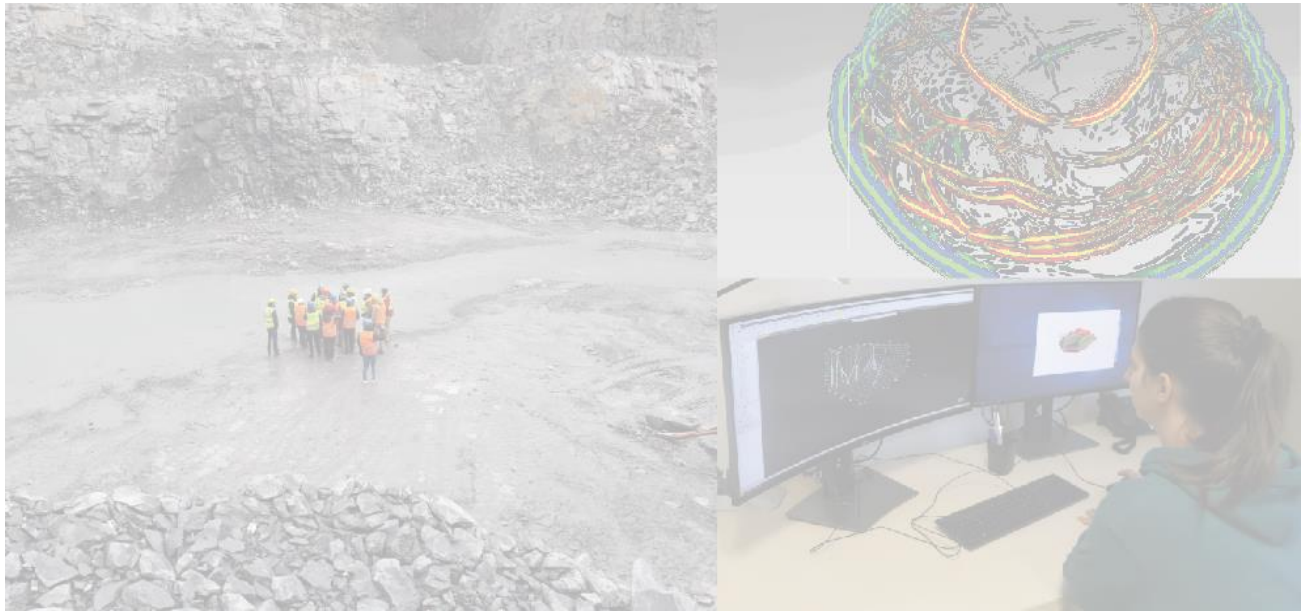


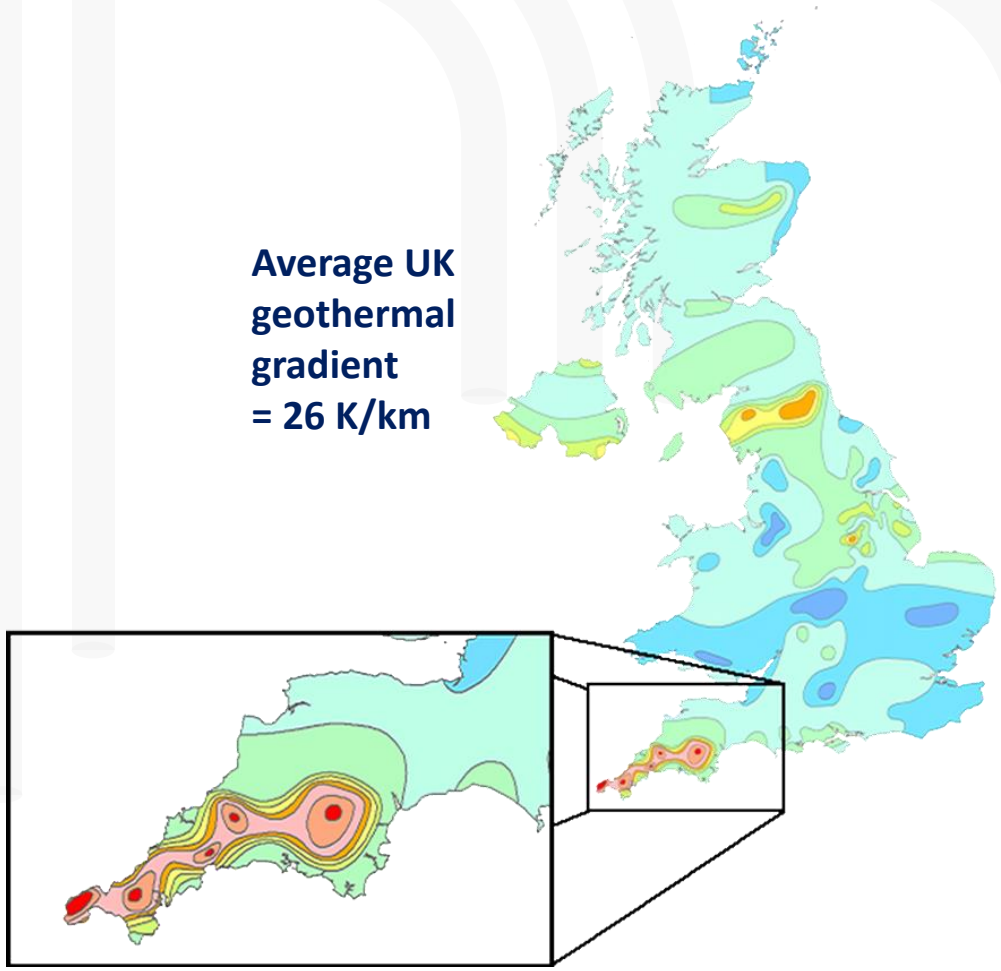
United Downs Deep Geothermal Project, UK

John Reinecker (GeoT)

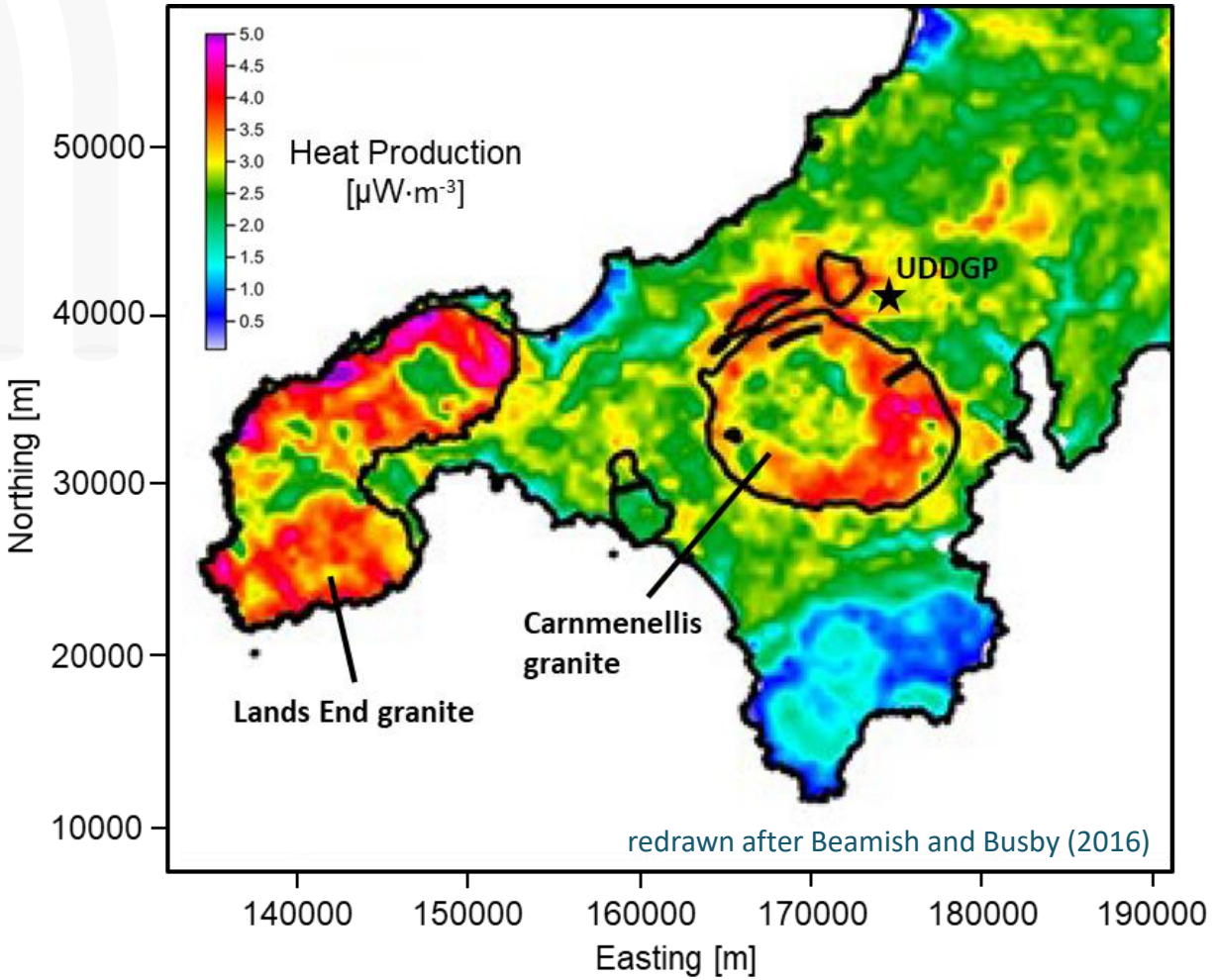
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 792037

Why Geothermal in Cornwall?

