

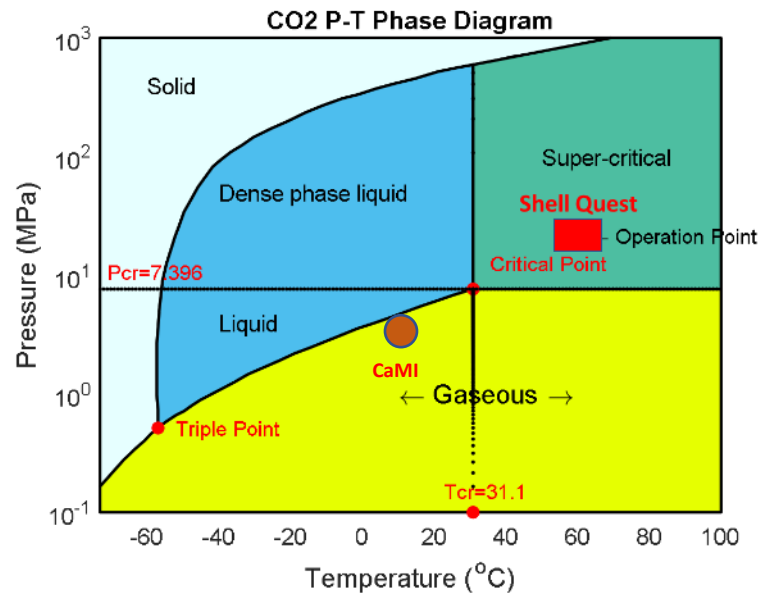
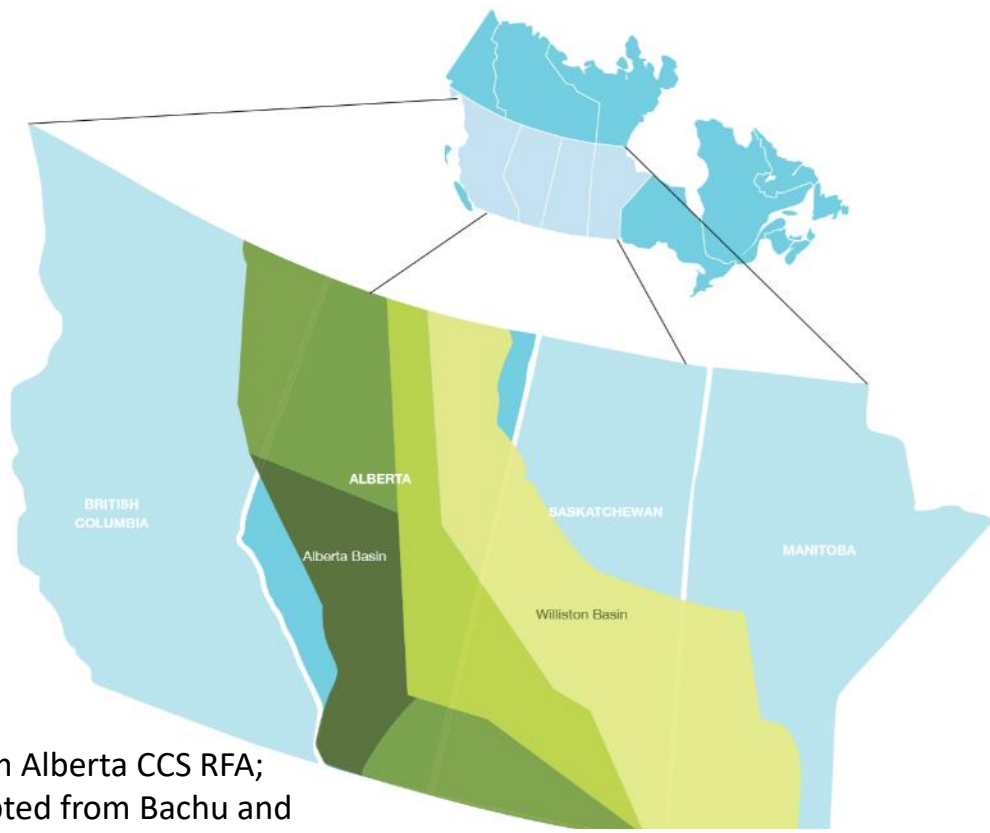


Part II: the CMC-Containment and Monitoring Institute (CaMI) Field Research Station

Don C. Lawton and the CaMI team
CMC Research Institutes Inc and the University of Calgary
Don.Lawton@cmcghg.com; lawton@ucalgary.ca

April 14, 2021

CCS in western Canada (depth > 1 km)



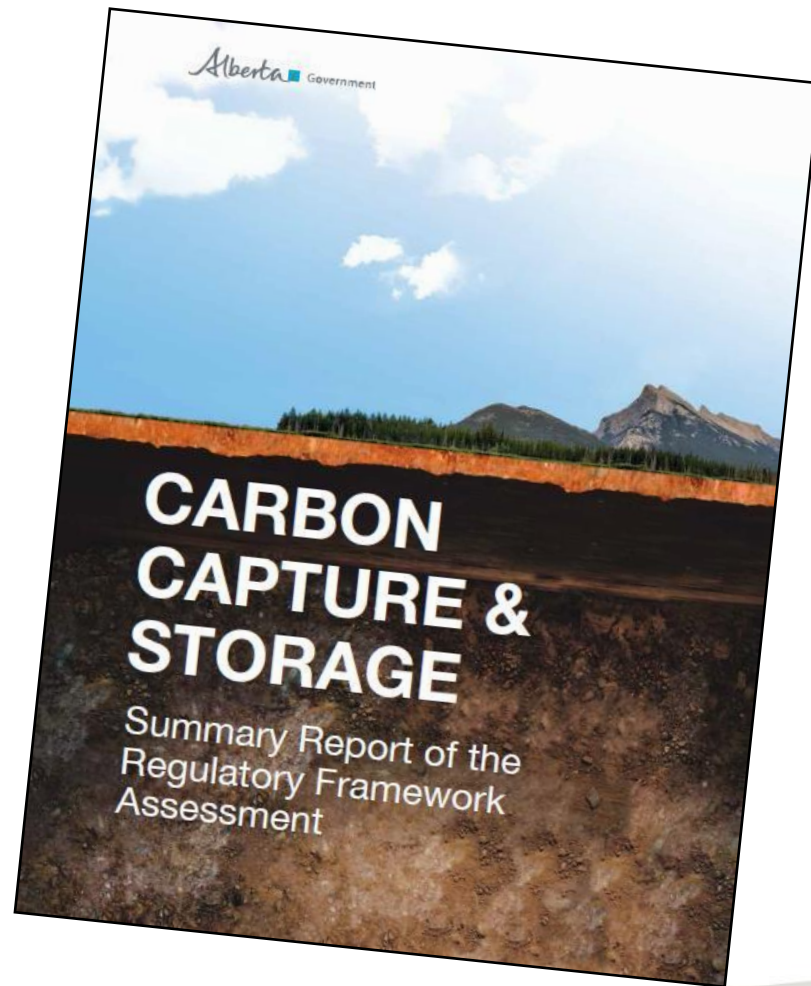
(from Alberta CCS RFA; adapted from Bachu and Stewart, 2002)



Government of Alberta Regulatory Framework Assessment (RFA)

(August 2013)

**ALBERTA REGULATION 68/2011
Mines and Minerals Act
CARBON SEQUESTRATION TENURE REGULATION**

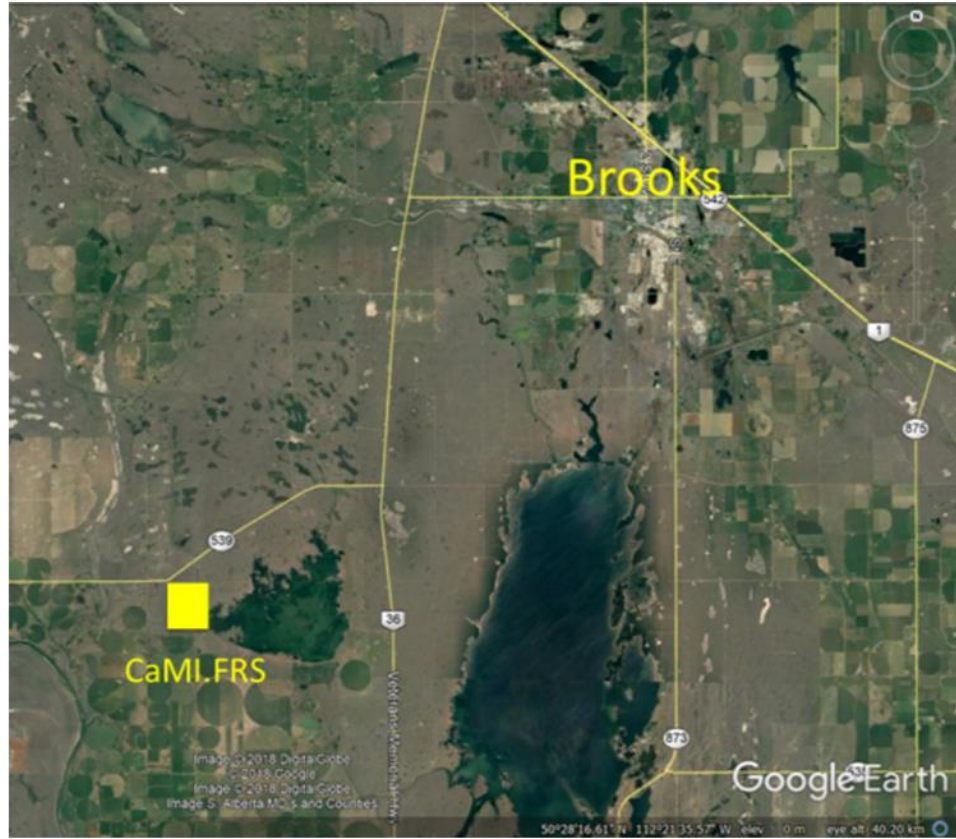
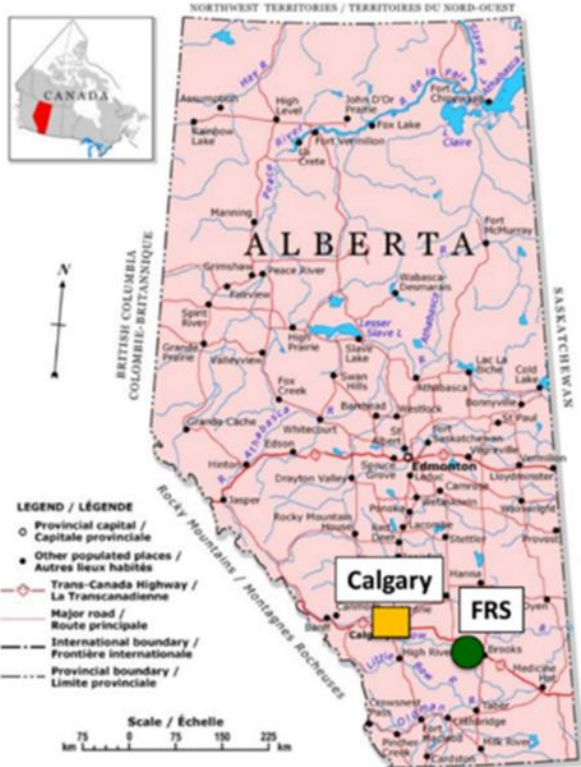


