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Monitoring geological carbon storage: detection threshold at the CaMI Newell County Facility and a look ahead at a sparse monitoring approach for gigatonne scale storage

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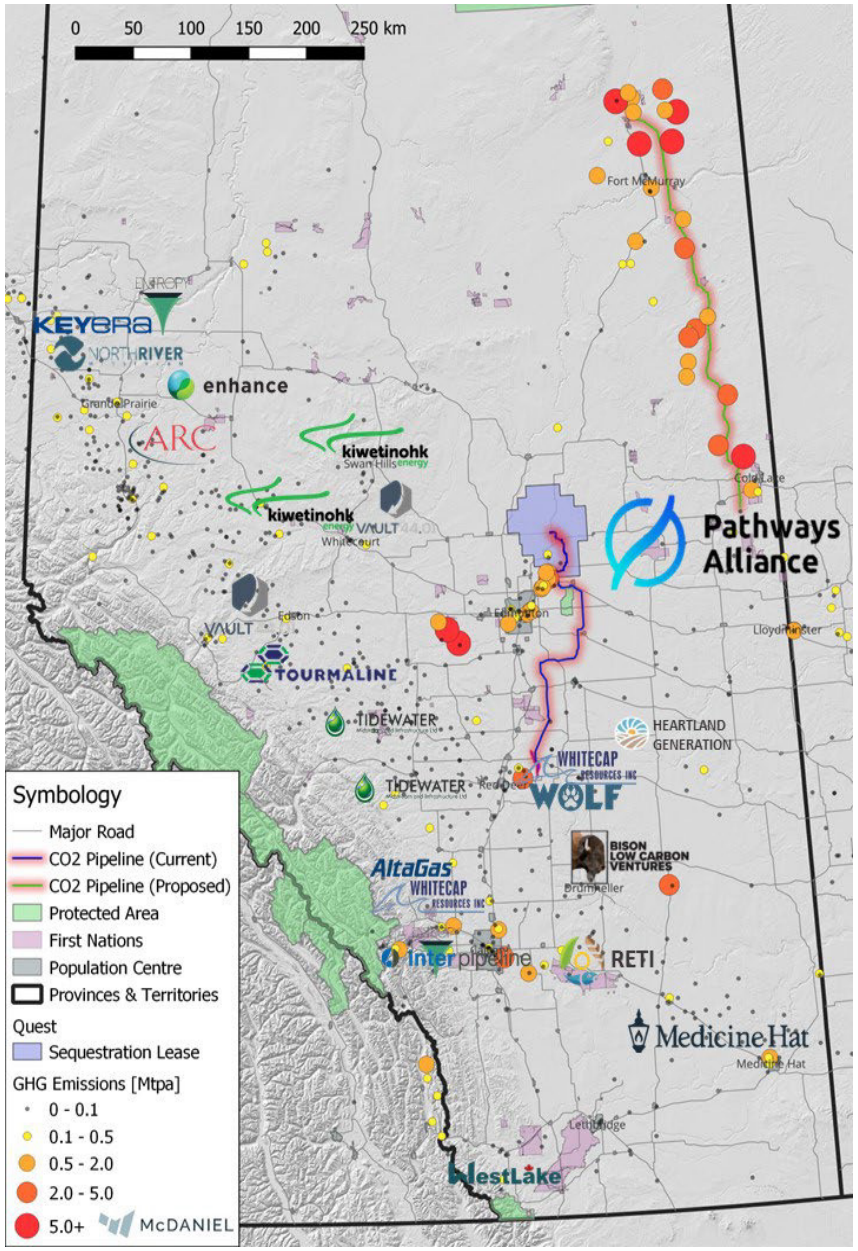
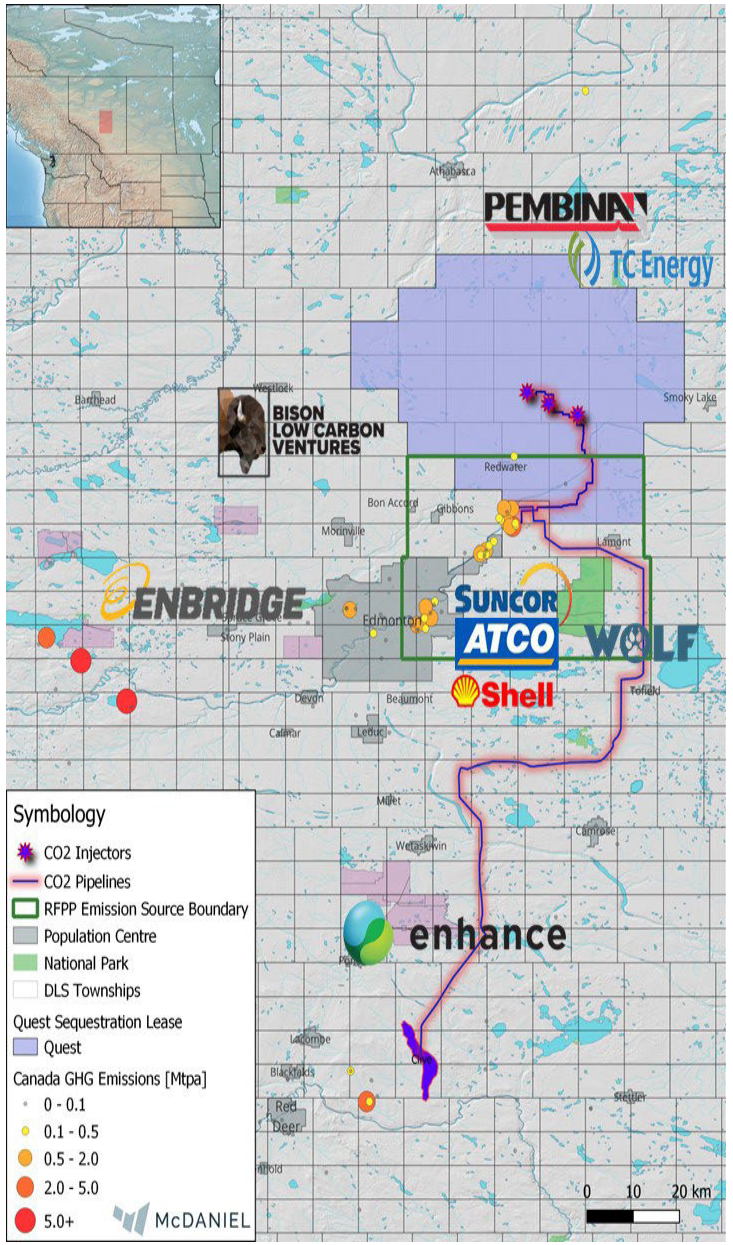
CREWES Annual Meeting, Banff, Dec 1, 2022

Outline

- Uptake in Carbon Capture, Utilization and Storage (CCUS).
- Requirements for Measurement, Monitoring and Verification (MMV) programs in Geologic Carbon Storage (GCS).
- The CMC CaMI Newell County Facility.
- Objectives of the programs at the site.
- CO_2 detection thresholds
- MMV for large-scale storage.

Approved CCS Hub evaluation permits in Alberta (25)





MMV principles

- Regulatory compliance
- Project and site specific; address regional impacts
- Risk-based and fit-for-purpose (e.g. induced seismicity, interference)
- Adaptive, with elaboration through successive project stages
- Provide timely warning of containment and conformance anomalies
- Monitorability in geosphere, hydrosphere, biosphere, and atmosphere.
- Transparency
- Best available technologies economically achievable (BATEA) - based on sound science and engineering

After: Govt of Alberta, 2022. Monitoring, Measurement and Verification Principles and Objectives for CO2 Sequestration Projects

MMV principles (geophysics)

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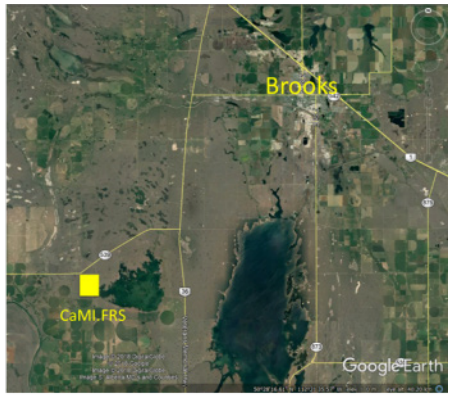
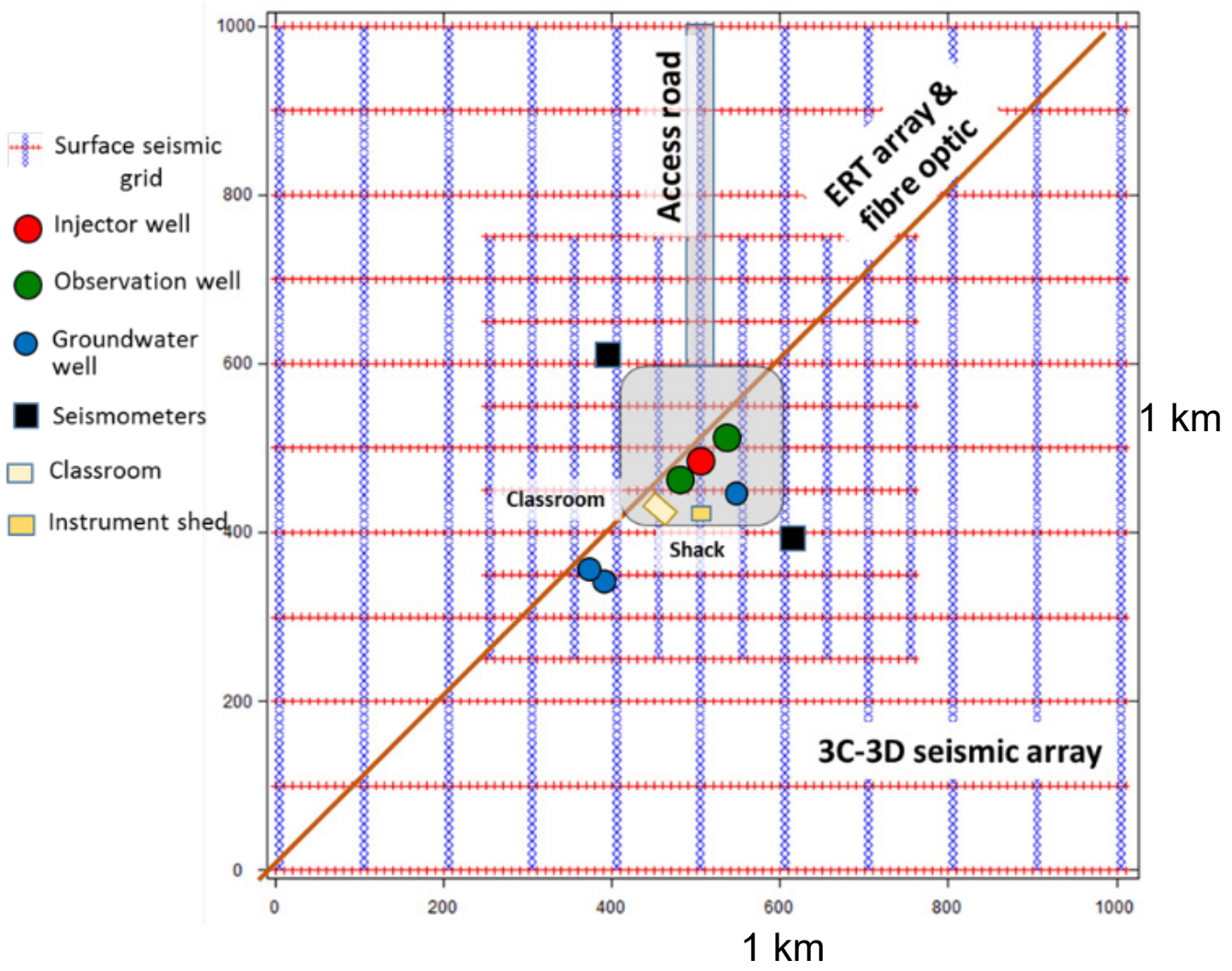
After: Govt of Alberta, 2022. Monitoring, Measurement and Verification Principles and Objectives for CO2 Sequestration Projects