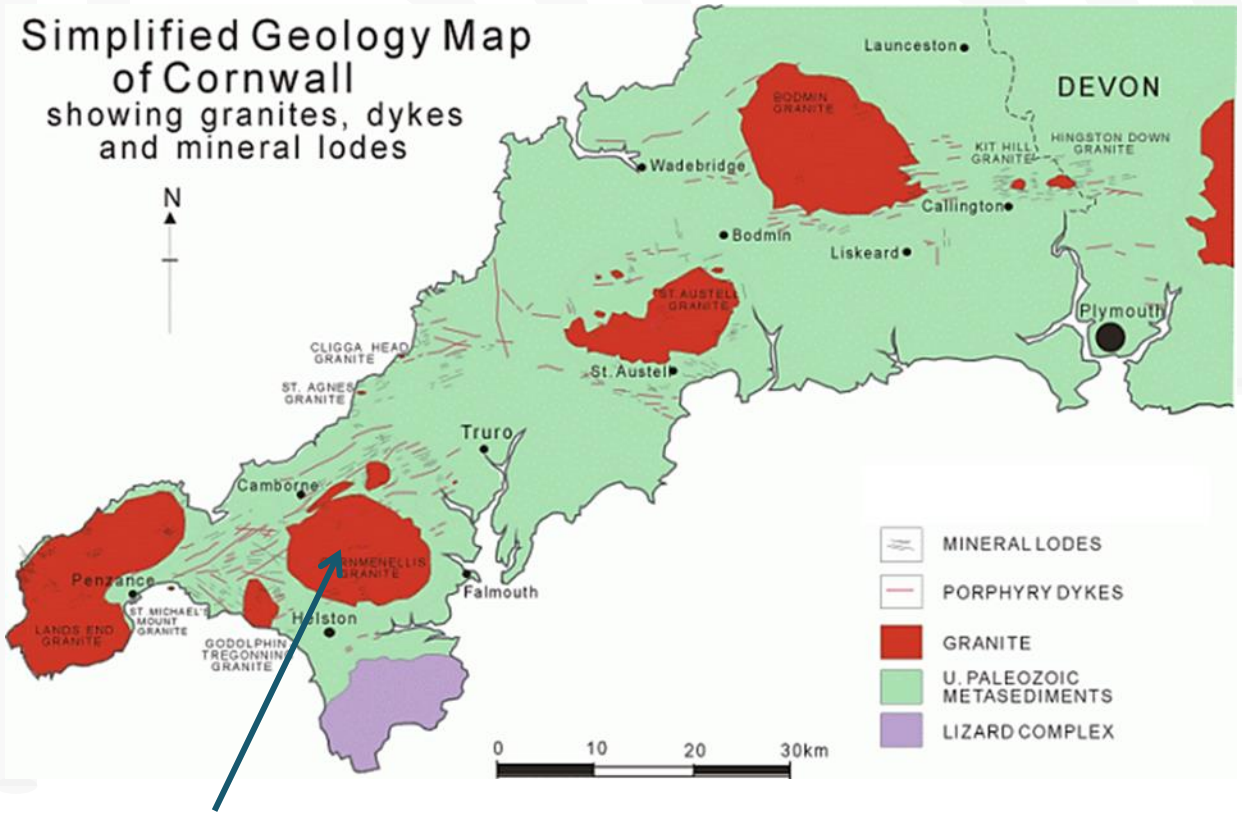
Average UK geothermal gradient = 26 K/km



Geothermal gradient of the Carnmenellis Granite 33-35 K/km

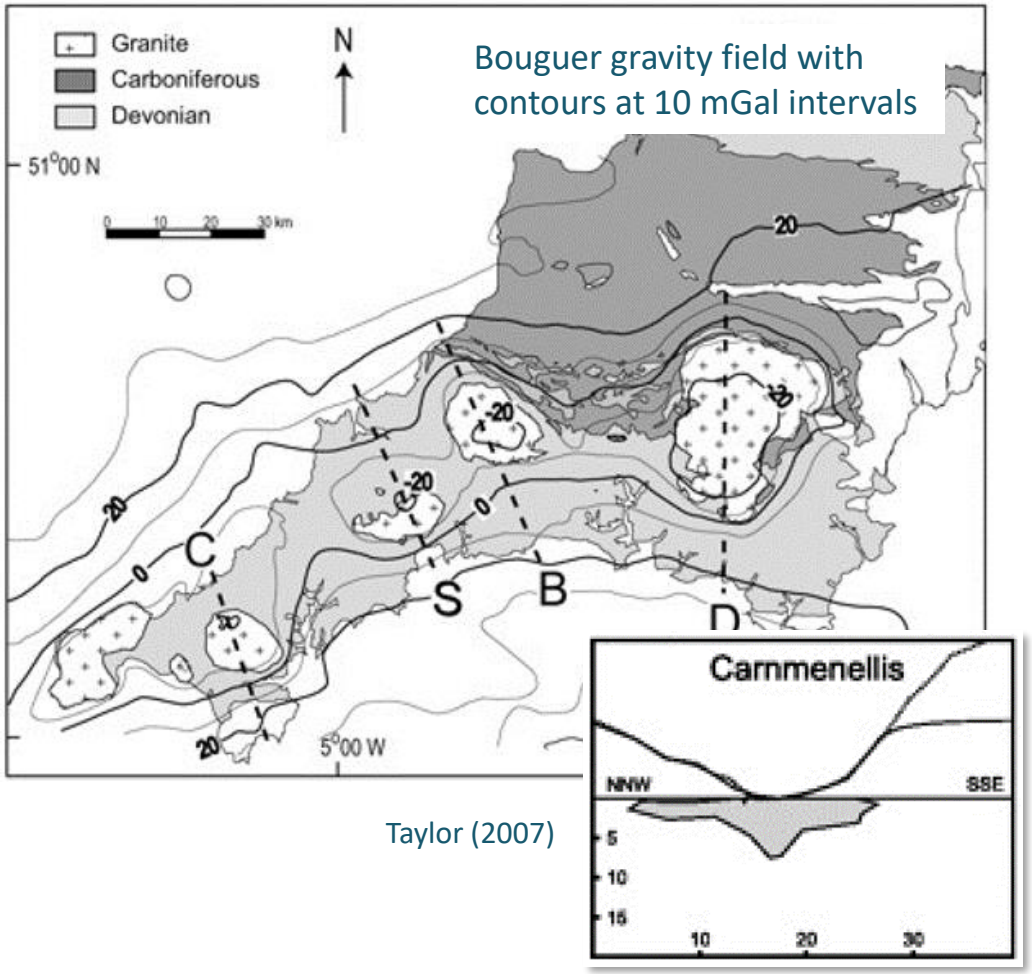


Geology of Cornwall



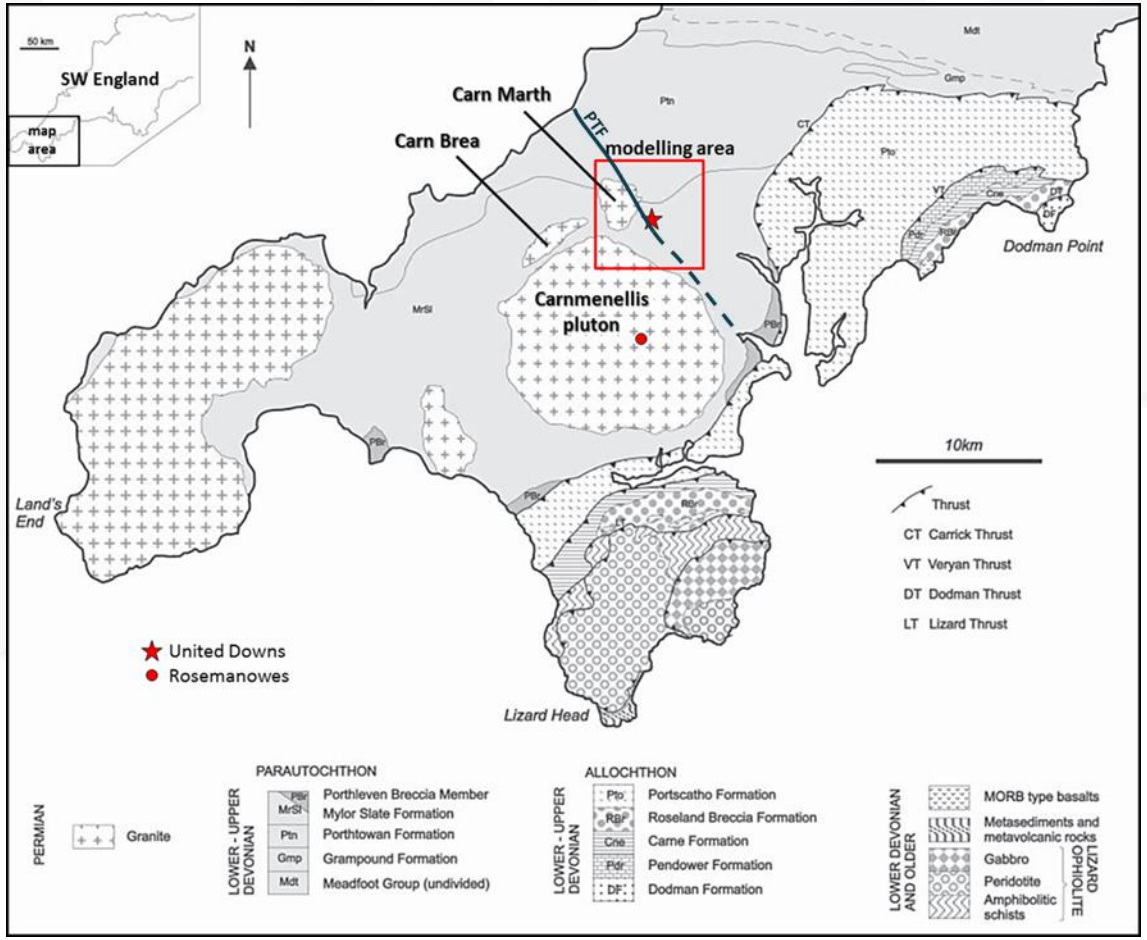
Carnmenellis Pluton

LeBoutillier (2002)