“Require MMV and closure plans to be based on a project-specific risk assessment, and include the use of best available technologies to monitor the atmosphere, surface, ground and surface water, and subsurface.”

CaMI.FRS location



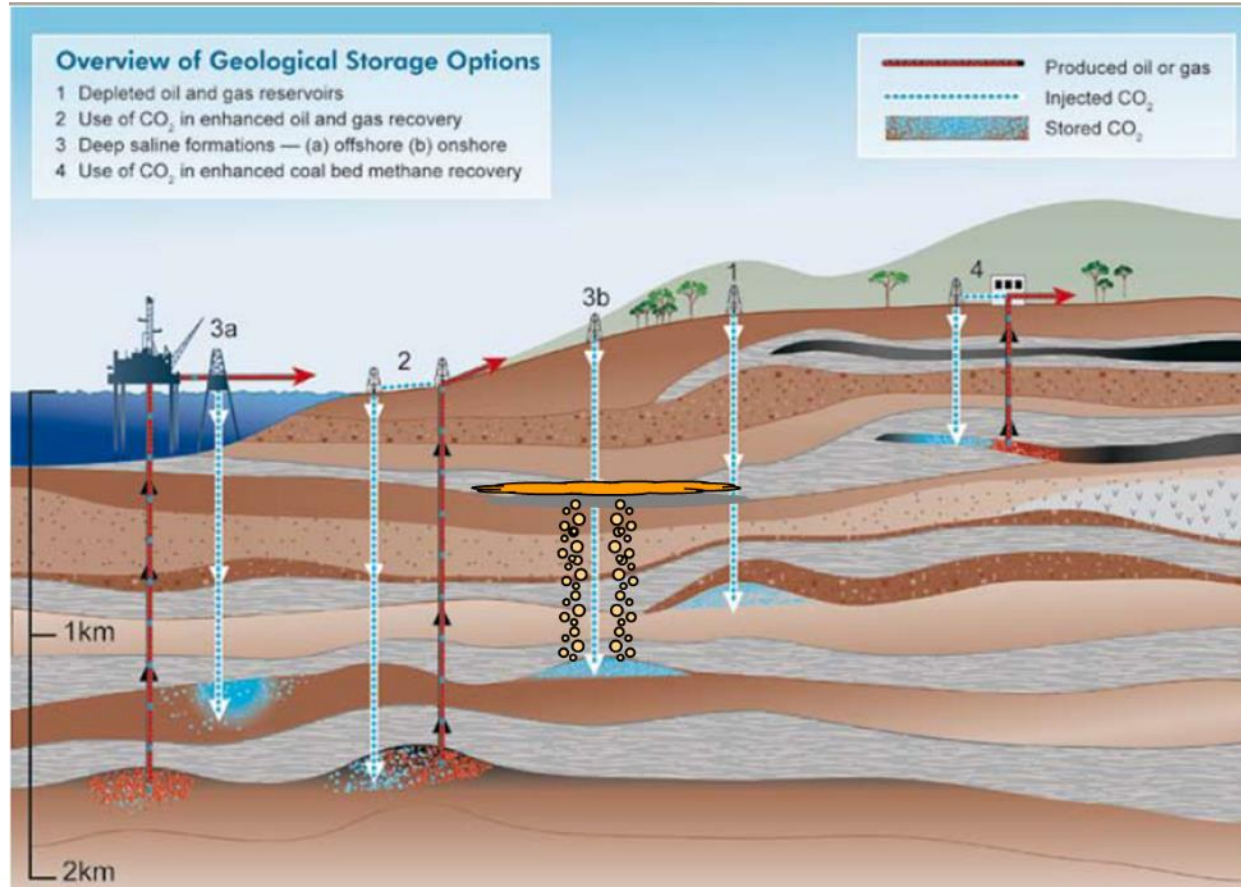
UNIVERSITY OF
CALGARY



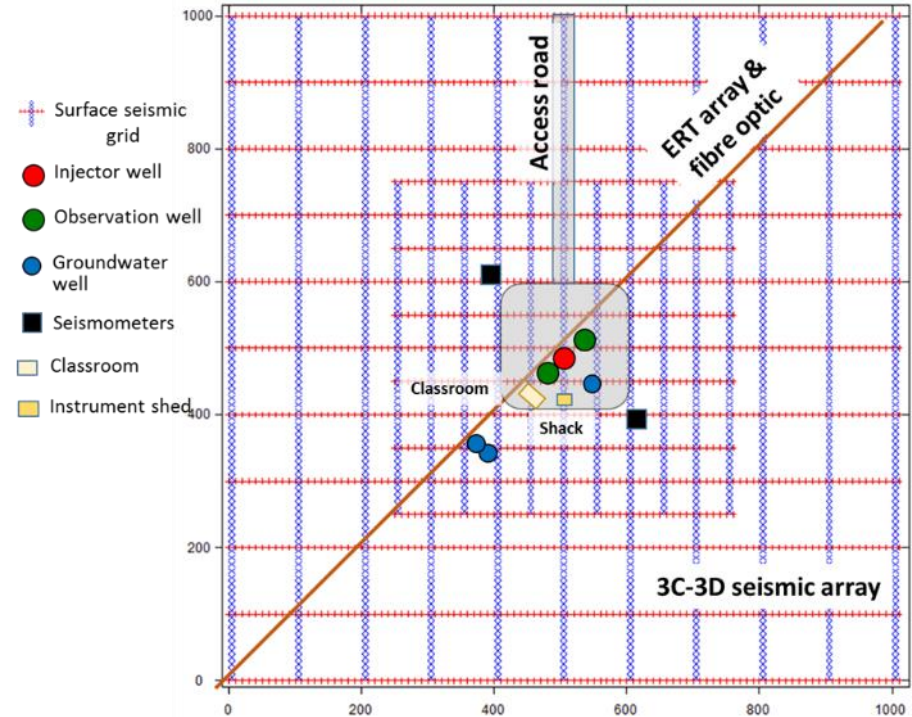
- A site for development and validation of MMV technologies for CO₂ storage containment and conformance
- Focused on methods for early detection of CO₂ leaking from a deep storage reservoir
- Determine the CO₂ detection threshold at a depth of 300 m
- Develop reservoir, caprock and overburden surveillance technologies
- Monitor for CO₂ migration at shallow to intermediate depths and impacts on groundwater



CaMI.FRS goals



CaMI Field Research Station (FRS)



Operations room and classroom

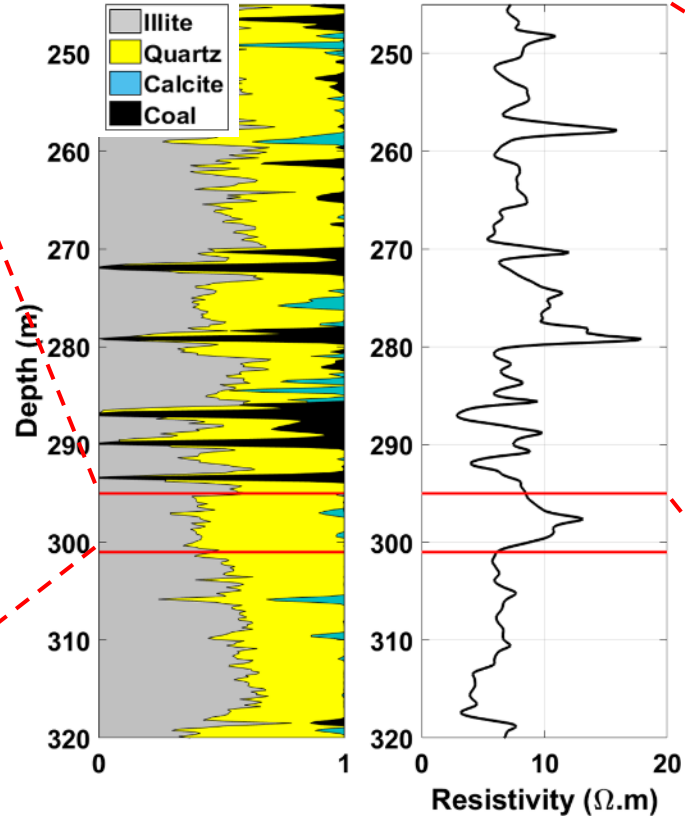


Lithology of the CaMI.FRS storage complex

Reservoir



Basal Belly River Sst



Seal



Foremost Fm

Continuous

- Downhole pressure & temperature
- DTS
- Electrical resistivity tomography (ERT)
- Well-based and surface-based microseismicity