CMC-CaMI Newell County Facility





Goals

- Develop and validate MMV technologies for CO_2 storage containment and conformance
- Determine the CO_2 detection threshold at a depth of 300 m - simulating leakage from a deep CCS project
- Develop reservoir, caprock, and overburden surveillance technologies
- Monitor for CO_2 migration at shallow to intermediate depths and impacts on groundwater
- Test centre for demonstrations of new technologies
- Develop and validate MMV technologies for quantitative monitoring of emissions including methane
- Applied technical training

Monitoring technologies being assessed

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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 - geochemistry

- Groundwater sampling from wells
- Soil gas (CO_2 and CH_4) monitoring
- Surface casing vent flow monitoring
- Observation well fluid sampling and analysis
- Tracer studies including noble gases
- Atmospheric methane detection

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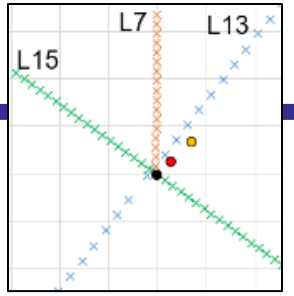
Near-field monitoring – close to injection well

Timelapse walkaway VSP data



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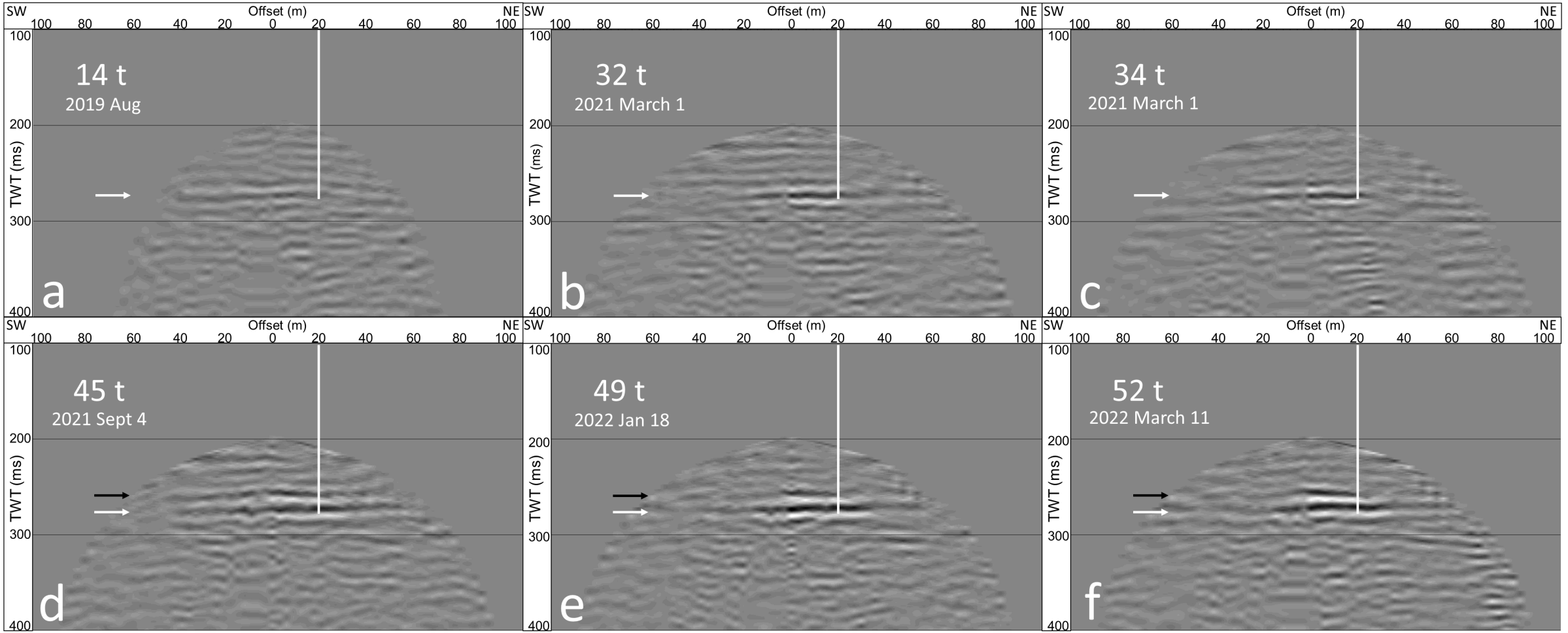
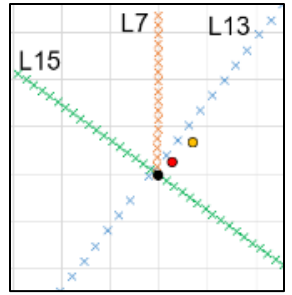
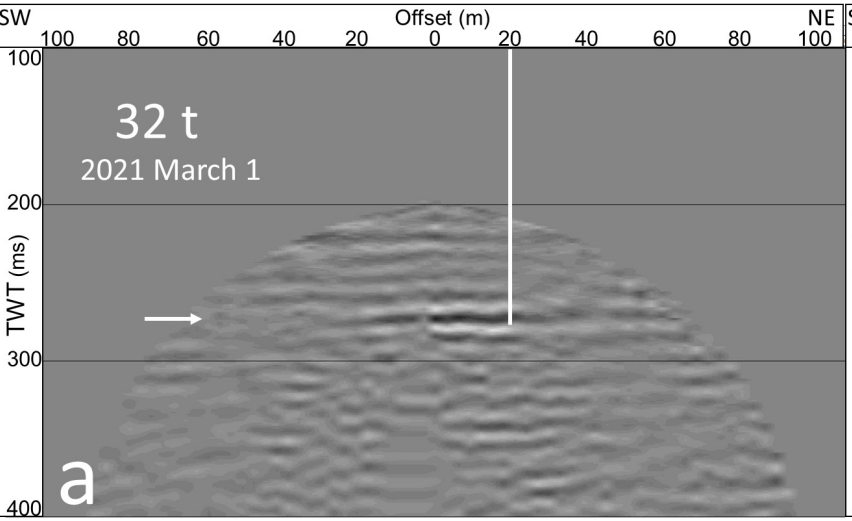
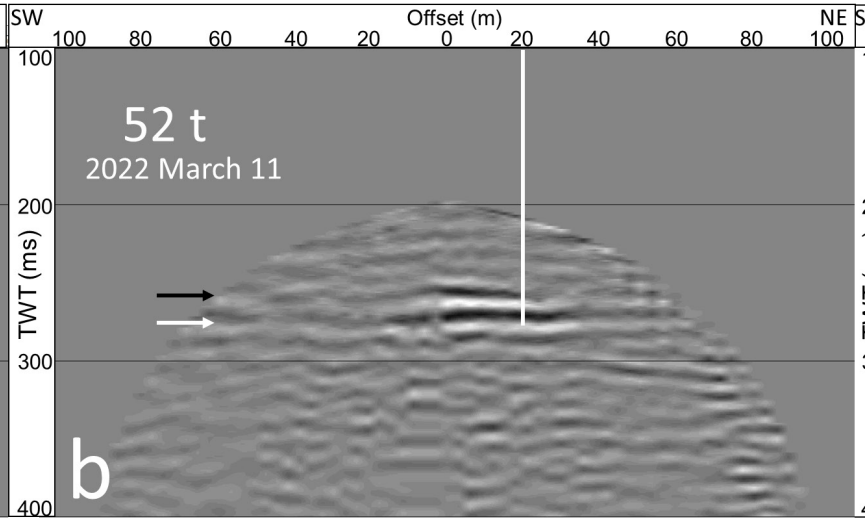