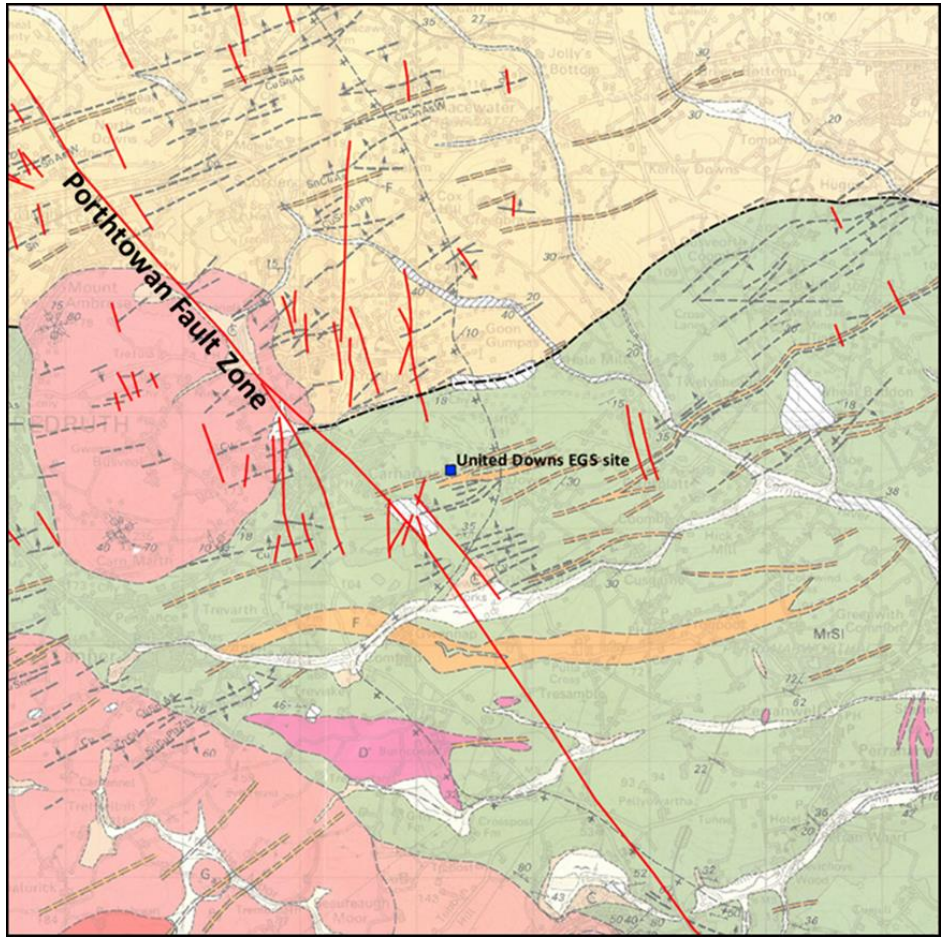


Taylor (2007)

Geology of Cornwall

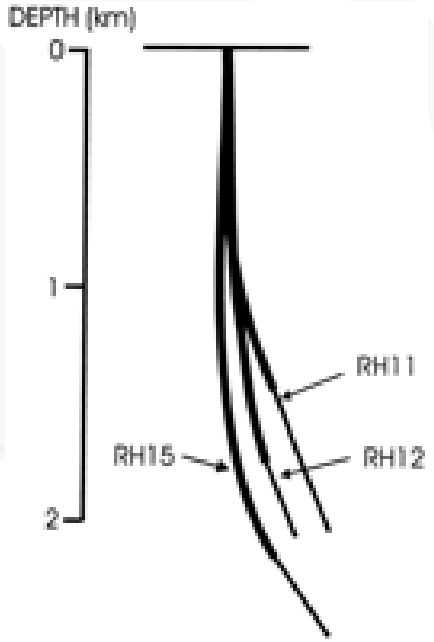


modified from Leveridge and Hartley (2006)



BGS, sheet 352 (Falmouth)

HDR in Cornwall



Rosemanowes, Cornwall, UK 1984

Where:	- Rosemanowes (quarry), near Penryn
Why here:	- Granite with highest heat flow in UK (120 mW/m²)
When:	- 1977 until 1991
Motive:	- 1973 oil crisis
Funding:	- Department of Energy and European Commission
Aim:	- Stimulation of a pre-existing fracture system to hydraulically connect boreholes in hot dry rock
	- Testing a wealth of new methods

UDDGP

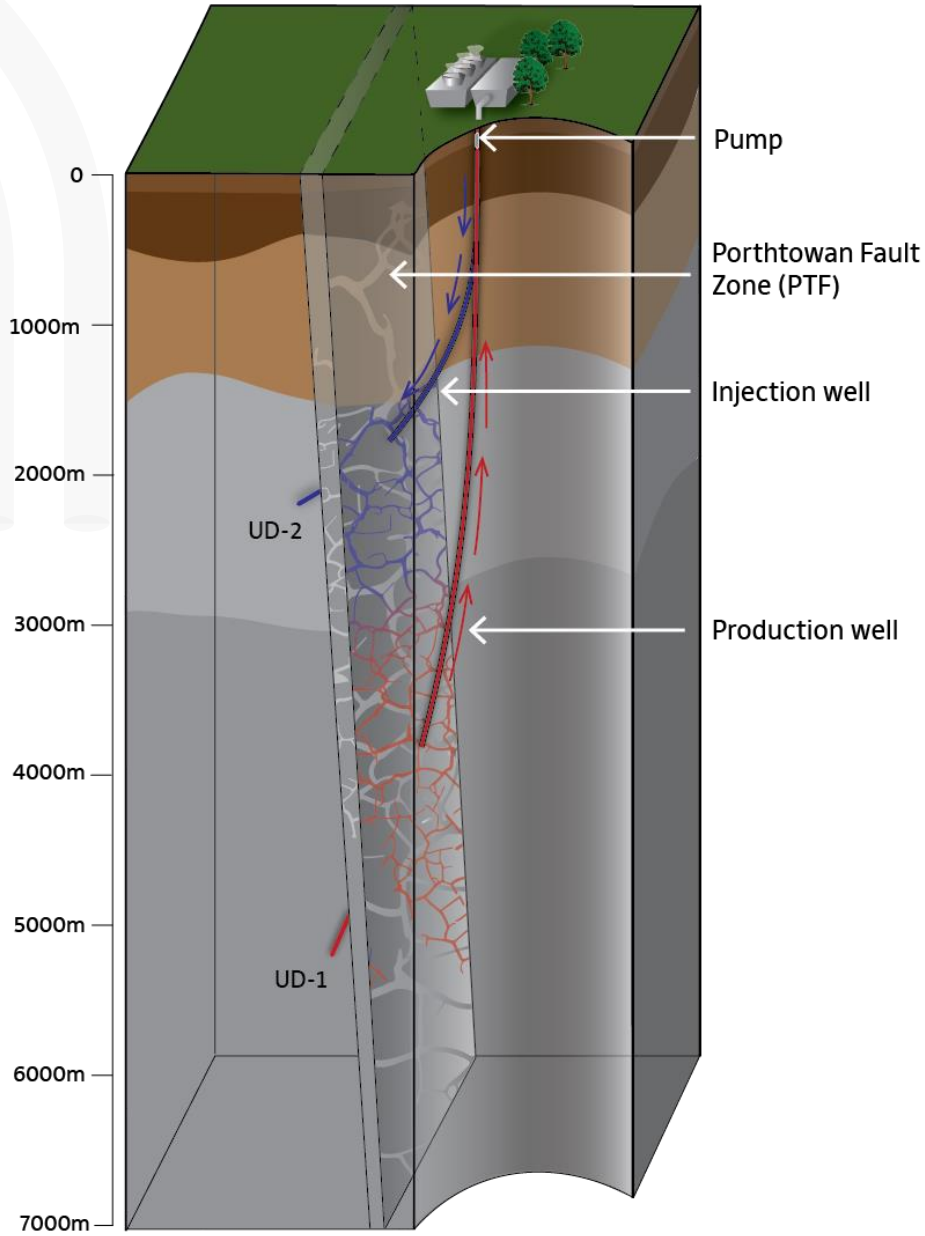
Where: - United Downs (industrial estate), near Redruth
Why here: - Large fault structure, site infrastructure (grid connection)
When: - Since 2009
Motive: - Prove that geothermal power possible in UK
Funding: - Public and private funds including the European Regional Development Fund, Cornwall Council, £5m crowdfund and Thrive Renewables plc.
Developer: - Geothermal Engineering Ltd.

