

Geo **4** all

innovatieprogramma



Distributed Temperature Sensing (DTS)

de eerste praktijkervaringen

1. Ervaringen bij Geothermie Delft

- Susanne Laumann *TU Delft*
- Laurens van der Sluijs *Gaia Energy*

2. Ervaringen bij HVC

- Sander Maat *HVC*
- Charlotte de Wijkerslooth *HVC*

3. Plannen in Bleiswijk

- Jurriaan Reijs *Gaia Energy*
- Loes Buijze *TNO*



GEOOTHERMIE DELFT
Delftse bron van duurzame energie en kennis

TU Delft

DTS and other fibre optic measurements

Geothermie and HTO Delft

Photo credit: Aardyn



Fibre optic cable plans vs reality

Plan

- Injector
 - Fibre optic cable connected to casing and cemented in place
 - Measurement capabilities: DSS, DAS, DTS
- Producer
 - Fibre optic cable with 12 in-line pressure gauges
 - Measurement capabilities: DPS, DAS, DTS



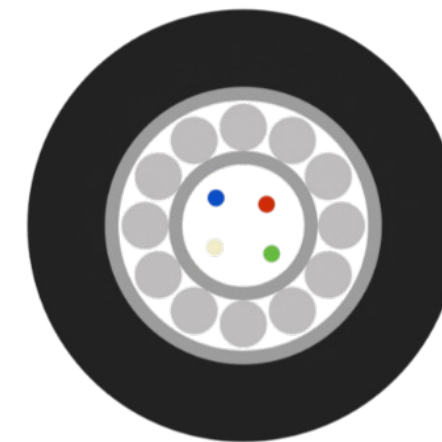
Reality

- Injector cable could not be installed outside the casing due to hole stability issues
- Producer cable was not manufactured on time
- Simple cable with DTS/DAS measurement capabilities installed in both wells

Fibre optic cable installation

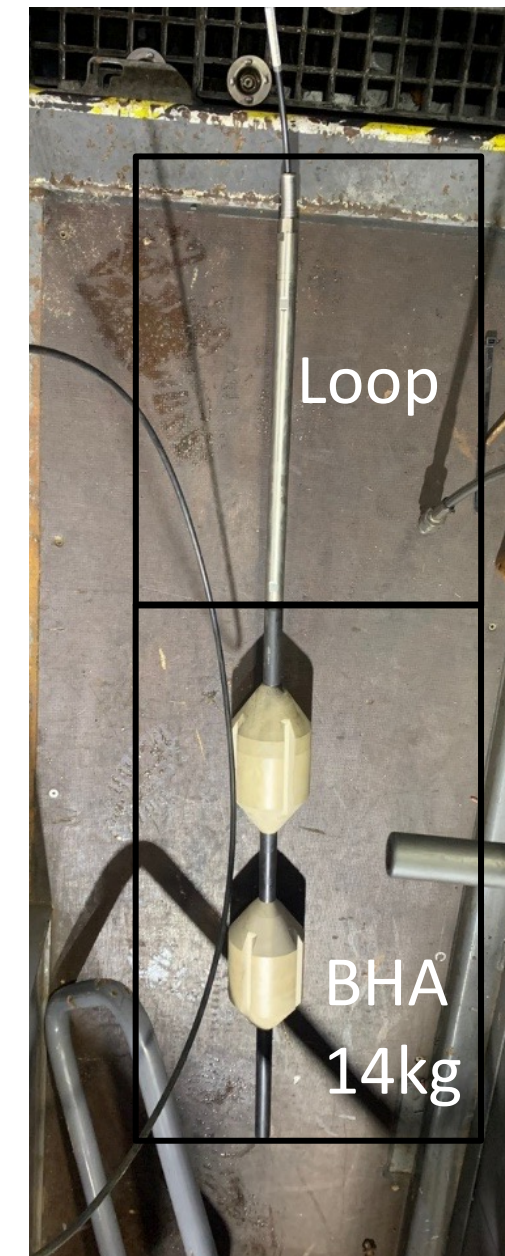
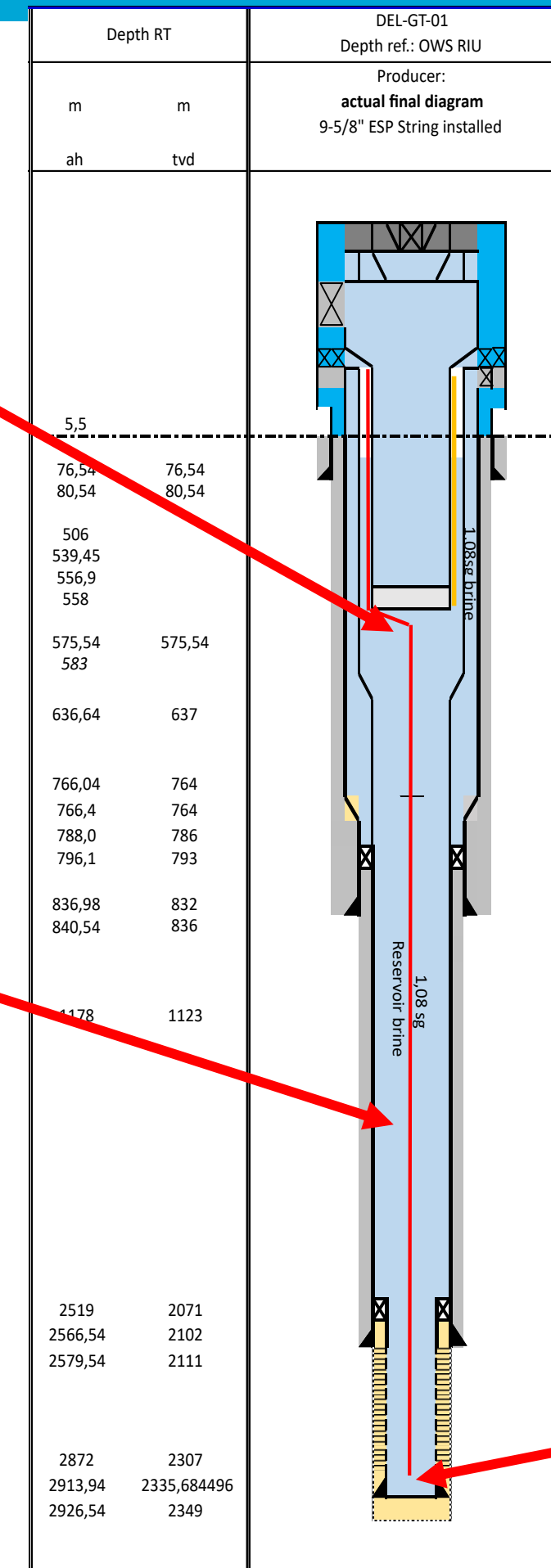
Producer DEL-GT-01

- Simple FO cable hanging underneath ESP
 - 2MM (DTS)/2SM (DAS/DTS) fibres; looped
- Timeline:
 - Installation 27-11-25, OTDR traces confirmed on SM
 - After connection to interrogator, MM broken at app 550m along hole
 - 17-12-25 **fibres broken around loop**; most likely BHA/loop not connected anymore
 - 24-02-26 production test; SM and MM **fibres broken at 1000m along hole**



BRUsens Temperature for up to 85°C
 Cable Diameter: 6.40mm
 Fibers: 2MMF + 2SMF (DTS and DAS)
 Cable - Design:

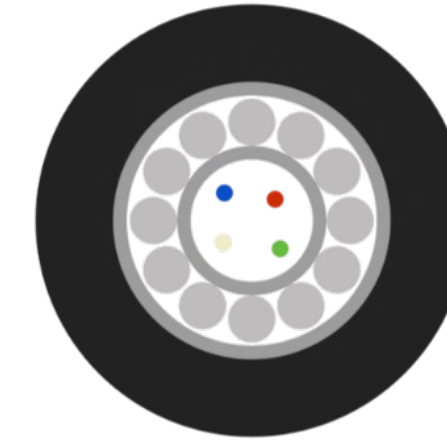
- FIMT with hydrogen scavenging gel
- Stranding Layer with galvanized steel wires
- Encapsulation Tube
- PP outer sheath"



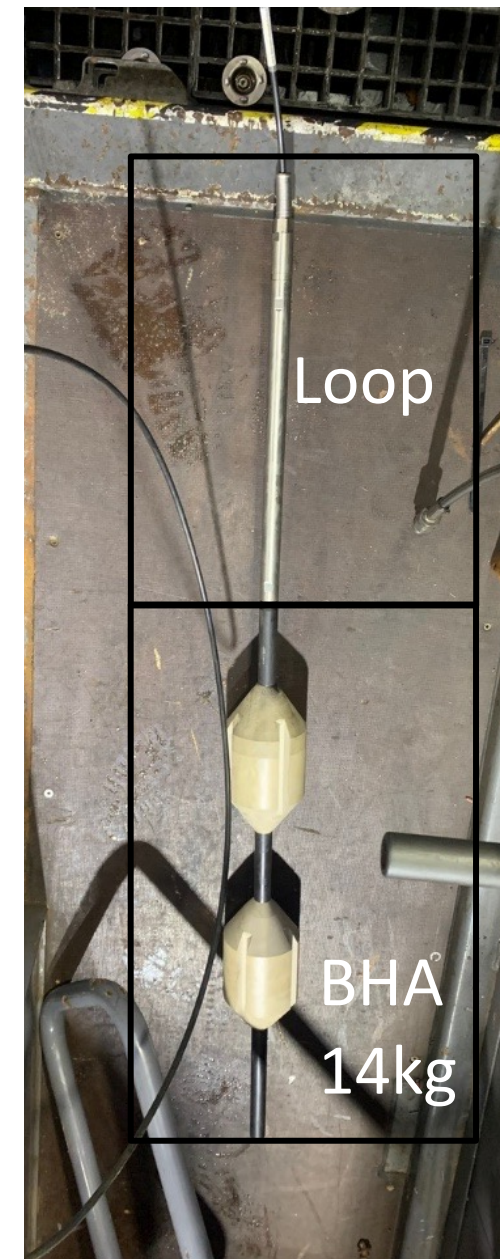
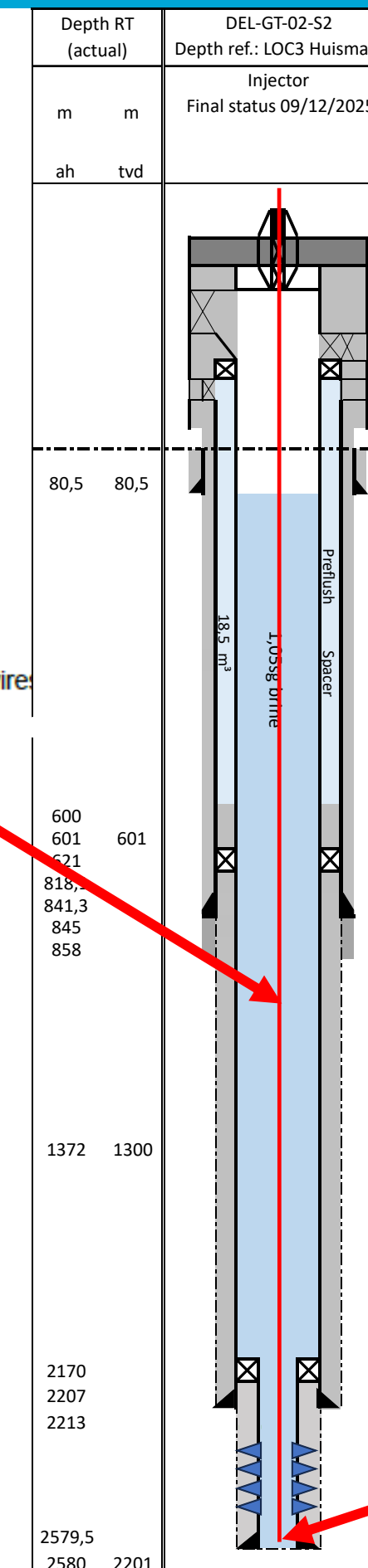
Fibre optic cable installation