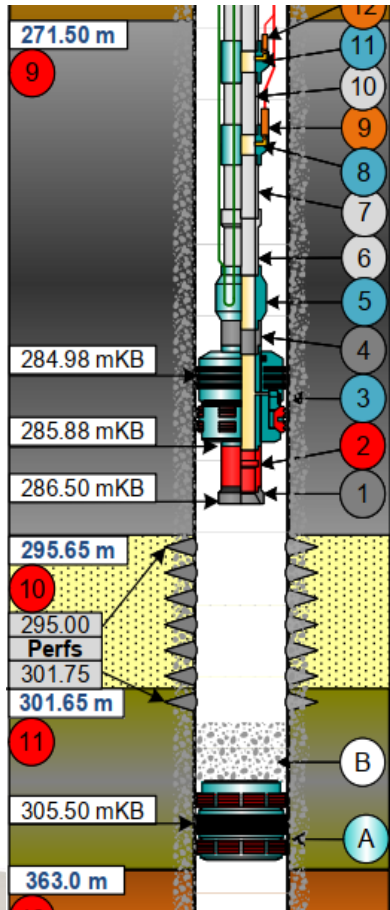
Periodic - geophysics

- Borehole and surface seismic
- Borehole and surface DAS
- Cross-well seismic and electromagnetic surveys
- Surface-borehole electromagnetic surveys
- Magnetometric resistivity surveys: MMR
- Time-domain electromagnetic surveys
- Well-logs : pulsed neutron, sonic, induction

Periodic - geochem

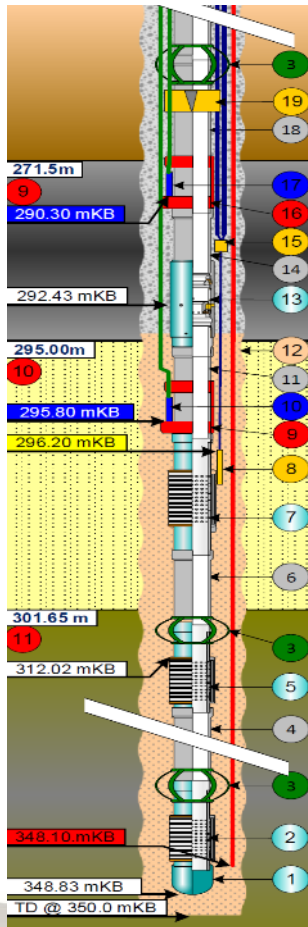
- Groundwater sampling from wells
- Soil gas (CO₂ and CH₄) monitoring
- Surface casing vent flow monitoring
- Observation well fluid sampling and analysis
- Tracer studies including noble gases
- Atmospheric methane detection

CaMI.FRS Injection well



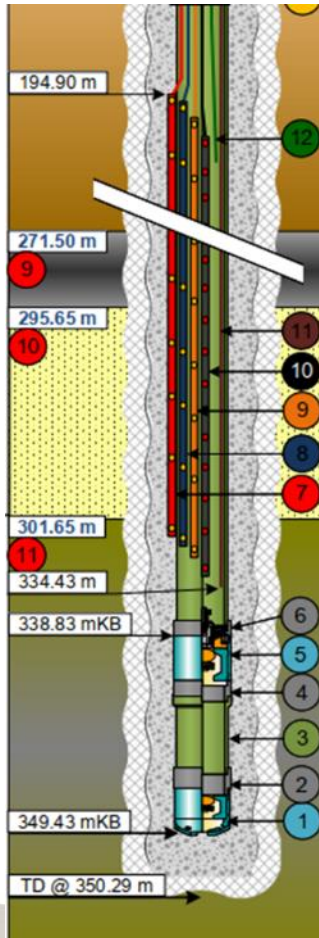
- Instrumentation;
 - U-Tube capillary line for fiber optic (DTS)
 - Redundant (tandem) piezo P-T gauges above the packer
- Instruments terminate above the packer for completion and packer selection simplicity
- Casing across the formation is 13 CR-80 material for added corrosion resistance
- The packer and completion accessories are treated with ENC (Electroless Nickel Coating) for corrosion resistance
- Uses a conventional hydraulic set, retrievable packer, also ENC treated
- Annulus filled with inhibited fresh water

CaMI.FRS Observation well #1 (geochem)

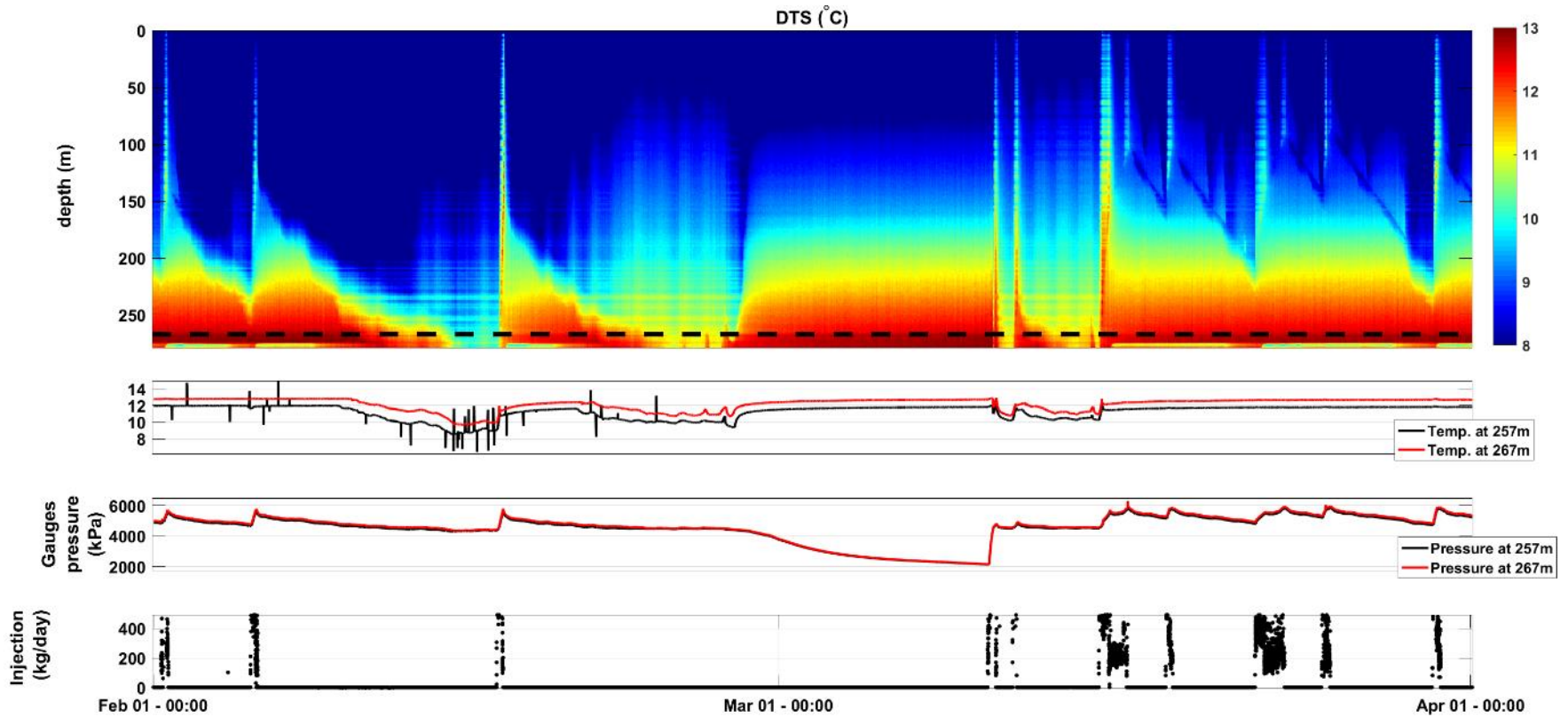


- 350 m deep
- Steel casing
- Screens across reservoir zone
- Uncemented sand pack 295 m – TD
- PT gauges in uncemented sand pack
- Above zone PT gauges outside casing
- Stainless steel capillary U-tube for reservoir samples
- Integrated fibre optic cable pack (DAS, DTS)
- Heat-pulse cable
- Well accessible for wireline tools

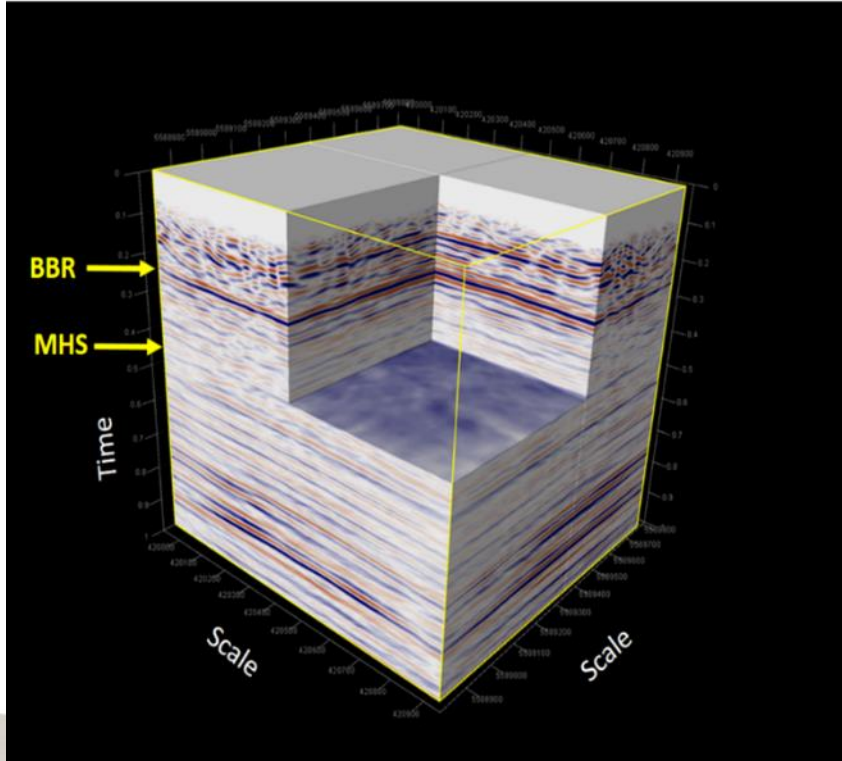
CaMI.FRS Observation well #2 (geophysics)



