GEOTHERMIE DELFT

Delftse bron van duurzame energie en kennis

EBN Dag van de Warmtetransitie
13 december 2023

Gloednieuw Delfts doublet met veelbelovende wetenschappelijke toekomst

Beer van Esser (TU Delft)
Walter Eikelenboom (Aardyn)

Introductie

Geothermie Delft (GTD) is een samenwerking tussen Aardyn, EBN, Shell en de Technische Universiteit Delft.

Twee doelstellingen:

1. Het **winnen** en **gebruiken** van duurzame energie in de vorm van **geothermische warmte**
2. **Wetenschappelijk onderzoek** naar en onderwijs in geothermie

Opzet presentatie

Deel 1 – Boor operaties en resultaten

Walter Eikelenboom, Manager Subsurface, Aardyn

Deel 2 – Onderzoek en ontwikkeling programma

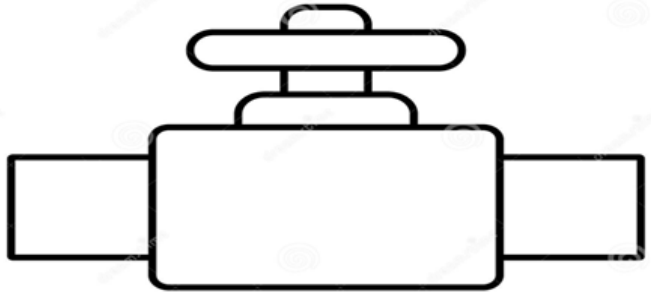
Beer van Esser, Operational Project Manager, Technische Universiteit Delft

Disclaimer: de boring is een week geleden afgerond, dus de data is nog niet compleet en niet volledig geanalyseerd!

Warmteketen Delft

Geothermie

Infrastructuur



TU Delft Campus +
Woon coöperaties

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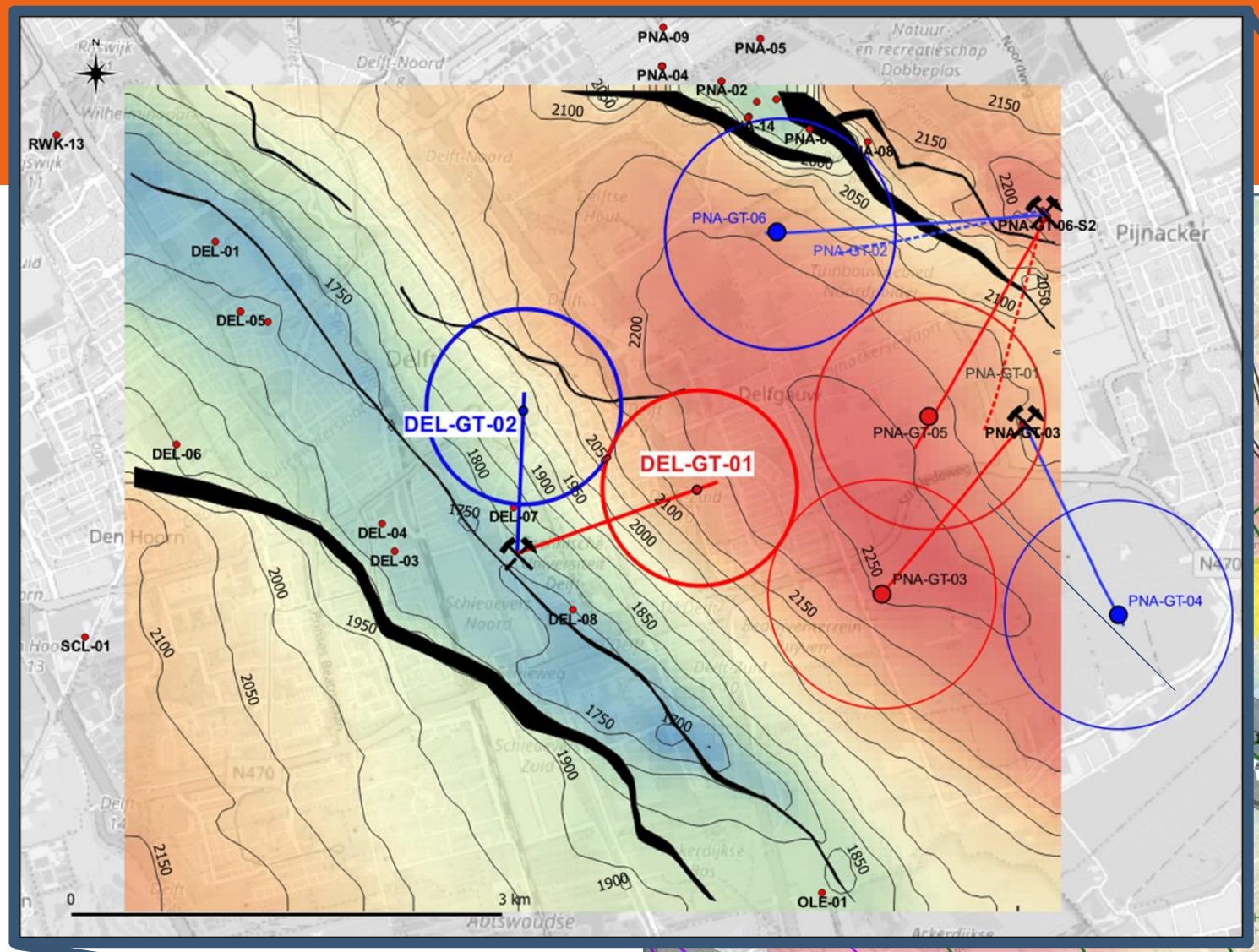
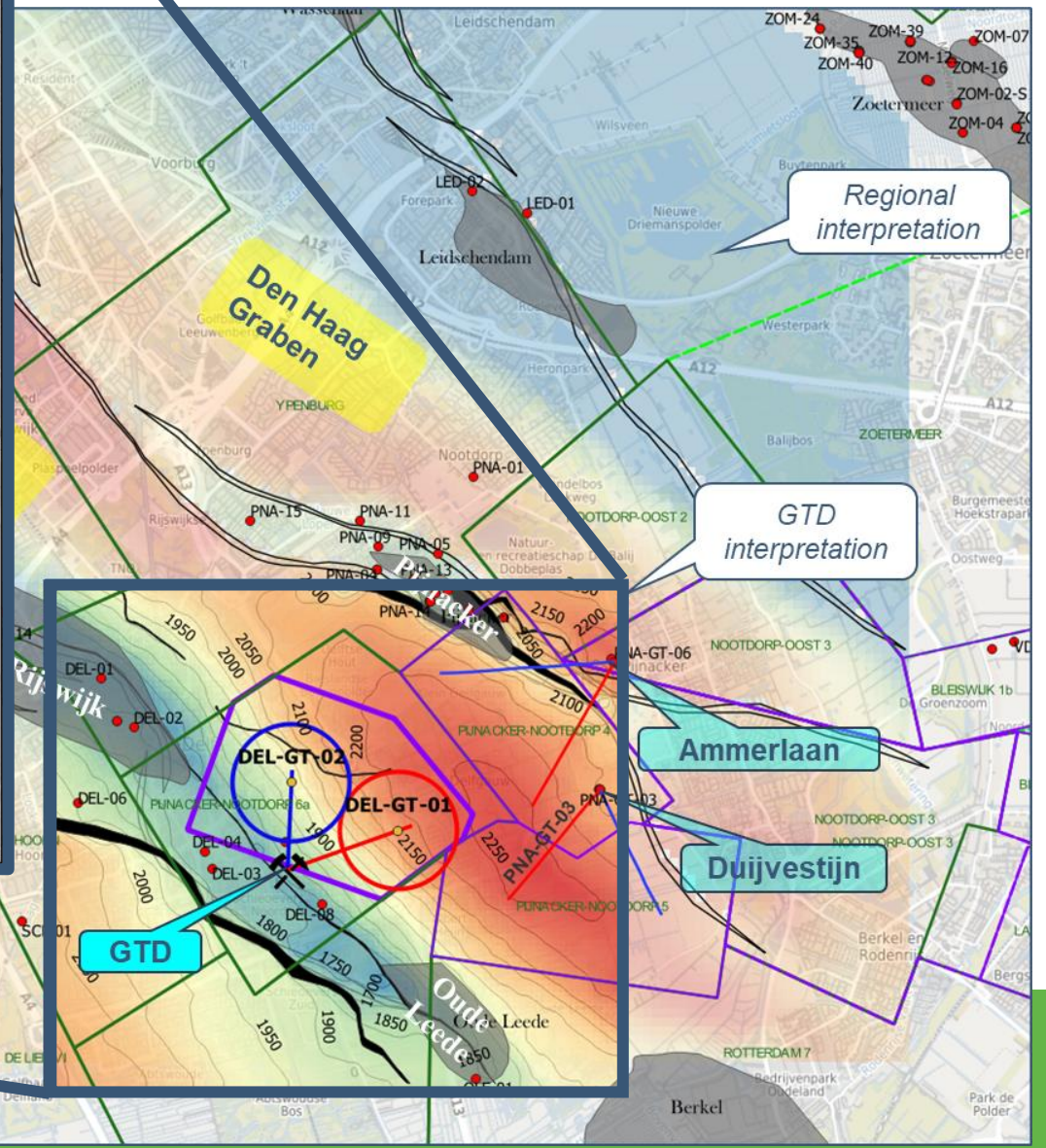
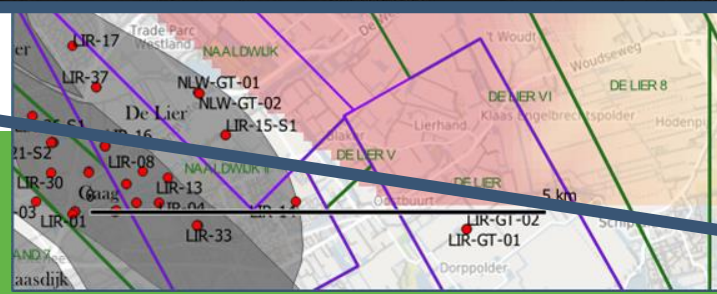
Tijdslijn

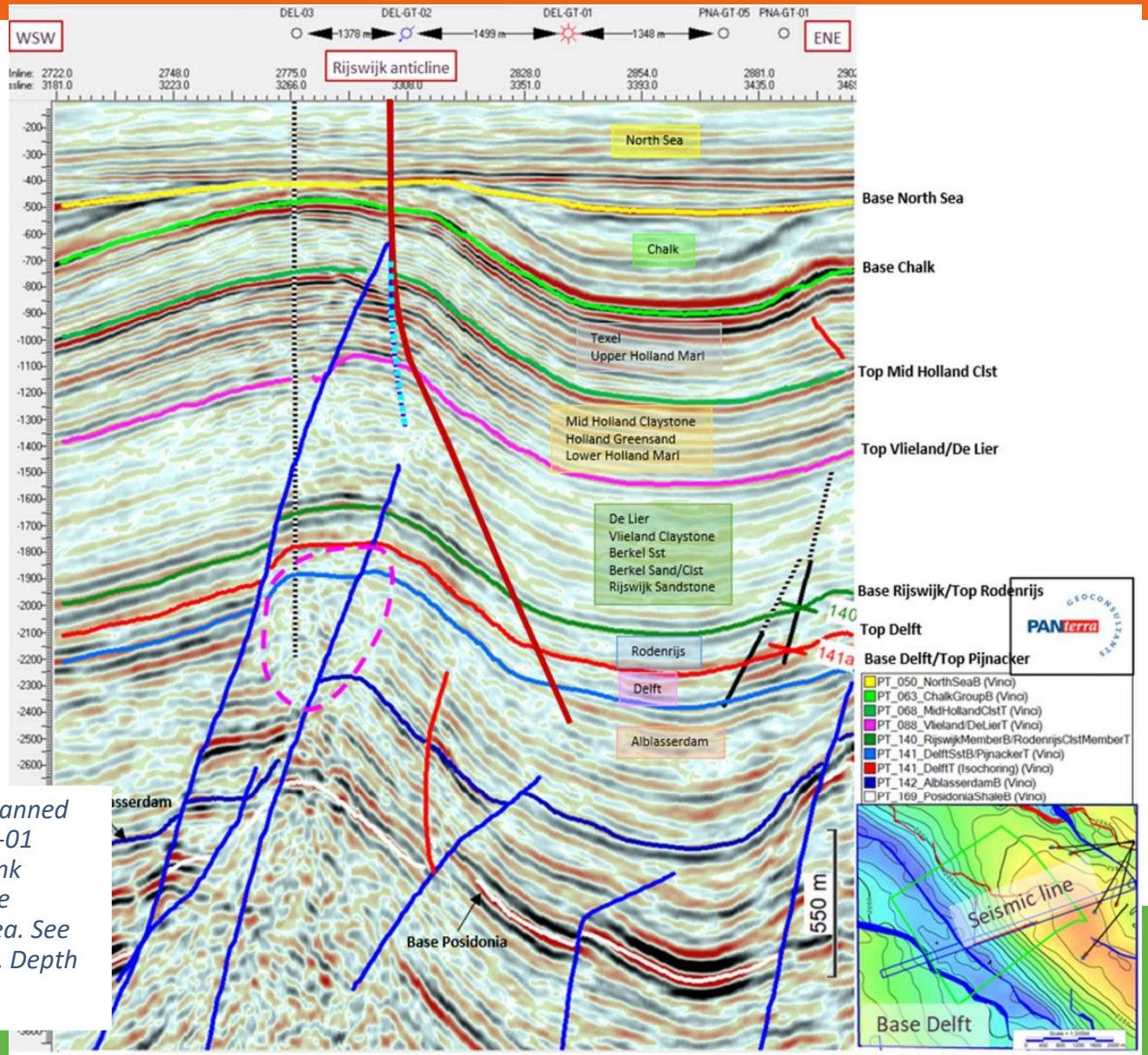
GEOTHERMIE DELFT
Delftse bron van duurzame energie en kennis


PNA-09
PNA-05
PNA-04
PNA-02
RWK-13
DEL-01
DEL-05
DEL-06
DEL-04
DEL-03
SCL-01
DEL-08
DEL-07
OLE-01
PNA-GT-06
PNA-GT-02
PNA-GT-06-S2
PNA-GT-01
PNA-GT-05
PNA-GT-03
PNA-GT-04
DEL-GT-02
DEL-GT-01
Pijnacker
Delft-Noord
Den Haag
N470
0
3 km

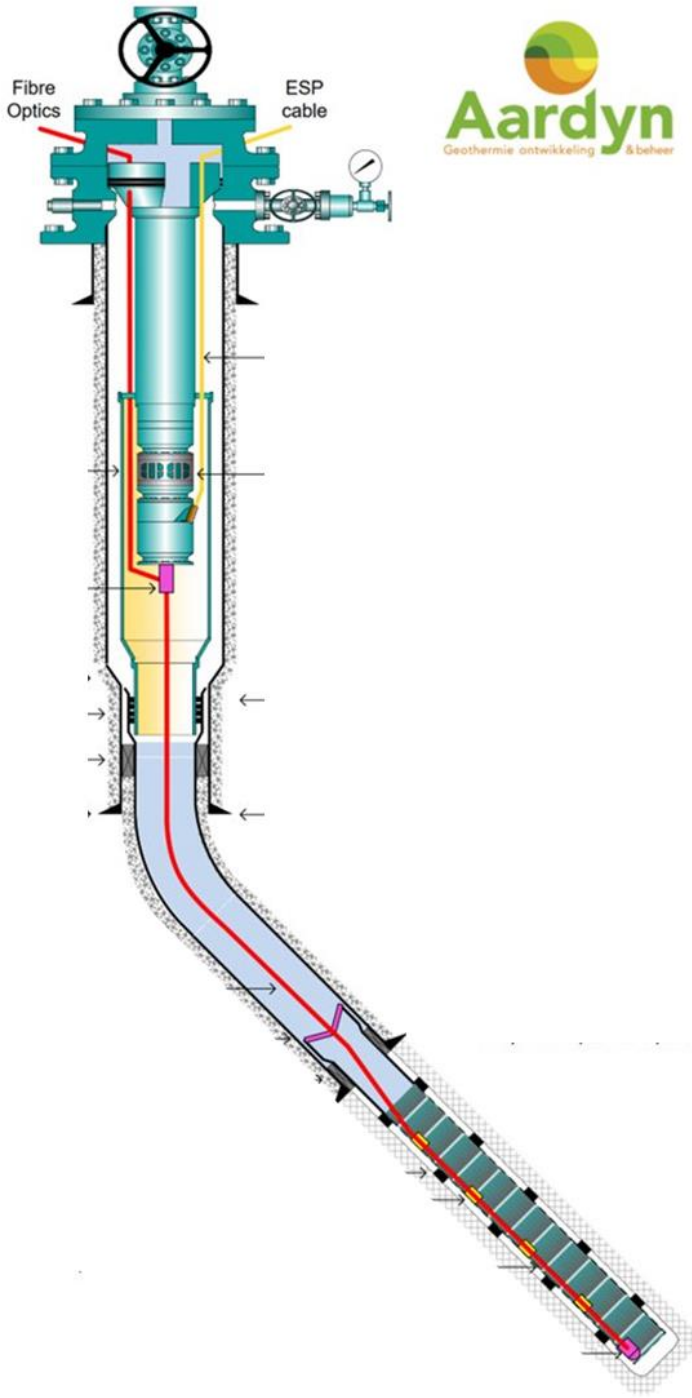

Regional interpretation
GTD interpretation
Den Haag Graben
Leidschendam
Zoetermeer
Ammerlaan
Duijvestijn
NOOTDORP-OOST 3
DEL-GT-02
DEL-GT-01
PNA-GT-03
GTD
Oude Leede
Berkel