Concept of UDDGP

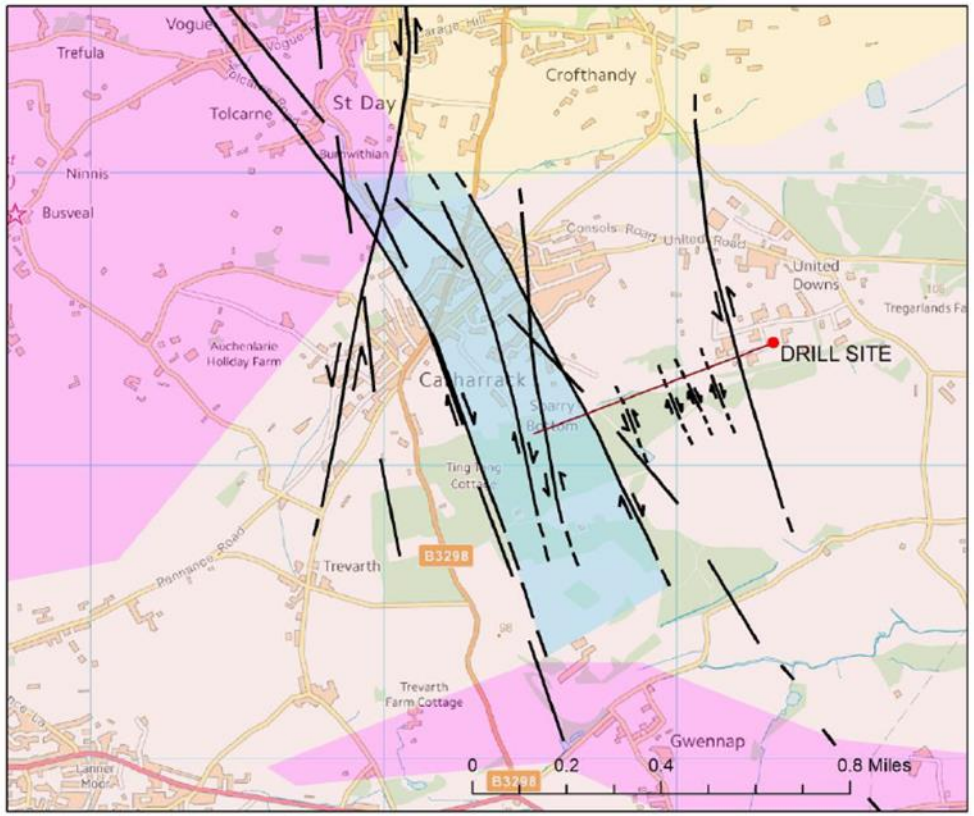
- Injection well – 2500 m
- Production well – 4500 m
- Target structure: Porthtowan Fault Zone
- Temperature of water delivered to surface: 175 °C
- Re-injection temperature: about 80 °C

Open questions:

- How is the reservoir characterised?
- What controls fluid flow in the reservoir?
- Does the natural fracture system have the right characteristics to host a geothermal reservoir?



Concept of UDDGP



Legend

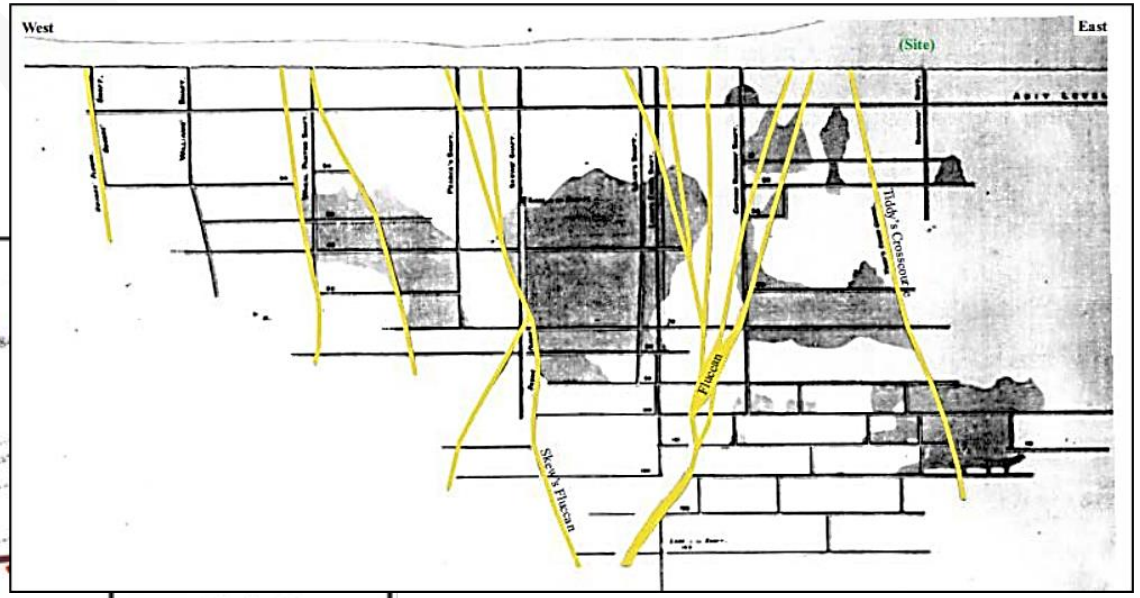
- DRILL SITE
- Drill Trajectory
- Faults (Major)
- Faults
- Porthtowan Fault Zone

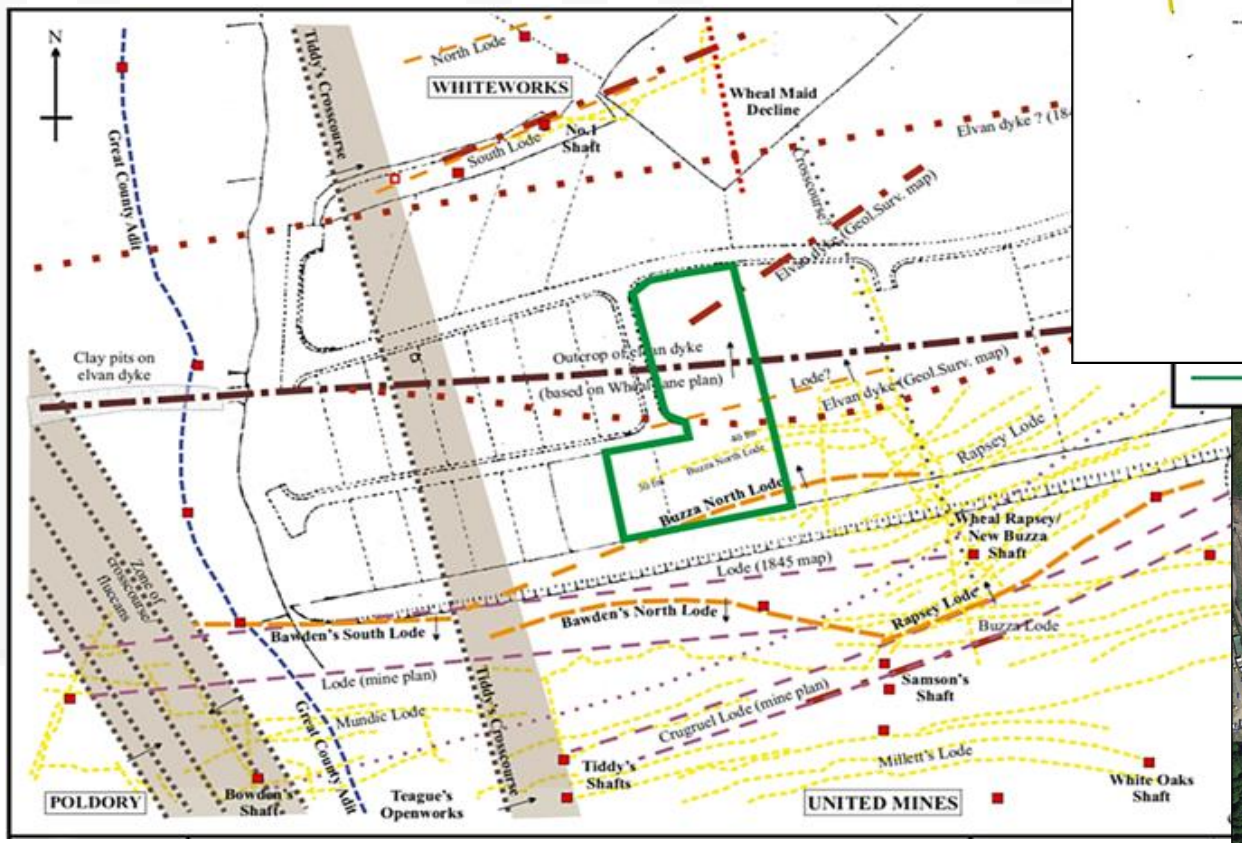
Bedrock Geology

LEX_RCS_I

UNNAMED IGNEOUS INTRUSION, CARBONIFEROUS TO PERMIAN - FELSIC-ROCK	*Uiicp-felsr*
UPPER DEVONIAN ROCKS (UNDIFFERENTIATED) - MUDSTONE, SILTSTONE AND SANDSTONE	*Udev-mdss*
MIDDLE DEVONIAN (UNDIFFERENTIATED) - MUDSTONE, SILTSTONE AND SANDSTONE	*Mdev-mdss*

Drill site


West
East
(Site)
Tiddy's Crosscourse
Flucan
Slee's Flucan


N
North Lode
WHITEWORKS
Wheal Maid Decline
No.1 Shaft
South Lode
Tiddy's Crosscourse
Great County Adit
Elvan dyke ? (18
Crosscourse
Elvan dyke (Geol.Surv. map)
Clay pits on elvan dyke
Outcrop of elvan dyke
(based on Wheal Jane plan)
Lode?
Elvan dyke (Geol.Surv. map)
Rapsey Lode
Buzza North Lode
Wheal Rapsey/ New Buzza Shaft
Lode (1845 map)
Bawden's South Lode
Bawden's North Lode
Rapsey Lode
Buzza Lode
Zone of crosscourse fluccans
Lode (mine plan)
Mundic Lode
Great County Adit
Tiddy's Crosscourse
Samson's Shaft
Crugruel Lode (mine plan)
Millett's Lode
Tiddy's Shafts
White Oaks Shaft
POLDORY
Bowden's Shaft
Teague's Openworks
UNITED MINES
Site boundary


Anmelden
Orchards scrap Yard
The Tuning-shop
Laser Master
United Downs Industrial Park
United Downs Industrial Estate
Tonkin Recovery Ltd (Redruth)
Kernow Storage
Schweißbedarf Cornish Welding Supplies
Pressure Services
Ample Store Storage
Tor Mark Press
GFS Fibreglass
United Mines Recycling Ce
Sparry Ln
3D
Google

Drilling UD-1 and UD-2

UD-1

Drilling started	8th November 2018
December 2018: decision that the first well will be the deep production well	
Drilling finalised	24th April 2019
Total depth: 5,058 m TVD (5,275 m MD)	
UDFT1 production test (airlift)	2nd May 2019