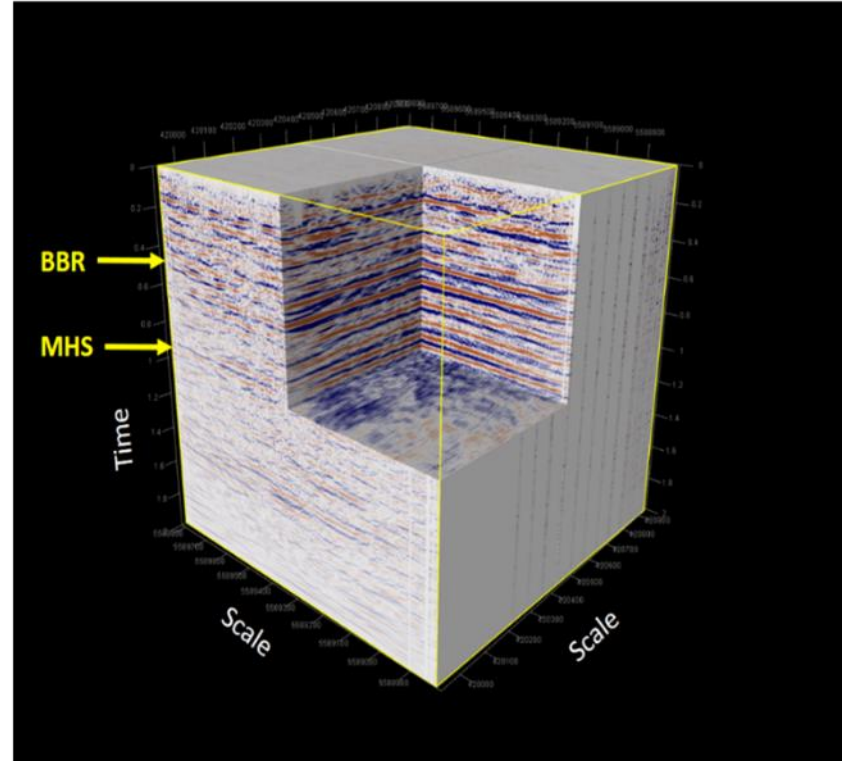
- 350 m deep
- Fibreglass casing
- Integrated fibre optic cable pack (DAS, DTS)
- Heat-pulse cable
- Experimental helical-wound DAS cable
- 16-level electrical resistivity cable (ERT) @ 5 m intervals outside casing
- 24-level 3C geophone array @ 5 m intervals outside casing
- Well accessible for wireline tools



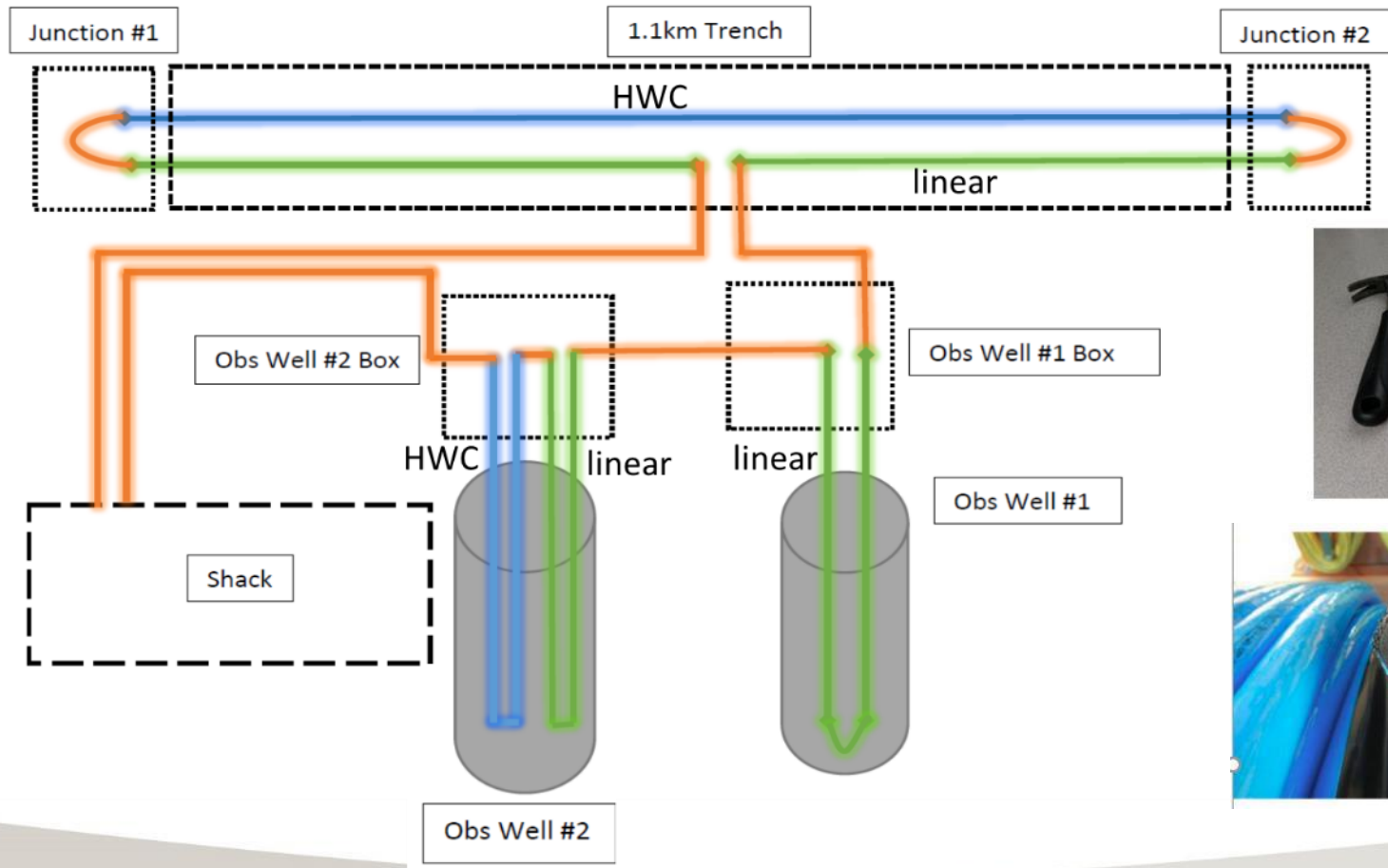
PP



PS

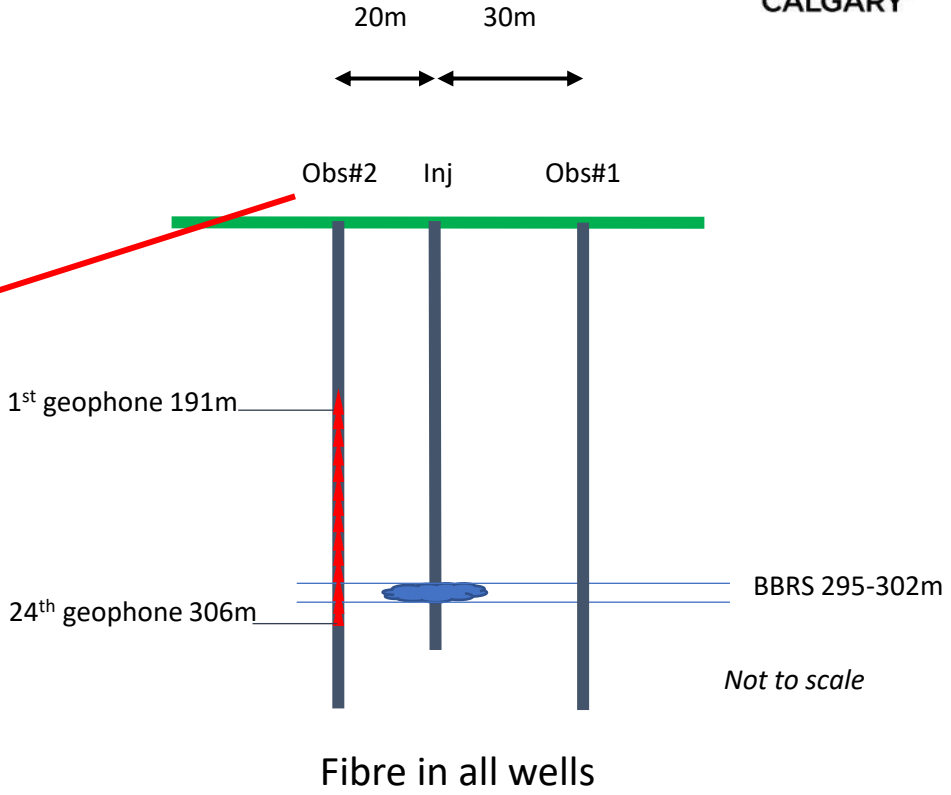
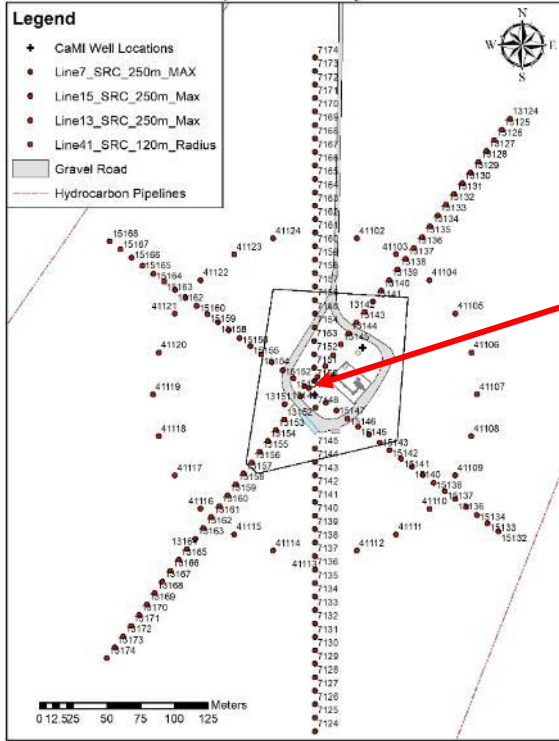


