scanaardwarmte.nl

# NIET AANRAKEN • DON'T TOUCH

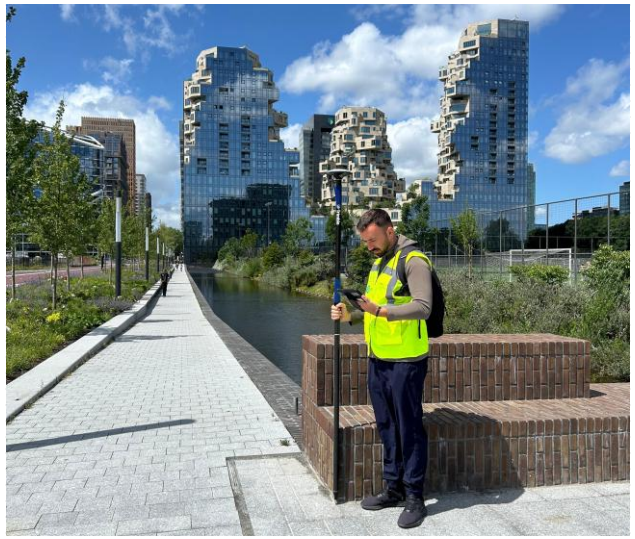
CONTACT: SCANAARDWARMTE.NL

DIT MEETKASTJE VERZAMELT GEGEVENS UIT DE ONDERGROND.
LAAT HET KASTJE A.U.B. OP DE GROND LIGGEN.

Onderzoek in de ondergrond naar aardwarmte

# Wat kunt u hiervan opmerken?

# What can you notice in the area of the SCAN operations?



Land surveyor

Sonic Drill Tractor

Vibroseis truck (large)

Geophones or receivers

Watch the video:

Seismisch onderzoek in de Metropoolregio Amsterdam

Vibroseis truck (medium)

# SCAN 2026 2D seismic data acquistion

- ➜Province Utrecht Noord-Oost (~156 km)
- ➜MRA Noord en West (~270 km)
  - ➜Program partly financed with subsidy from Province Noord-Holland
- ➜Identical technical parameter as SCAN 2D previous acquired and processed
- ➜Mix of shotpoint and Vibroseis acquisition
- ➜Execution planned in second half 2026
- ➜Data will be processed matching a consistent ‘SCAN’ grid

Daalsesingel 1
3511 SV Utrecht
info@scanaardwarmte.nl

www.scanaardwarmte.nl

Ministerie van Klimaat en Groene Groei

# Cores on display

EDE-01 (total 21 boxes)

1. Vlieland Claystone:
   Core 1: box 1-3 = 3 boxes
2. Vlieland Sandstone:
   Core 1: box 31-33 = 3 boxes
3. Vlieland Sandstone:
   Core 2: 15-17 = 3 boxes
4. Core 5 Box 4-7 (Psay to Adb)
5. Core 8 Box 4-5 (fractures)
6. Core 8 Box 9-14 (Adb-Ads, truncation)
7. Core 8 Box 17-18 (BPU)

ASD-01 (total 18 boxes)

1. Core 9 Box 10-14 (Adb-Ads)
2. Core 9 Box 19 (Adb bimodal)
3. Core 9 Box 27-28 (anhydrite cement)
4. Core 11 Box 25-29
5. Core 11 Box 44-48

BLT-01 (total 21 boxes)

1. Rogenstein: Core 5 box 25-29 = 4 boxes
2. Core 6 Box 4-5 (Ela)
3. Core 6 Box 11 (contact Ads-Ela)
4. Core 6 Box 32 (transition Adb-Ads, anhydrite cement)
5. Core 7 Box 2 (anhydrite-cemented fracture/gash)
6. Core 7 Box 4 (anastomosing, closed fractures, anhydrite cement)
7. Core 7 Box 14 (Ads, cm-scale bedding with ripple laminations and grading)
8. Core 7 Box 22 (Ads, as above)
9. Core 7 Box 29 (potential open fracture, this may be the one visible on the production test results)
10. Core 8 Box 11 (Ads, thicker bedded, internally structureless)
11. Core 8 Box 13-14 (truncation, Adb, fracture)
12. Core 8 Box 21 (Adb, bimodal, abundant anhydrite cement)
13. Core 8 Box 24 (Ads, cm-scale bedding with ripple laminations and grading)
14. Core 8 Box 30-33 (Psay, basal truncation, upwards transition to Adb-Ads)