Skid rig by 8 m to drill UD-2

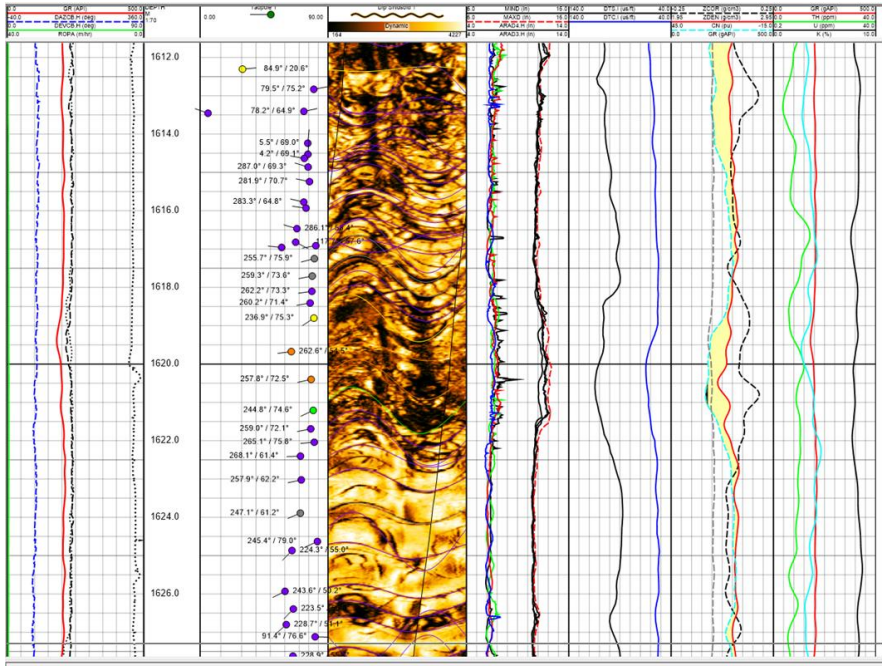
UD-2

Drilling started	11th May 2019
Drilling finalised	28th June 2019
Total depth: 2,214 m TVD (2,393 m MD)	
UDFT2 injection test (with drill pipe in hole)	1st July 2019
UDFT3 injection test (without drill pipe)	2nd July 2019

Demobilise rig

Data from UD-1 and UD-2

	UD-1	UD-2
Well data		
drilling data	x	x
cuttings	x	x
suite of wireline logs	x	
sidewall cores	x (reservoir section)	
PTS	x	
Induced seismicity	x	
Hydraulic test data	x	x



suite of wireline logs:

- spektral GR
- caliper
- denisty
- sonic
- acoustic and resistivity image

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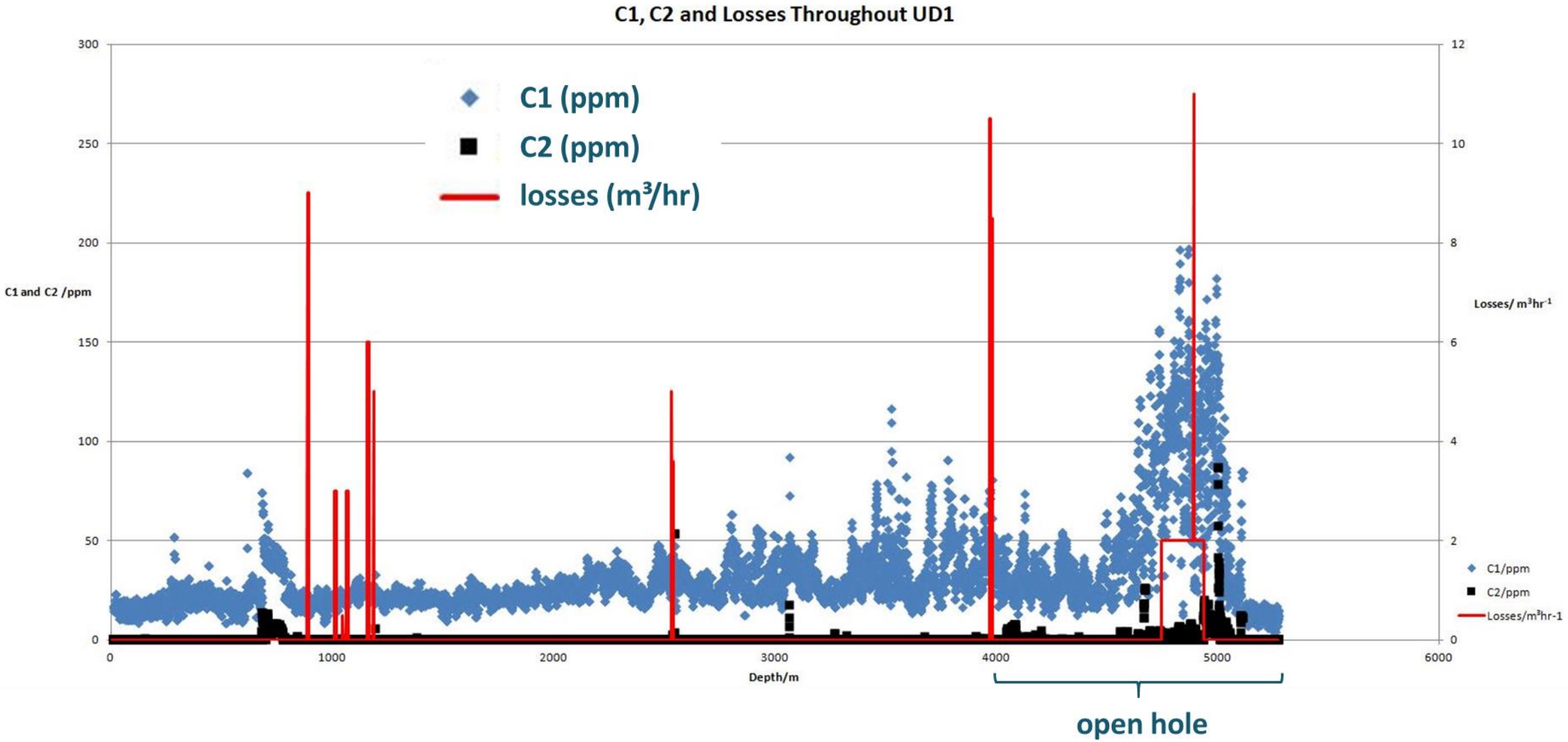
UD-1: Evidence of Permeability at Depth (whilst drilling)



UD-1: Evidence of Permeability at Depth (whilst drilling)

First observations:

- Many fractures (on acoustic image logs)
- Mud losses while drilling
- Induced seismicity
- Hydraulic testing results below expectations

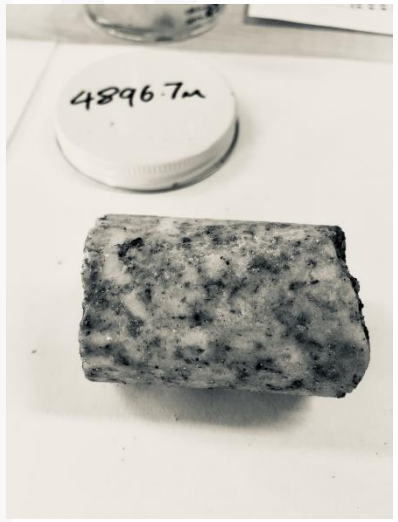
Workover, testing and stimulation of UD-1

Workover including sidewall coring, PTS

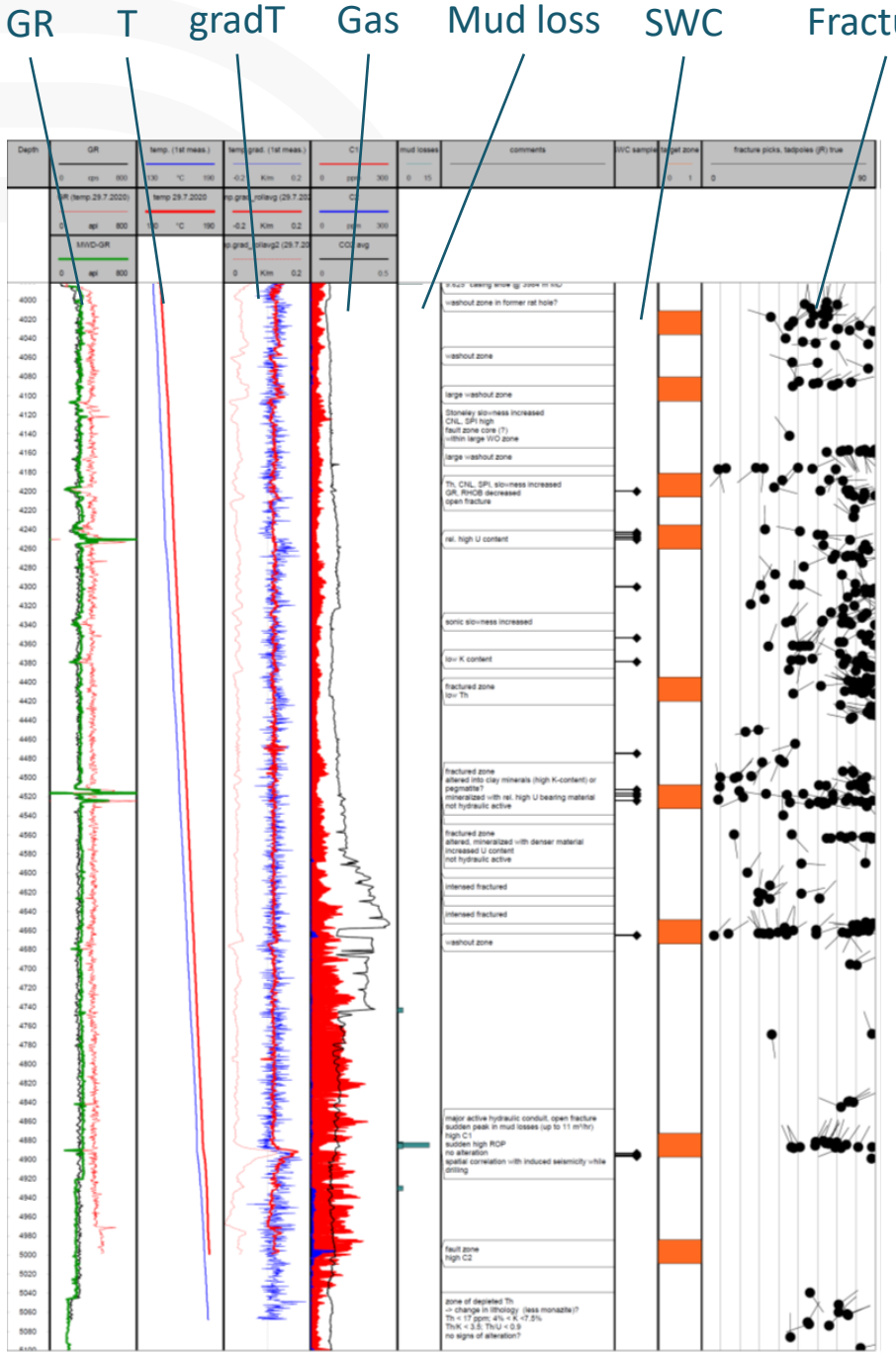
24th July – 4th August 2020

Sidewall coring

- sidewall coring to investigate fracture mineralisation and to test stimulation acid in the lab
- target zones for chemical stimulation