Injector DEL-GT-02-S2

- Simple FO cable hanging loose in the well
 - 2MM (DTS)/2SM (DAS/DTS) fibres; looped
- Timeline:
 - Installation 9-12-25, OTDR traces confirmed on SM
 - MM and SM fully functional after connection of interrogator
 - 2-01-26 **fibres broken around loop**; most likely BHA/loop not connected anymore
 - DAS and DTS measurements can only be carried out as single ended measurements

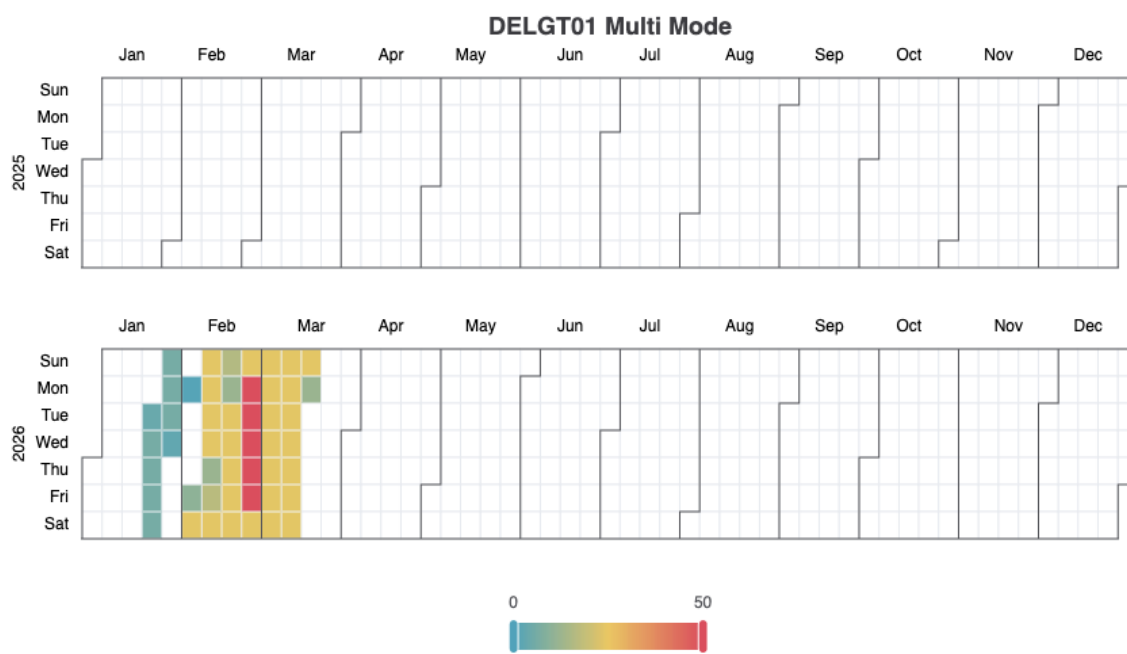


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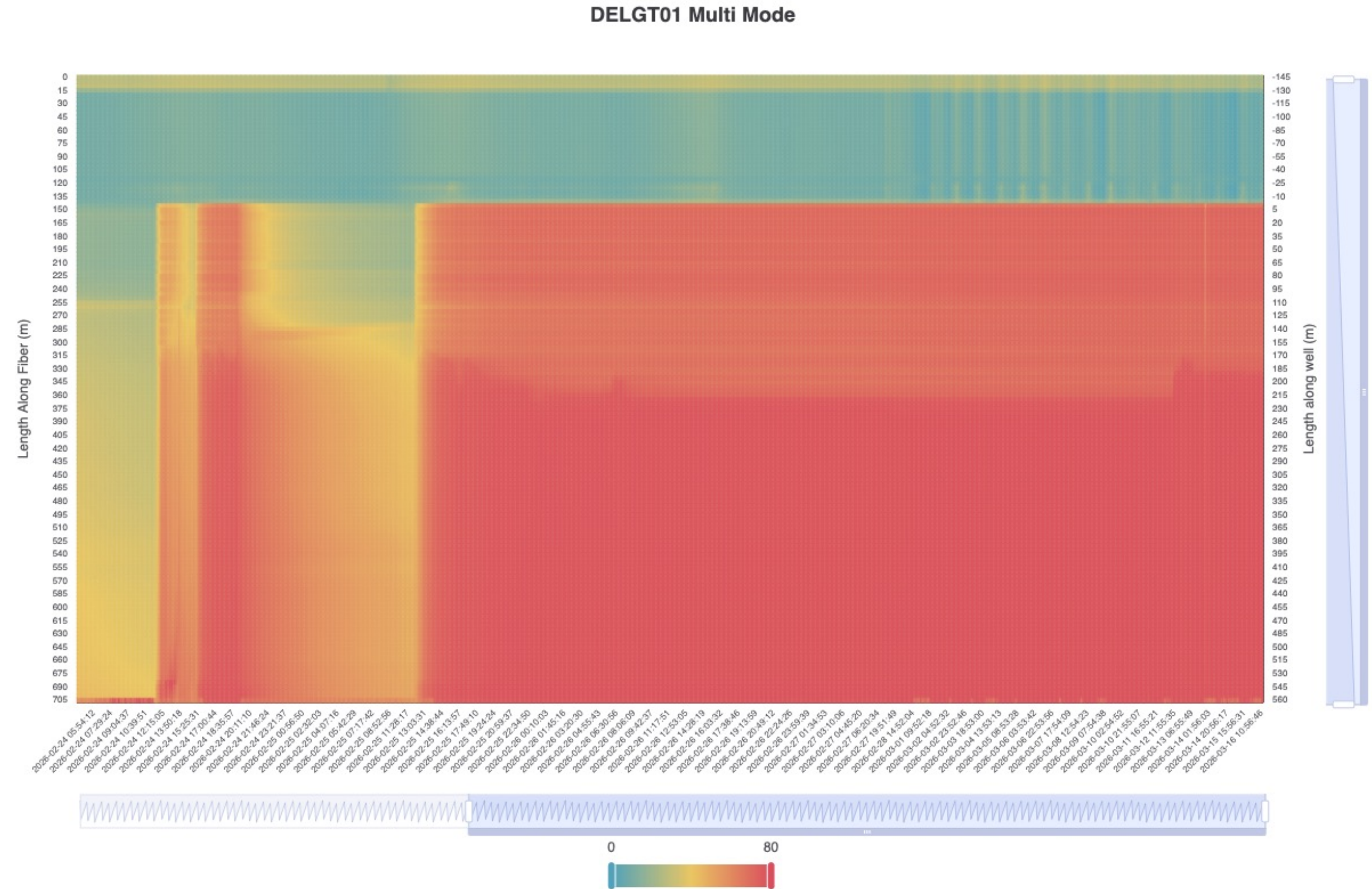