NAALDWIJK
De Lier
NLW-GT-01
NLW-GT-02
LIR-15-S1
LIR-GT-02
LIR-GT-01
5 km

Productieput

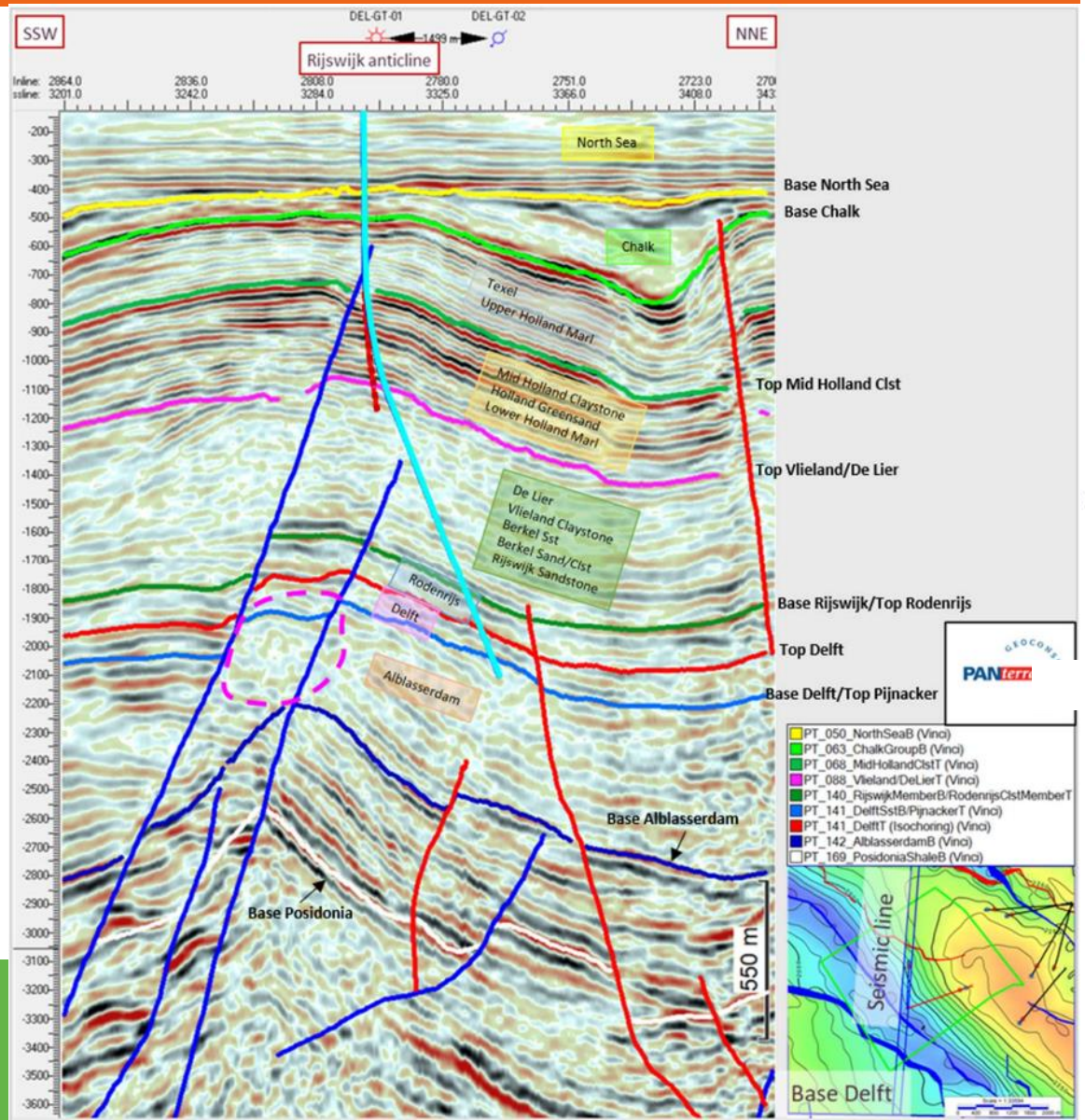


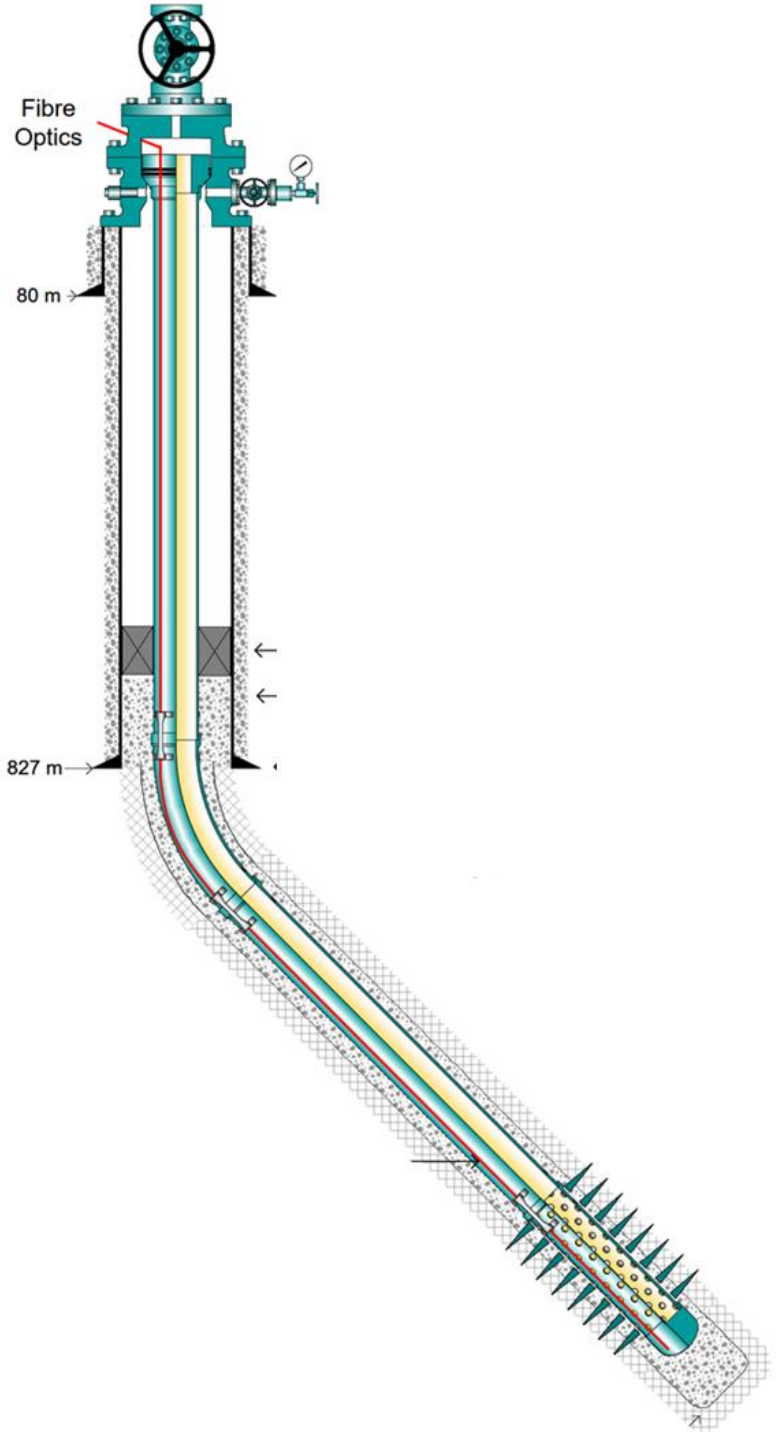
Seismic section along planned production well DEL-GT-01 (dark red trajectory). Pink dashed line indicates the potential gas pocket area. See insert for line trajectory. Depth in mTVDSS.



Injectieput

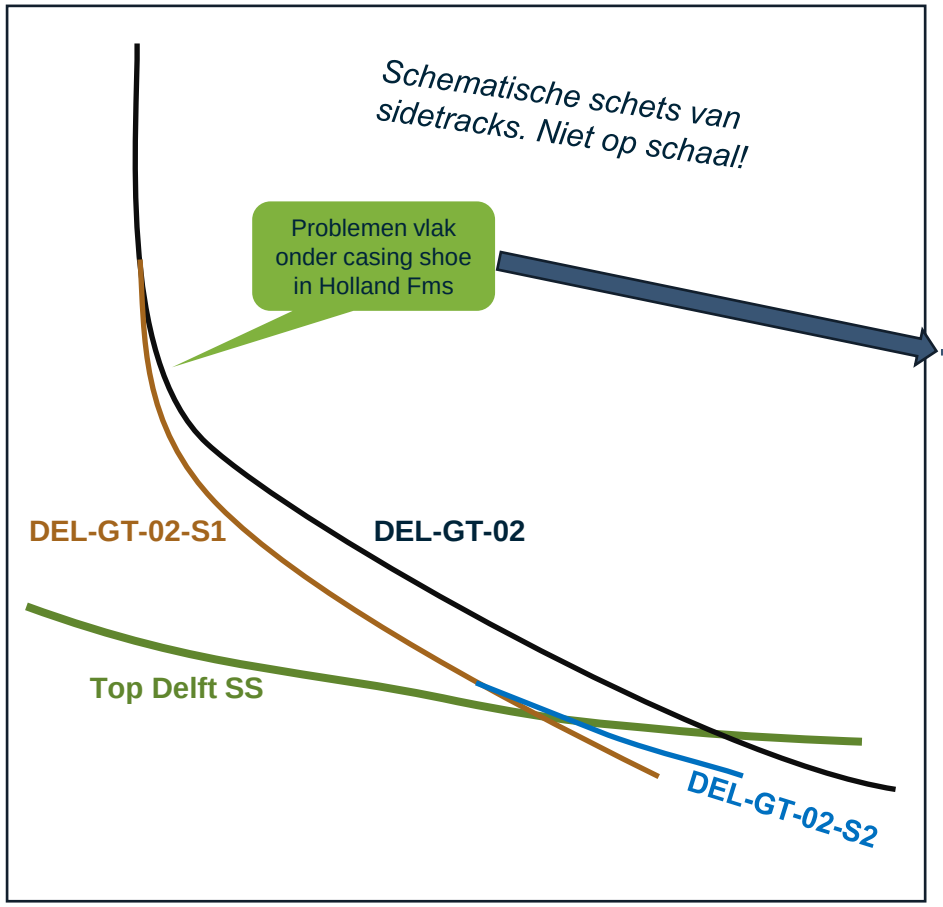
- Een lange sectie vanaf de Mid Holland Kleisteen (~850 m MD) tot aan het diepste punt
- Geomechanische berekeningen gaven aan dat dit mogelijk was

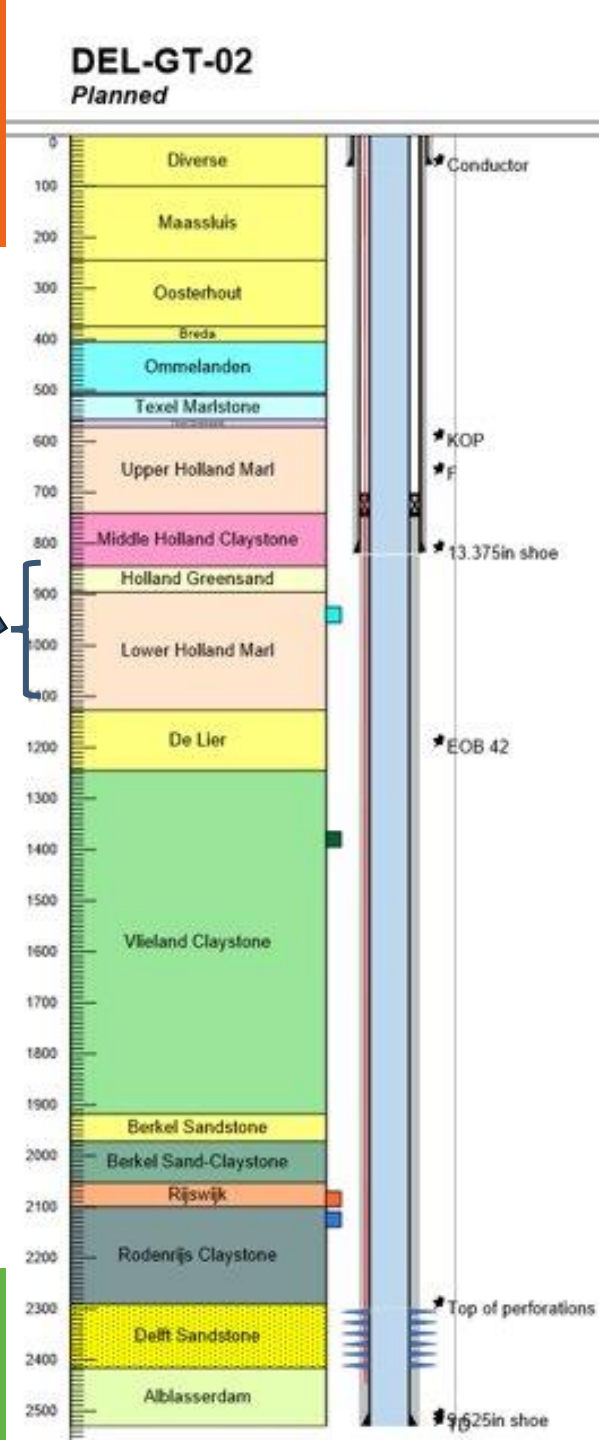




Boorproces (zeer verkorte versie)

- DEL-GT-01
  - Lichte pack-offs rond Lower Holland Mergel
  - Verliezen in Rijswijk Fm, verholpen door LCM pil
- DEL-GT-02
  - Pack-offs rond Lower Holland Mergel
  - Beitel vast ter hoogte van Vlieland
- DEL-GT-02-S1
  - Geen problemen tot einddiepte
  - Bij laatste POOH cavings
  - 1e poging casing te zetten mislukt
  - Cement plug over caprock
  - 2e poging casing te zetten vast op ~140 m voor einddiepte
- DEL-GT-02-S2
  - Sidetrack vanaf Rodenrijs

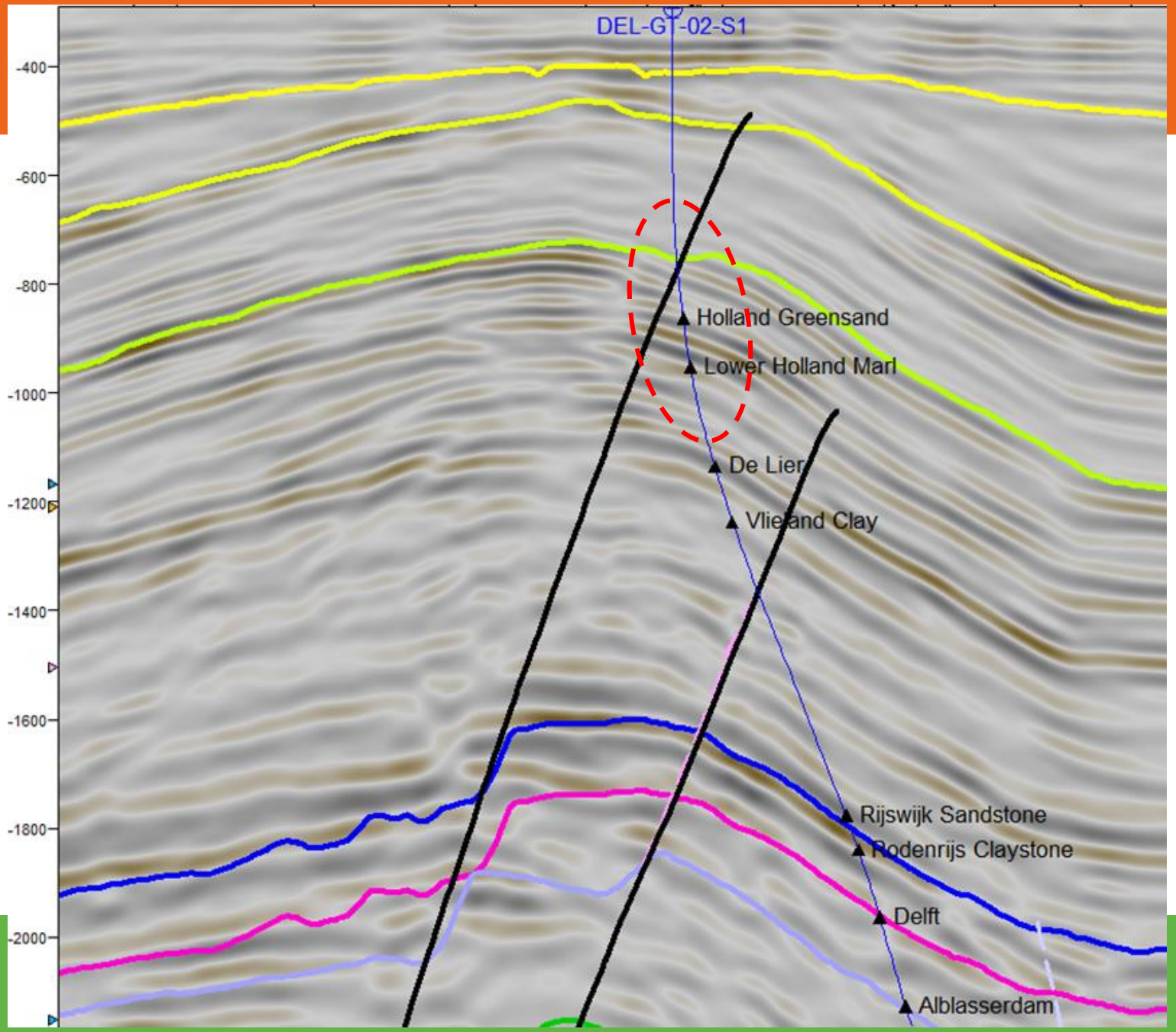




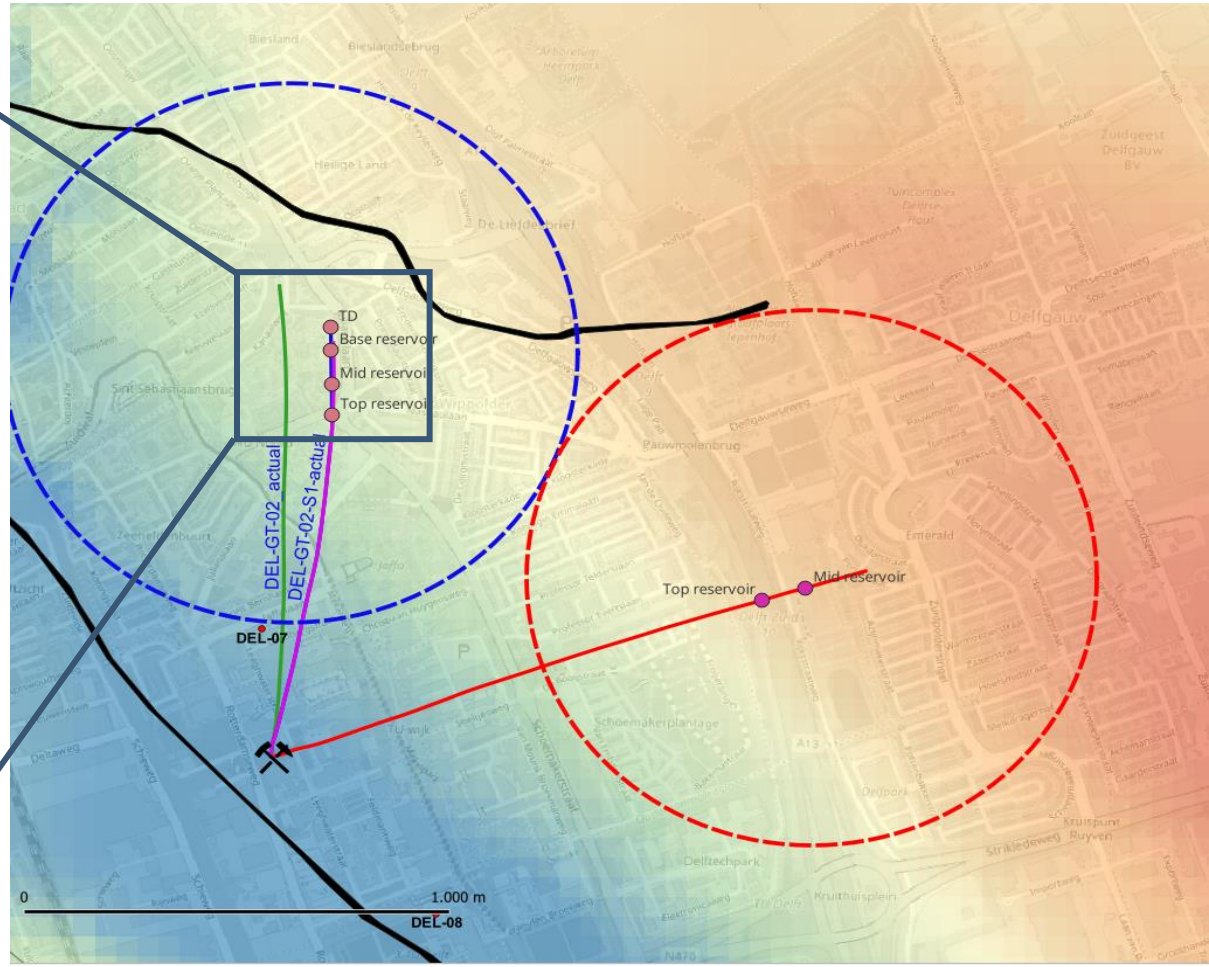
Cavings & pack-offs

Verklaringen...