30 SWC were planned
19 SWC could be retrieved

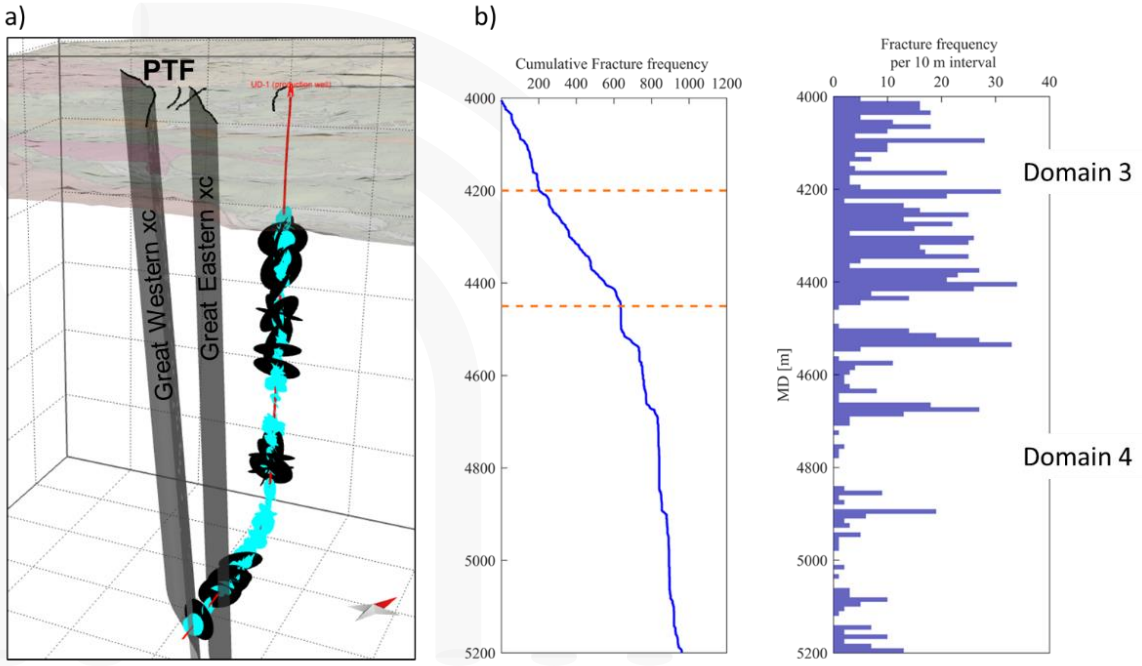


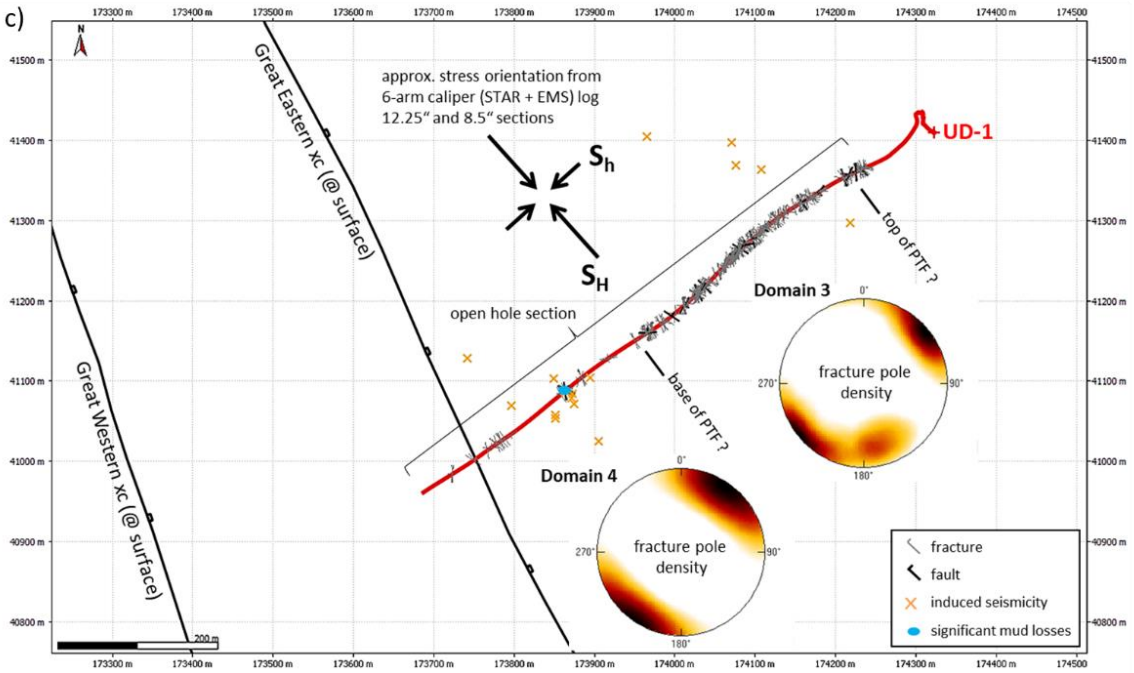
Sample locations defined using:
- temperature log,
- gamma log
- mud losses,
- gas influx,
- drilling breaks and
- fracture density and UXPL log

Targets:
- all granite varieties
- open fracture zones
- mineralized fracture zones