Fibre optic cable – DTS data

Producer DEL-GT-01

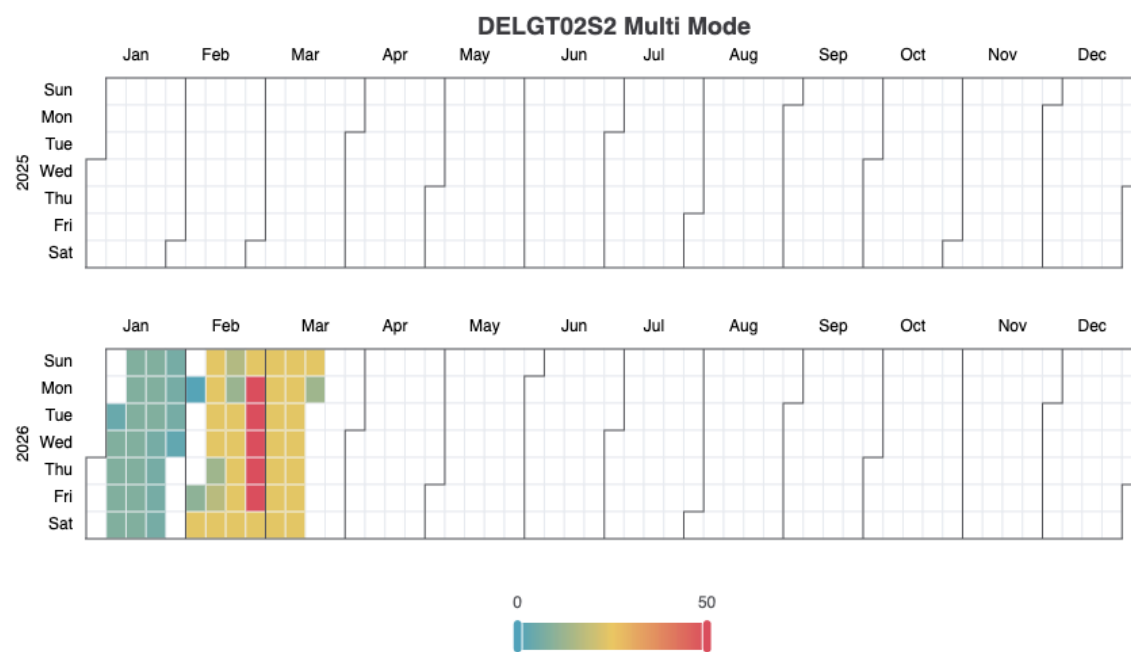


Results before start production
show natural gradient



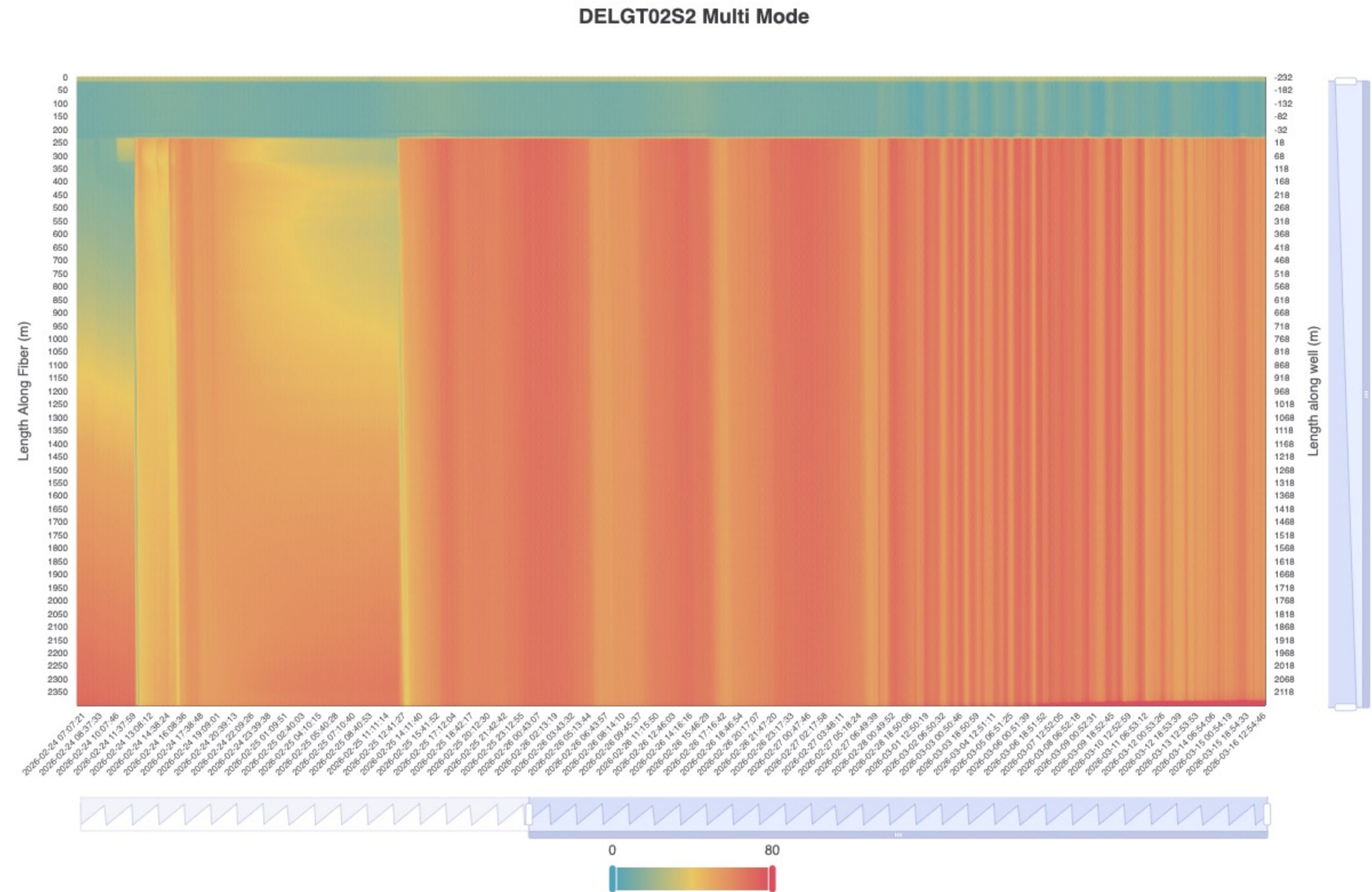
Fibre optic cable – DTS data

Injector DEL-GT-02-S2



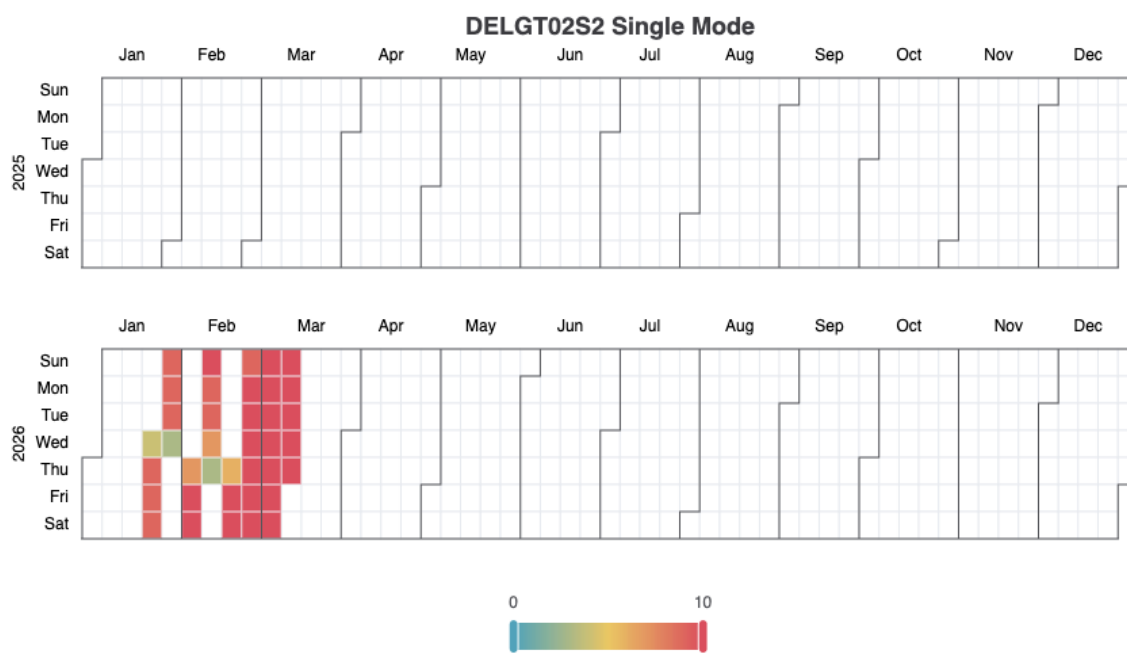
Multi-mode

- better signal-to-noise ratio than SM
- Accuracy $\pm 0,1 - 0,5$ °C
- T data calibrated in interrogator
- Shorter distance (app 10km)



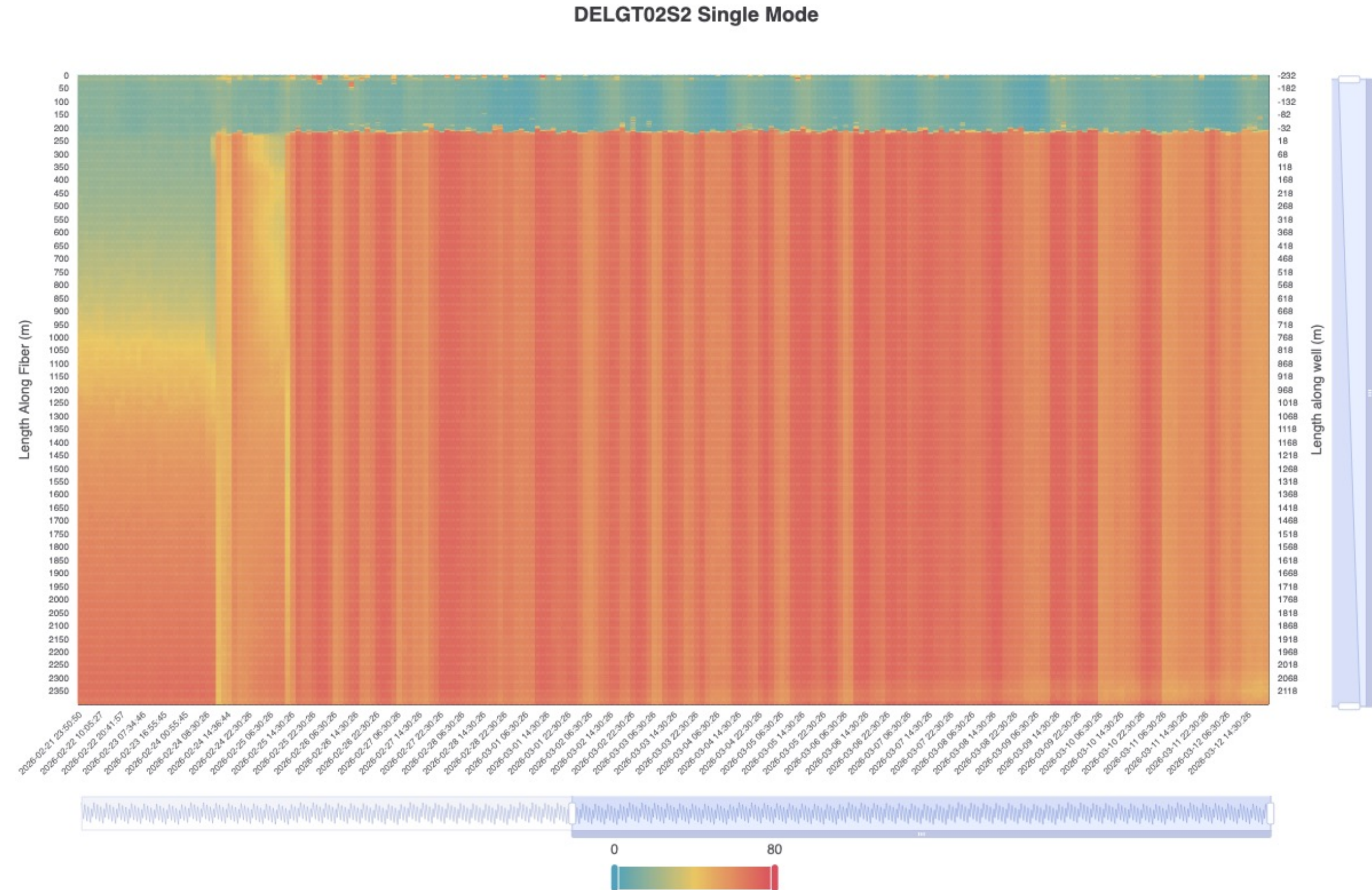
Fibre optic cable – DTS data

Injector DEL-GT-02-S2



Single-mode

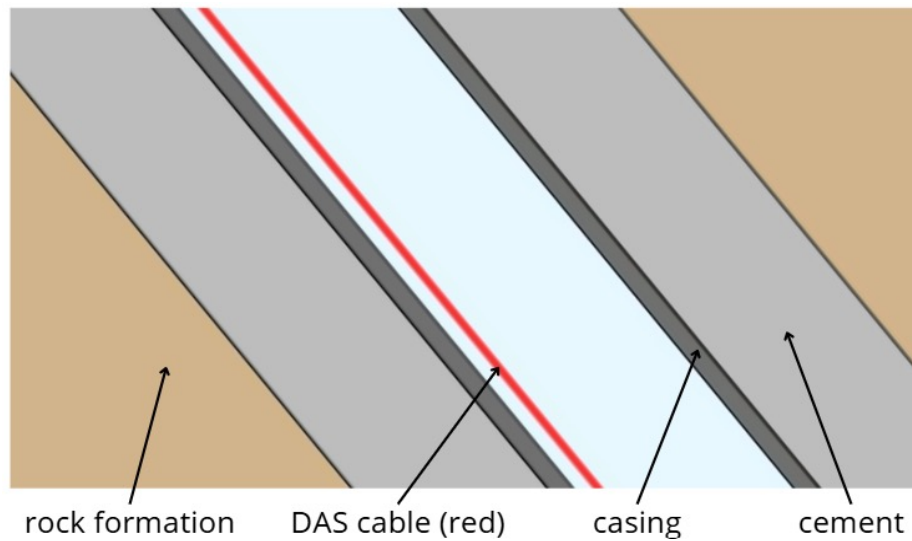
- Accuracy $\pm 1^{\circ}\text{C}$
- T data needs calibration
- longer distance