Disruptive monitoring technology – optical fibre

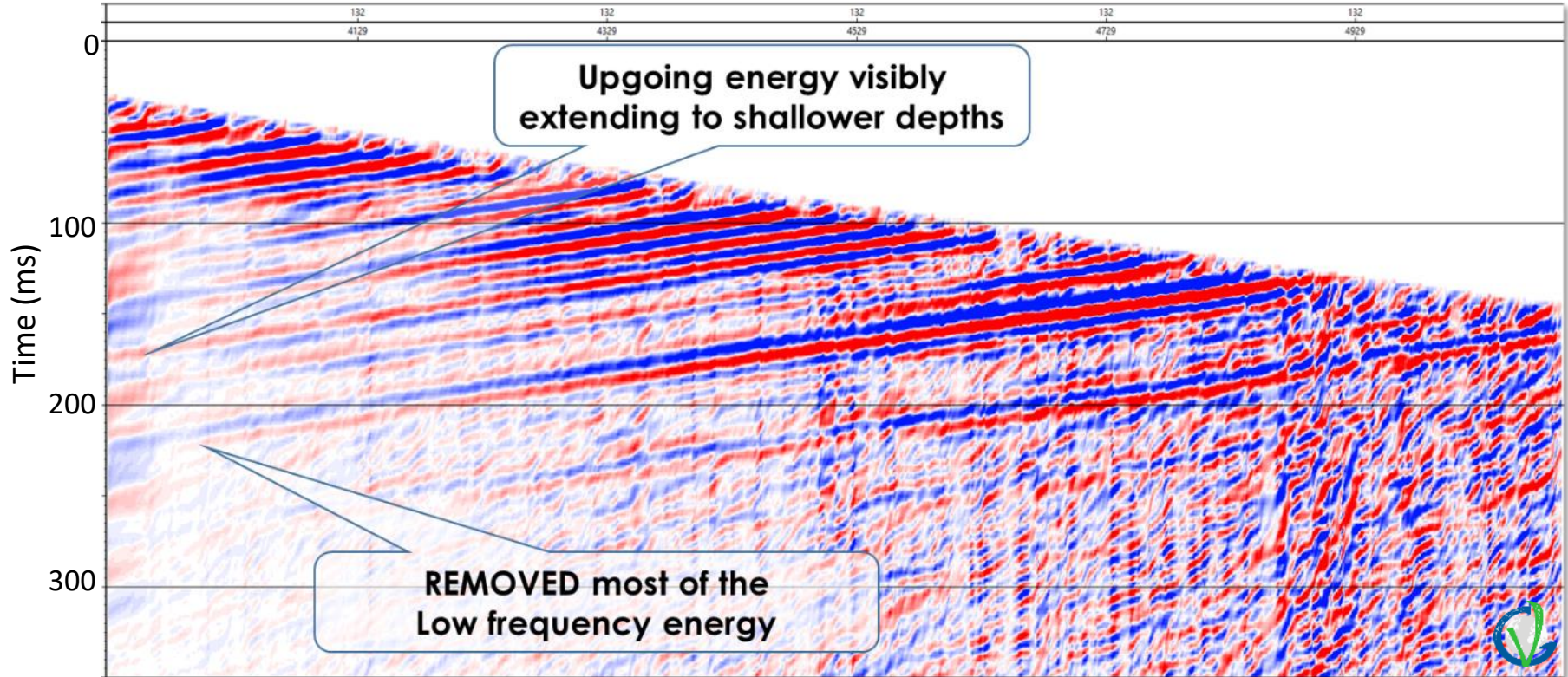


Vertical Seismic profiles (VSP)

CaMI.FRS Time-Lapse VSP Layout

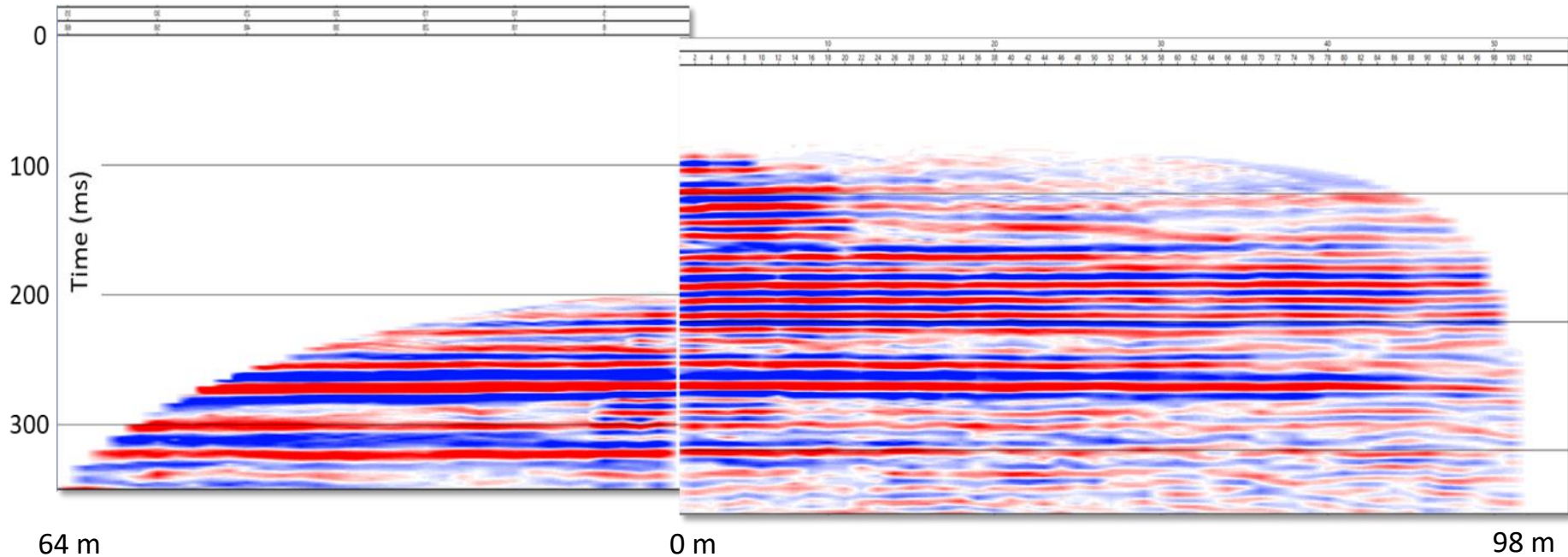


DAS upgoing wavefield from DAS VSP (median + FK filter)

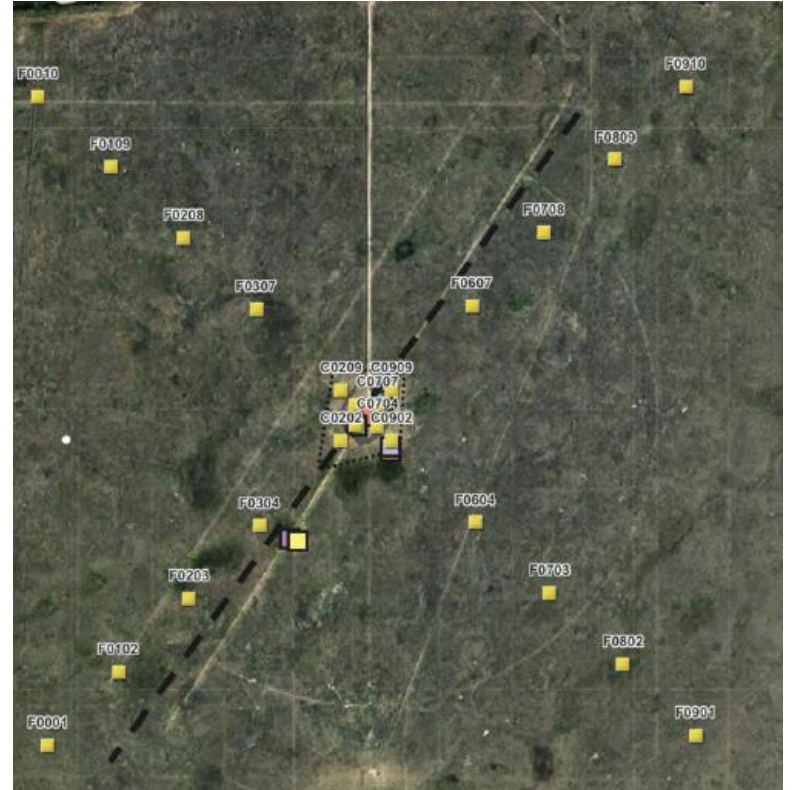
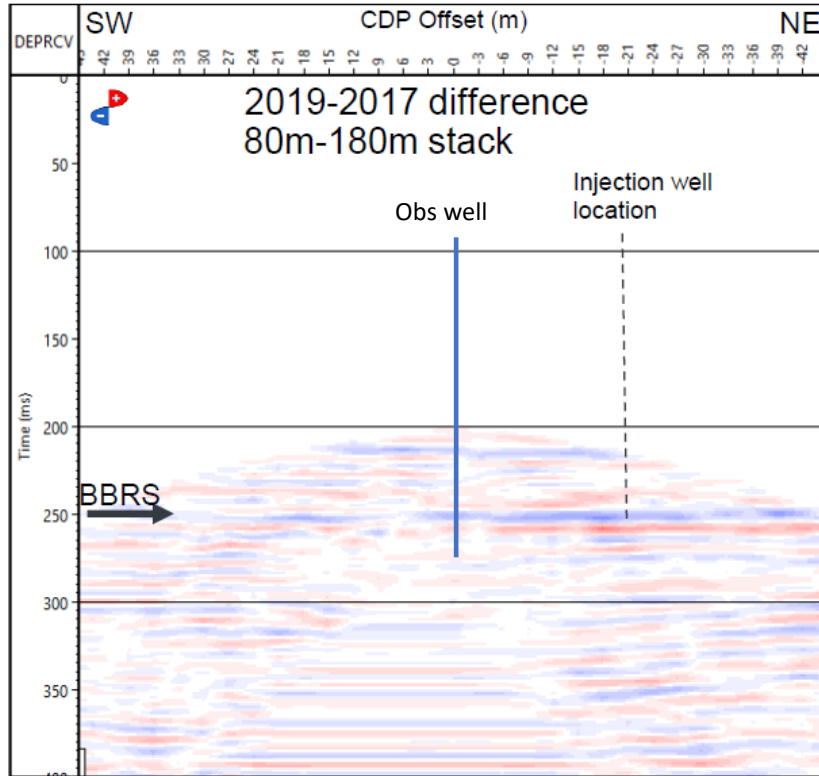