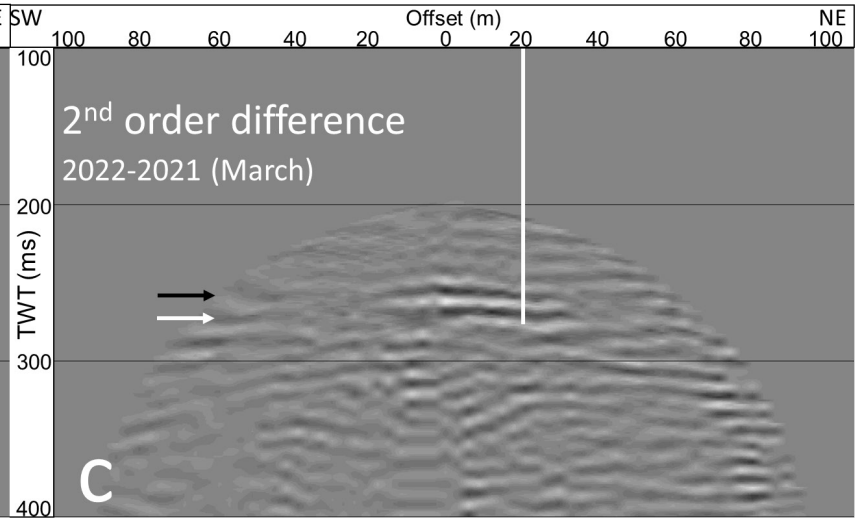
Timelapse walkaway VSP data



March 2021 | March 2022 | Difference





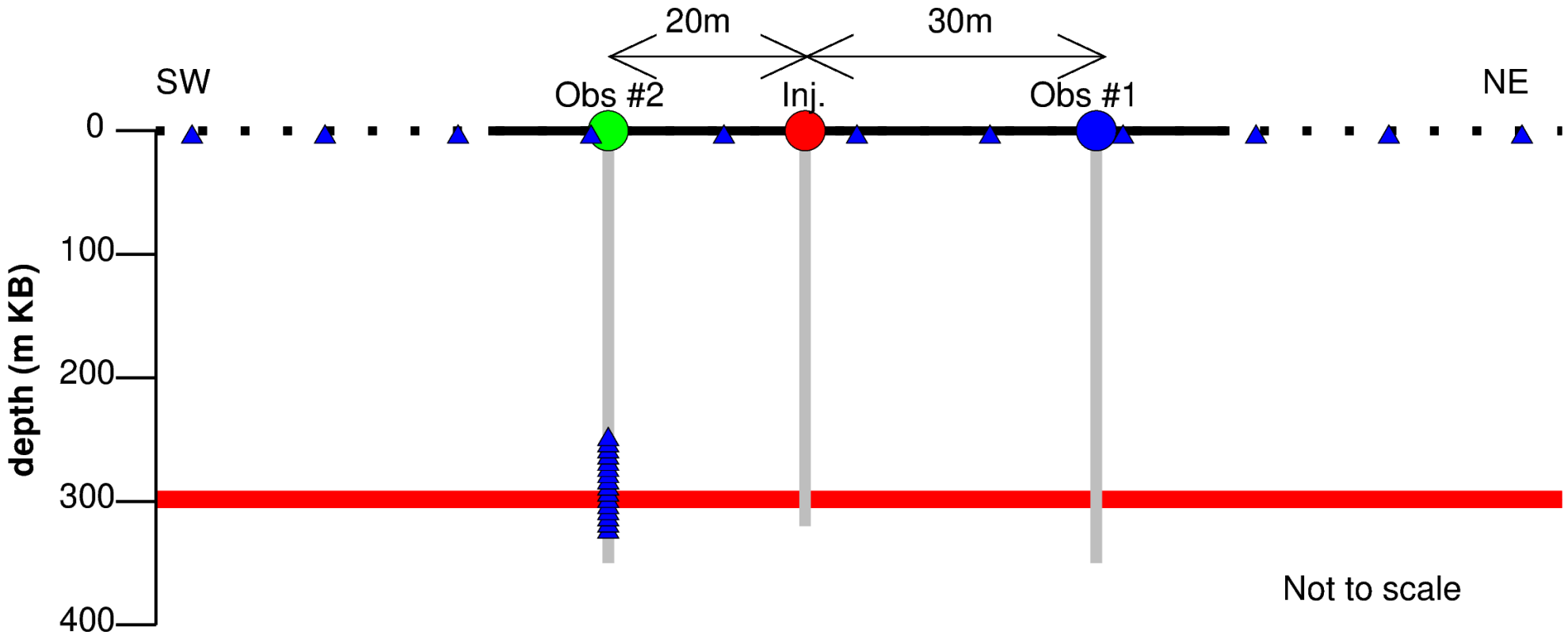


Brendan Kolkman-Quinn

Electrical resistivity tomography (ERT)

16 electrodes in the observation well #2
250 to 325 mKB depth
5 m spaced

112 electrodes in the 1.1 km trench
1 m depth
10 m spaced

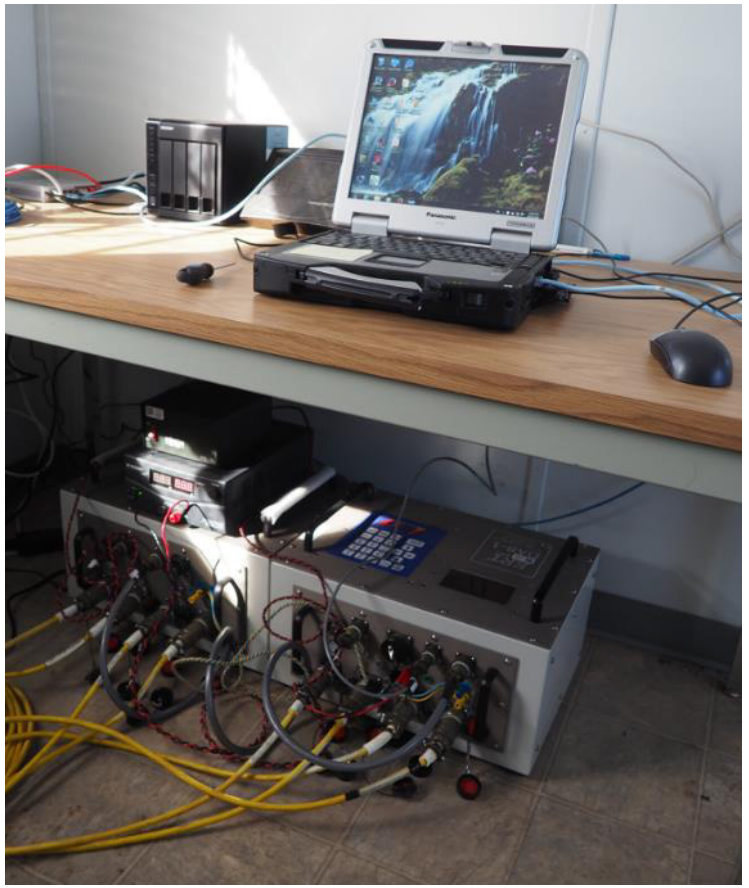


Marie Macquet

Borehole electrode on fiberglass casing

Surface electrode in the trench

Multi-Phase acquisition systen



ERT vs seismic response to S_{CO2}

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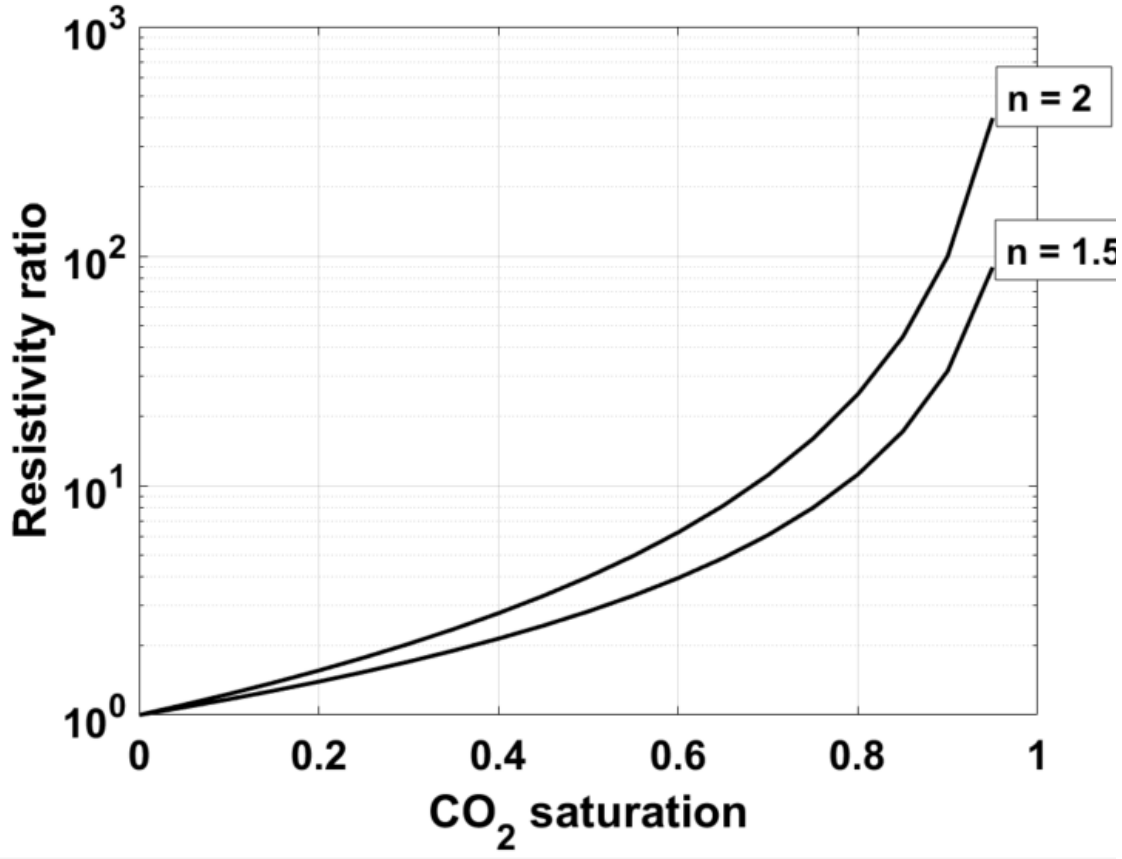
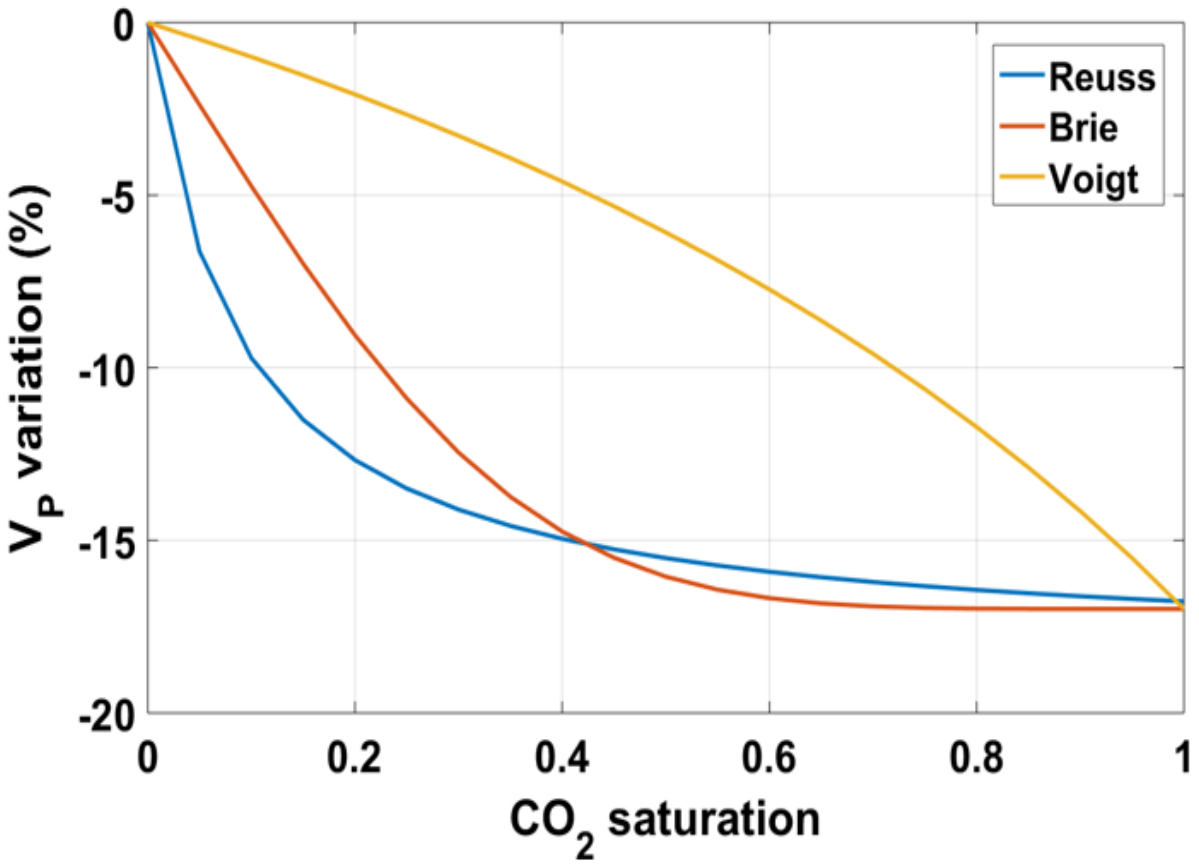
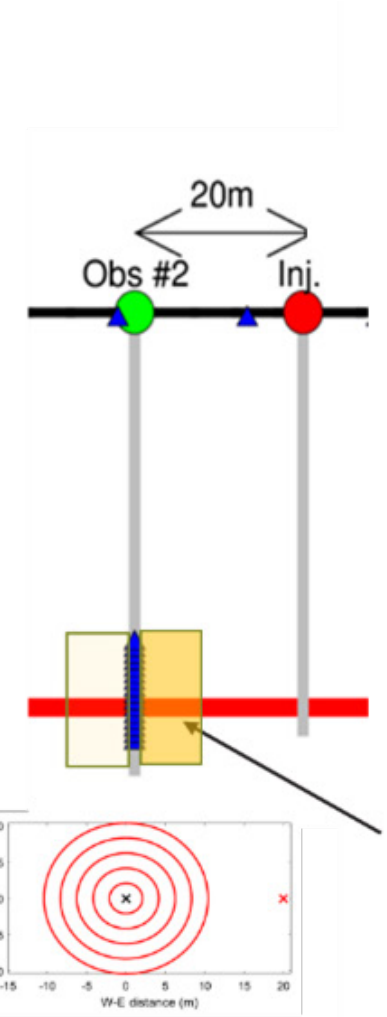
Resistivity