Fibre optic cable – added value DAS data

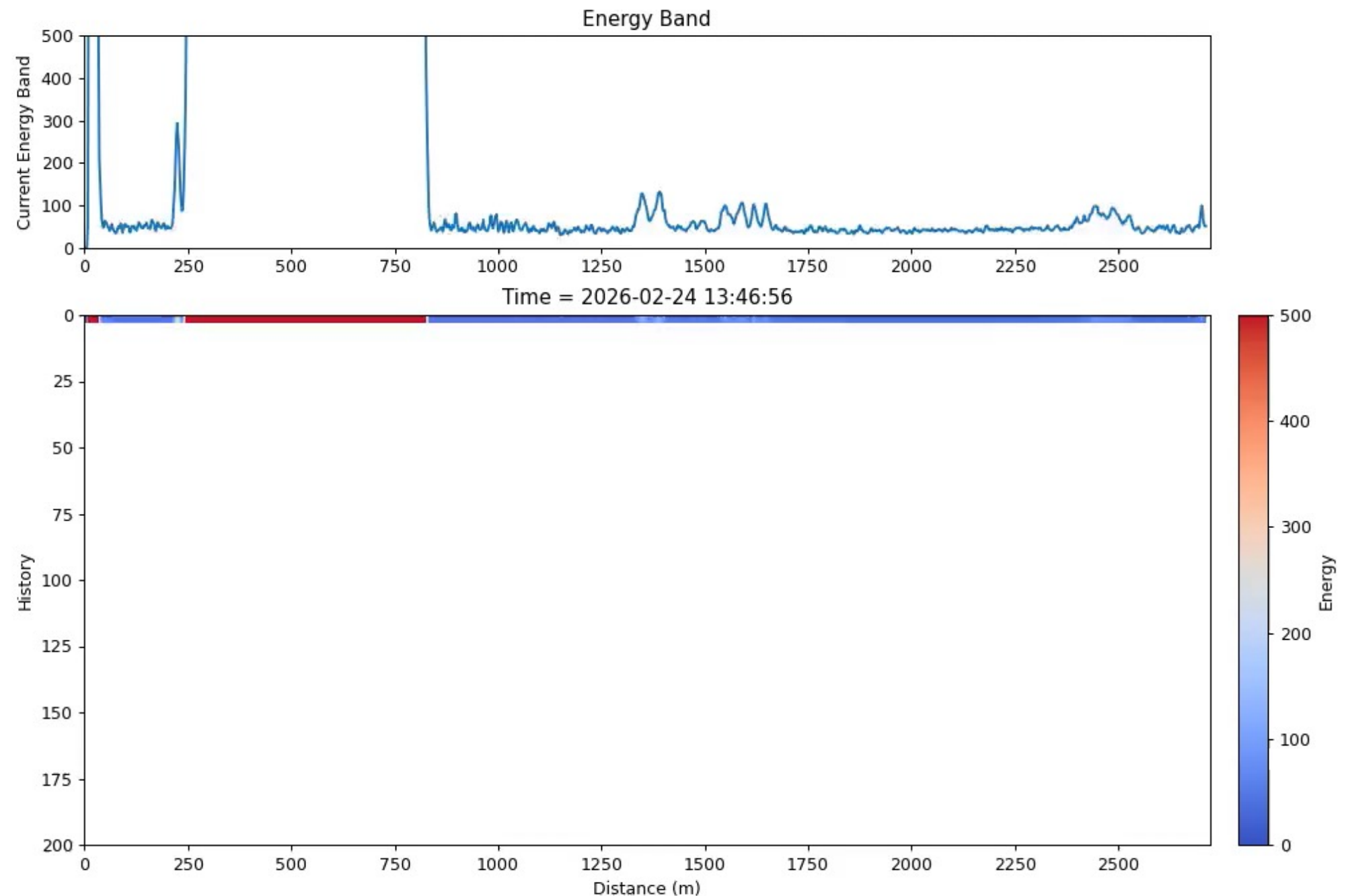
Distributed acoustic sensing

- SM fibre allows to measure acoustic signal
- DAS ideally requires coupled cables (cemented in place)