- Mogelijke verklaring verbreukte zone ter hoogte van de Holland Greensand en Lower Holland Marl



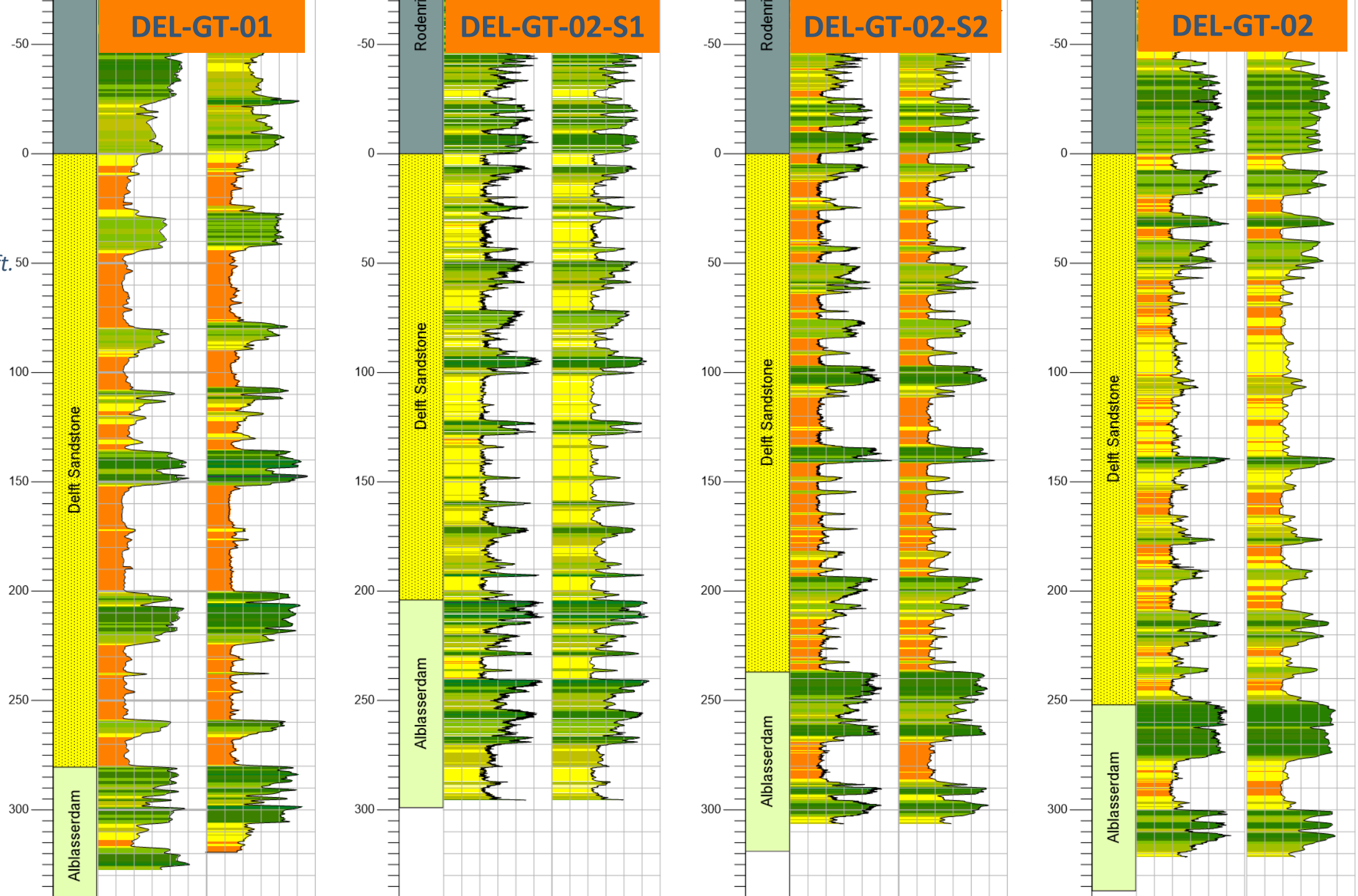
Bovenaanzicht GTD doublet



Uitgelijnd op top Delft.

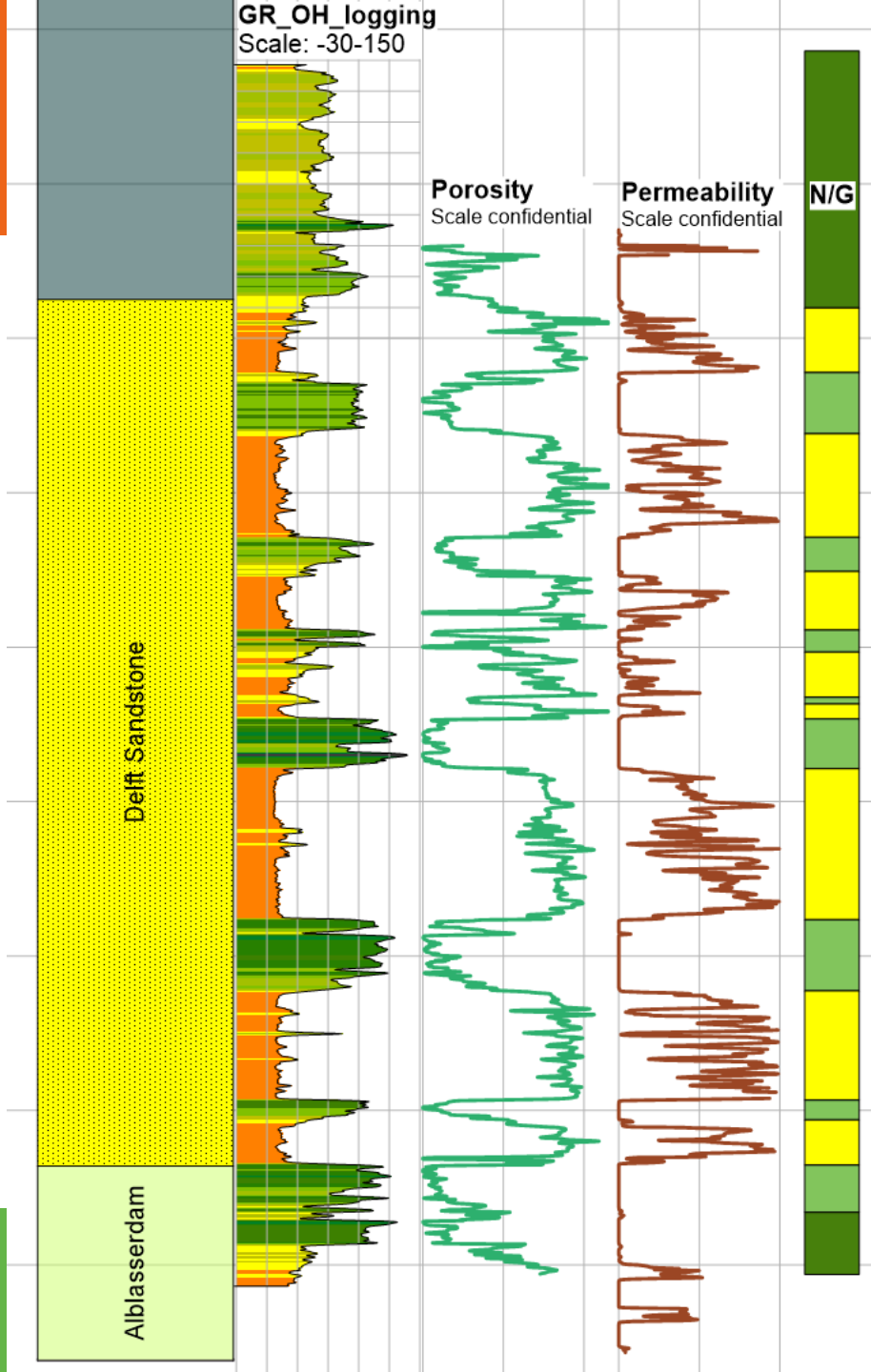
Dieptes in m AH.

Rechter GR originele resolutie, links uitgesmeerd.



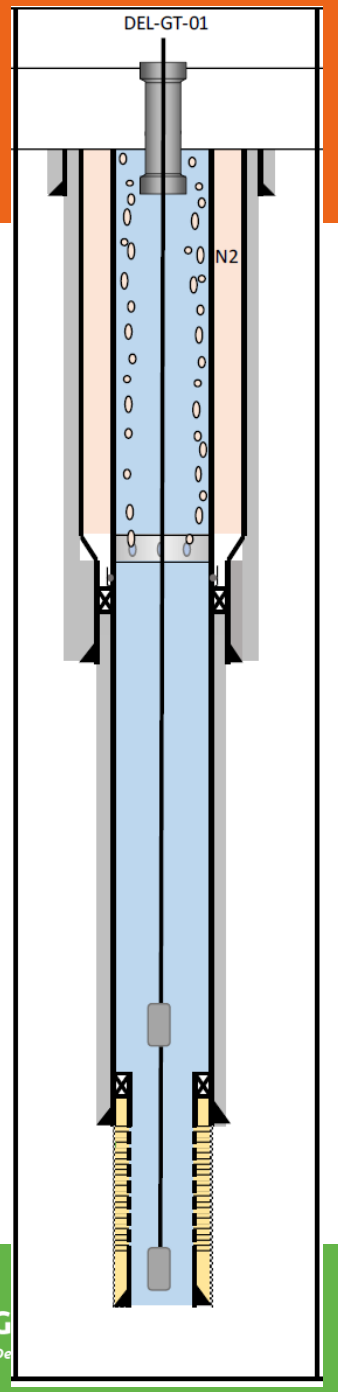
Reservoir sectie productieput

- Uitgebreide open hole wireline logging over de reservoir sectie
- Netto stratigrafische dikte 20% dikker dan verwacht
- Permeabiliteit 30% hoger dan verwacht
- Top reservoir 65 m TV ondieper
- Geothermische gradiënt lijkt lager dan aangenomen, maar data nog niet goed genoeg



Puttest met stikstof lift

- Meestal wordt een puttest uitgevoerd doormiddel van een ESP
- In Delft is de test gedaan middels het injecteren van stikstof (N_2) op ongeveer 750 m diepte
- Dit maakte het mogelijk om een PLT te gebruiken tijdens de test
- Opschonen van de put koste wat moeite, daarna goede stroming



Productiewater steeds schoner

Opschoonfase

Testfase

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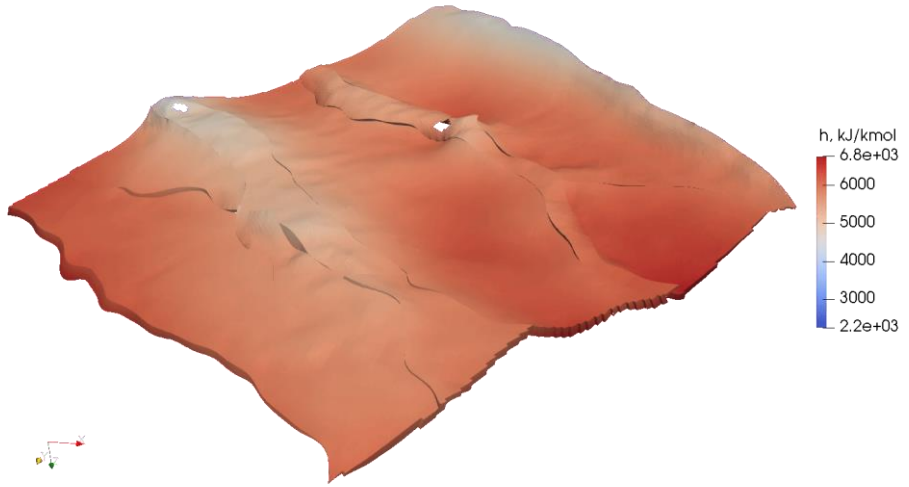
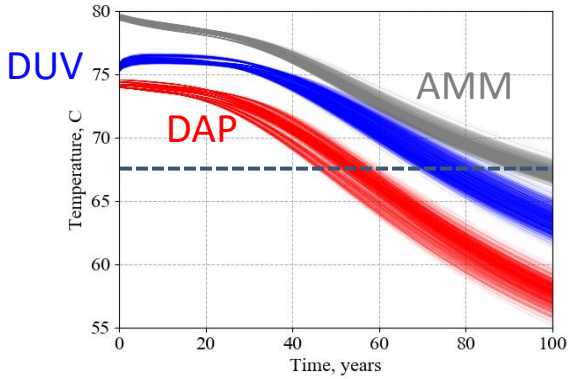
Wetenschappelijk onderzoek

Onderzoeksvragen

- **Hoeveel energie kan er geproduceerd worden?**
  - What is the long-term flow and heat flow behaviour?
  - Reliable predictions, interference
  - Safe operating windows



- **Hoe kunnen we geothermie projecten het beste monitoren?**
  - For energy production
  - For surface impacts



- **Hoe gedragen (nieuwe) materialen zich?**
  - Reservoir variability / heterogeneity
  - Geothermal fluids, geochemical processes, engineered materials

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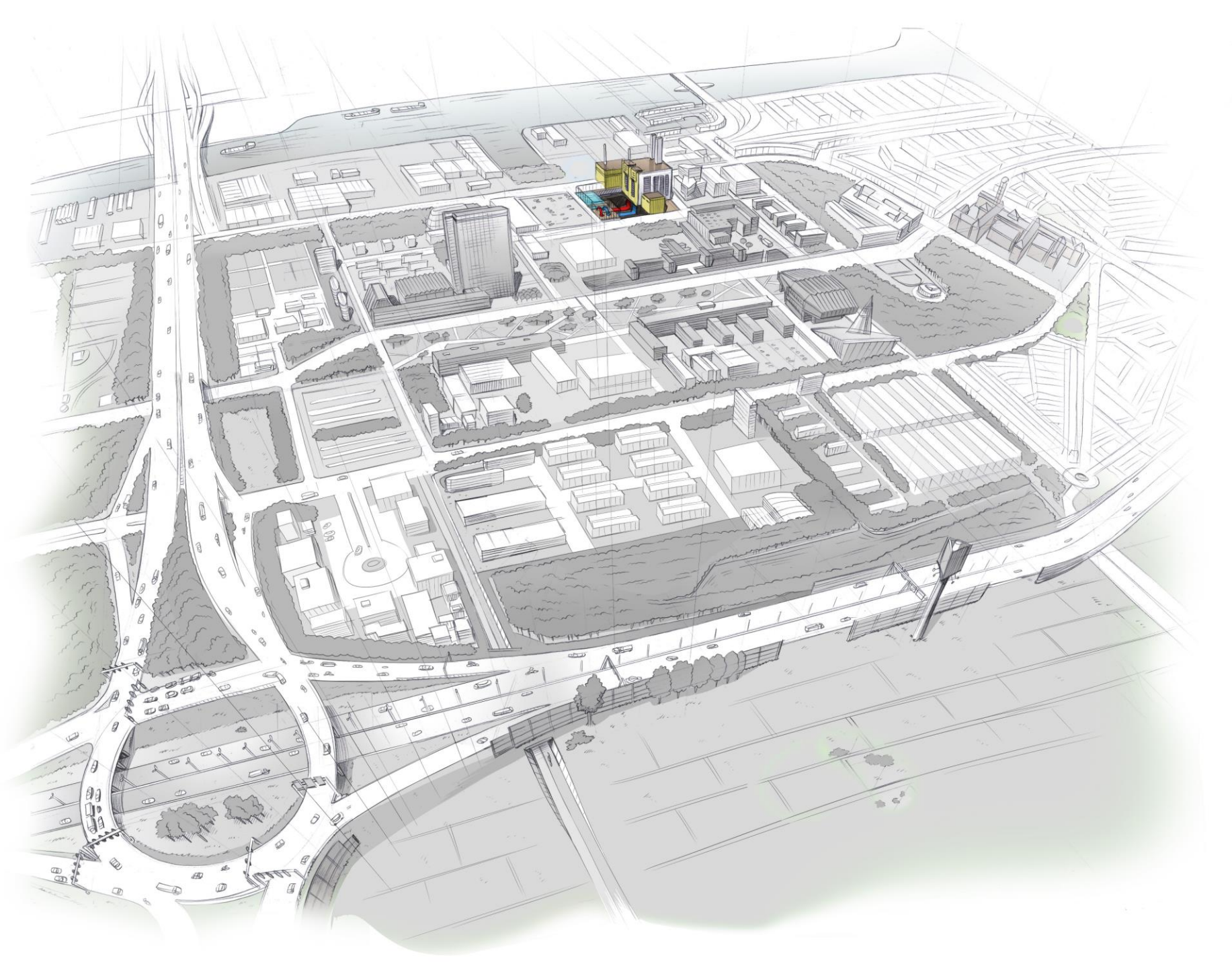
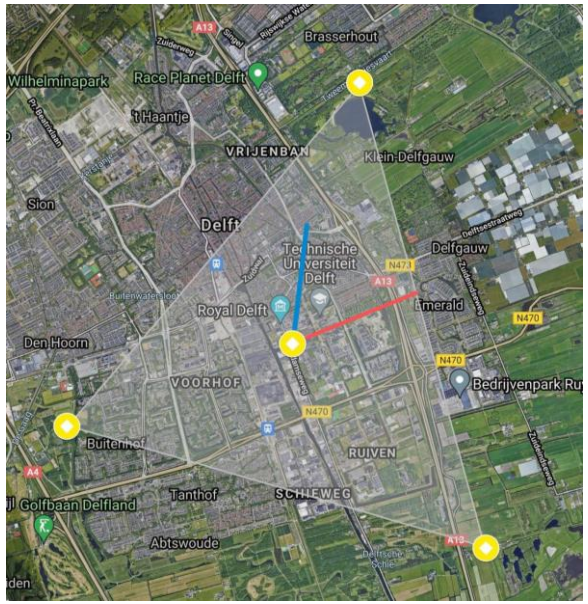
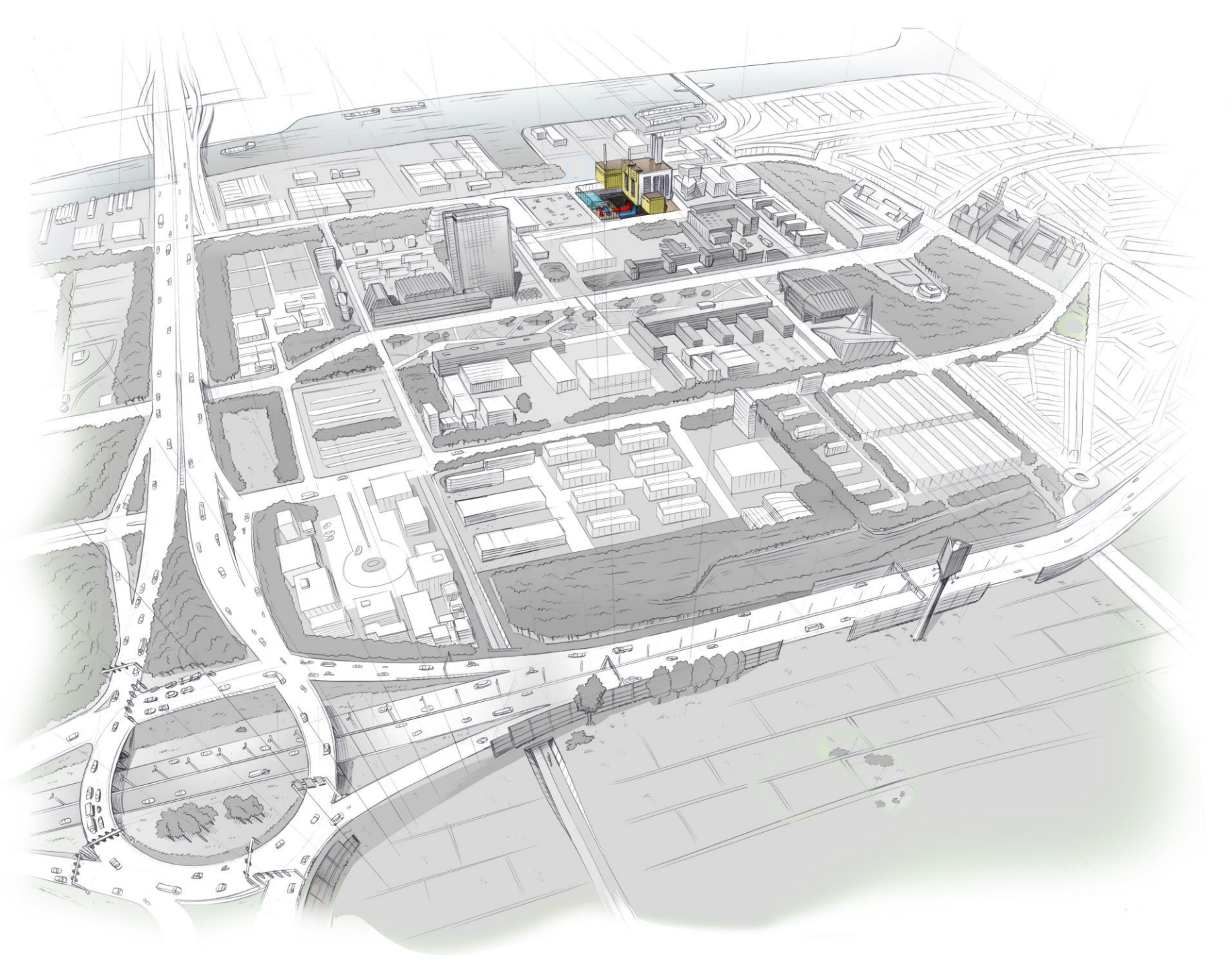
DSUEL