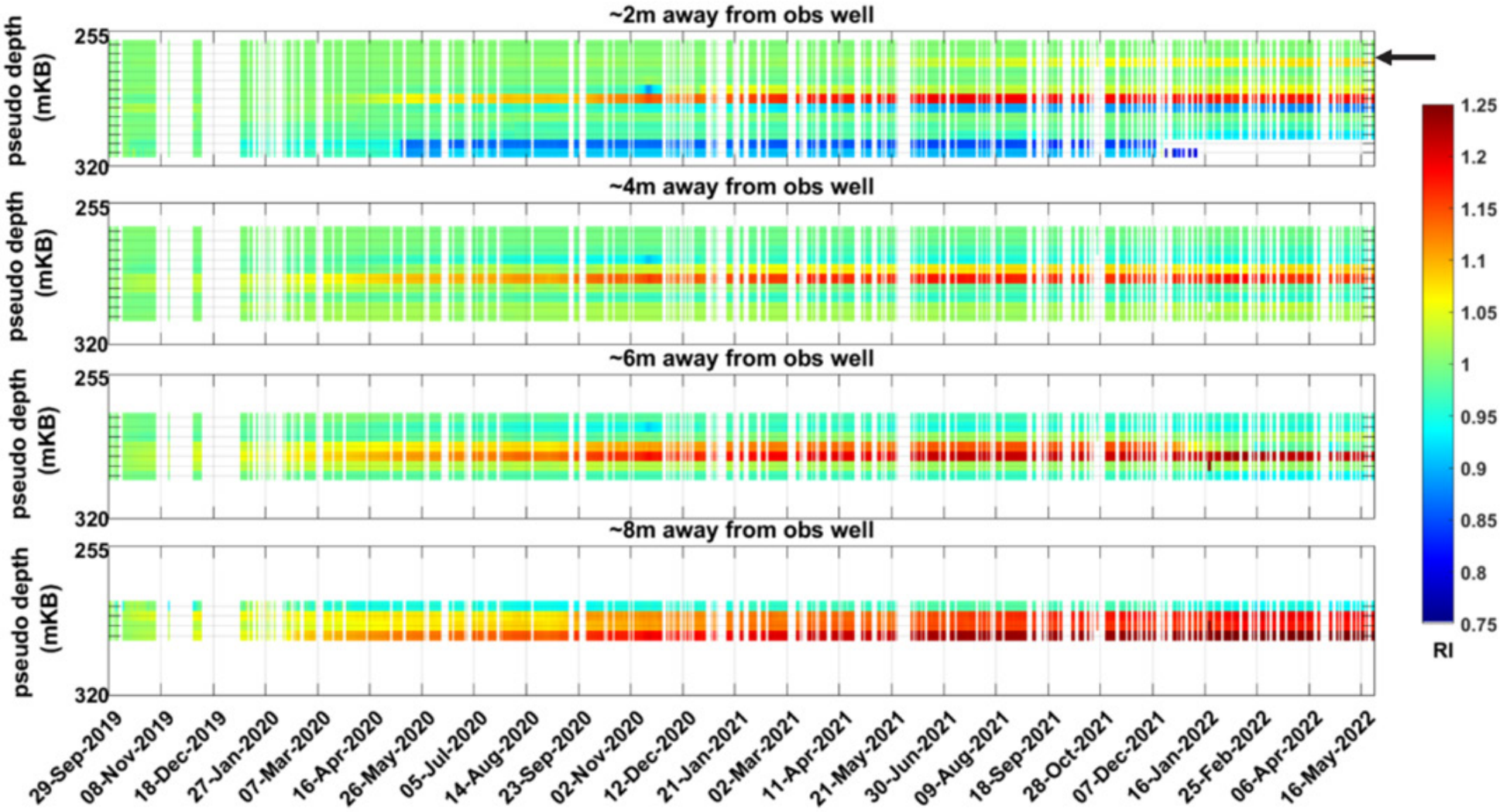


Seismic

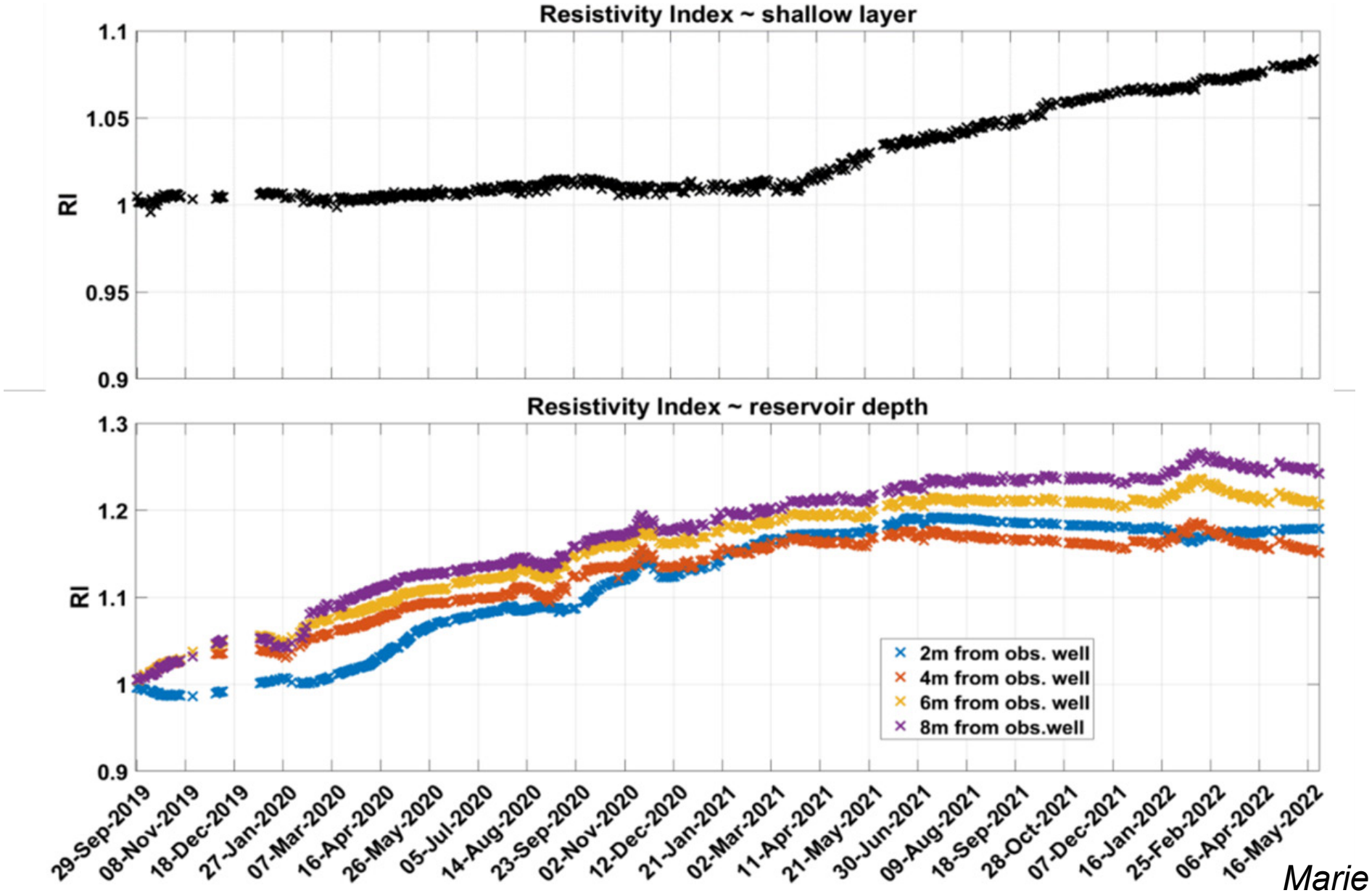


Timelapse ERT – resistivity index



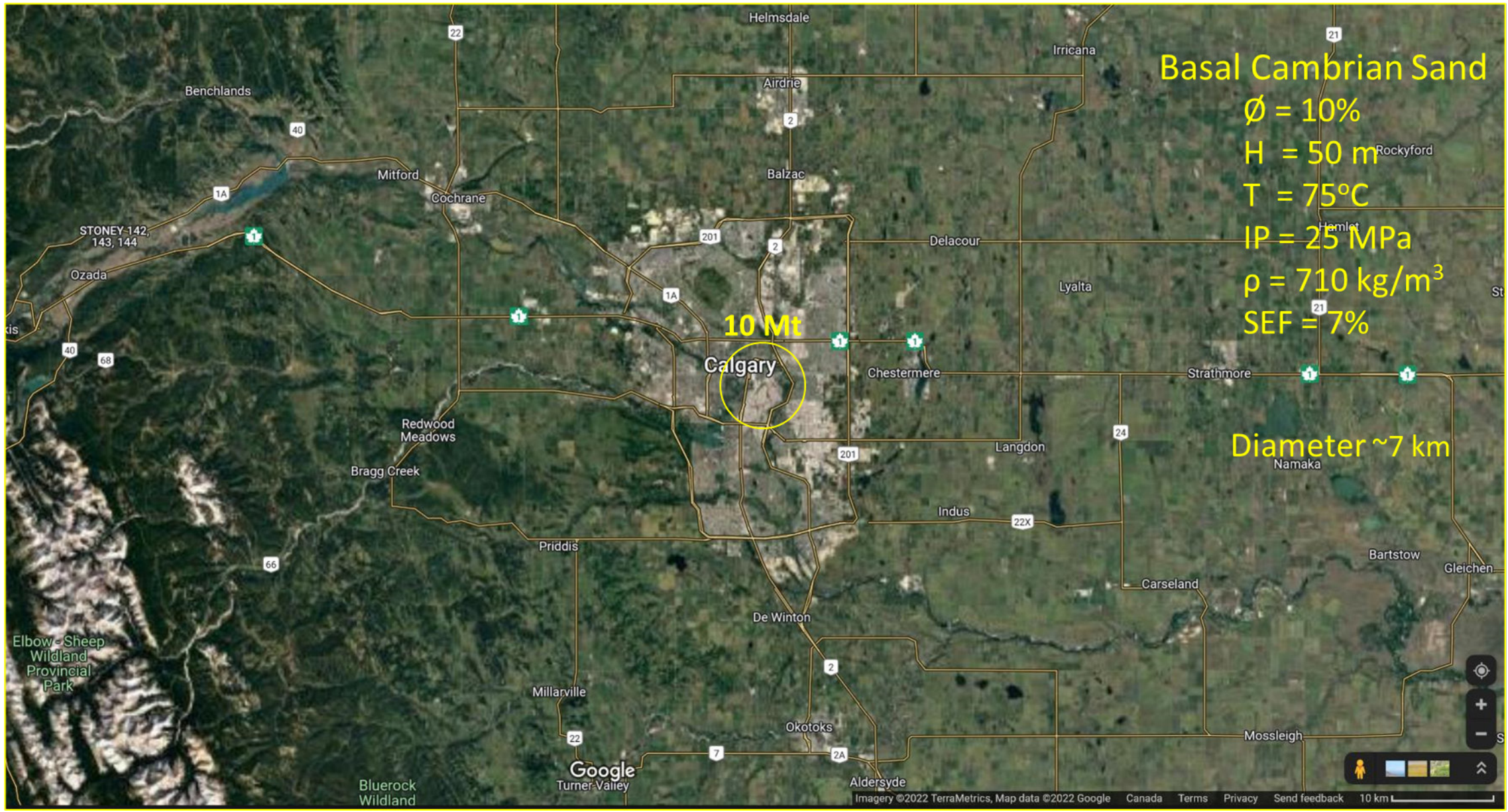