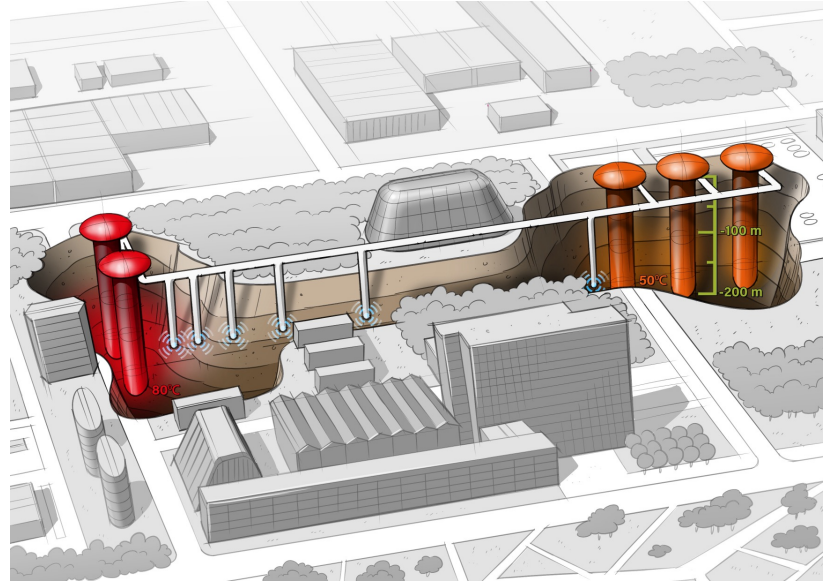


Three event categories identified

- Deep → through DSS
- Shallow → casing and cement
- Borehole guided

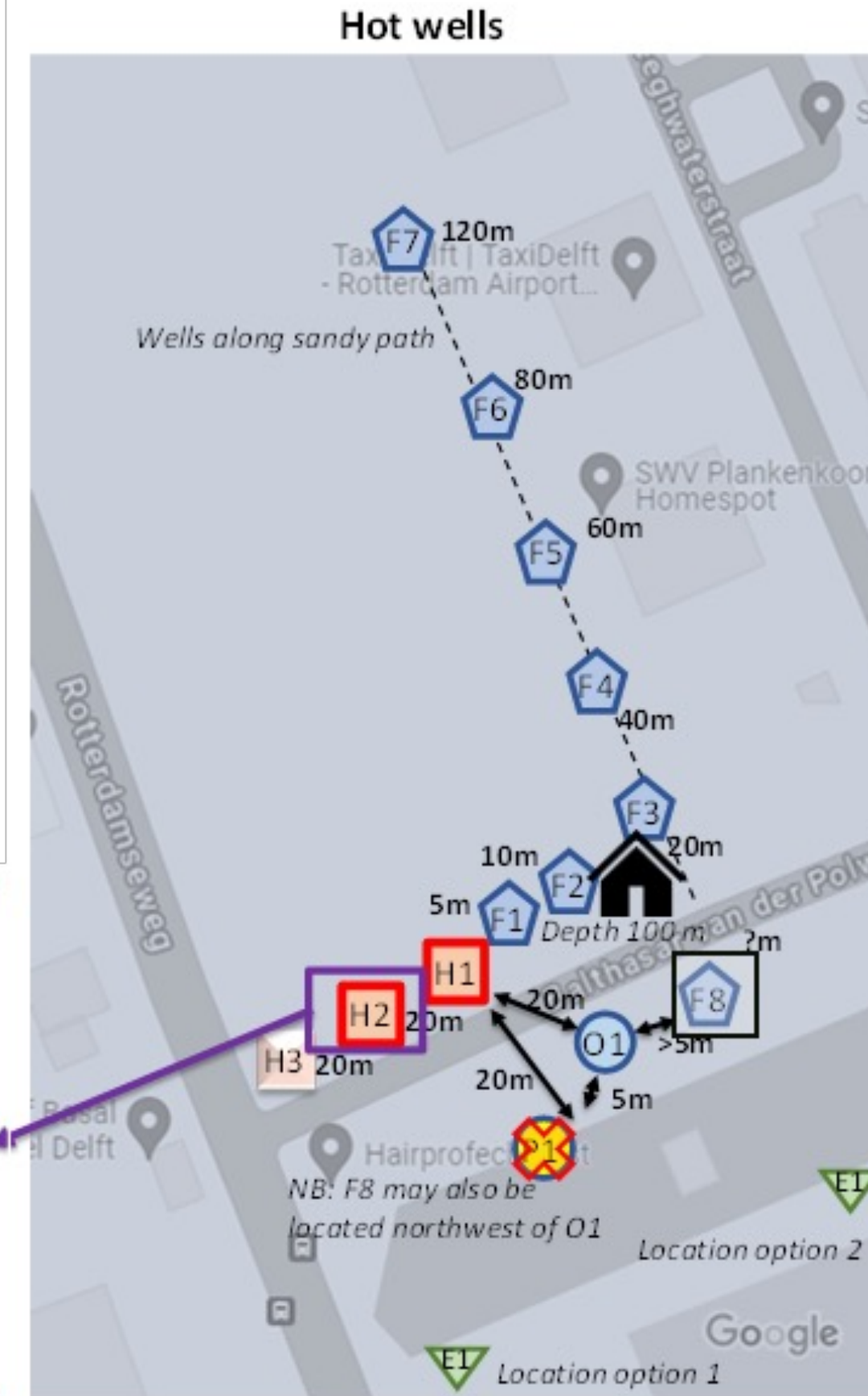
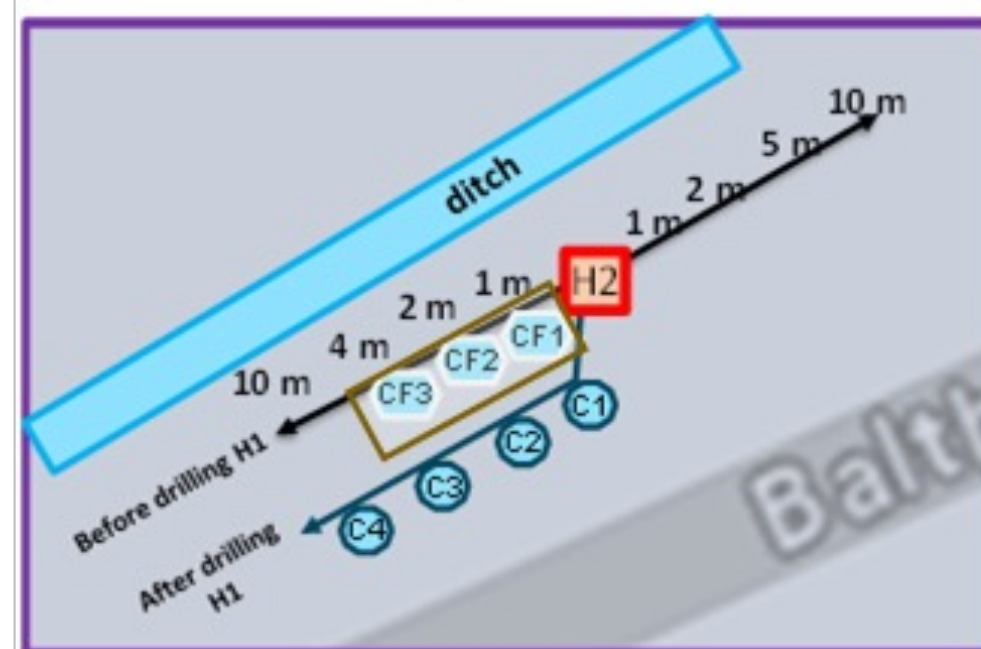
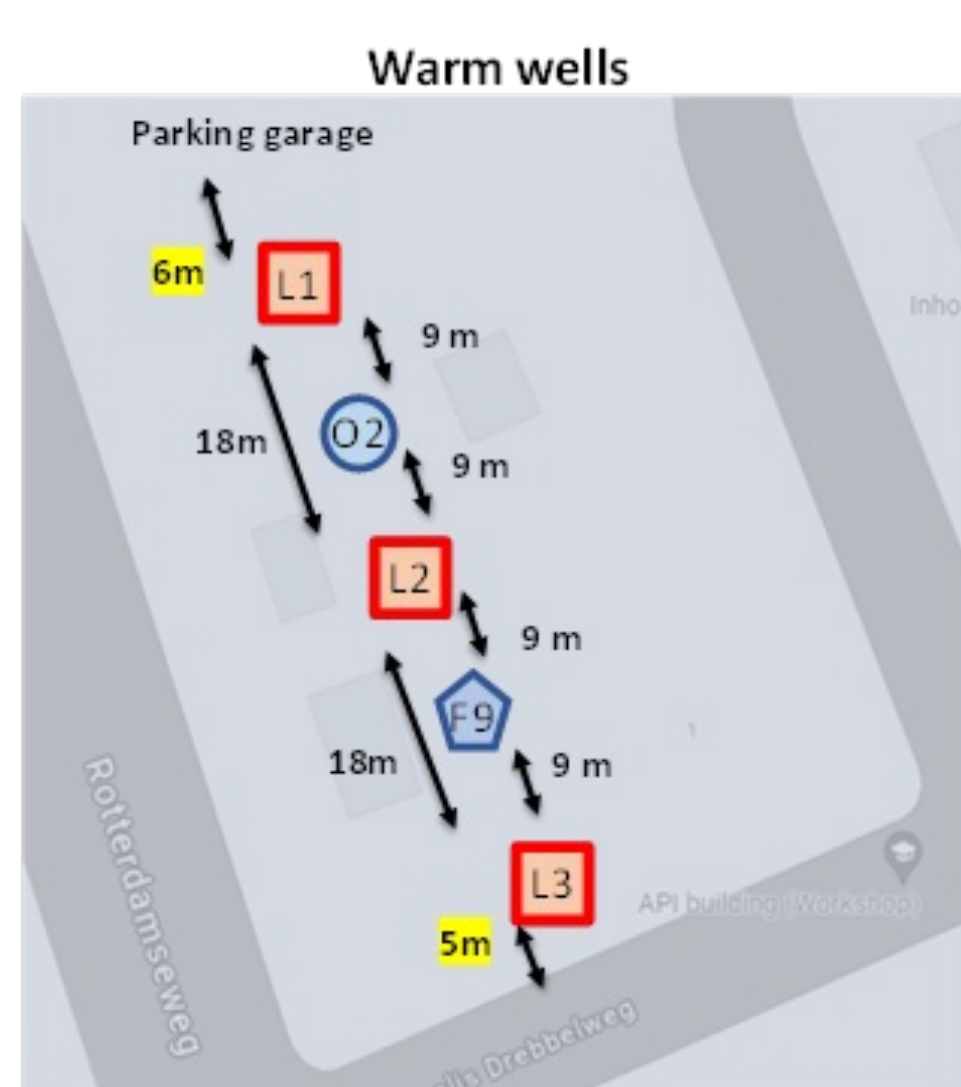


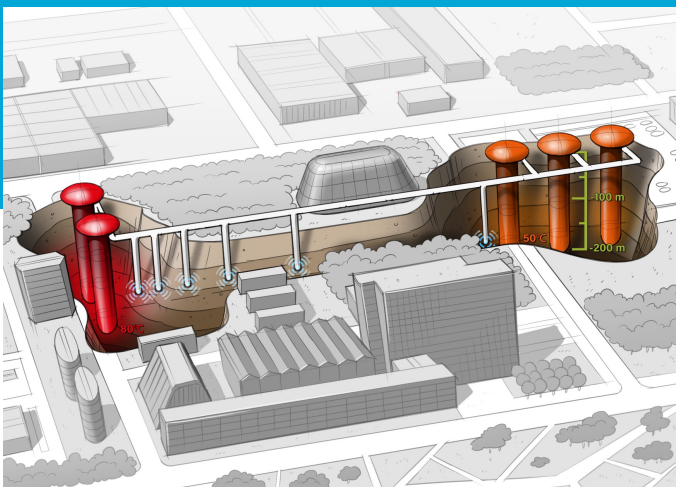
HTO Delft – fibre optic monitoring system



Legend

-  Hot (H) or Lukewarm (L) production well
-  Observation well (O) and pump test borehole (P)
-  Fibre optics borehole (F) - Depth 190 m
-  CPT driven Fibre optics (CF) – Depth +/- 30 m
-  Cone Penetration Test (C) – Depth +/- 30 m (after drilling wells)
-  EM borehole (optional)
-  Optional production well (L/H)
-  Optional fibre optics borehole (F)
- XXm Distance from production well H1 (unless indicated otherwise)





HTO Delft – fibre optic monitoring system



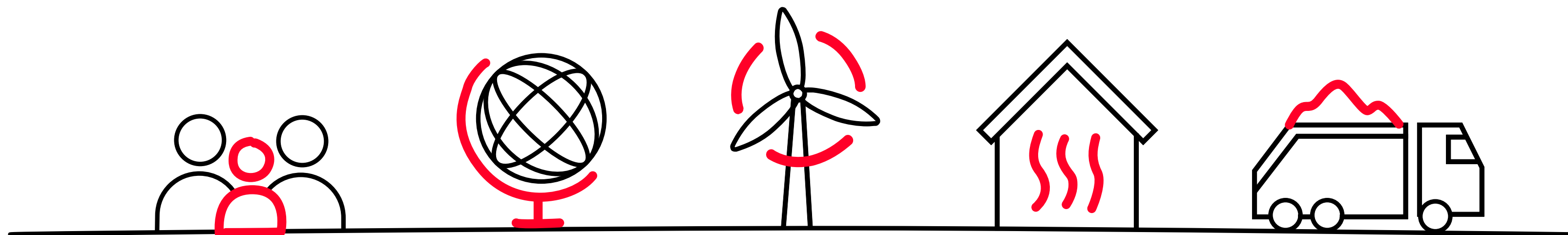
Cable Type	Primary Function	Fibre Type	T rating	Chemical resistance	Location	
Temp SM	Temperature Sensing	6 x SM	Not specified	No	O1	✓
Strain	Strain sensing	1xSM	Not specified	No	Cf1, Cf2, Cf3	✓
Multi	Multi-purpose sensing	2xMM, 2xSM, 10xSM	Up to 85C	No	F1-F9, O2	✓
AH-DTS	Active Heating DTS	4xMM	Up to 90C	Yes (10%NaClO, H2O2)	H1, H2, L1-L3	
Burial	Connecting cable	8xMM, 8xSM	-40 to +70C	Not specified	Trenches	

Monitoring capabilities

- Stress measurements during well installation → via strain sensing
- Temperature distribution → SM & MM temperature sensing, SM DAS/active seismics, Electromagnetics (not part of this presentation)
- Thermal conductivity and preferential flow paths → active heating DTS

hvc.