DSUEL

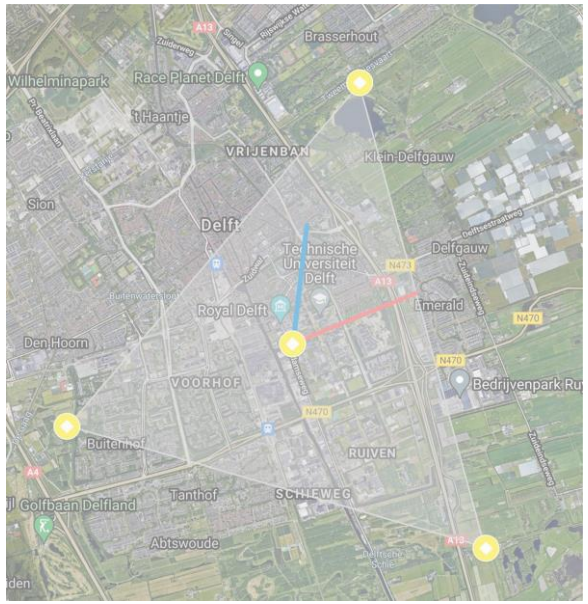
1) Monitoring stations

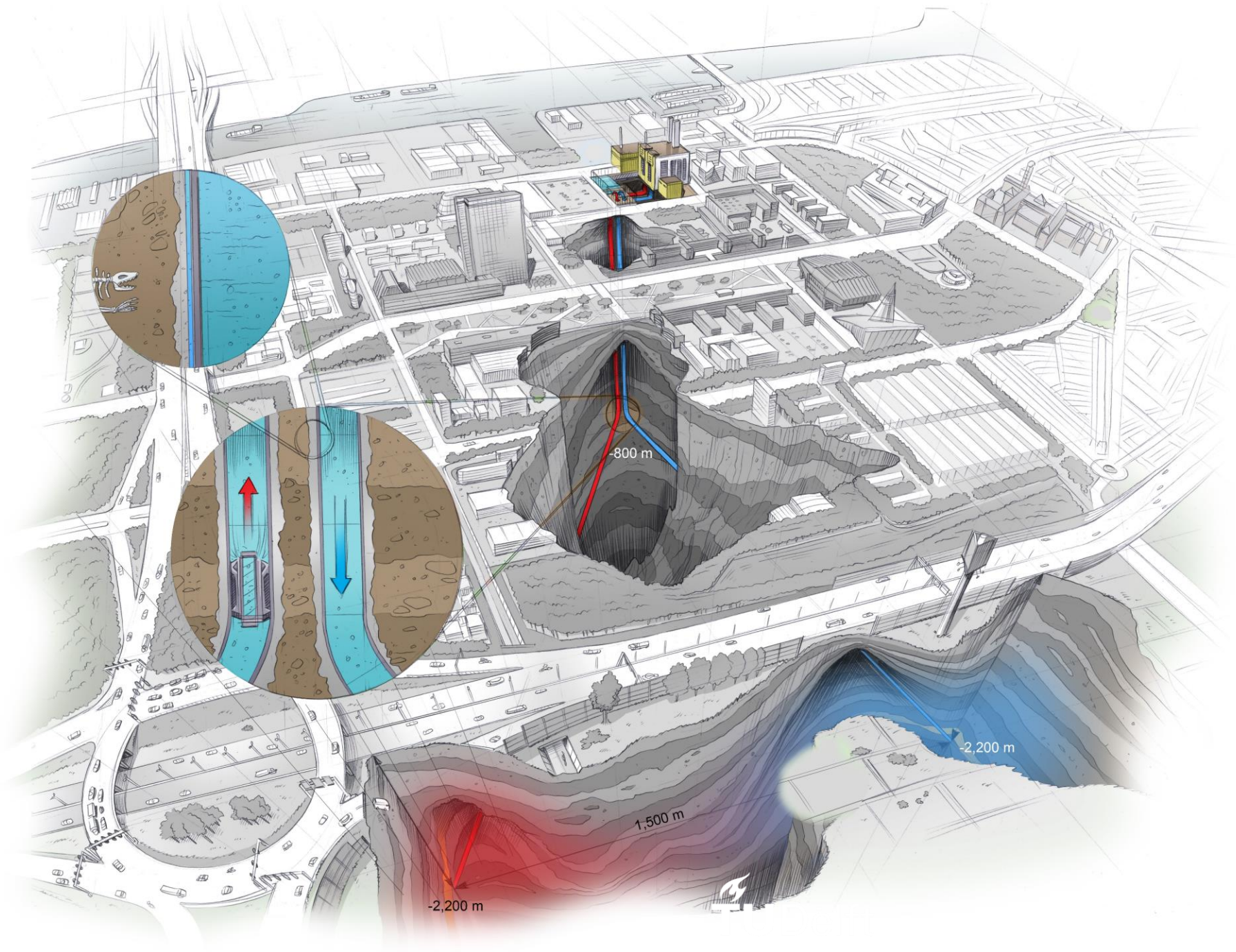




DSUEL

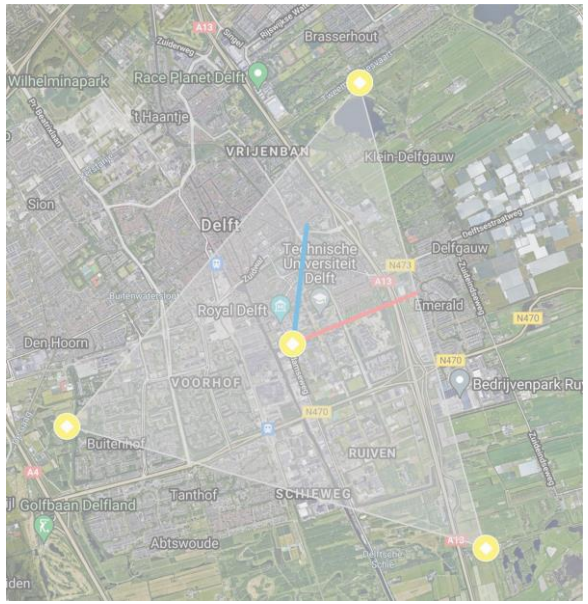
1) Monitoring stations
2) Geothermal doublet

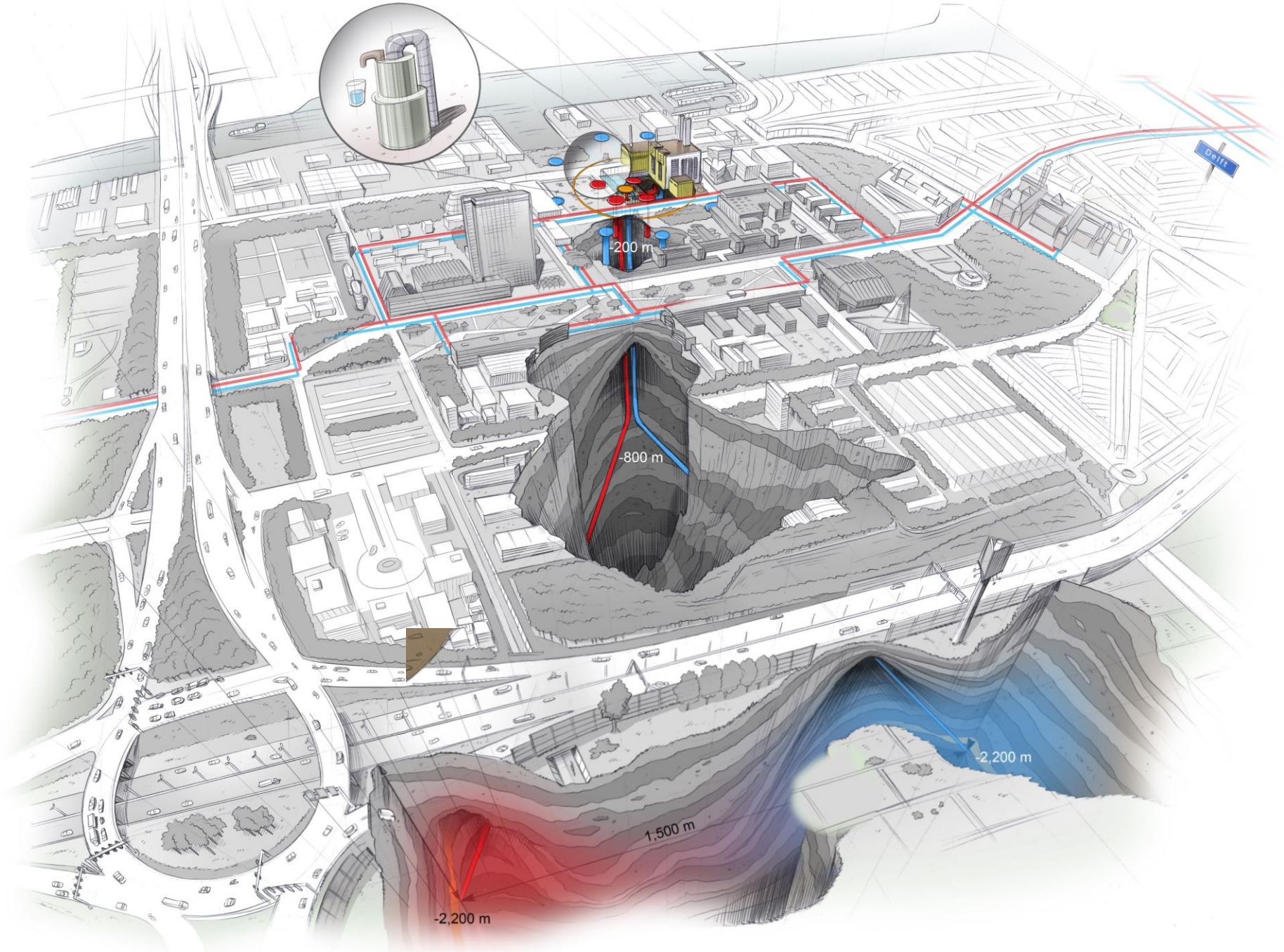




DSUEL

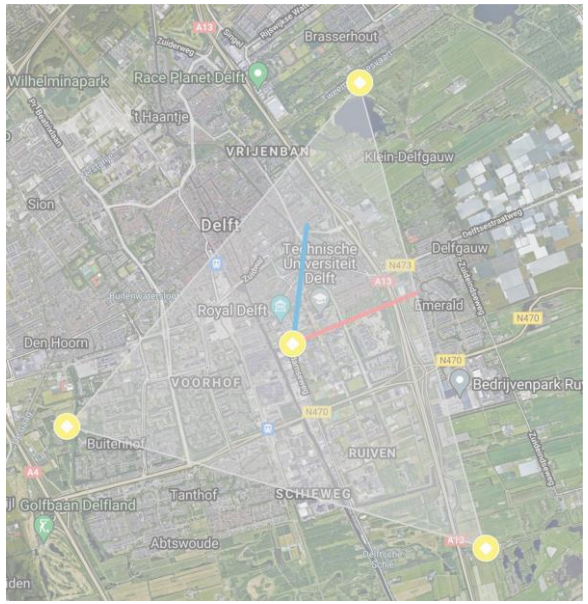
1) Monitoring stations
2) Geothermal doublet
3) HT-ATES

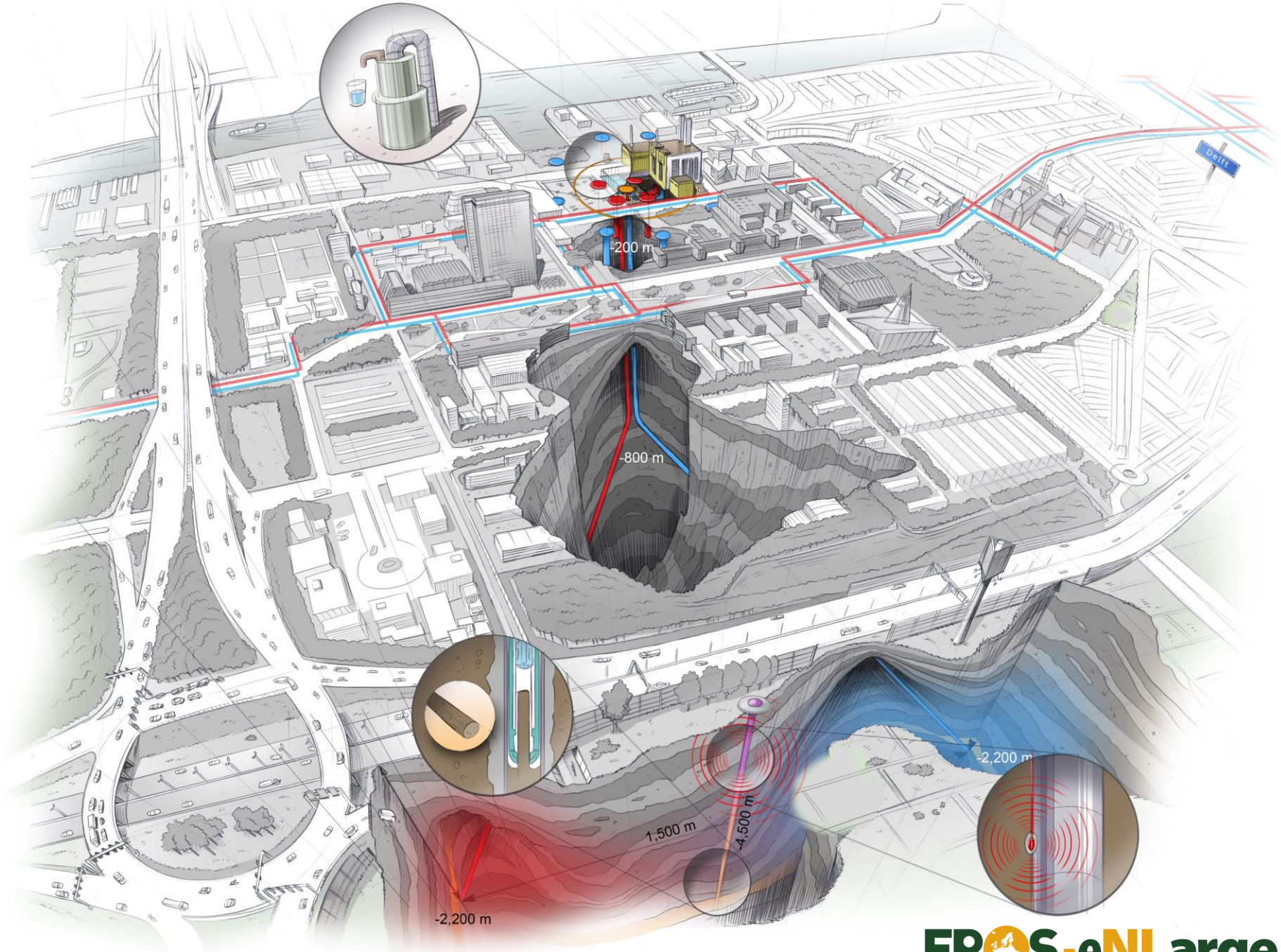




DSUEL

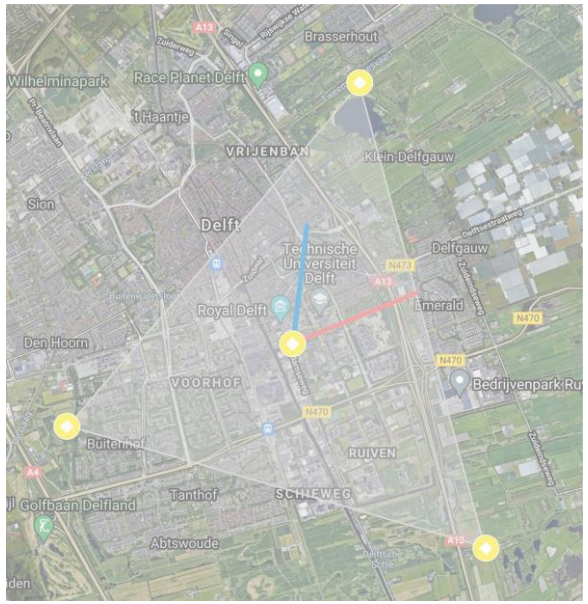
1) Monitoring stations
2) Geothermal doublet
3) HT-ATES
4) Deep monitoring borehole