Timelapse ERT – resistivity index

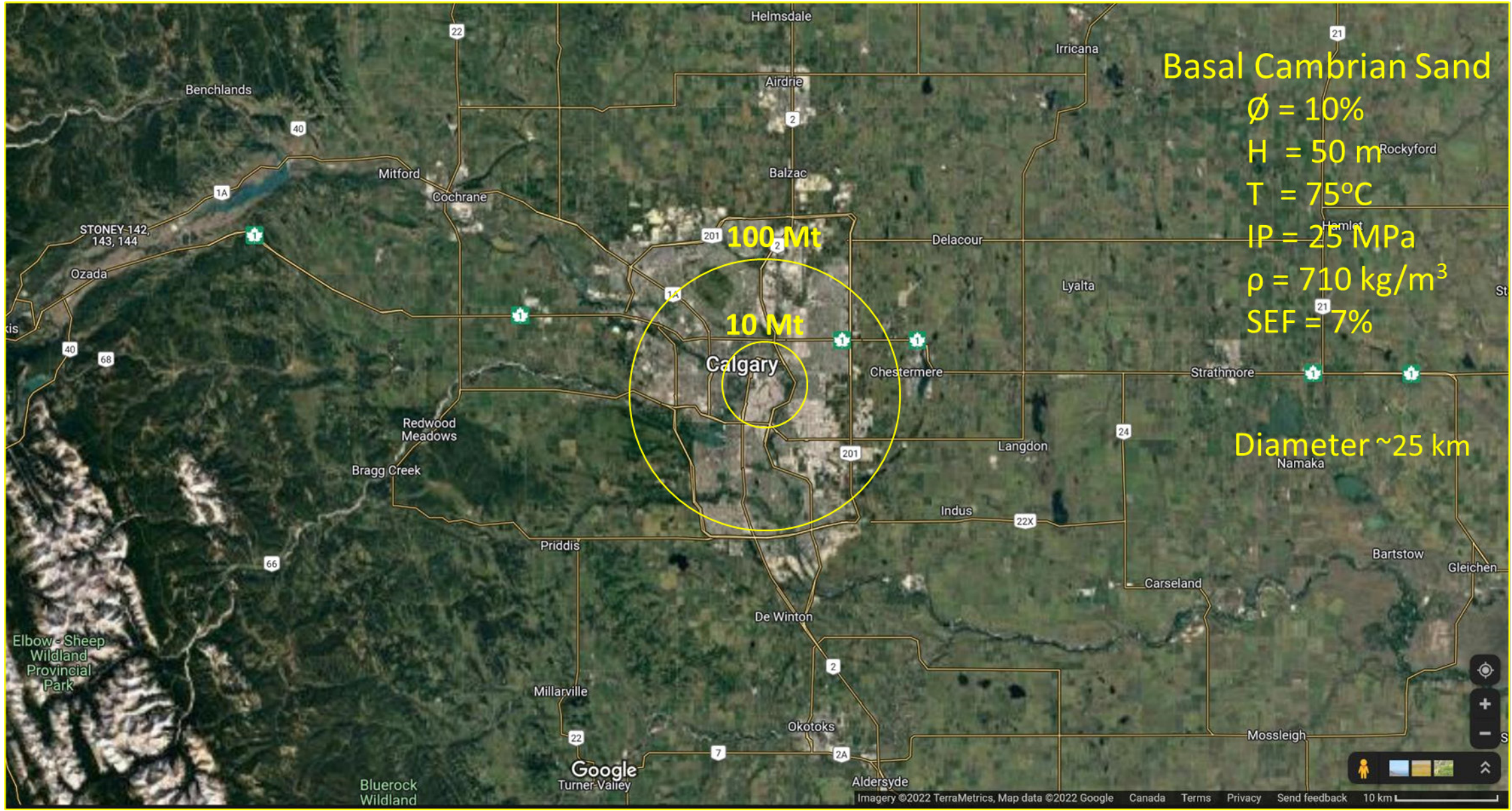


Far-field monitoring – distal plume monitoring

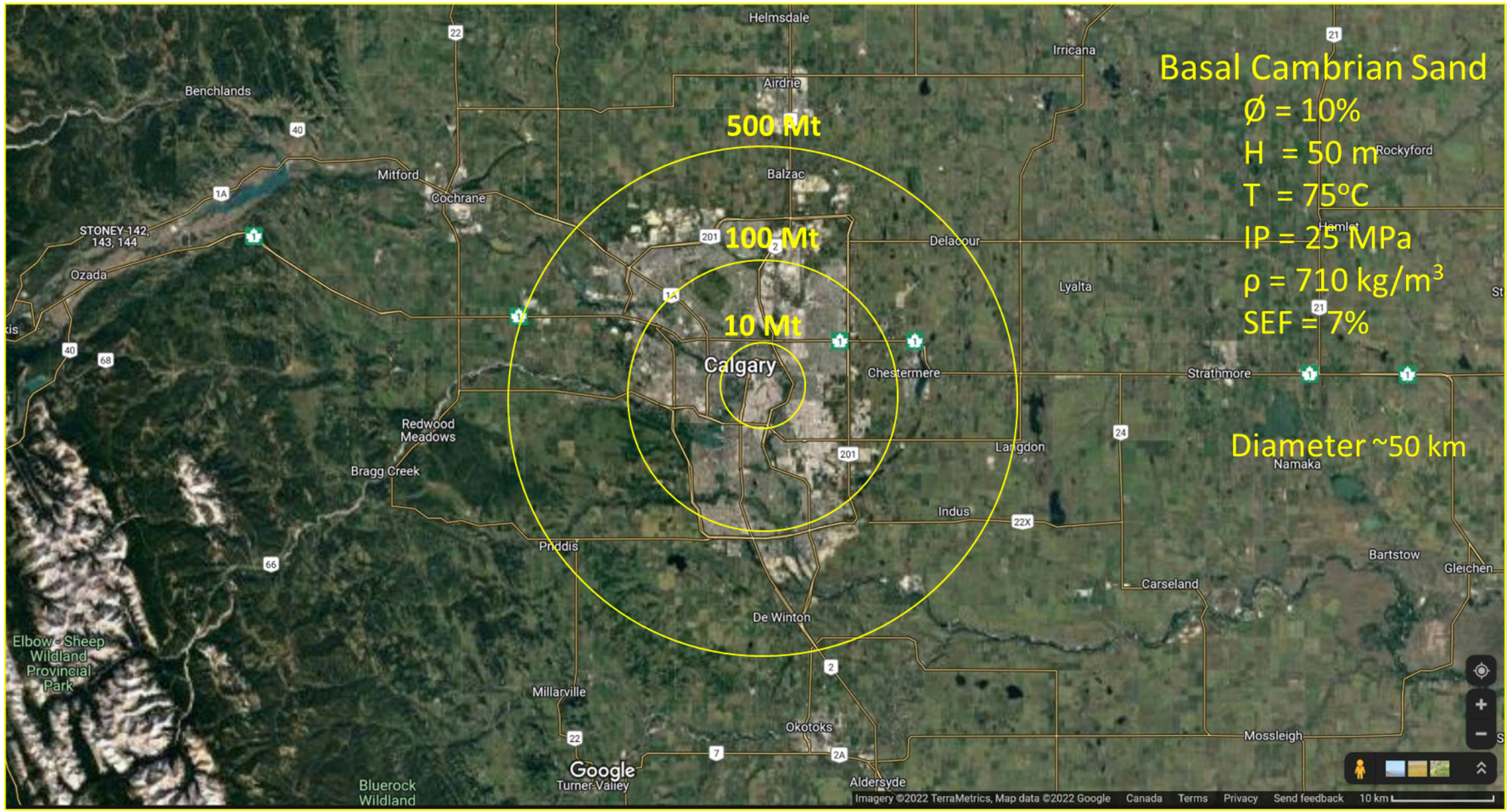
10 Mt CO_2 plume