energie en hergebruik

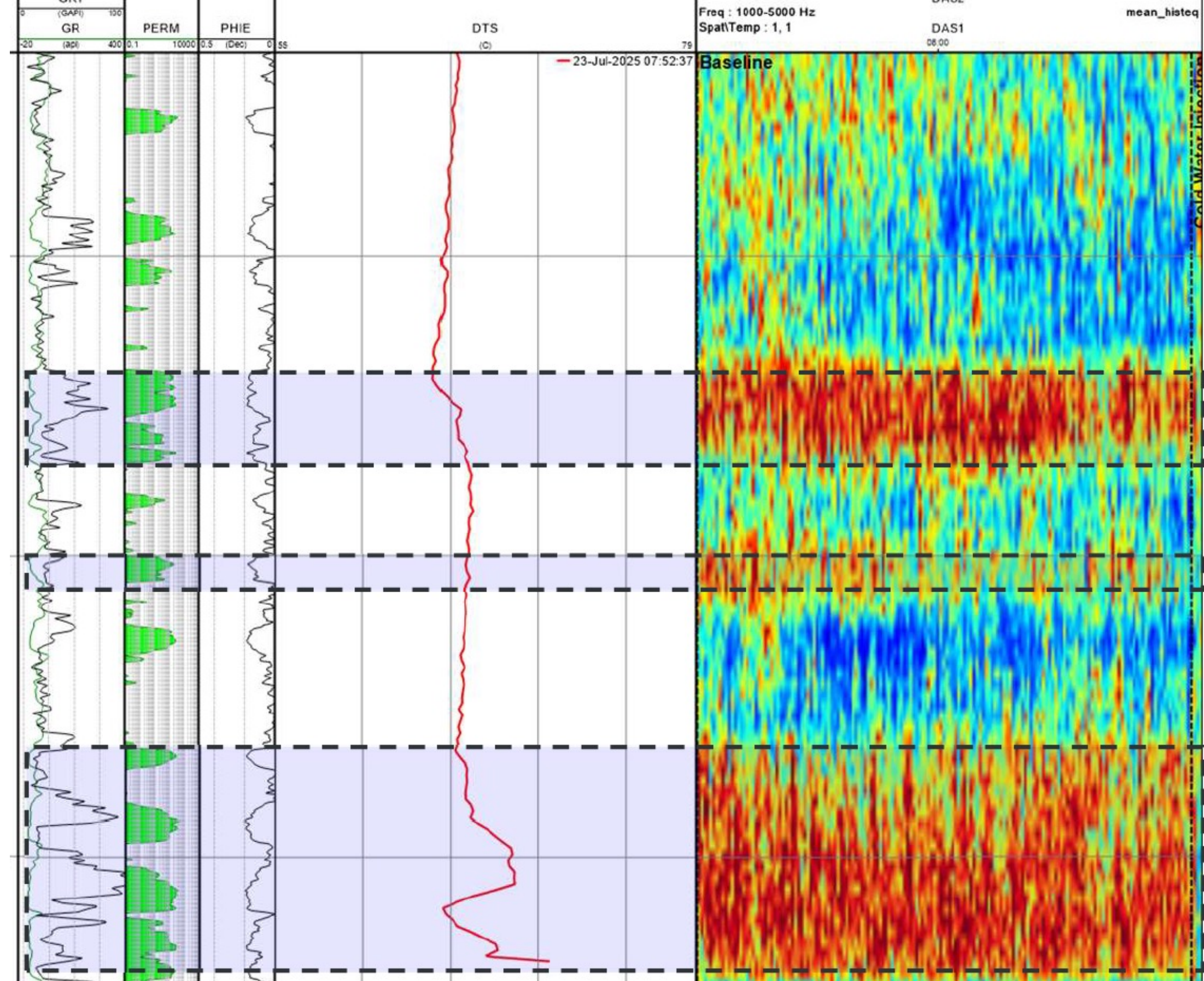


Doelen met DTS/DAS

- Kalibreren opwarmmodel (injectie temperatuur op reservoir niveau)
- Vervangen PLT Log
- Continue monitoring over reservoir, seal en put
- Afkoeling seal monitoren
- Modeleren met data/nieuwe inzichten
- Temperatuur logs (warmback logs)

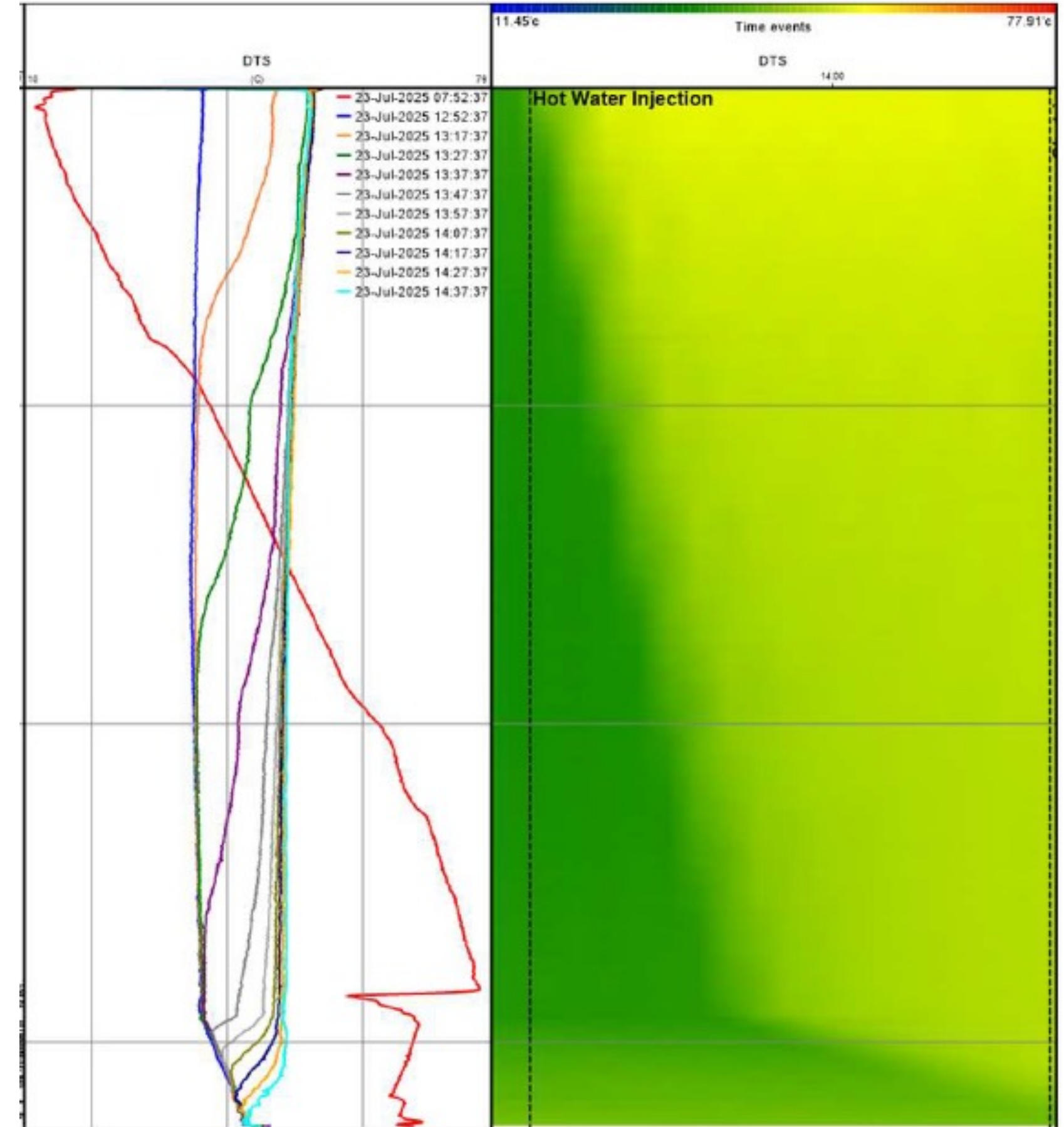
DAS in reservoir

- Goed om actieve zones te zien (shut in fase).
- Ook waar wel geperforeerd is maar niet mee doet
- Op ondiepere stukken kan je ook goed behind casing flow zien.
- Tijdens injectie voor ruis



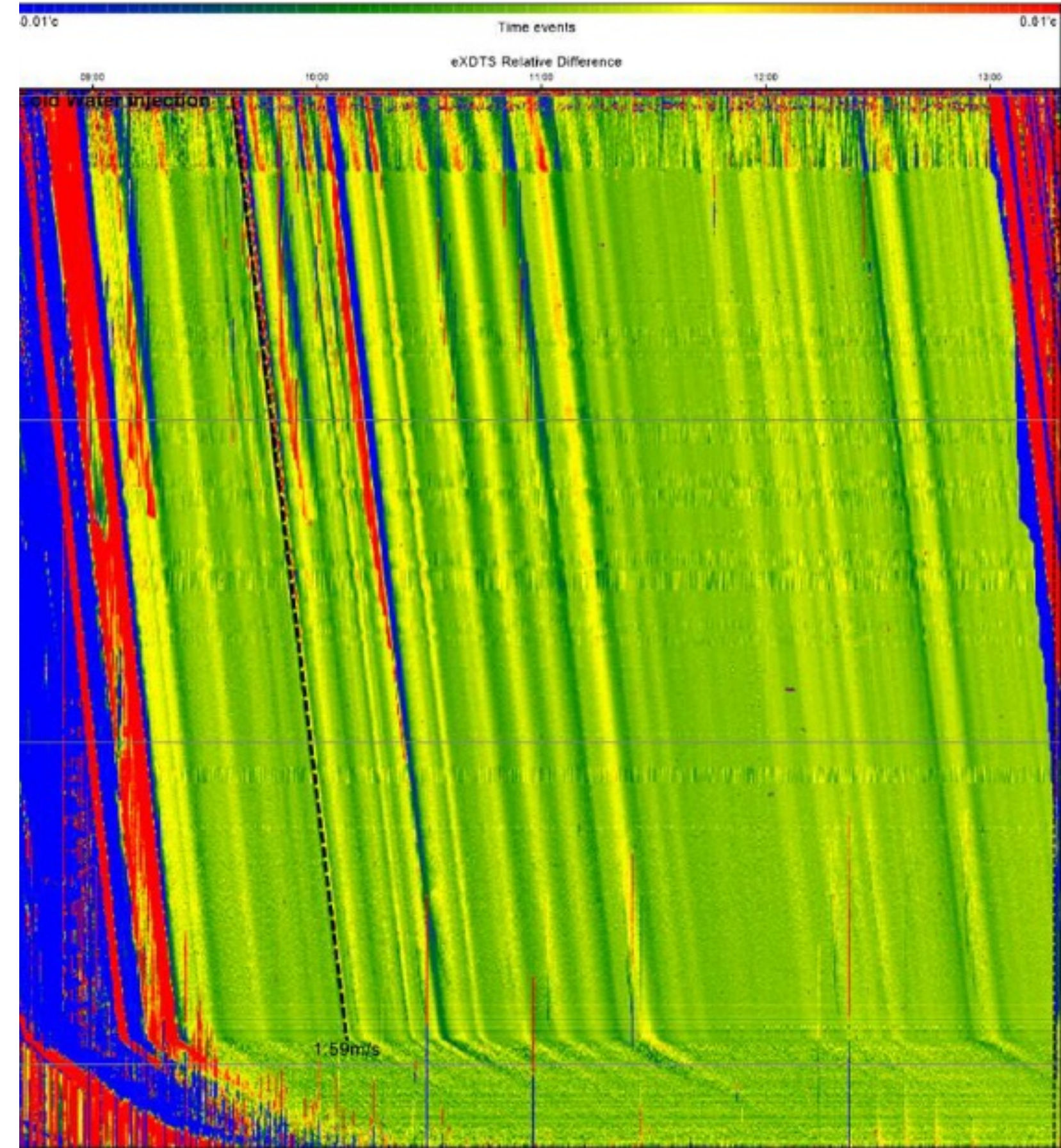
DTS

- Goed om te zien waar het water heen gaat
- Werkte niet optimaal, veel waas van temperatuur overgang
- Grote les: DTS was opgezet om op relatief lage resolutie de hele put te bekijken. In de toekomst testen met inzoomen op het reservoir op hogere resolutie



eXDTs over de put

- eXDTs lage frequente DAS
- Makkelijk om kleine veranderingen in temperatuur te zien, en daarmee goed de stromingssnelheden in de put.
- Van tevoren niet gedacht dat dit zulk goede informatie gaf.
- De beste manier om de output van een PLT mee te krijgen.