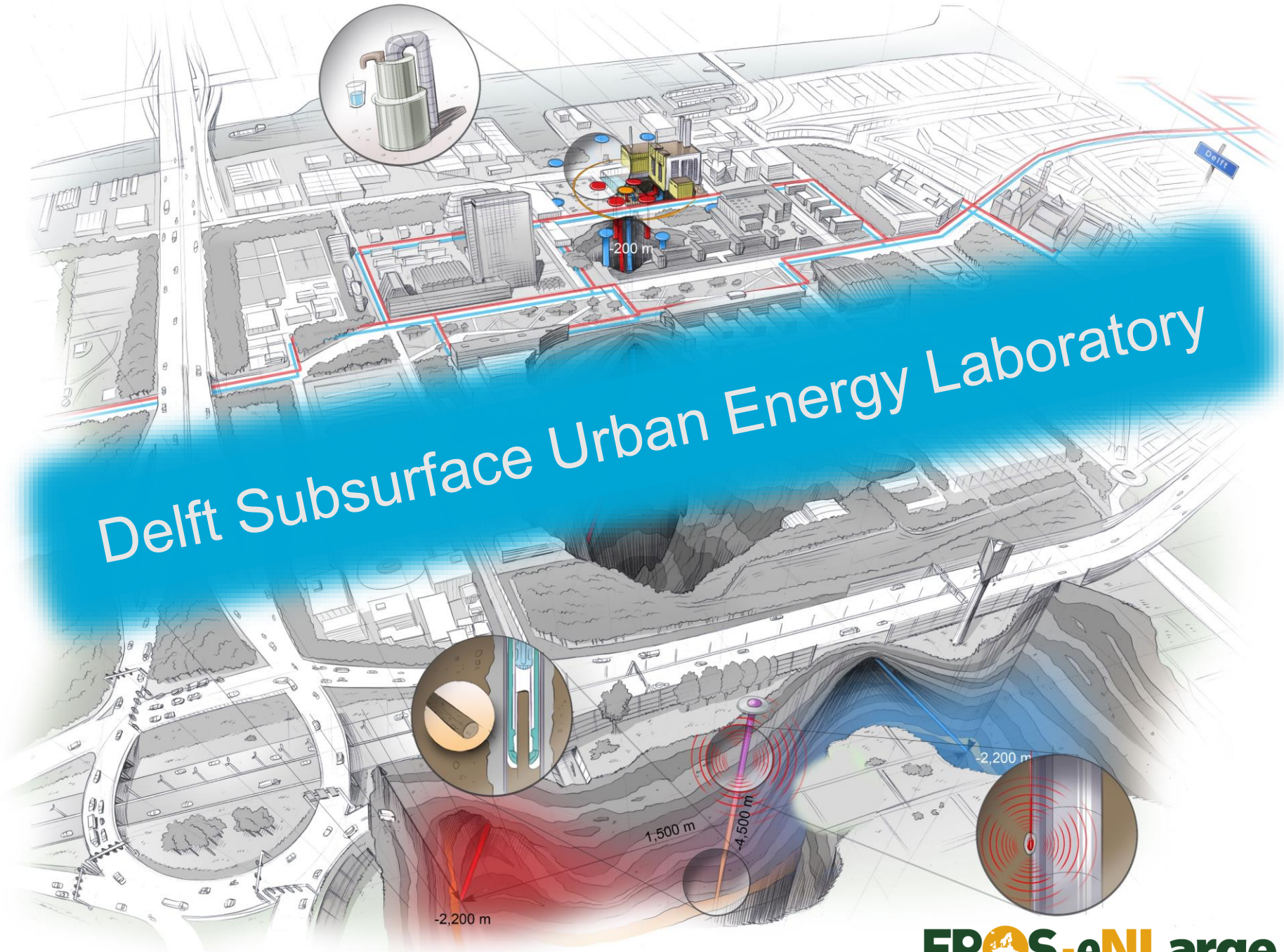




DSUEL

1) Monitoring stations
2) Geothermal doublet
3) HT-ATES
4) Deep monitoring borehole





Onderzoek DEL-GT-01/02

1. Kernen
2. Open-hole logging
3. Fiberoptica
4. Extra cutting sampling

Kernen

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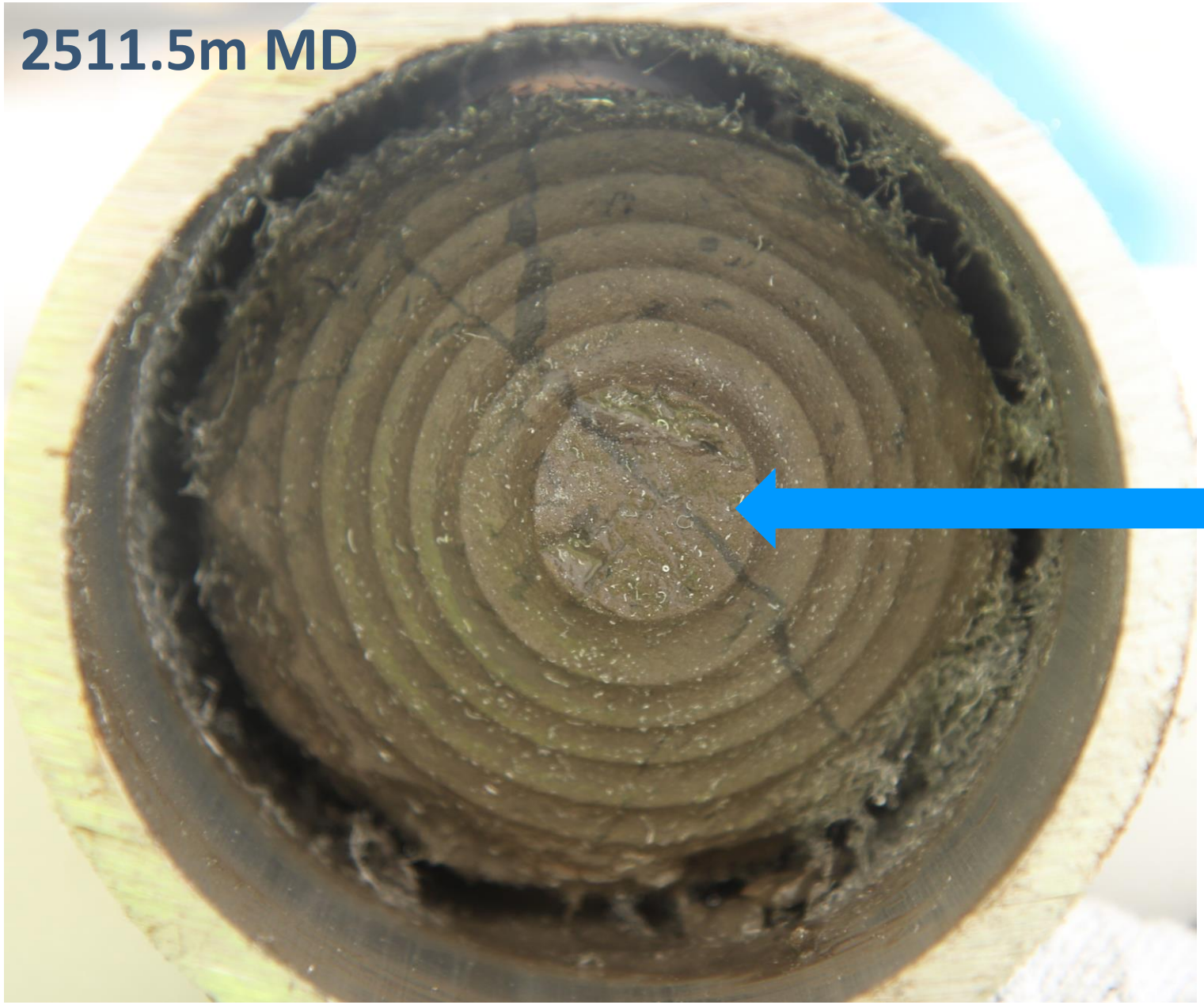
Kernen

Neerleggen eerste volle inner barrel



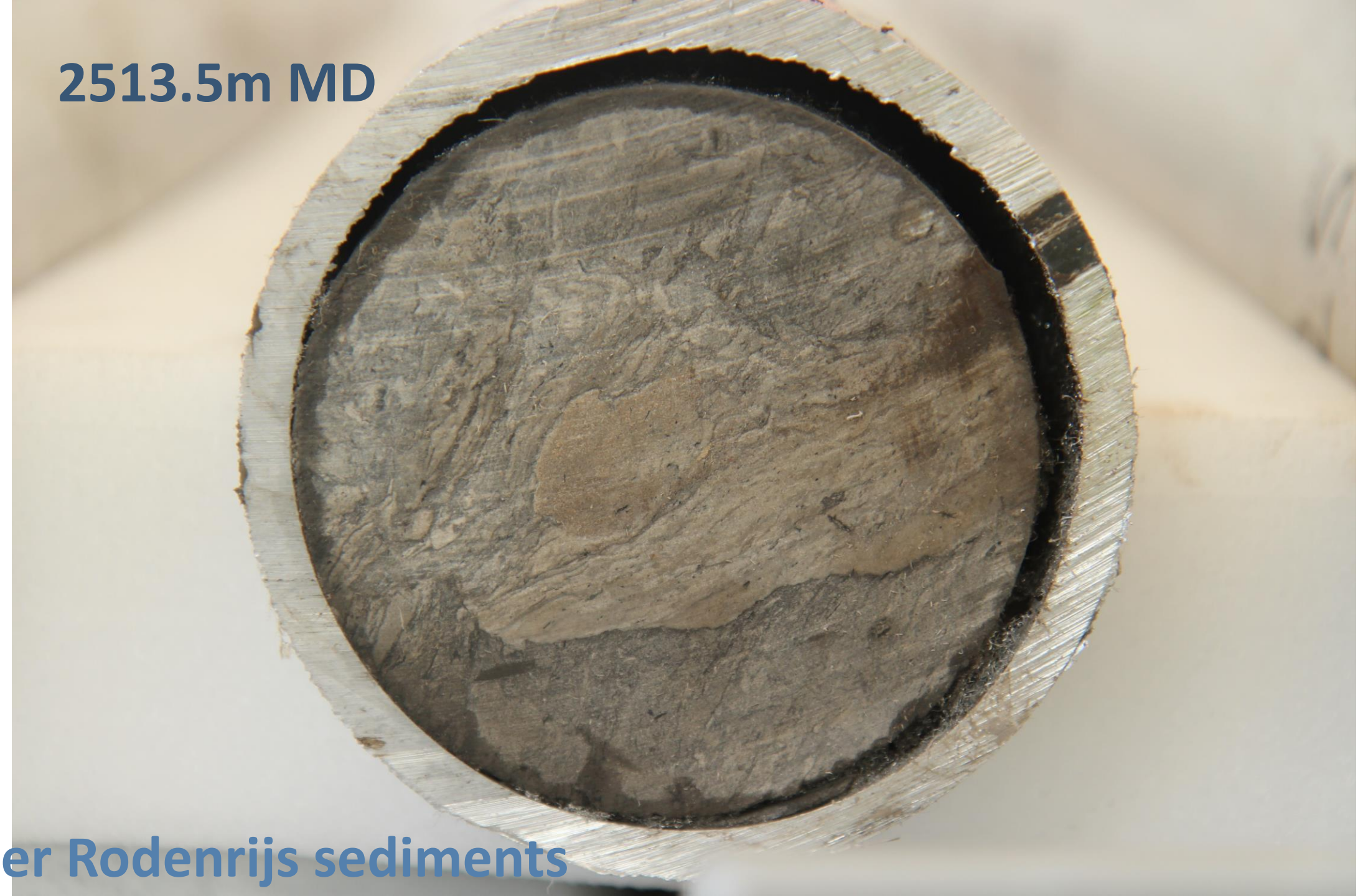
Top of core #1

Kernen

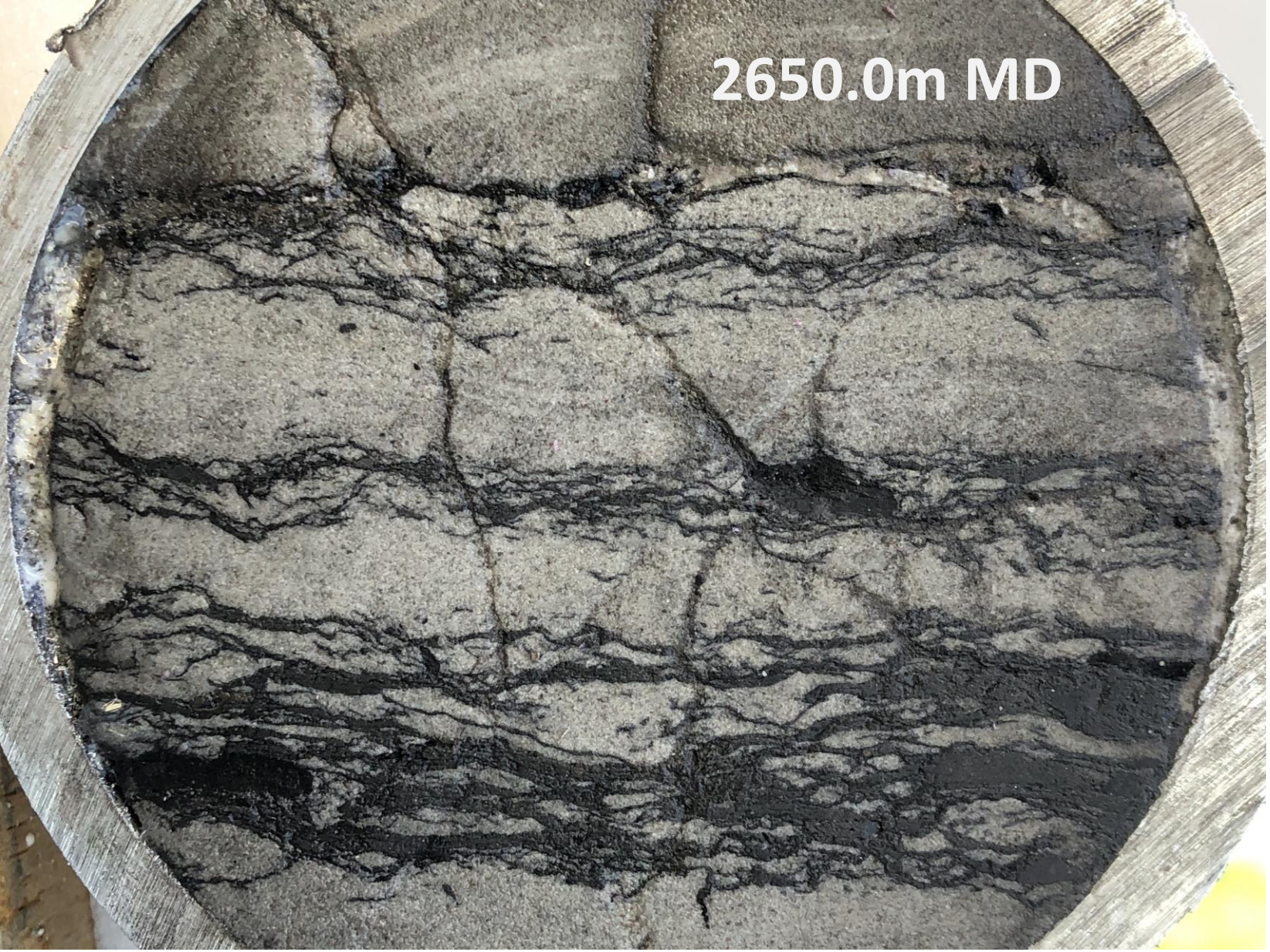
2513.5 MD

Lower Rodenrijs claystone

Stratigraphy and caprock properties



Lower Rodenrijs sediments



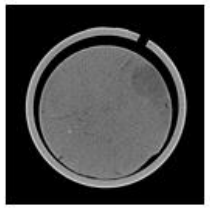
Delft Sandstone

Sedimentology and properties

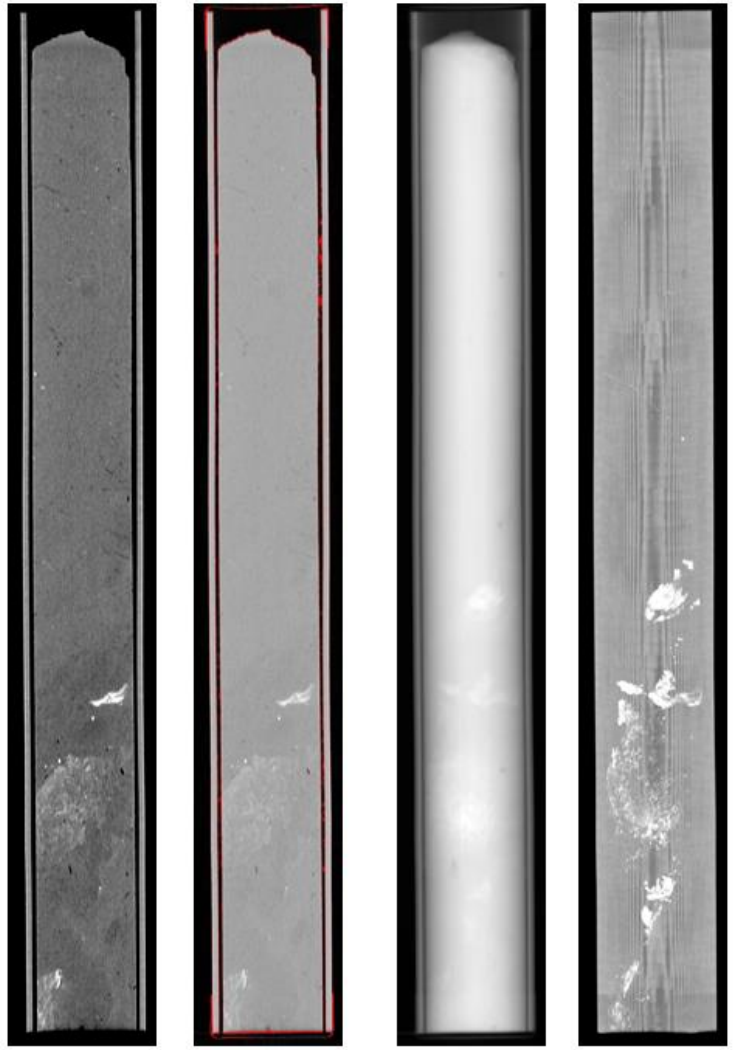
Verwerken en opslag

CT scannen kernen

DELGT01-C1-1

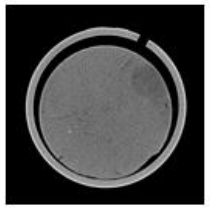


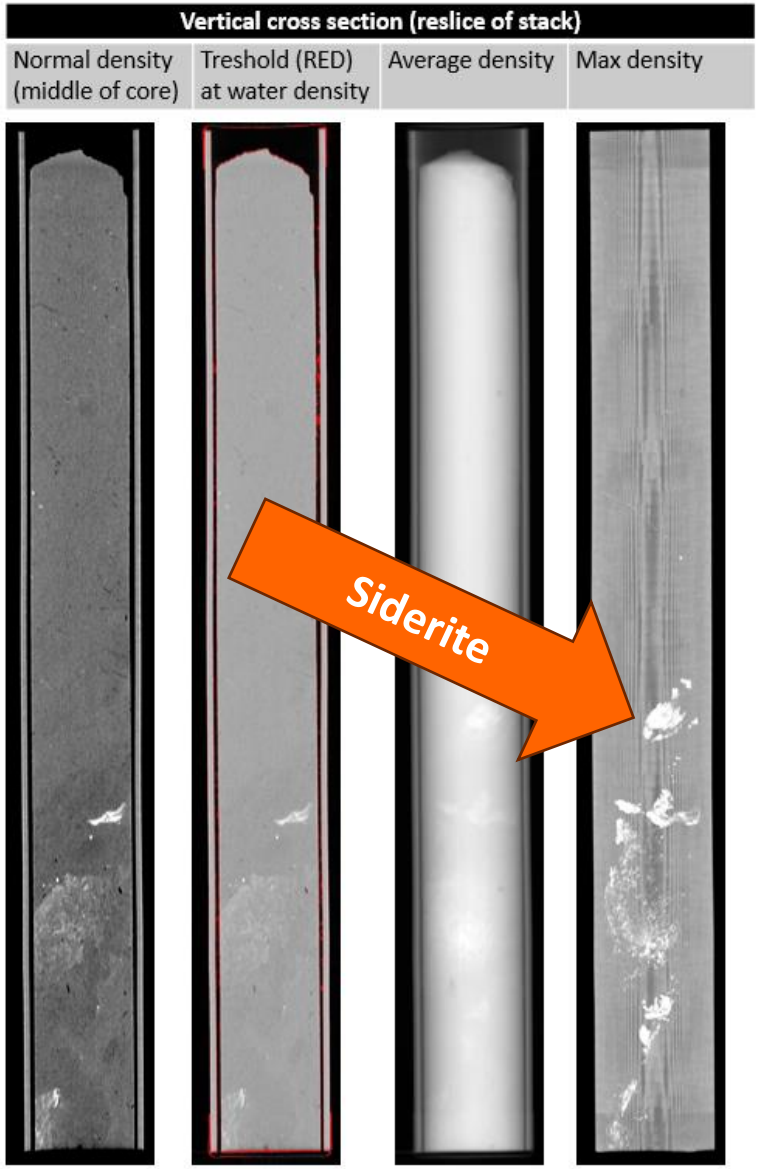
Vertical cross section (reslice of stack)			
Normal density (middle of core)	Treshold (RED) at water density	Average density	Max density