Geophones

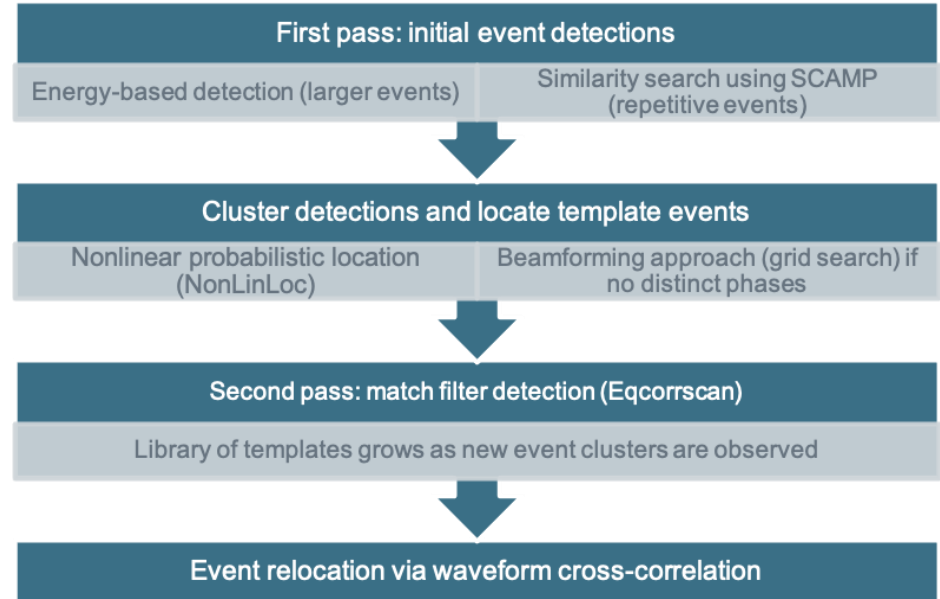
DAS

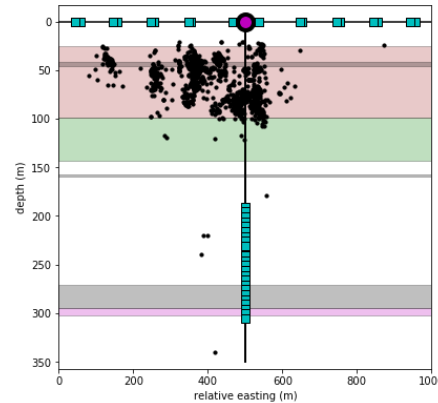
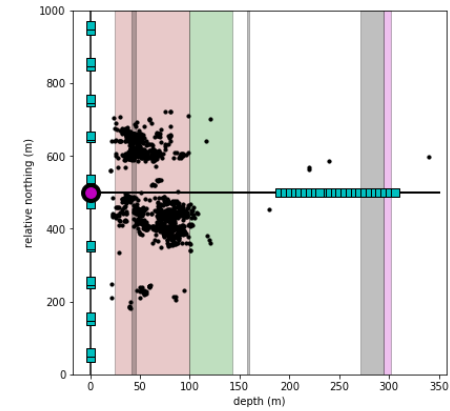
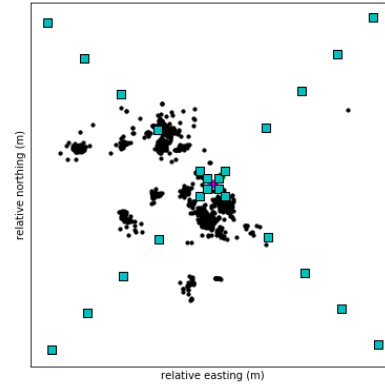
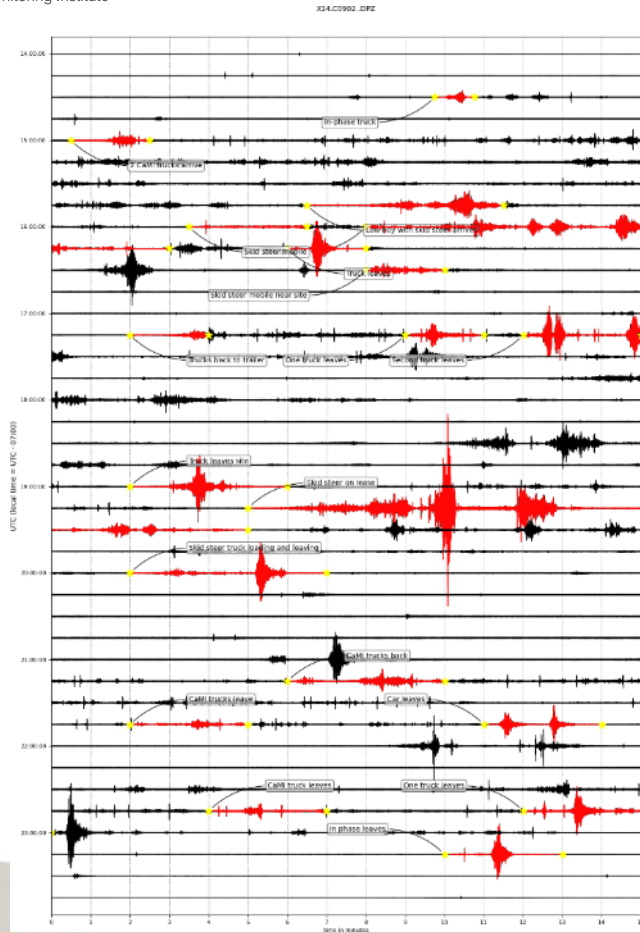


Timelapse VSP; permanent surface array



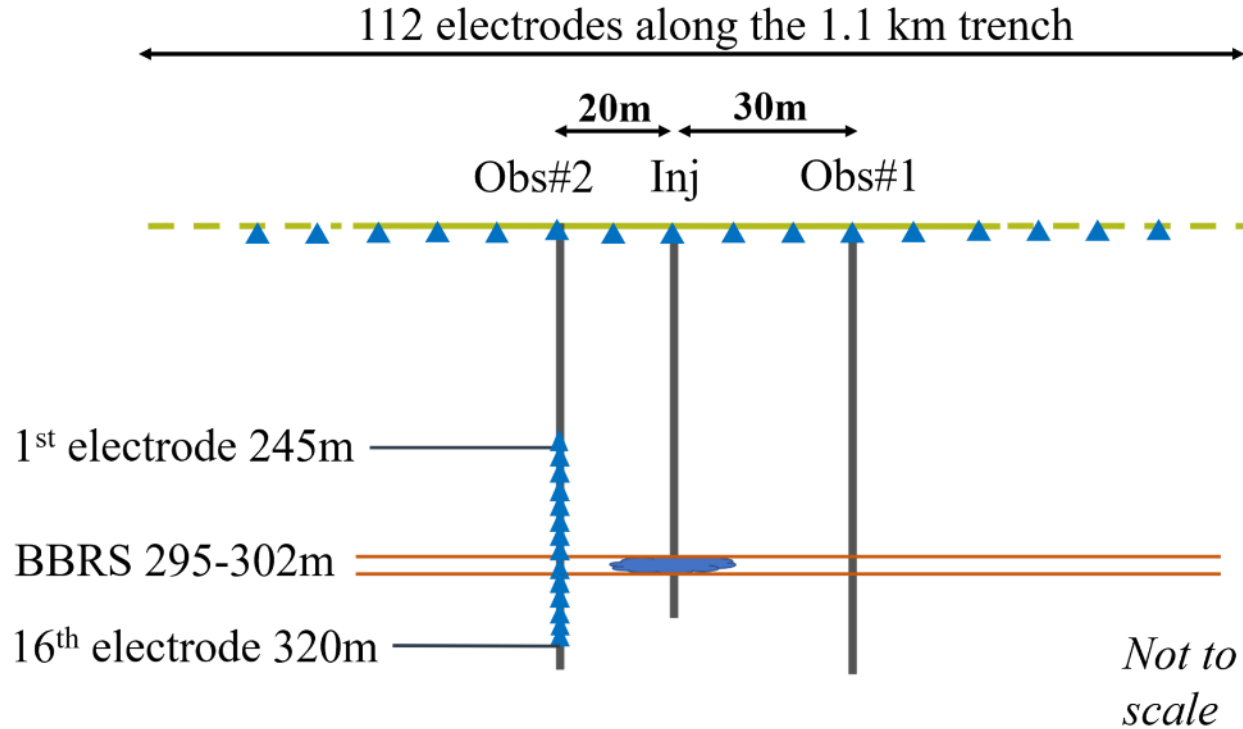
- Microseismicity is continuously monitored by:
 - “X” array of 24 surface geophones
 - Borehole geophones in observation well between ~195-305 m depth
- Events are detected through a combination of energy-ratio (STA/LTA) and similarity-search approaches