Lessen van DTS/DAS op wireline

- exDTS heel nuttig
- Goede resultaten door de injectietemperatuur te veranderen om te zien waar het water heen gaat (PLT)
- Vooral voor veel langer kijken in de toekomst, en tegelijk inzoomen op het reservoir
- Goede informatie verkregen over temperatuur logs en het kalibreren hiervan



GAIA
ENERGV

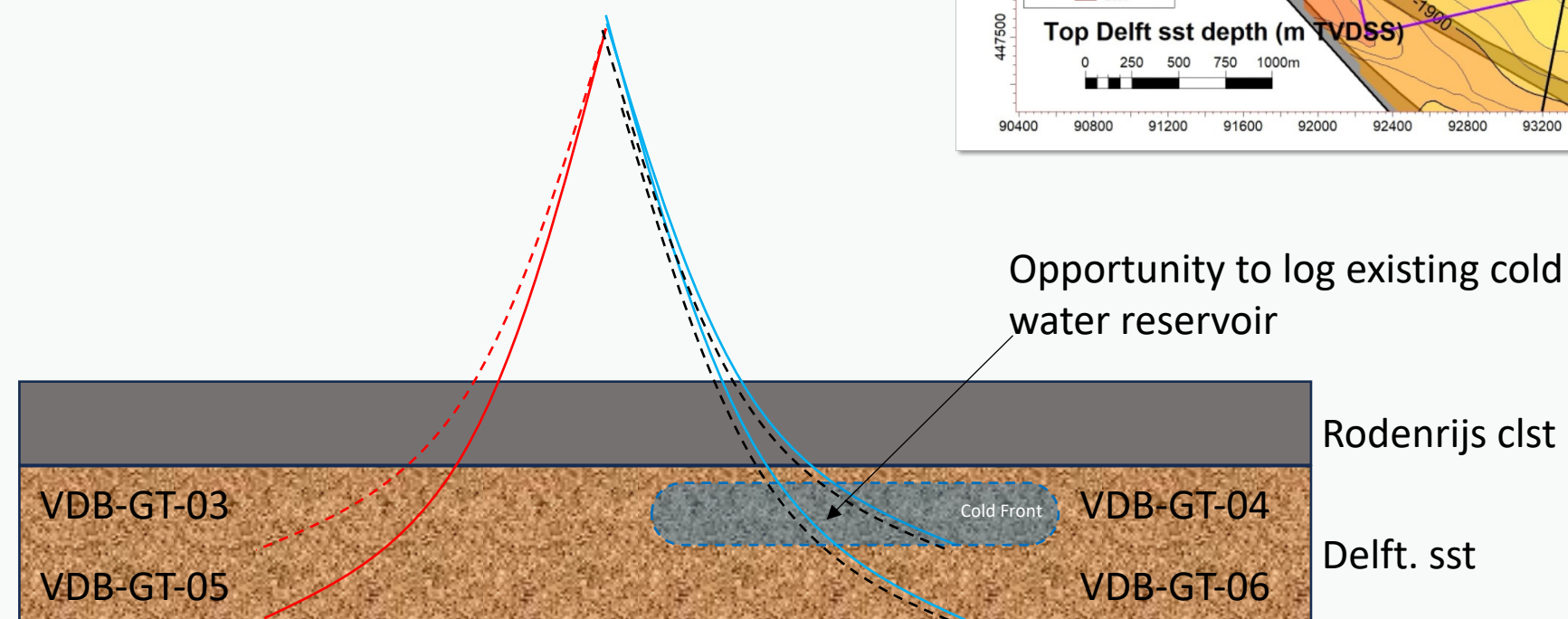
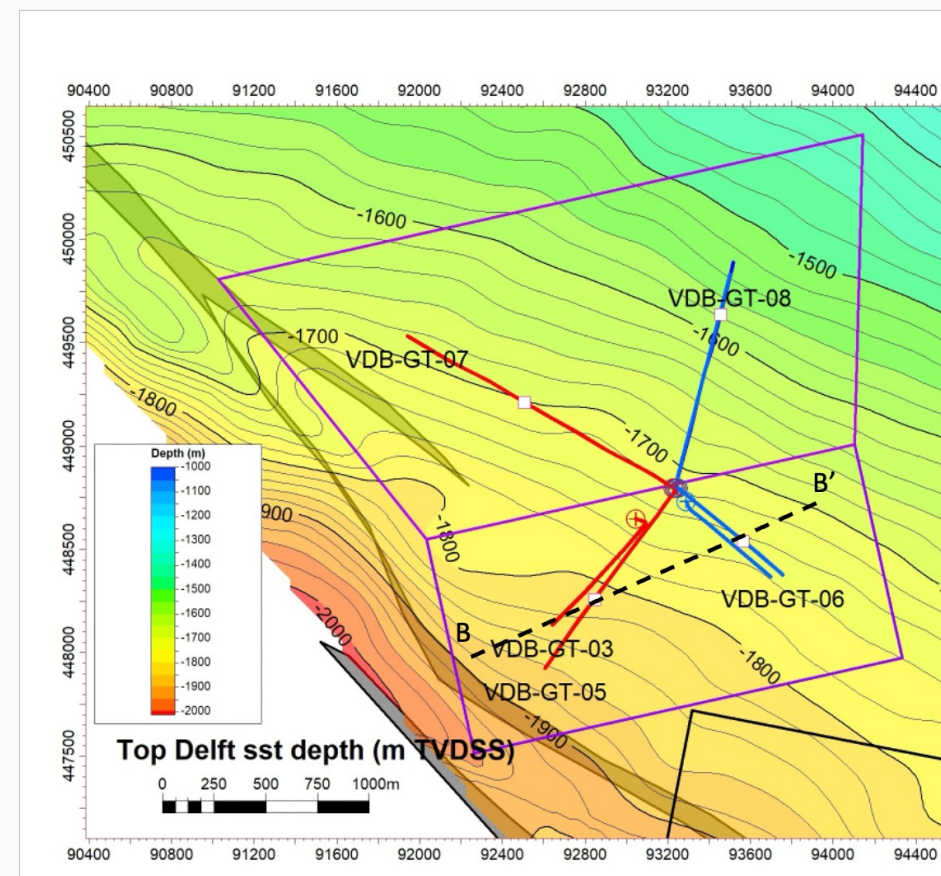
DTS plannen