Risks to be avoided:
- doglegs
- borehole breakouts or washouts
- open fractures

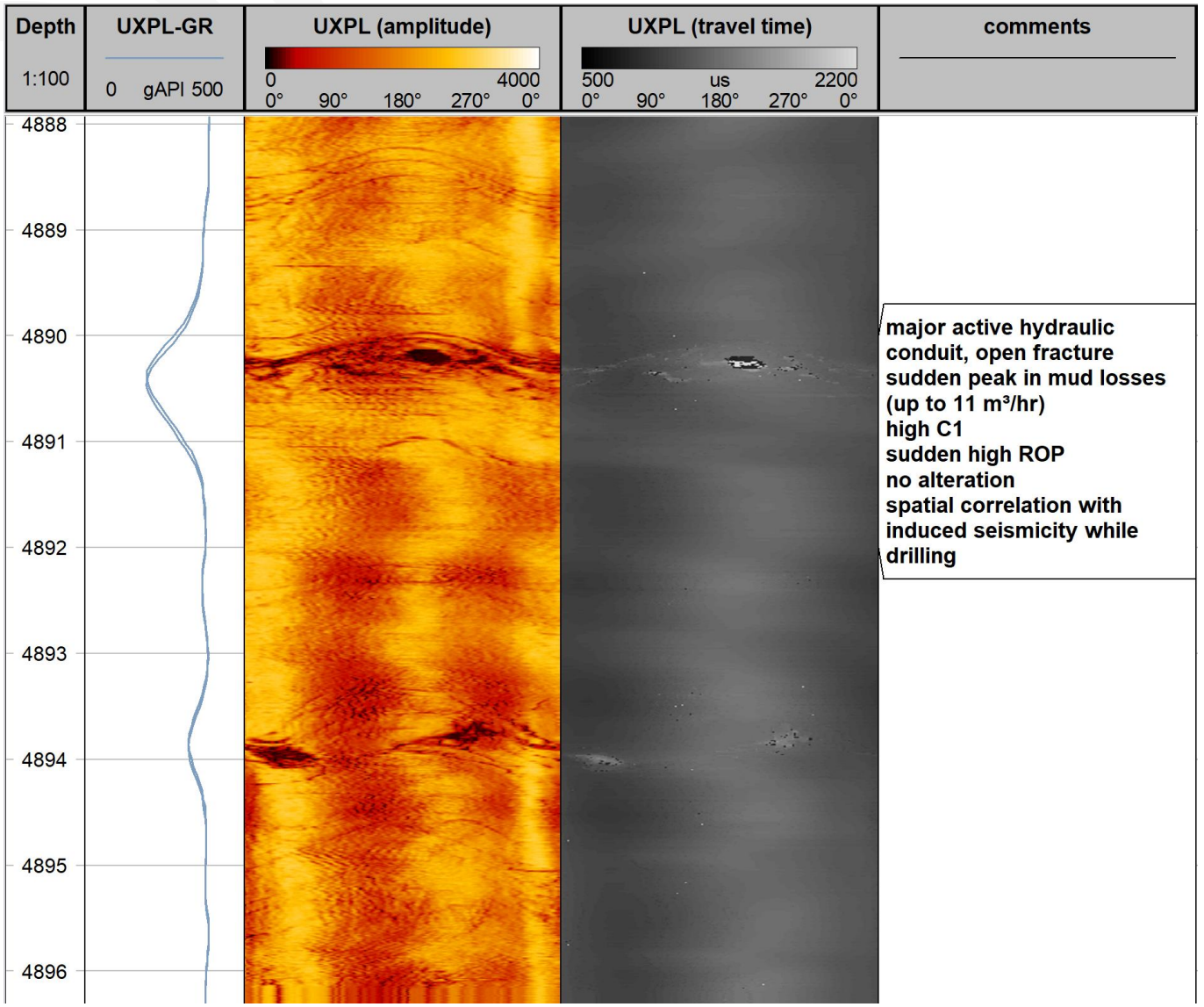
Fracture Network





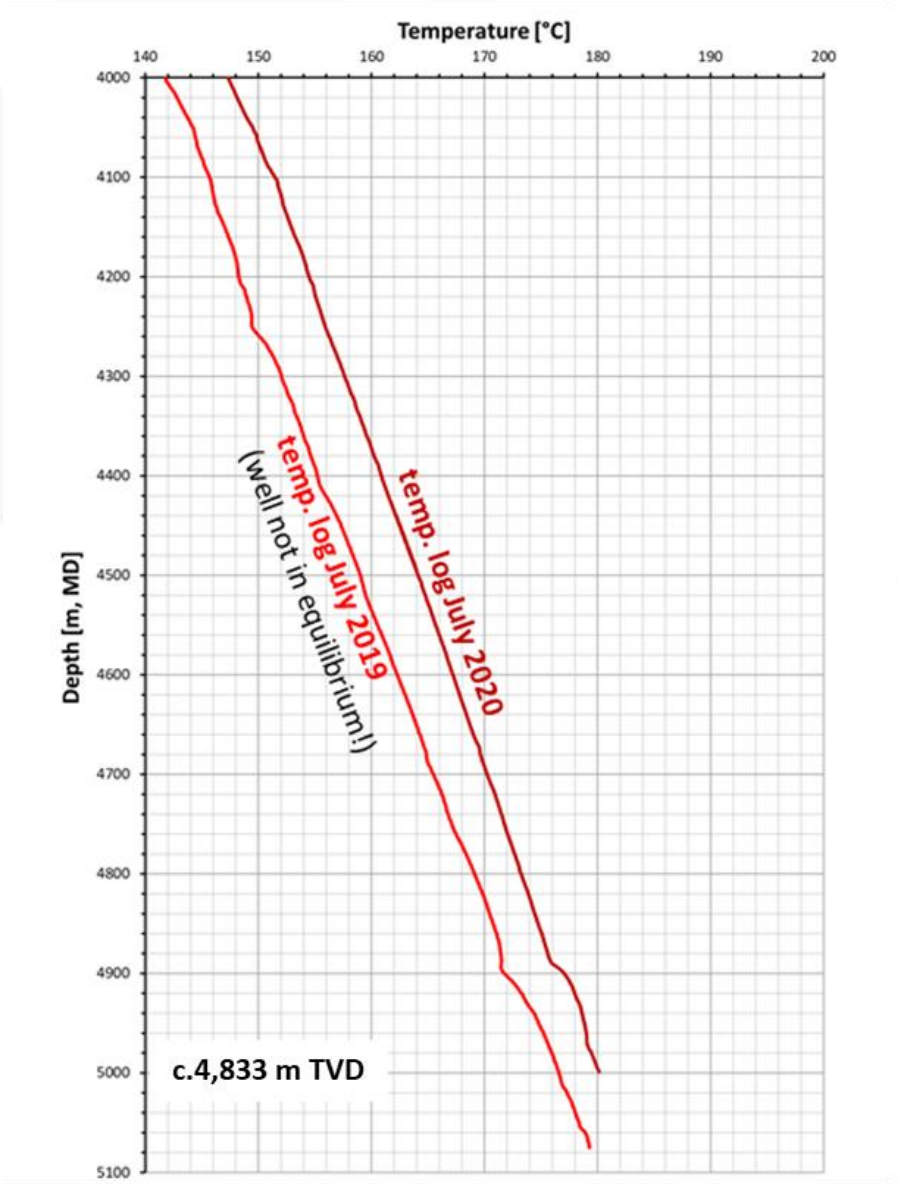
Reinecker et al. (in prep)

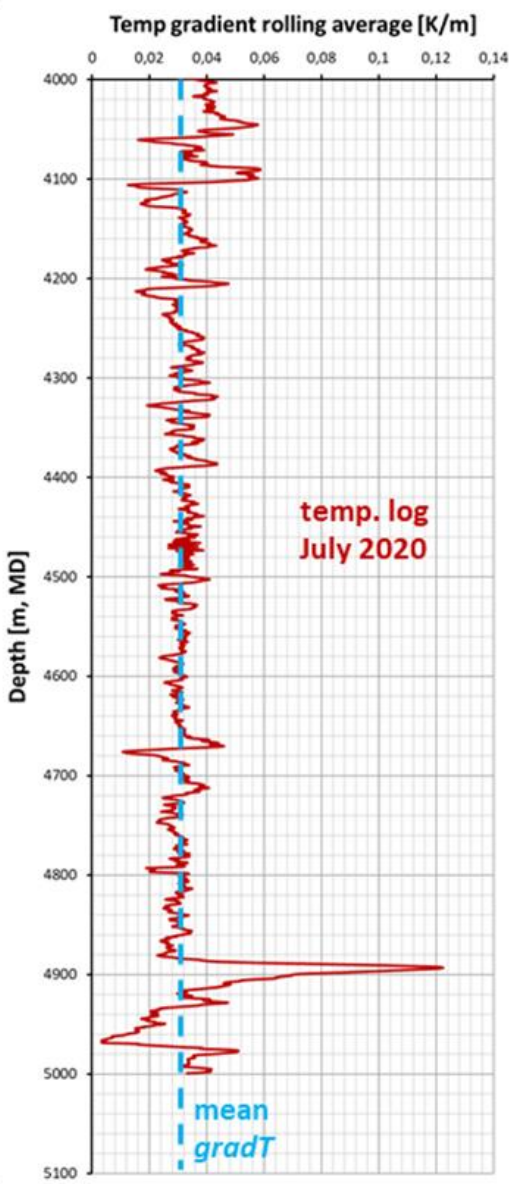
Main Hydraulic Zone (UD-1)



Geothermal Gradient

max. temperature recorded:
180 °C @ 4,833 m TVD



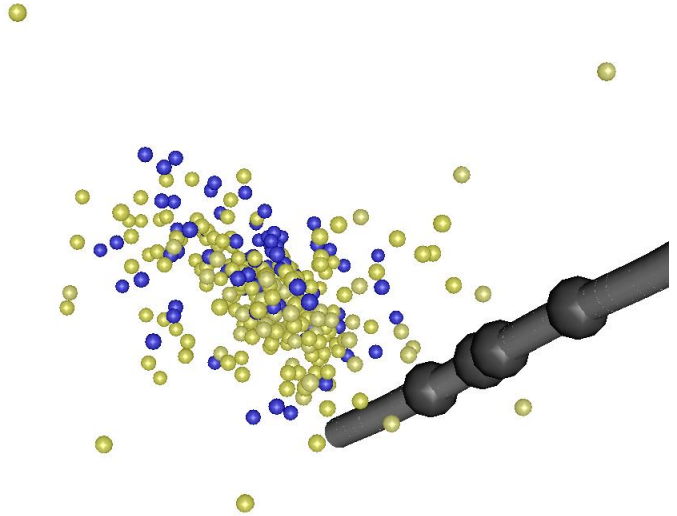


Induced Seismicity

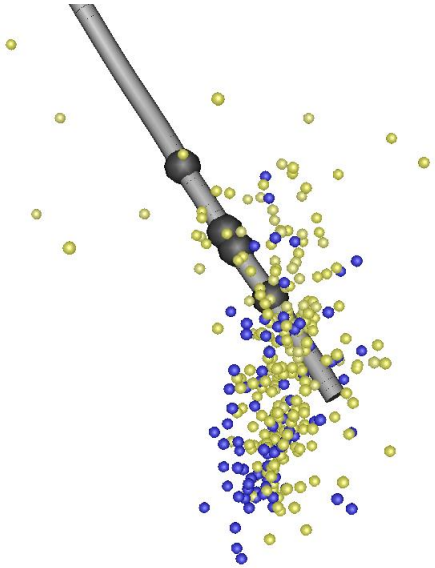
Seismicity prior to low flow rate injections in yellow.

During low rate injections blue.