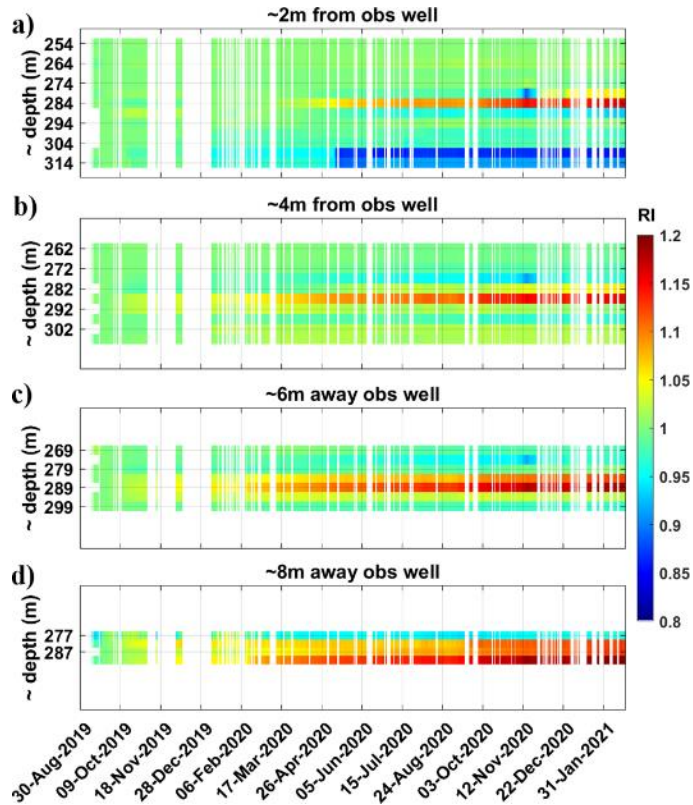


Event detection and Implementation of ML classification to separate surface anthropogenic sources from injection related sources.

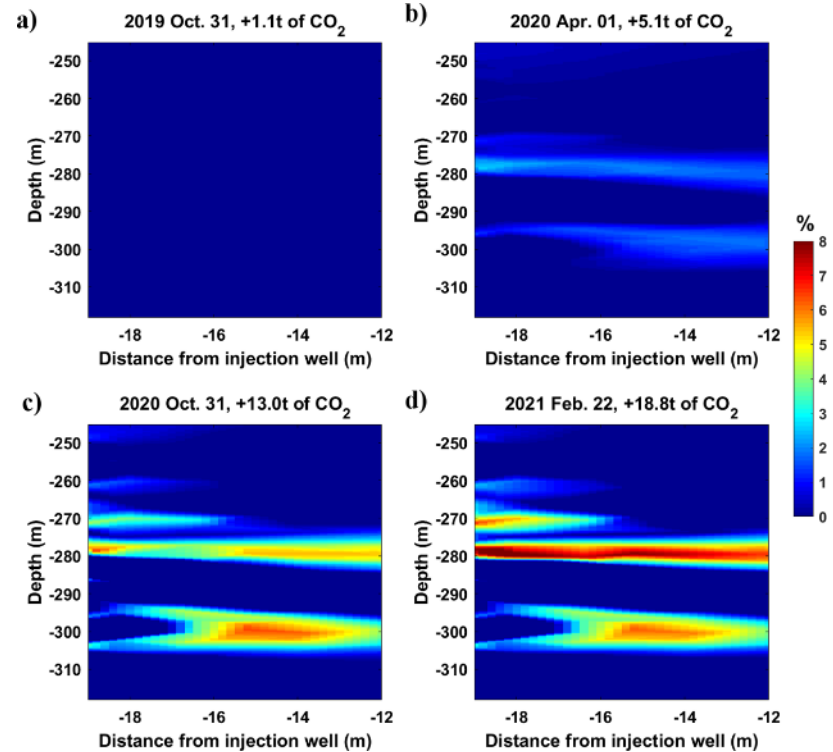
Electrical Resistivity Tomography (ERT)