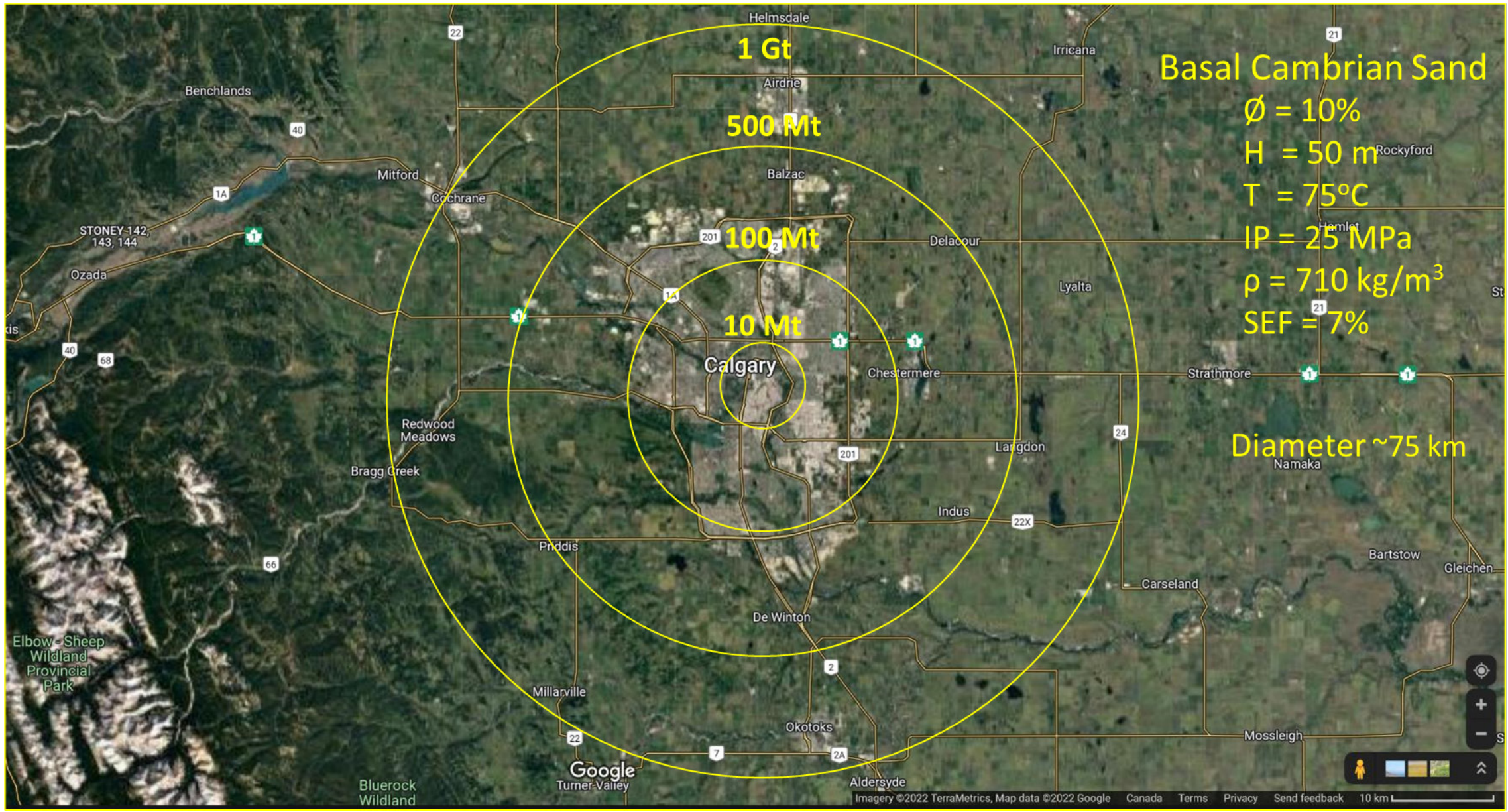
100 Mt CO_2 plume



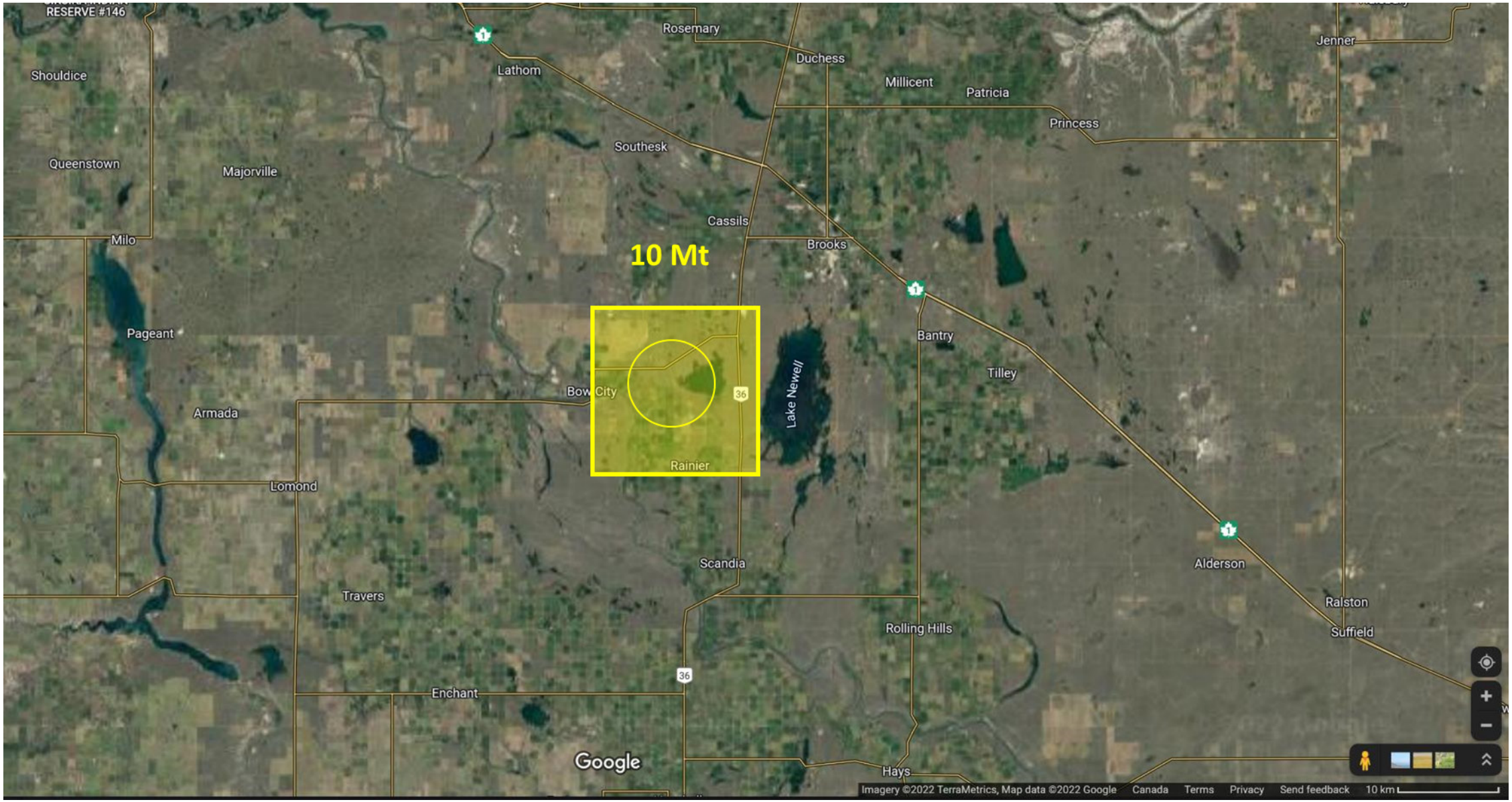
500 Mt CO_2 plume



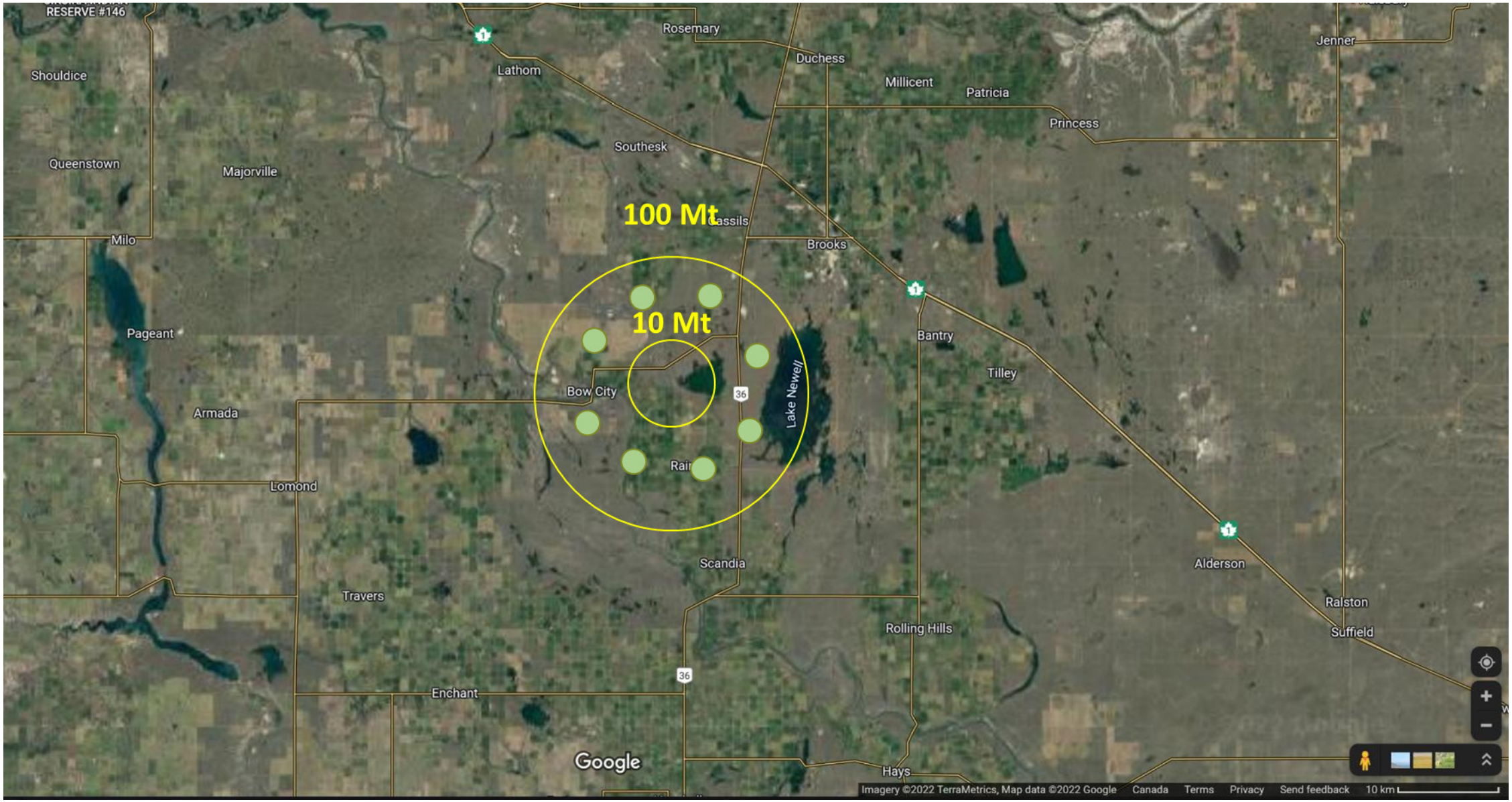
1 Gt CO_2 plume