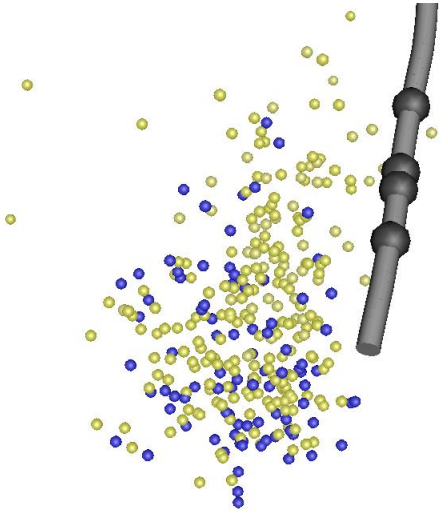
Map view



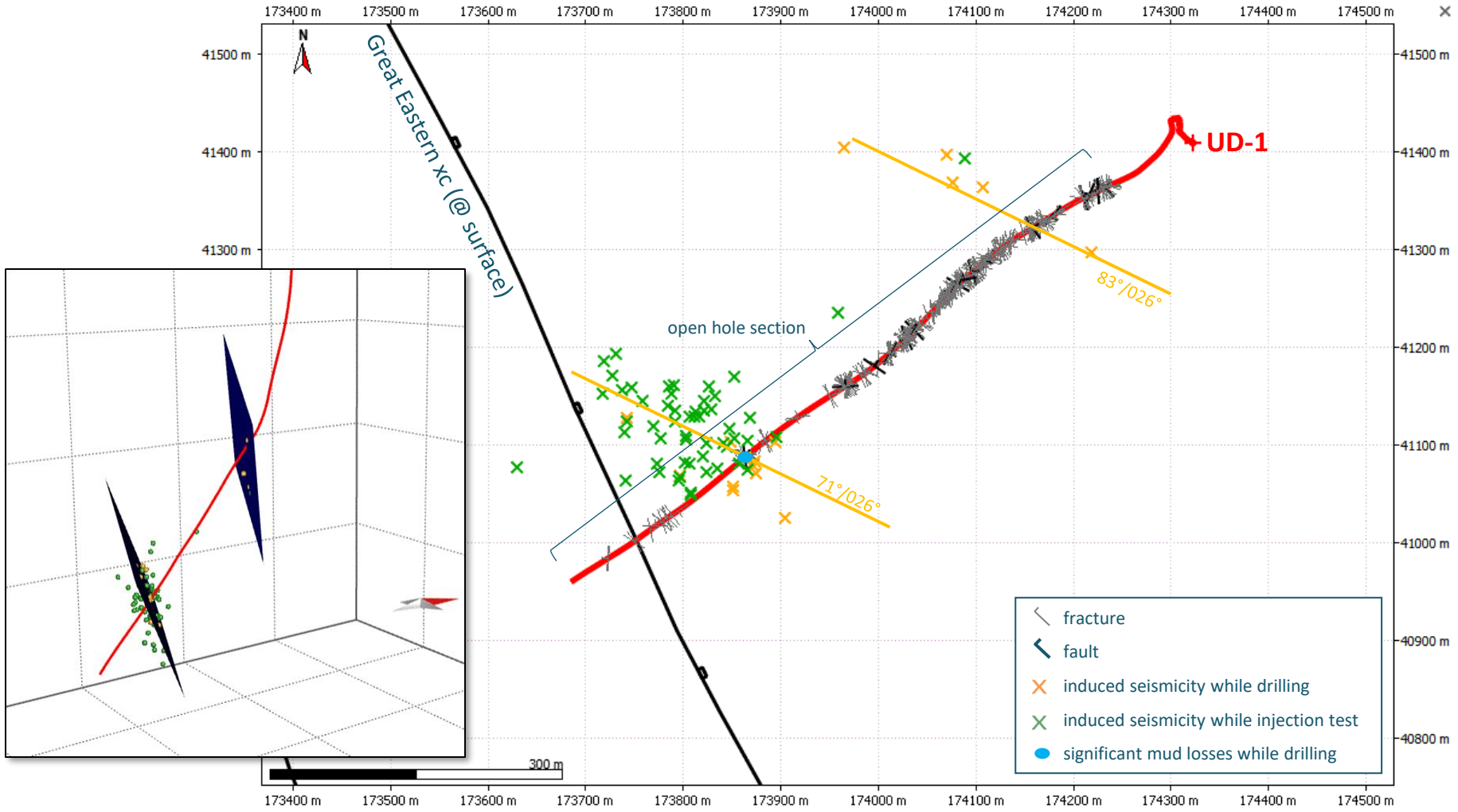
Side view – 305°



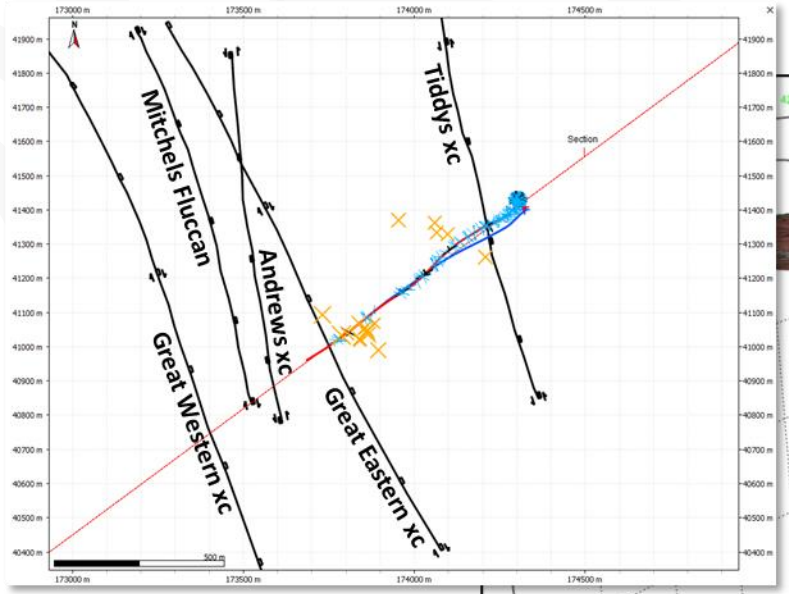
Side view – 215°

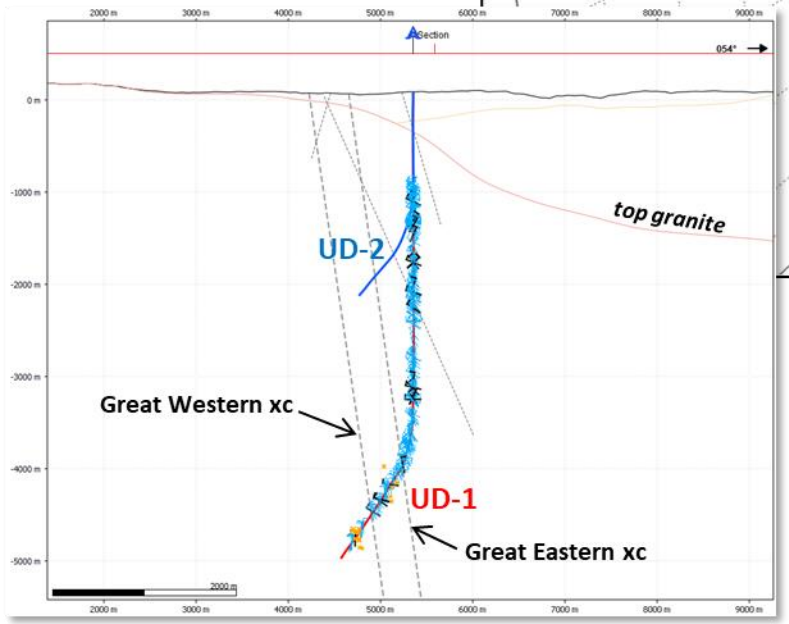


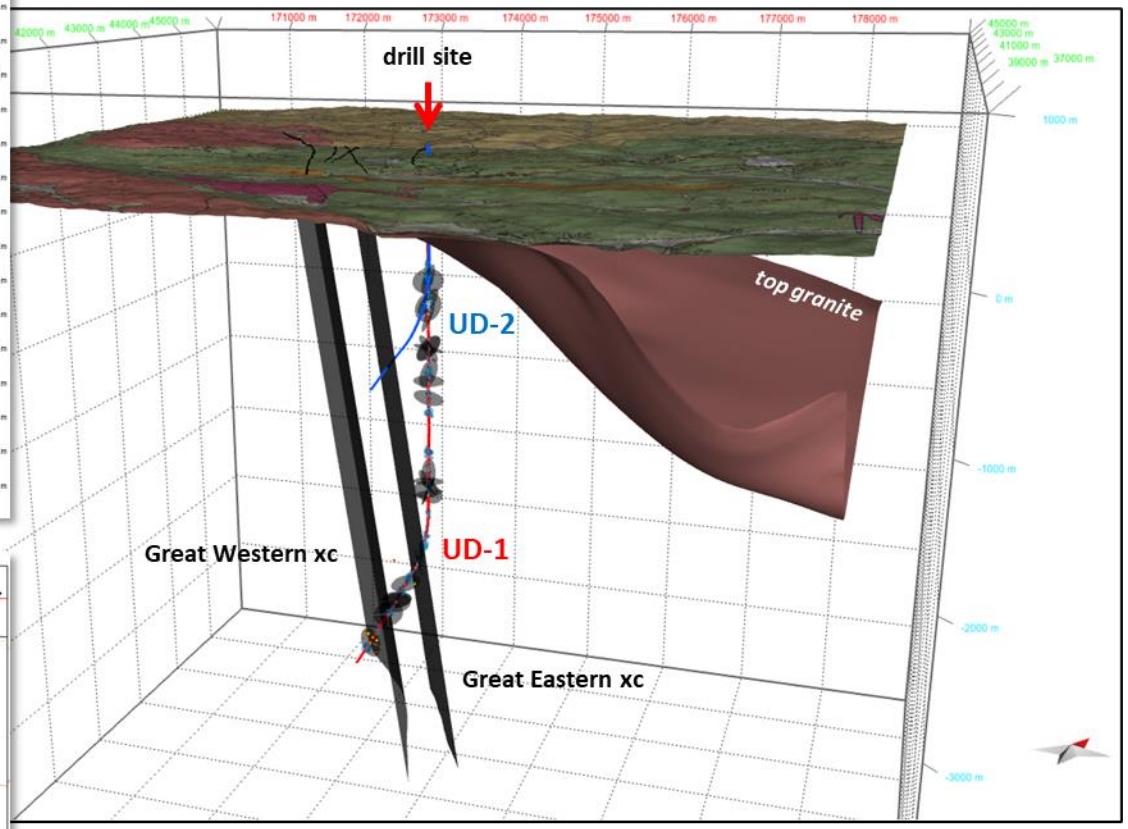
Induced Seismicity



Reservoir Model







open fracture
fault
induced seismicity

Next Steps

- Injection test UD-2 (February/March)
- Circulation test with ESP installed in UD-1 (April/May)
- Chemical treatment in UD-1 (June) [MEET]
- Power plant online Q2 2022

Geothermal Winter School 2021

Thank you very much for your attention

S4CE Science4CleanEnergy

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No. 764810

MEET Multi-sites EGS Demonstration

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No. 792037

UNITED DOWNS DEEP GEOTHERMAL POWER

GEL GEOTHERMAL ENGINEERING LIMITED

GeoScience Limited