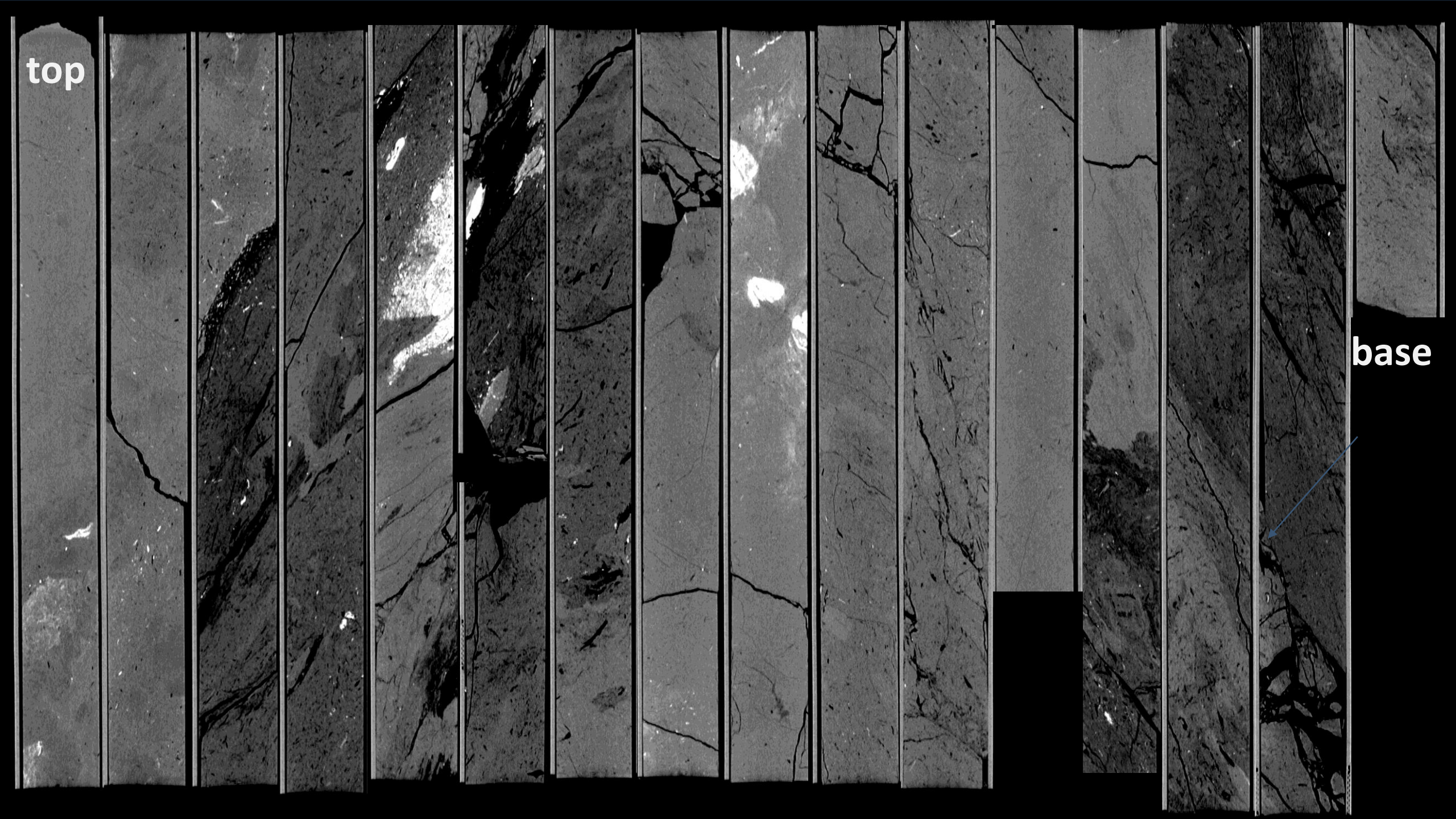


CT scannen kernen

DELGT01-C1-1

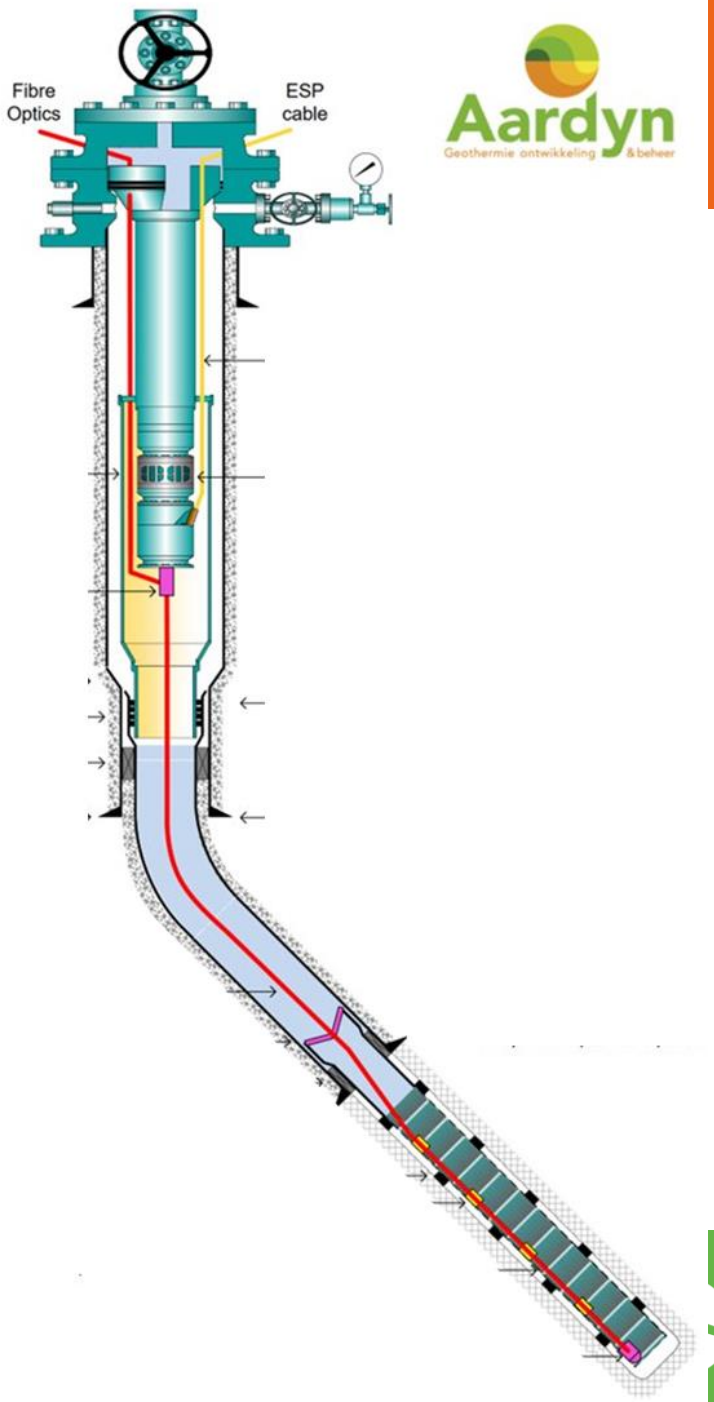





top
base

Fibre optics

Producer cable
Hanging in casing from ESP to TD
DTS / DPS / DAS
Single mode fibre
Total length 3000m
Will be installed with ESP



Fibre optics

Injector cable
Not installed / Available for other projects
2700m
DTS (single + multi mode fibre)
Pre-strained DSS
Enhanced backscatter DAS (for seismics)

Fibre optics

Injector cable
Not installed / Available for other projects
2700m
DTS (single + multi mode fibre)
Pre-strained DSS
Enhanced backscatter DAS (for seismics)

Open-hole logging

DEL-GT-01 Producer [September 2023] Rodenrijs claystone, Delft Sandstone, Alblasserdam Claystone

- Run 1: GR, Caliper, Induction, Full-wave form sonics (P & S waves)
- Run 2: GR, Resistivity Imager, Acoustic Imager
- Run 3: Spectral GR, Neutron Porosity/Density, NMR
- Cement Bond Logging towards surface

DEL-GT-02-S2 Injector [November 2023] Rodenrijs claystone, Delft Sandstone, Alblasserdam Claystone

- Run 1: GR, Caliper, Induction, Full-wave form sonics (P & S waves)
- Run 2: GR, Resistivity Imager, Acoustic Imager
- Run 3: Spectral GR, Neutron Porosity/Density, NMR
- Cement Bond Logging & behind casing (Vp, Vs, porosity/density)

Open-hole logging

DEL-GT-01 Producer [September 2023] Rodenrijs claystone, Delft Sandstone, Alblasserdam Claystone

- Run 1: GR, Caliper, Induction, Full-wave form sonics (P & S waves)
- Run 2: GR, Resistivity Imager, Acoustic Imager
- Run 3: Spectral GR, Neutron Porosity/Density, NMR
- Cement Bond Logging towards surface

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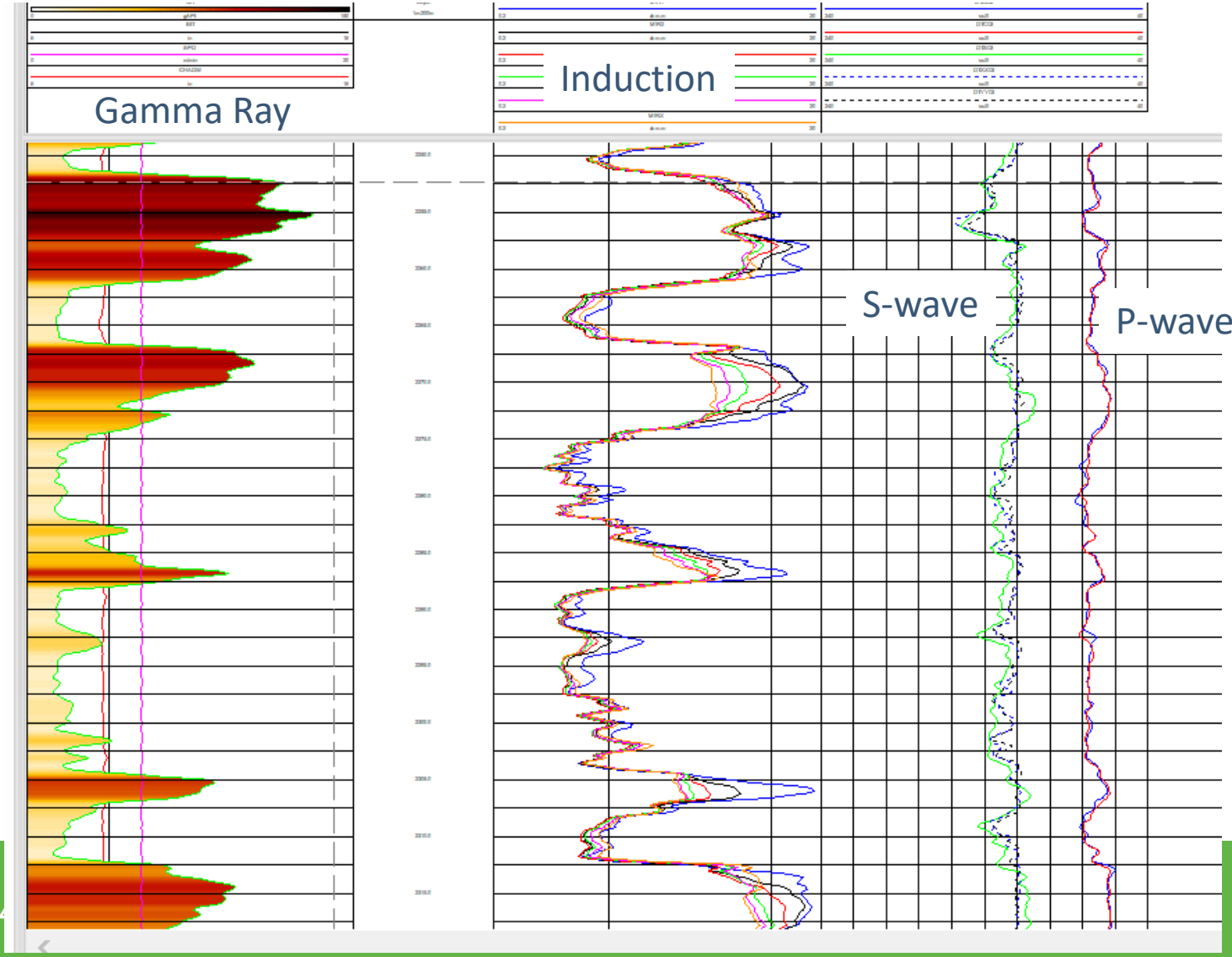
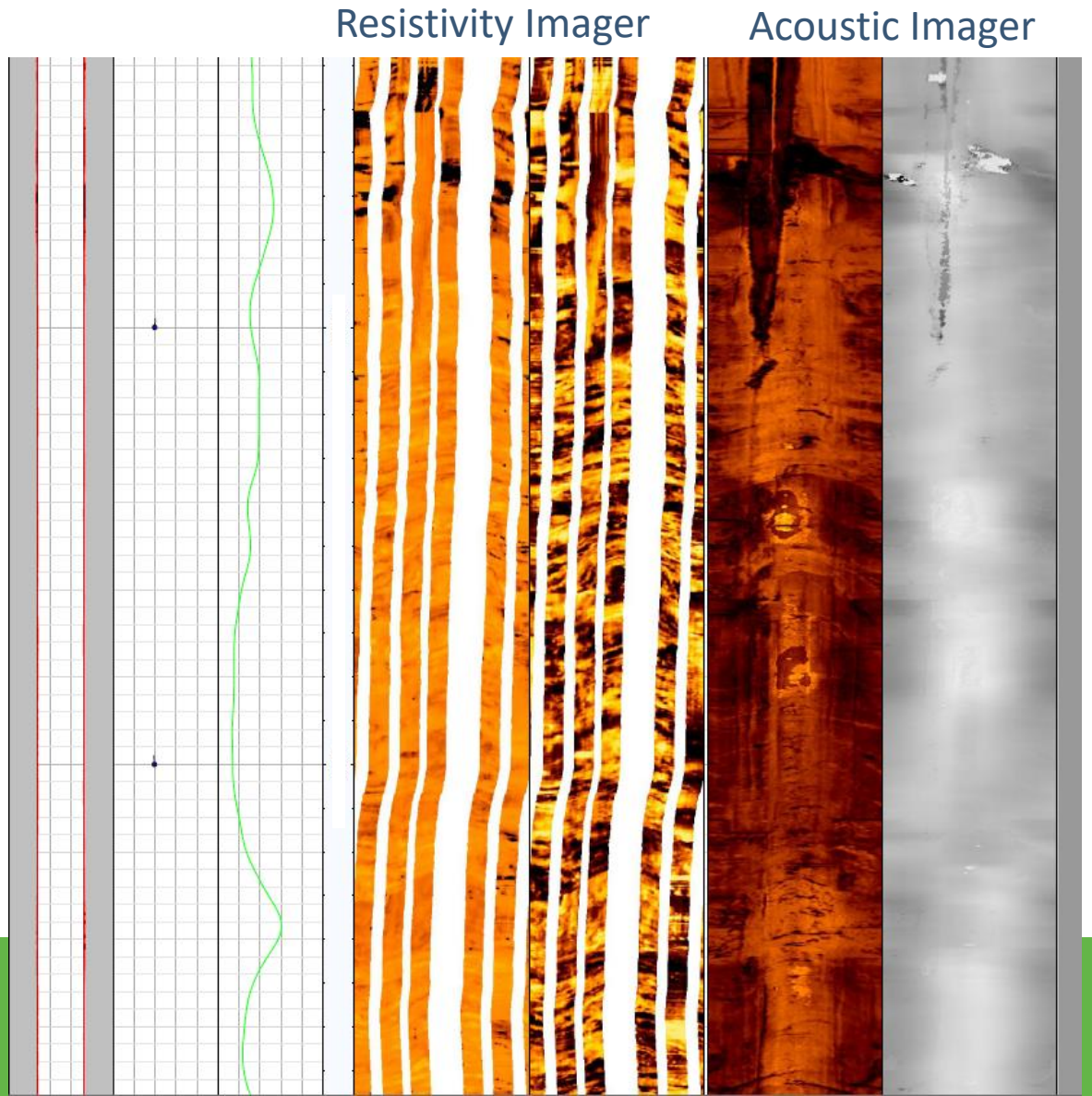
- Run 3: Spectral GR, Neutron Porosity/Density, NMR
- Cement Bond Logging & behind casing (Vp, Vs, porosity/density)