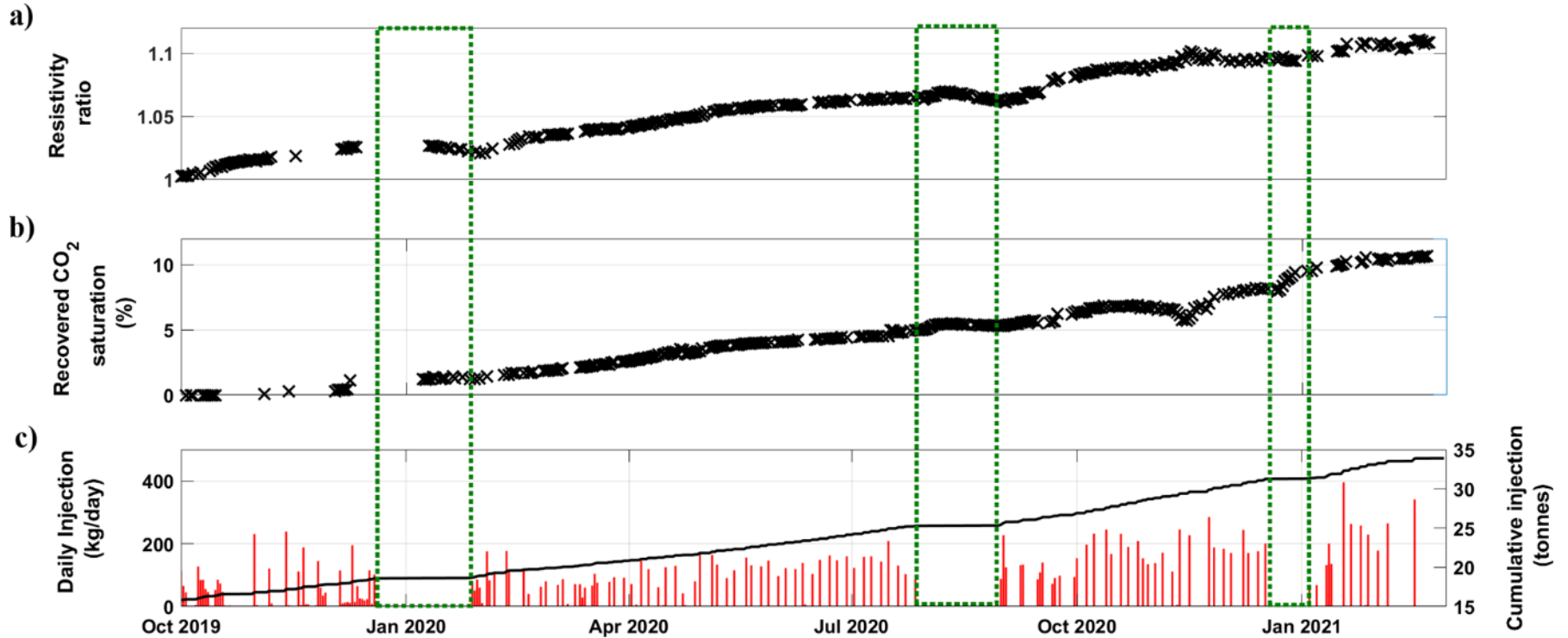
Timelapse ERT at Obs well #2



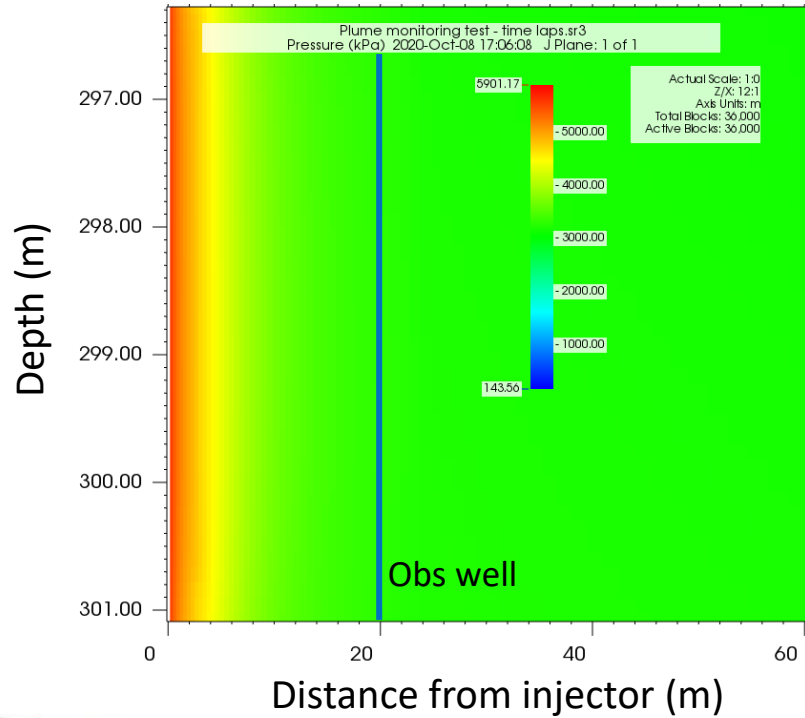
Resistivity ratio



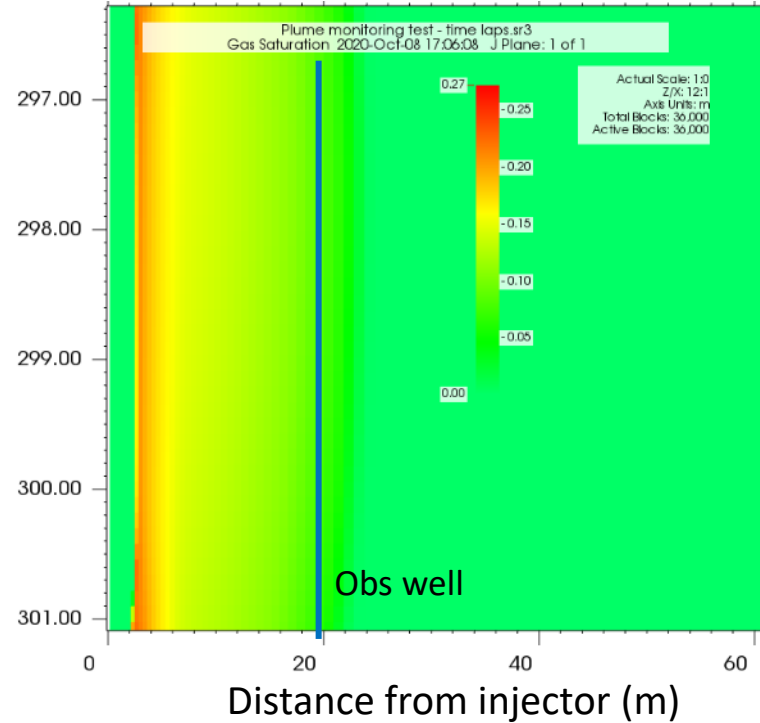
CO₂ saturation



Pressure



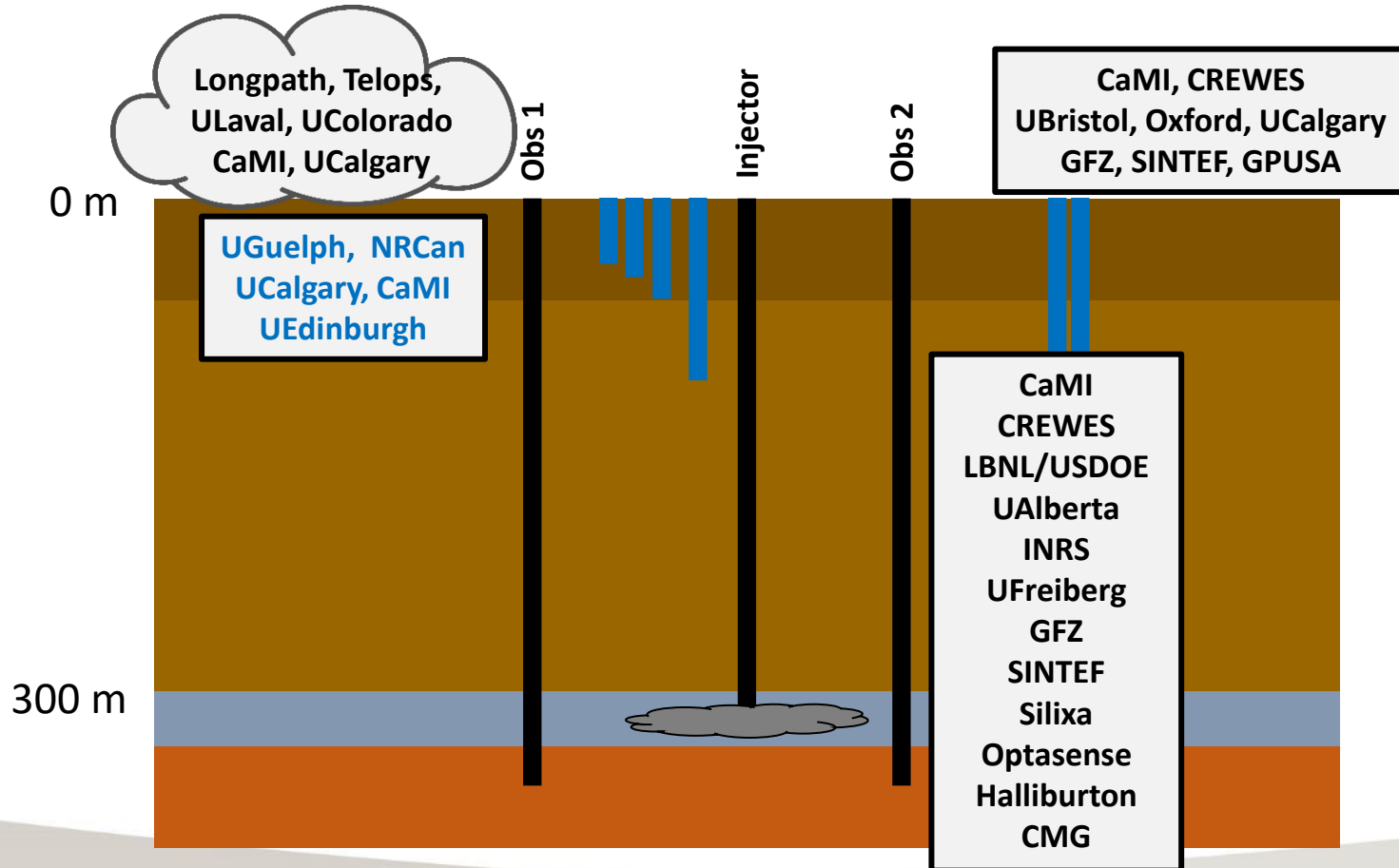
CO₂ saturation



Discussion & outcomes

- We will be able to rank various monitoring technologies with respect to effectiveness and cost profile.
- At the site we can test new monitoring technologies, including continuous surveillance
- We are able to determine detection threshold of CO₂
- ERT and seismic methods are effective for monitoring the CO₂ plume.
- This project provides public and regulatory assurance about the containment security of CO₂ geological storage
- Review of risk-based MMV protocols. How much and how often?
- Goal to accelerate CCS implementation to meet 2050 targets.

CaMI.FRS monitoring collaborators



JIP members and funding partners

OptaSense[®]
A QINETIQ company



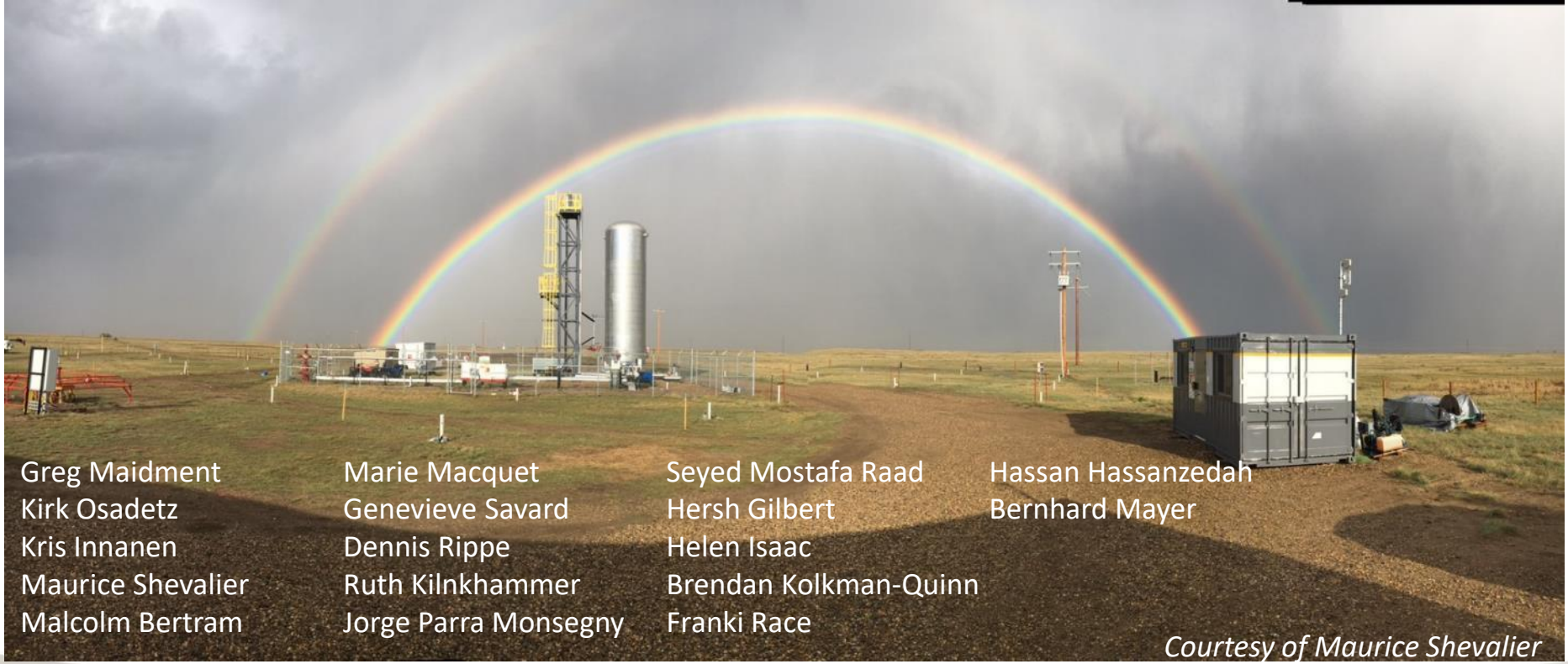
Western Economic
Diversification Canada
Diversification de l'économie
de l'Ouest Canada



UNIVERSITY OF CALGARY
Global Research Initiative
in Energy Research

We also acknowledge the support of Total and Petronas
for our applied research program

Youtube: https://youtube.com/playlist?list=PLmMcjtdfi-y7RWsumE0gycAL_HSE2pXRt



Greg Maidment

Kirk Osadetz

Kris Innanen

Maurice Shevalier

Malcolm Bertram

Marie Macquet

Genevieve Savard

Dennis Rippe

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