 **IPS** GEOTHERMAL

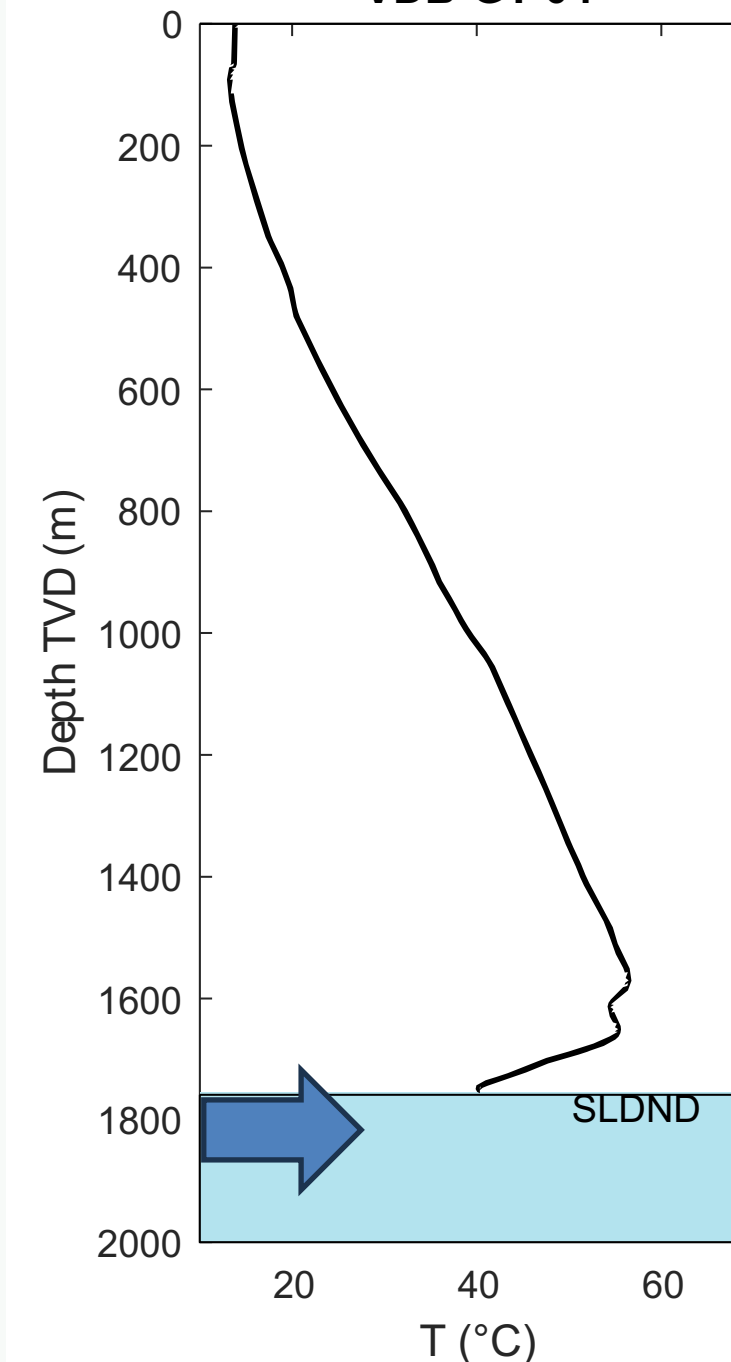


Geo4all plannen Bleiswijk/Verweijweg

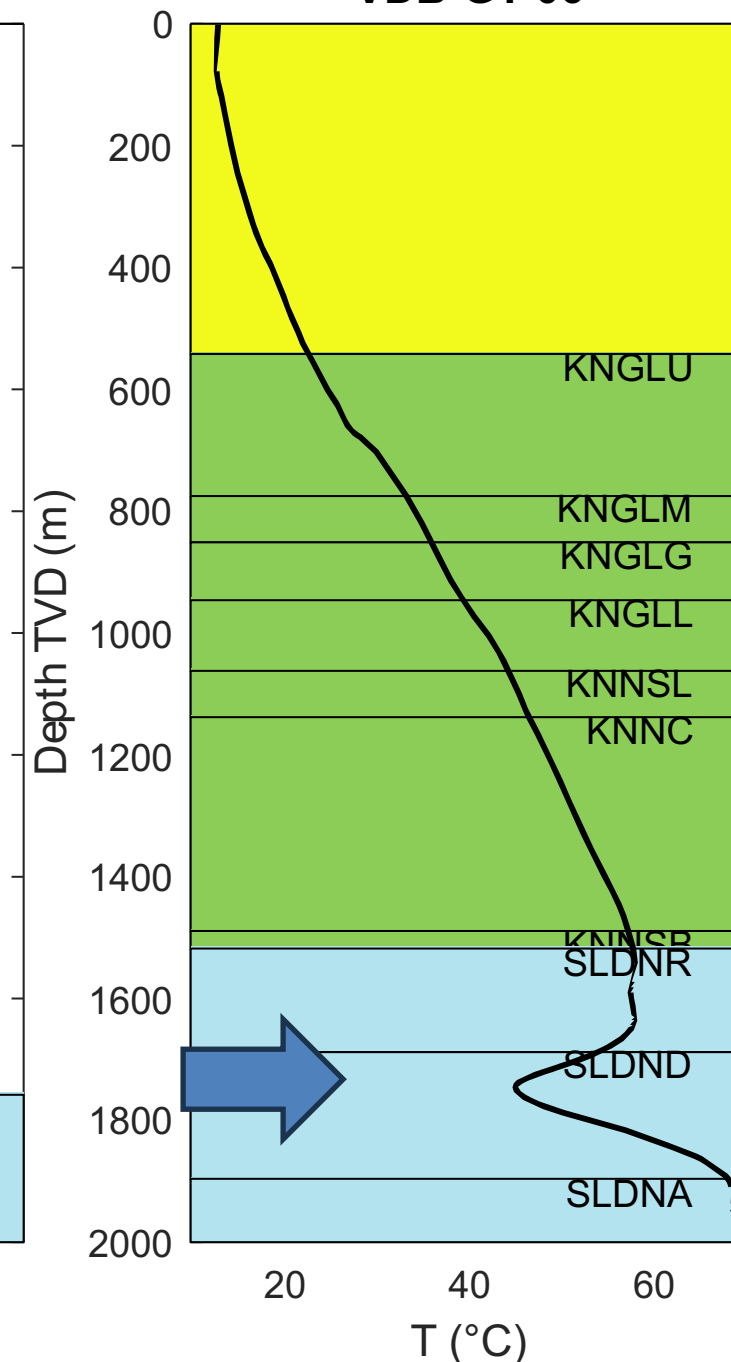
- Plaating van DTS/DAS kabels in VDB-GT-04 / VDB-GT-06



VDB-GT-04



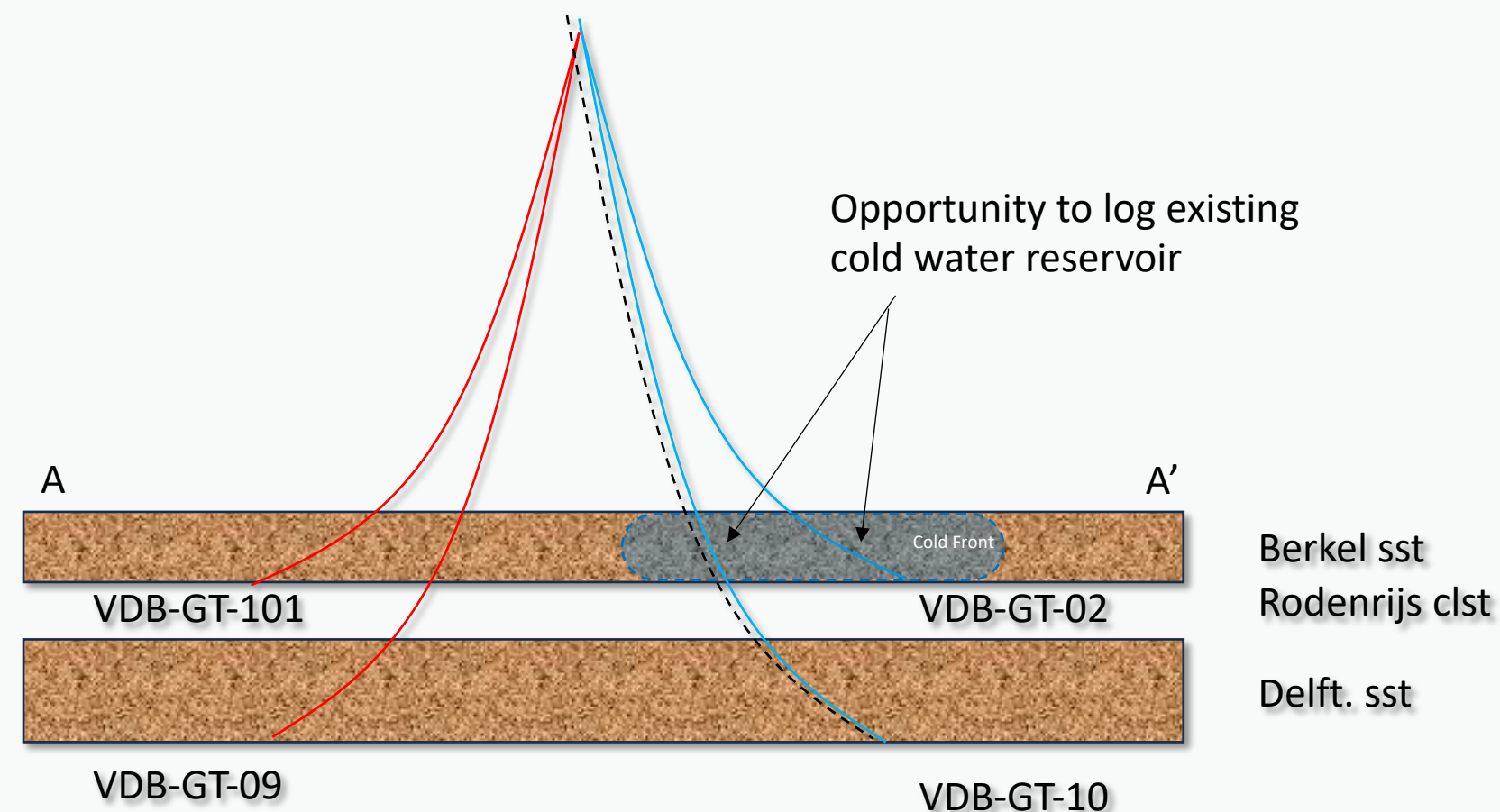
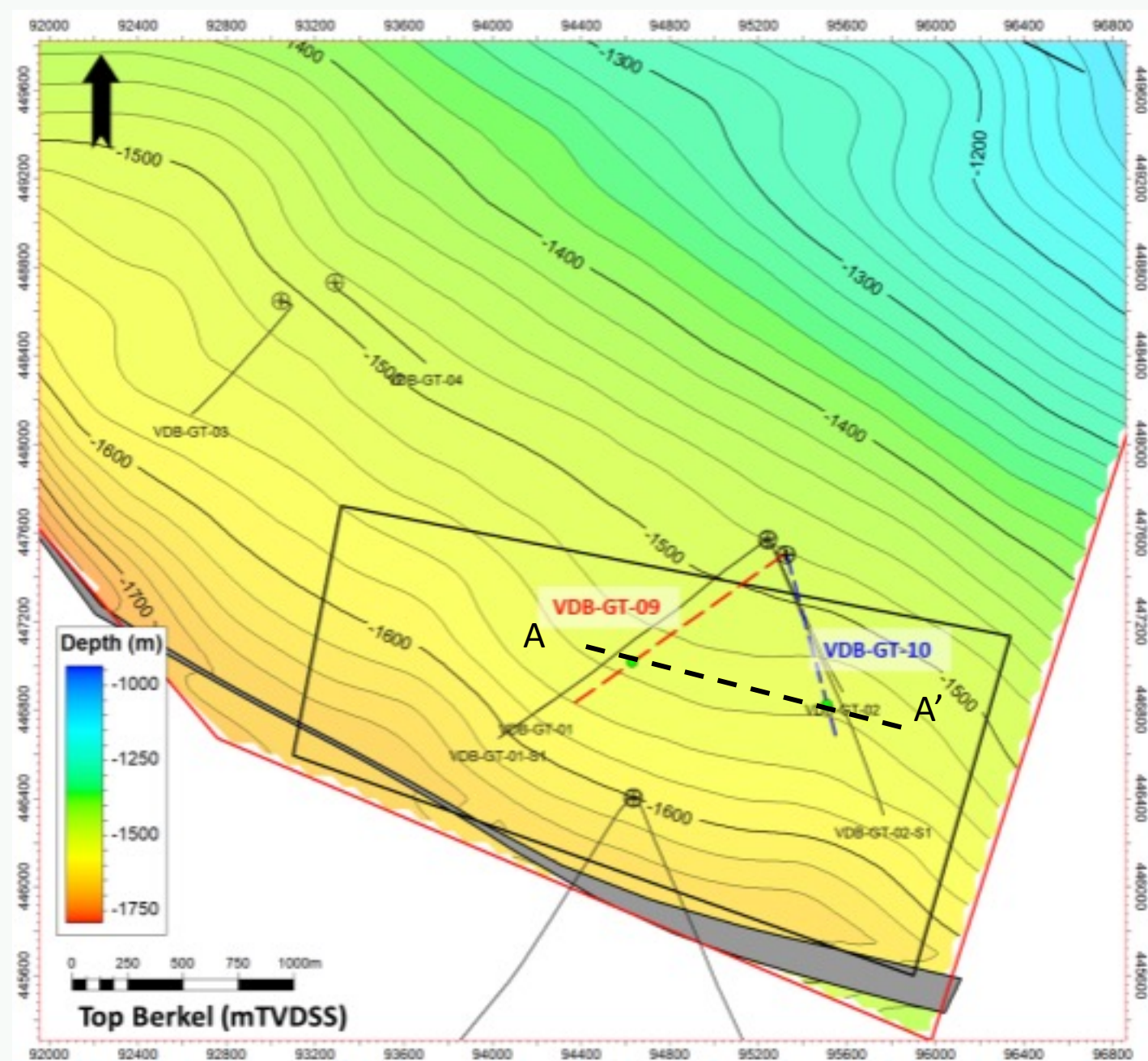
VDB-GT-06



Baseline T-data



Nieuw COOL-IT project op Petuniaweg



Installie van DTS kabel in VDB-GT-10:

- Meten van temperatuursontwikkeling in beide reservoirs boven en onder Rodenrijs Claystone
- Meten van afkoeling in Rodenrijs Claystone
- Beter inzicht in rstour temperatuur op reservoir niveau
- Beter inzicht in waar injectiewater heen gaat



Vragen?