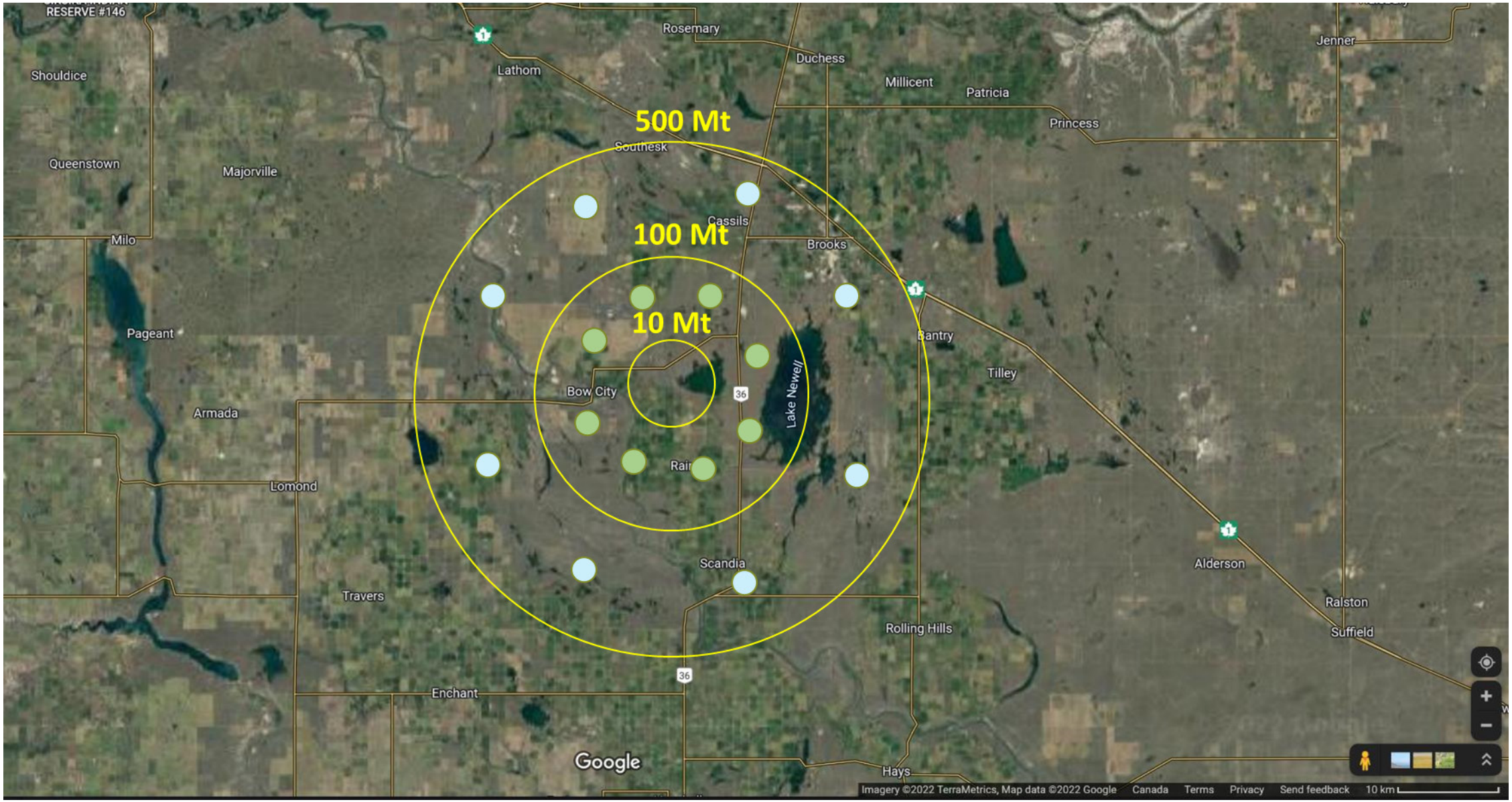
Monitoring at large scale: 10 Mt (3D seismic survey)



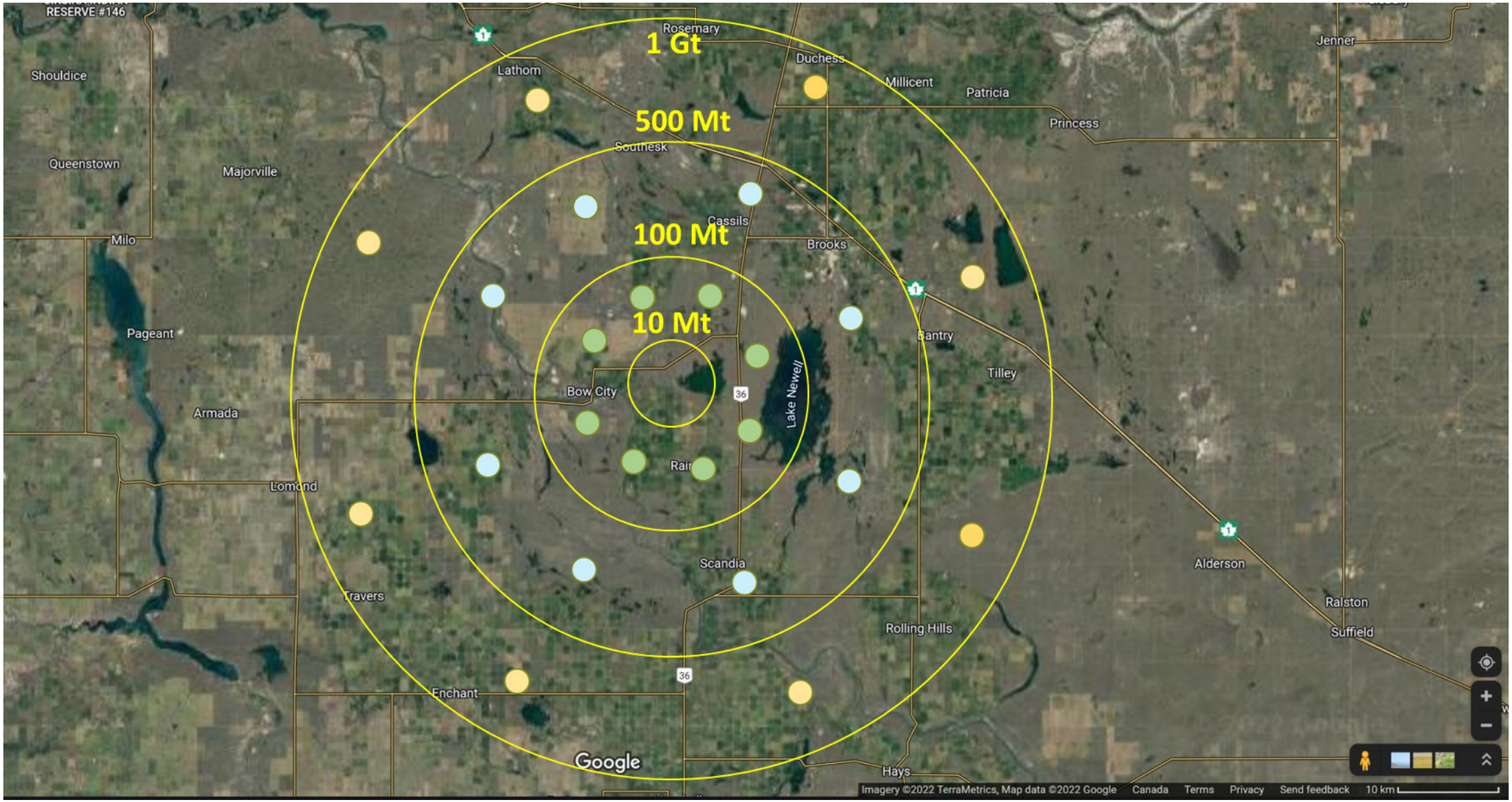
Monitoring at large scale: 100 Mt (nodes)