Een week geleden gelogd! Enkel initiële data, geen processing

DEL-GT-02-S2 Run 1: Gamma Ray, Caliper, Induction, P- and S-wave sonics



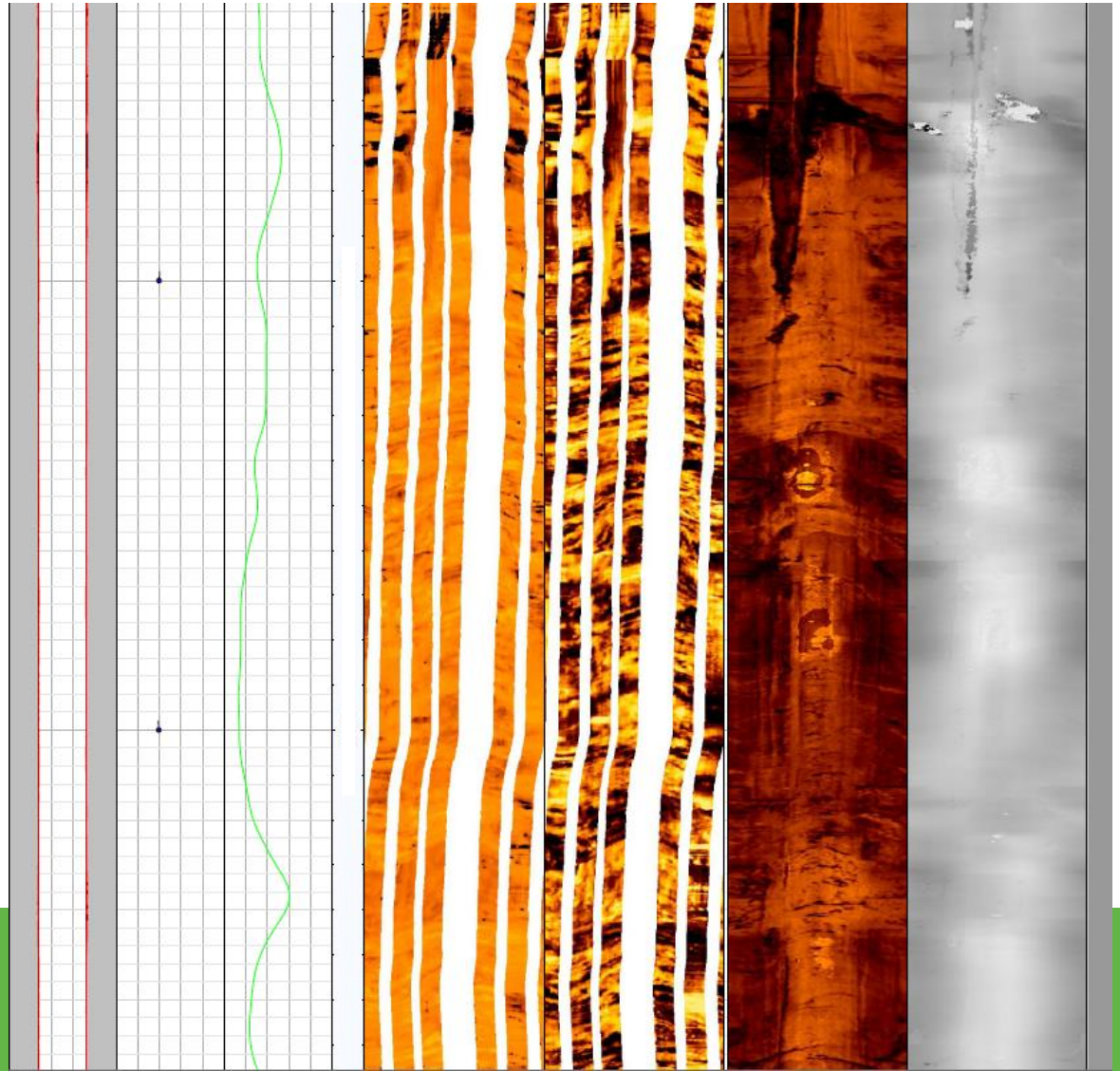
DEL-GT-02-S2 Run 2: Gamma Ray, Resistivity Borehole Imager, Acoustic Borehole Imager



DEL-GT-02-S2 Run 2: Gamma Ray, Resistivity Borehole Imager, Acoustic Borehole Imager

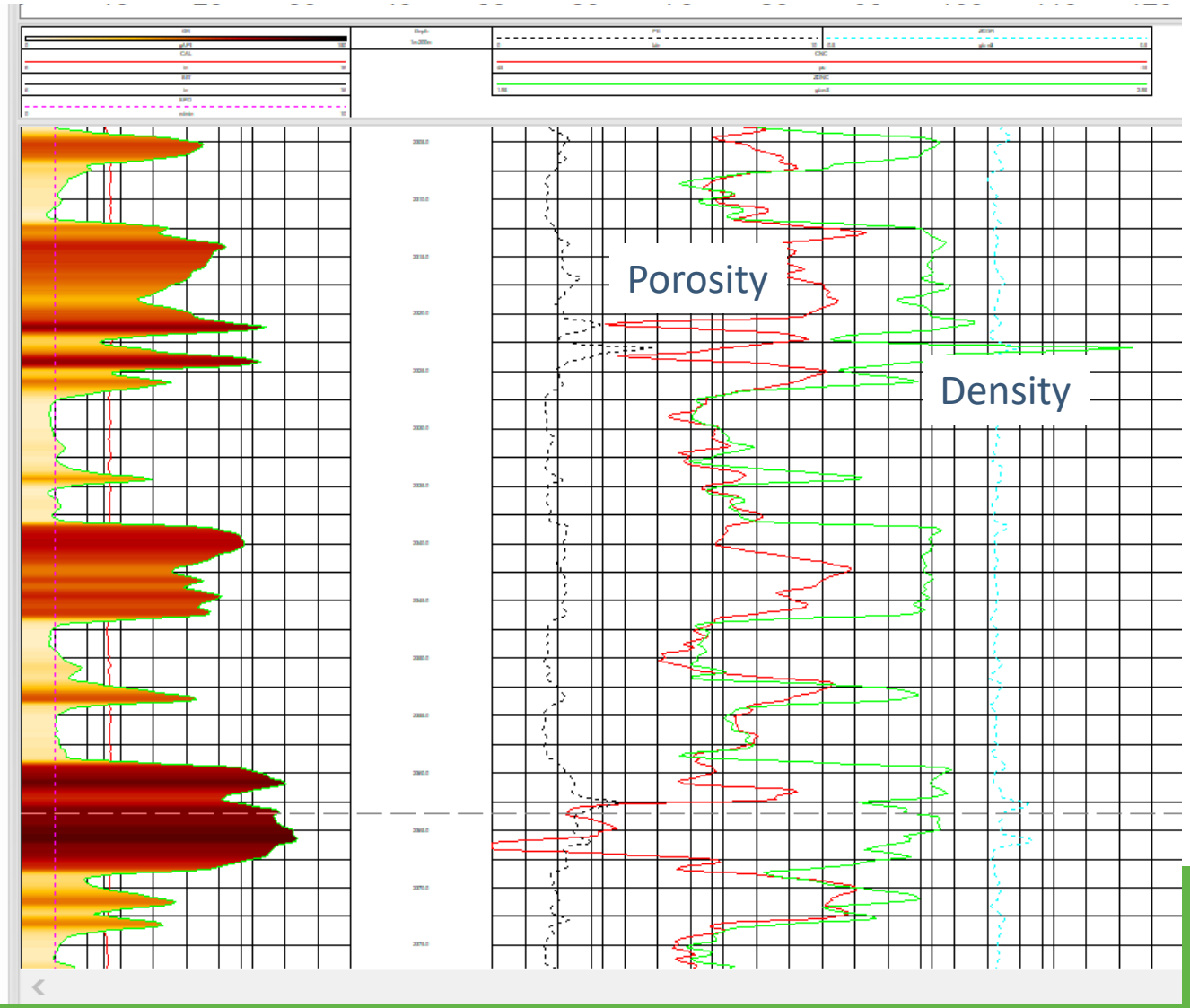
Resistivity Imager

Acoustic Imager



1m/min

DEL-GT-02-S2 Run 3: Gamma Ray, Neutron Porosity - Density



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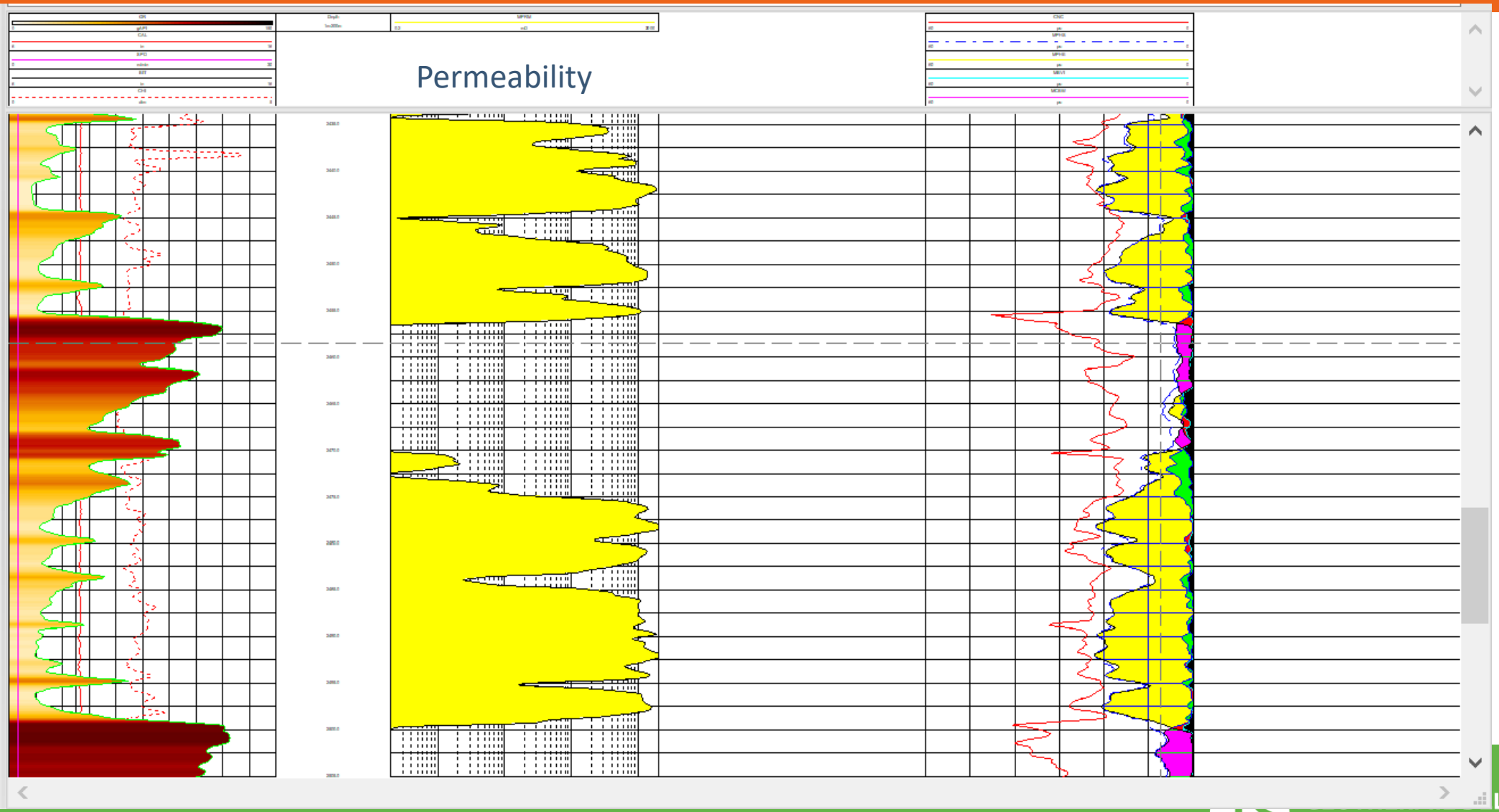
DEL-GT-02-S2 Run 3: Gamma Ray, NMR

Porosity & Fluid filling



Sidewall coring

Baker Hughes tools

- Maxcor 1.5”
- Pcor 1”

Houston chronicle

Offshore magazine

Sidewall coring

Sidewall coring

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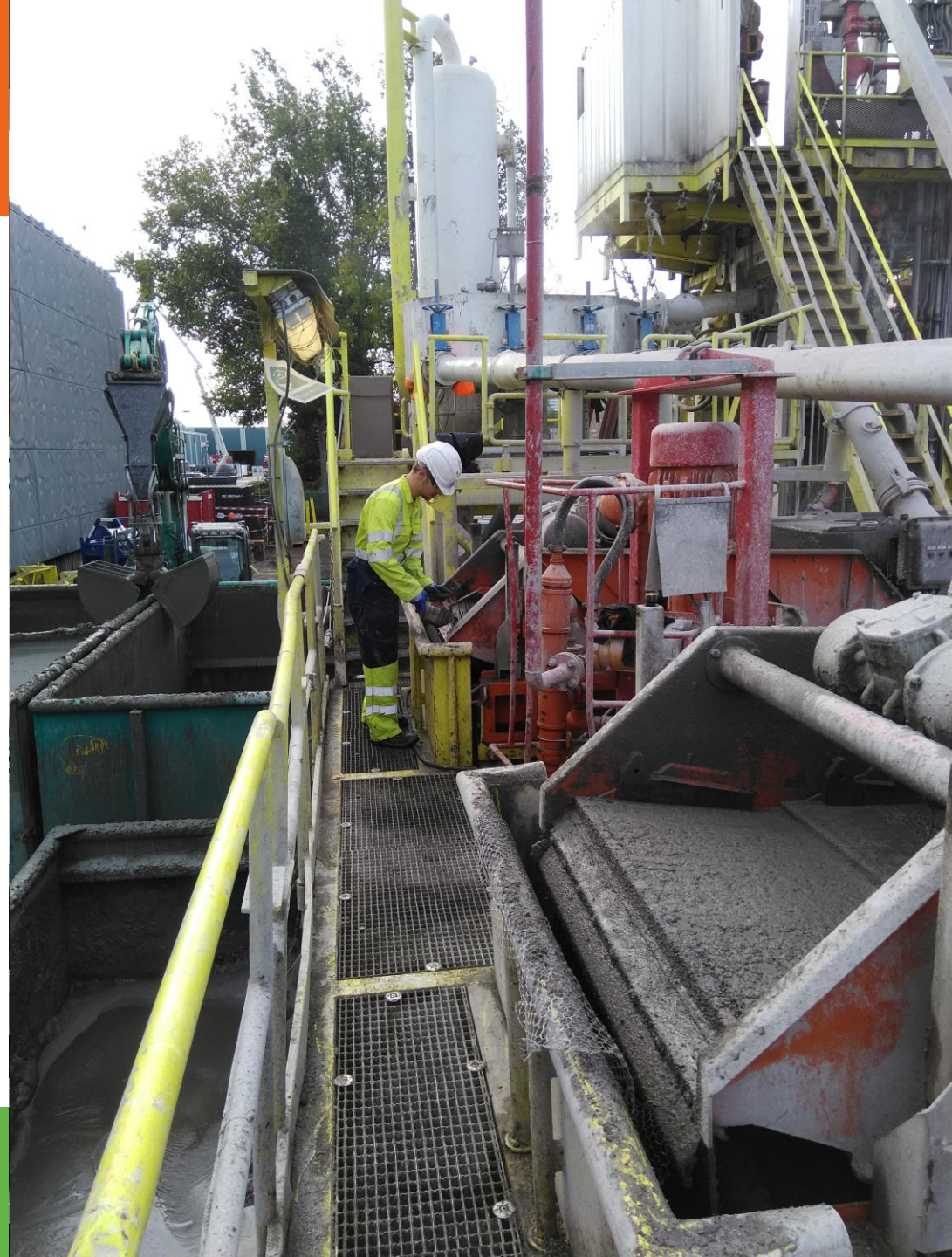
Sidewall coring

Extra cutting sampling

Depth	Frequency	Amount
90-800m	500ml sample / 10m	~150
800m to reservoir	500ml sample / 5m	~600
reservoir to TD	500ml sample / 3m	~500
		~1250

On top of sampling scheme by GTD/TNO



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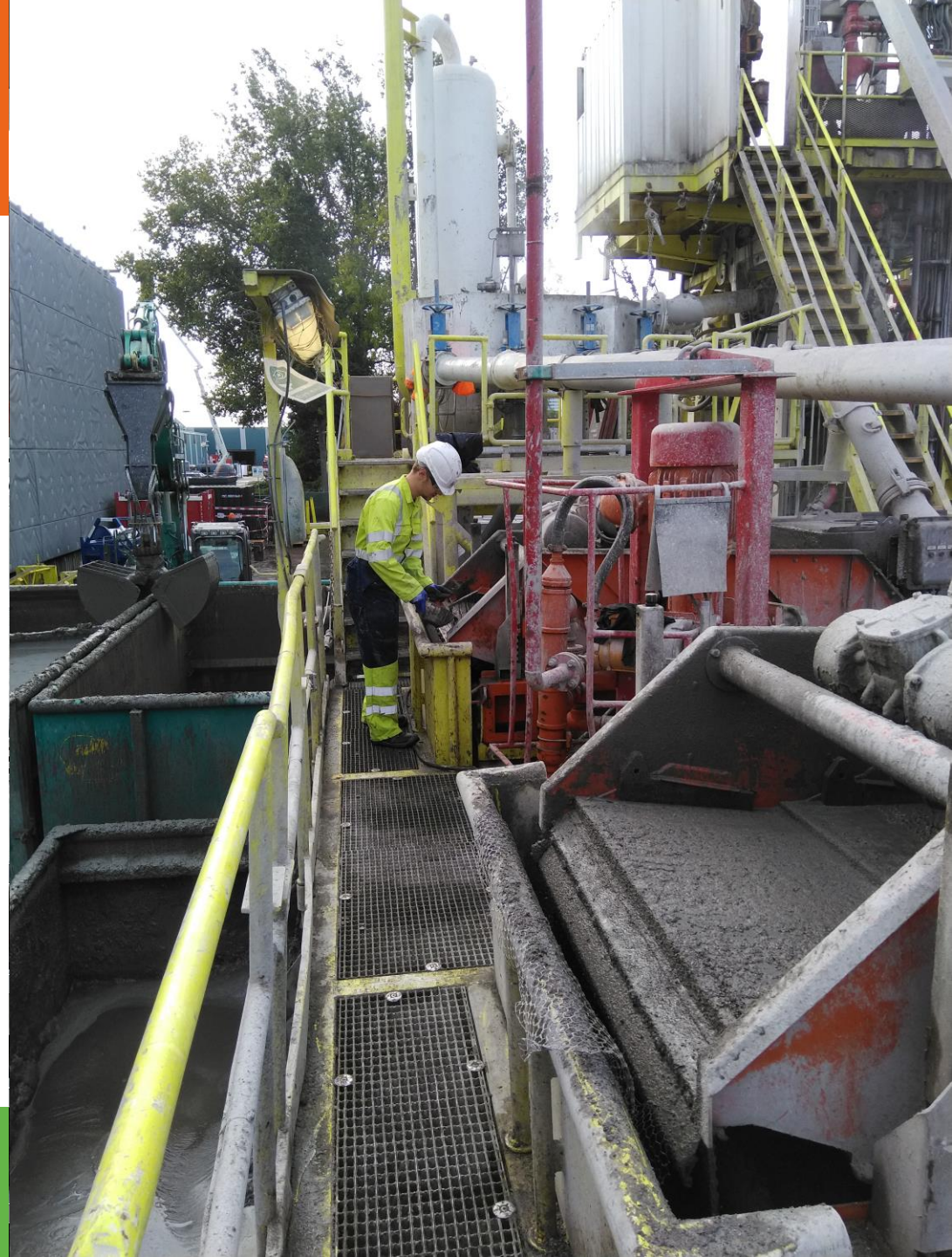
On top of sampling scheme by GTD/TNO

Focus on:

Rodenrijs Claystone

Delft Sandstone

Alblasserdam



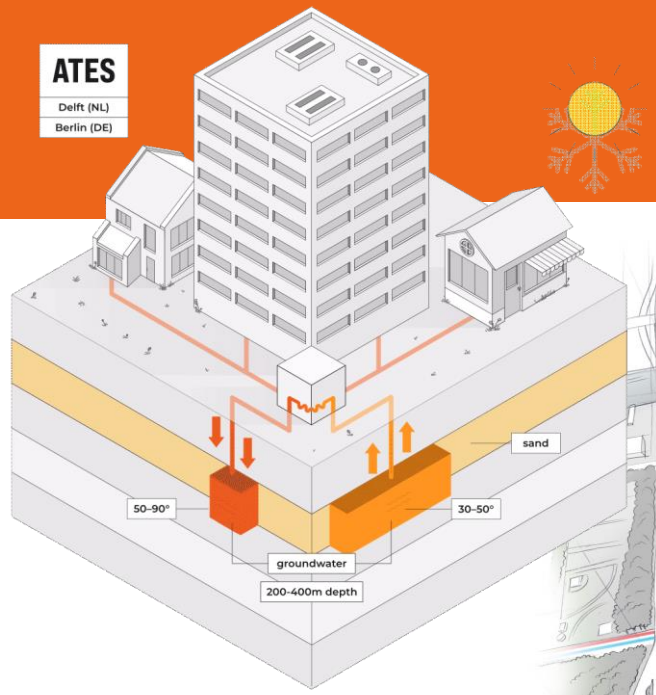
Extra cutting sampling

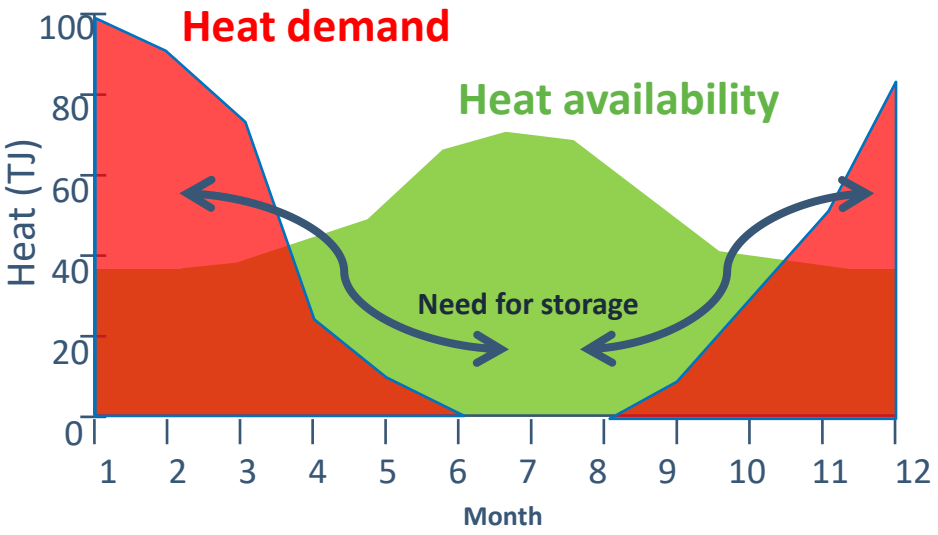
Depth	Frequency	Amount	Processing
90-800m	500ml sample / 10m	~150	250ml unwashed + 100gr dried
800m to reservoir	500ml sample / 5m	~600	250ml unwashed + 100gr dried
reservoir to TD	500ml sample / 3m	~500	250ml unwashed + 100gr dried
		~1250	~2500 samples

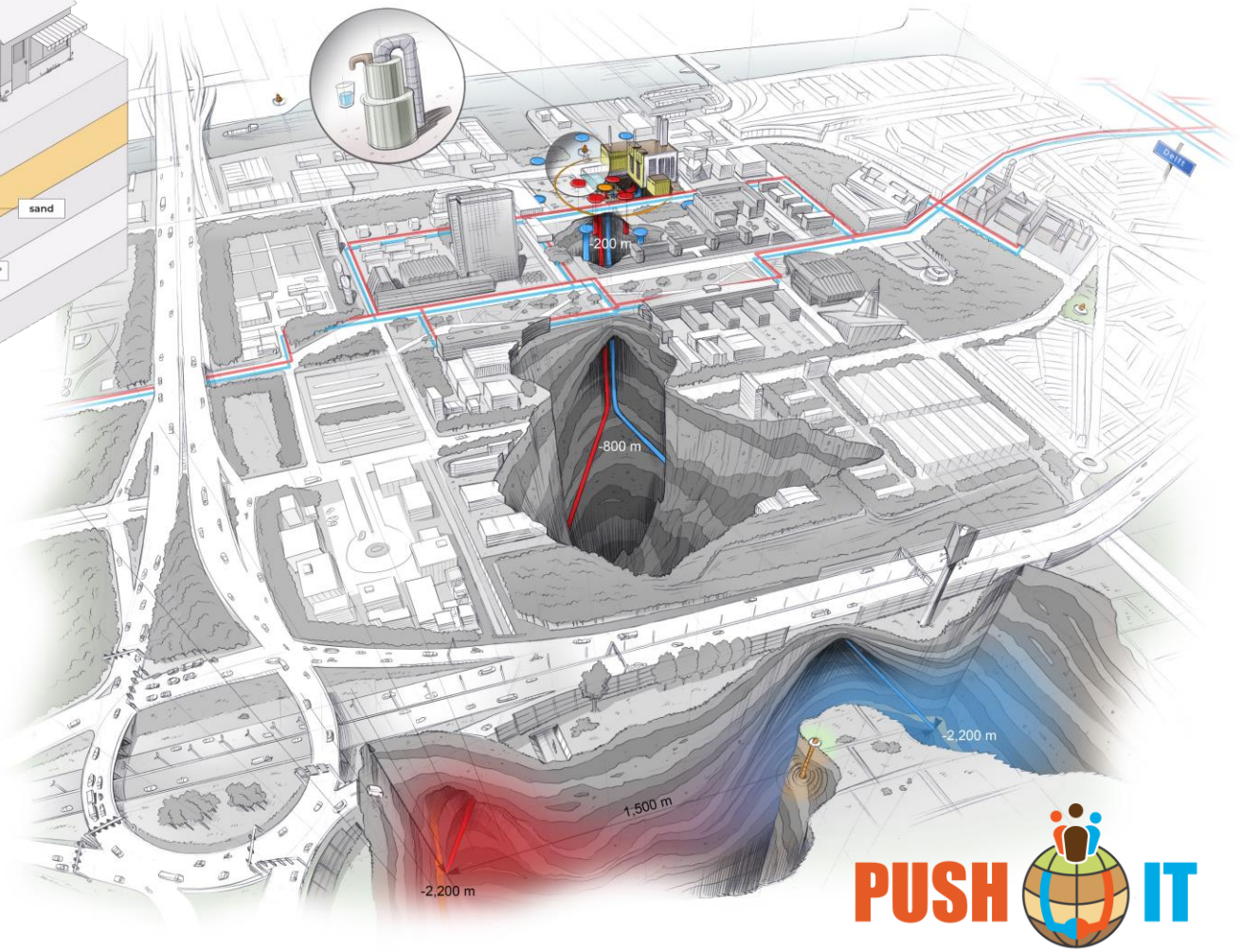
Future research

1. Verwerken van verkregen data
2. HT-ATES (Push-it)
3. Gedetailleerde scans van kernen
4. Productie experimenten (zomer)
5. Intensieve seismische monitoring
6. Deep monitoring borehole

PUSH-IT







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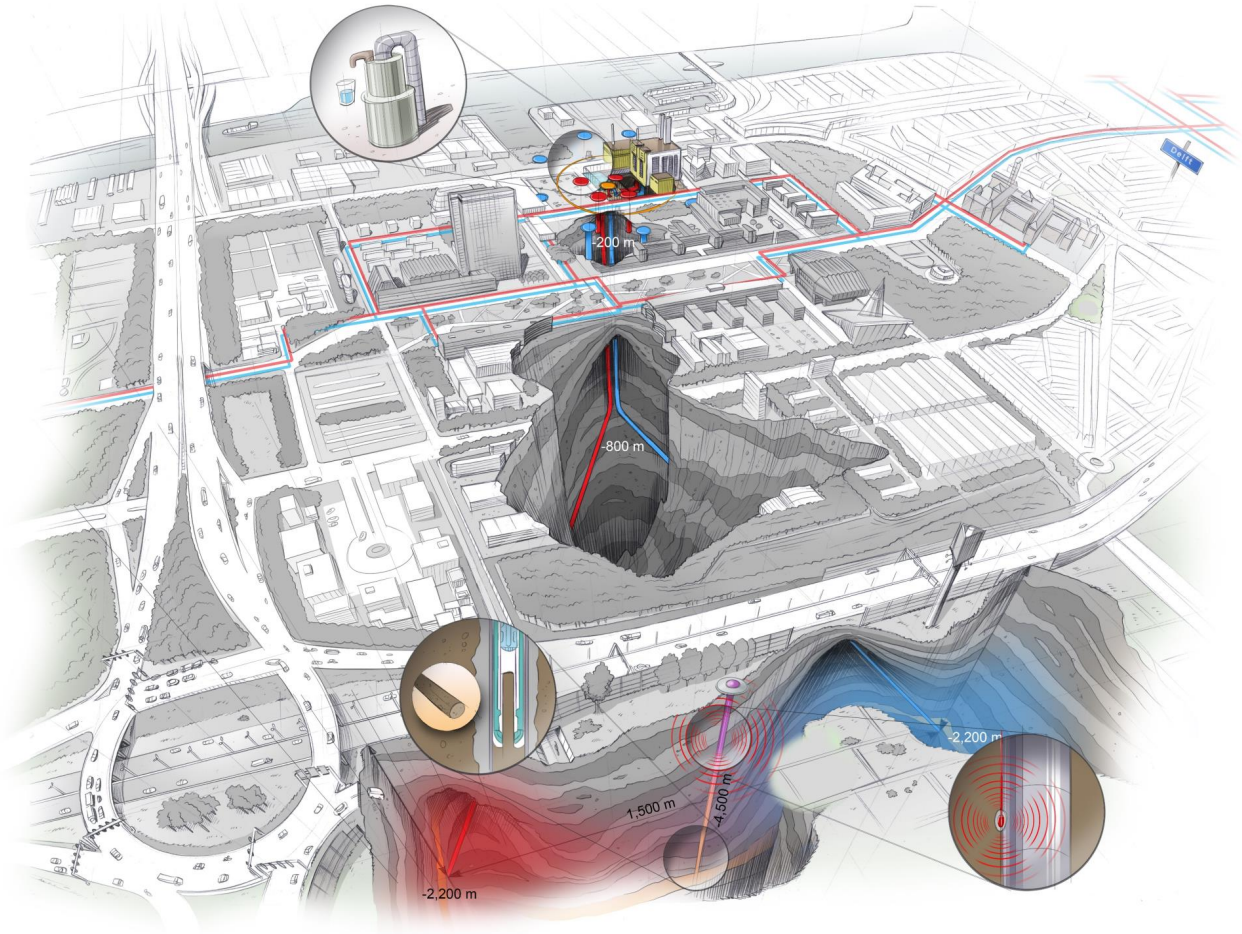
Deep monitoring borehole

- Funded, binnen 5 jaar boren
- (Bijna) verticale put
- Mogelijk tot 4500m diepte
- Niet vloeiende monitorings put
- Door reservoir tussen PROD & INJ
- Seismische monitoring
- Fiber optics
- Continuous coring

EPOS-eNLarge
EUROPEANPLATEOBSERVINGSYSTEM EPOS-Netherlands



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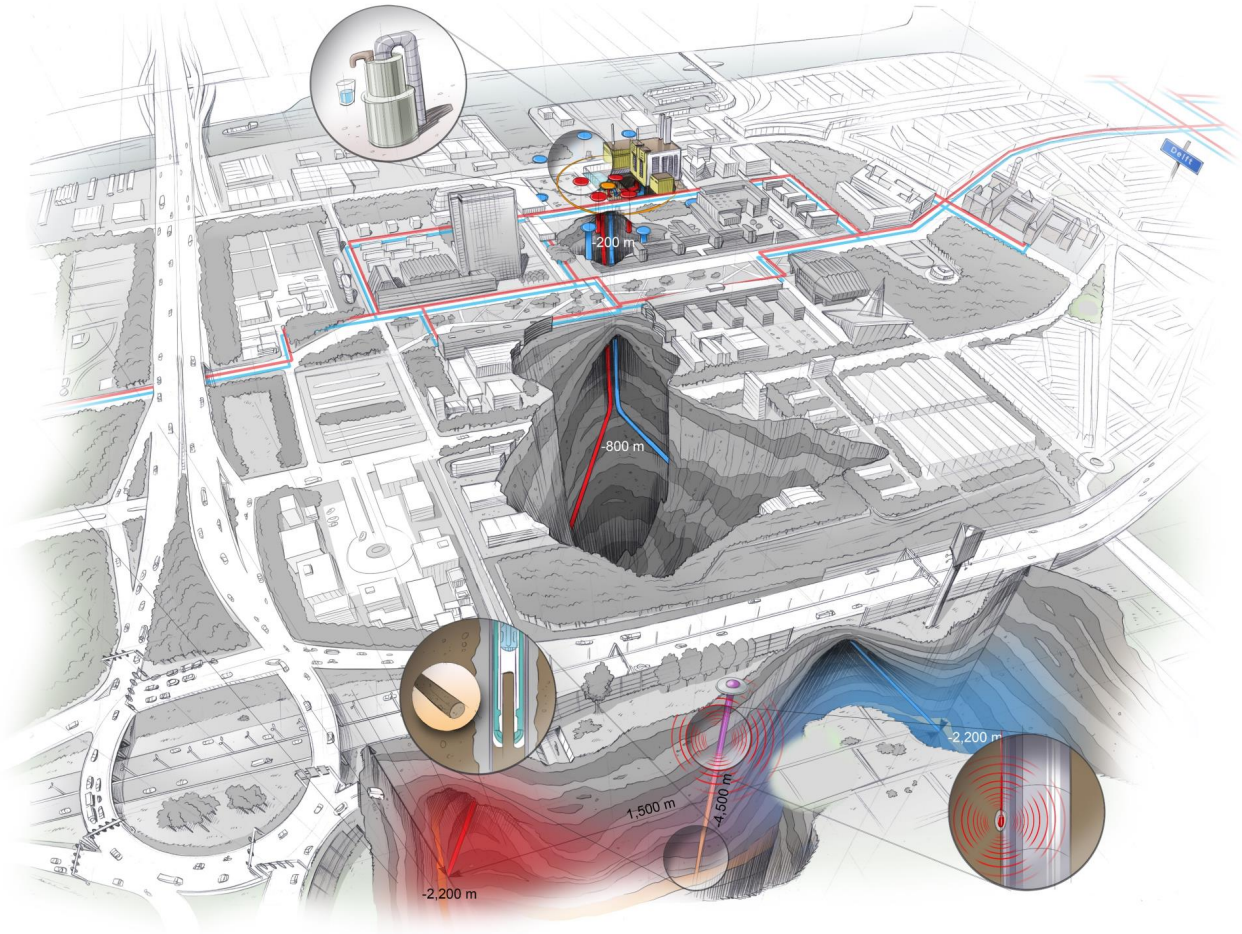

TNO innovation for life
Universiteit Utrecht
Koninklijk Nederlands Meteorologisch Instituut
Ministerie van Infrastructuur en Waterstaat
TU Delft
GEOTHERMIE DELFT
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Factsheet

Succesfull research campaign

A lot of exposure for urban geothermal

Many involved students

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Delftse bron van duurzame energie en kennis

Factsheet

Succesfull research campaign

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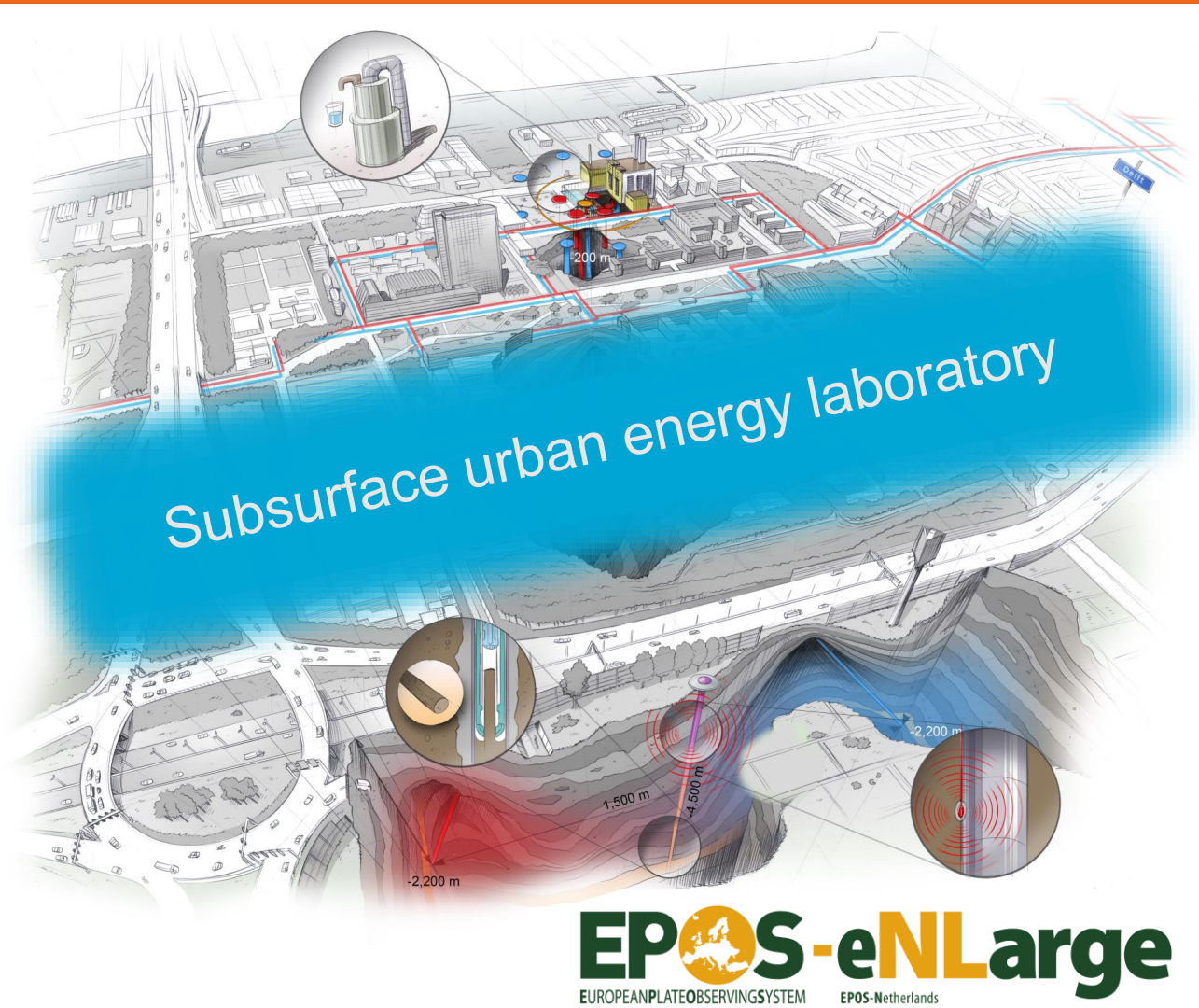
	amount
4” cores (meter)	86
Sidewall cores	79
Cutting samples	2500
Logging (meter)	1000
Bezoekers zichtlocatie	>1000
Studenten onsite	>100



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Toegevoegde waarde voor geothermie projecten

- Veel logging voor aquifer waaronder NMR / Imager / neutron tools
- Aankomende PhD’s / afstudeerders / publicaties
- Aangewakkerd enthousiasme bij studenten
- Sidewall cores om permeability te verifiëren naar logs
- Kernen + logging + cuttings + images op zelfde diepte
- Digital twin model met productie testen

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- ALLE DATA ZAL PUBLIEK BESCHIKBAAR GEMAAKT WORDEN
  Contacteer ons voor details

Samenwerkingen

Gefinancierd door:

EPOS-NL
EUROPEANPLATEOBSERVINGSYSTEM EPOS-Netherlands

Partners:

Aardyn Geothermie ontwikkeling & beheer

TU Delft

ebn

IOT GROUP

Baker Hughes

Huisman Geo

GEO SERVICE GMBH

HALLIBURTON

GEOCONSULTANTS PANterra

TNO

DAP

COVRA NV

WARMINGUP Innovatief Duurzaam Warmtecollectief

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Bedankt voor jullie interesse!