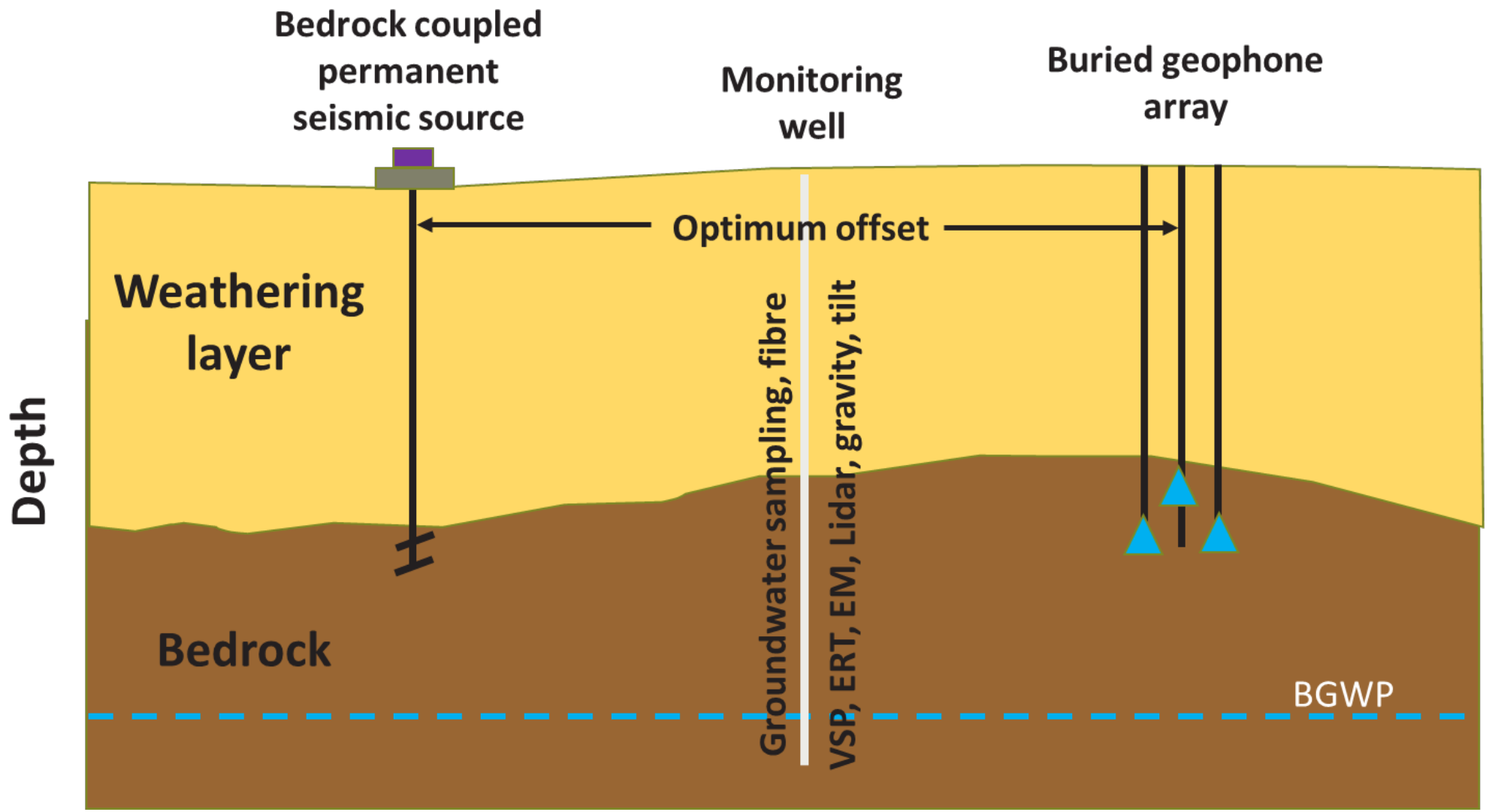
Monitoring at large scale: 500 Mt (nodes)



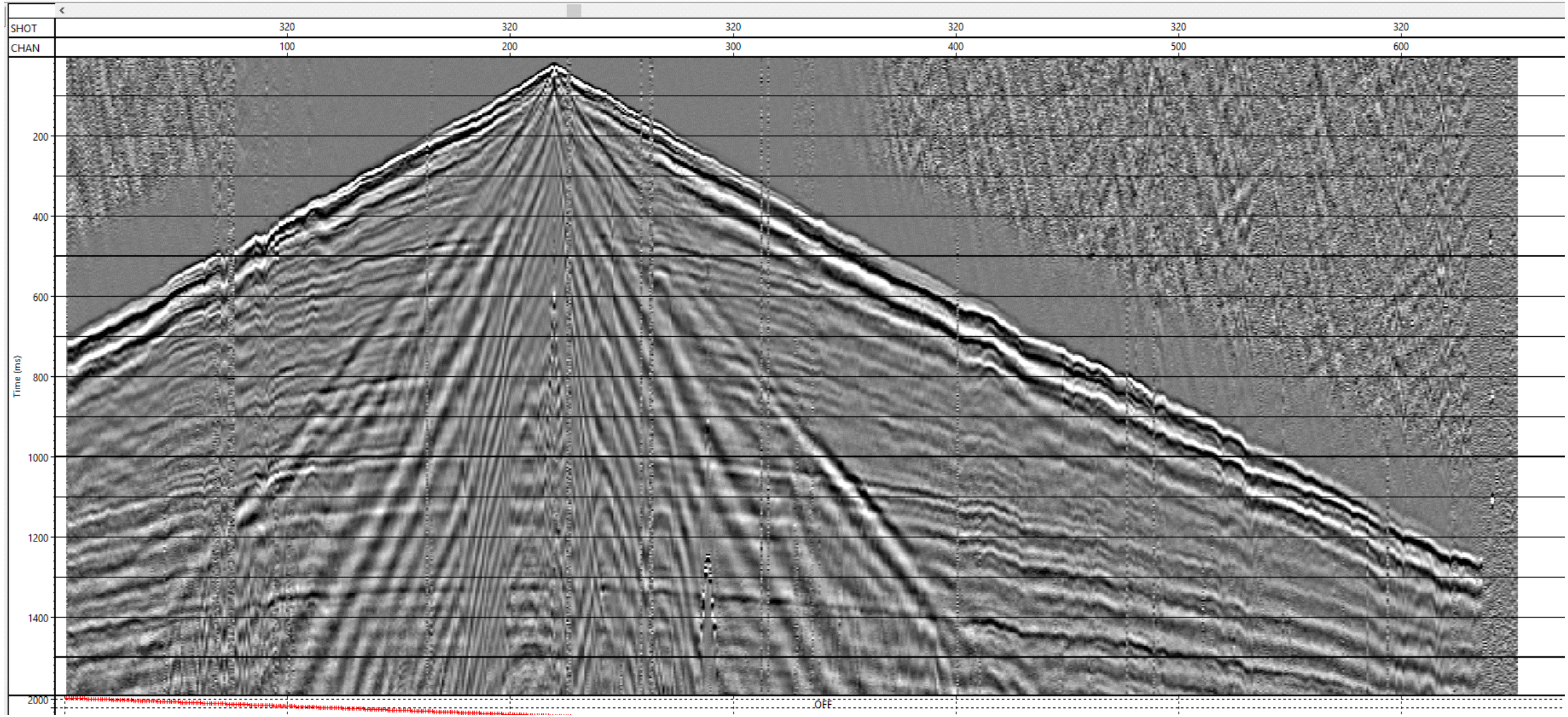
Monitoring at large scale: 1 Gt (sparse nodes)



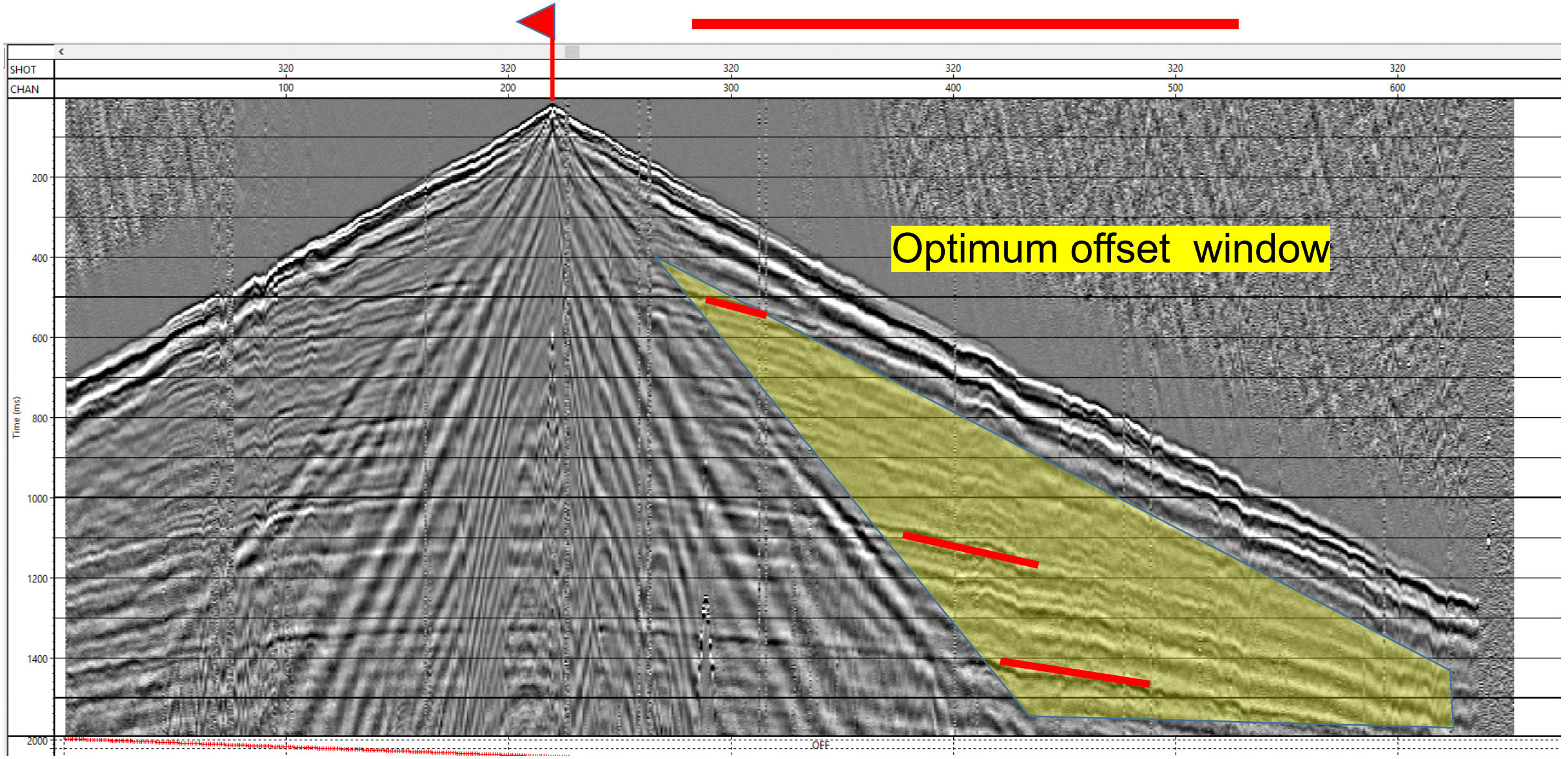
Sparse monitoring node



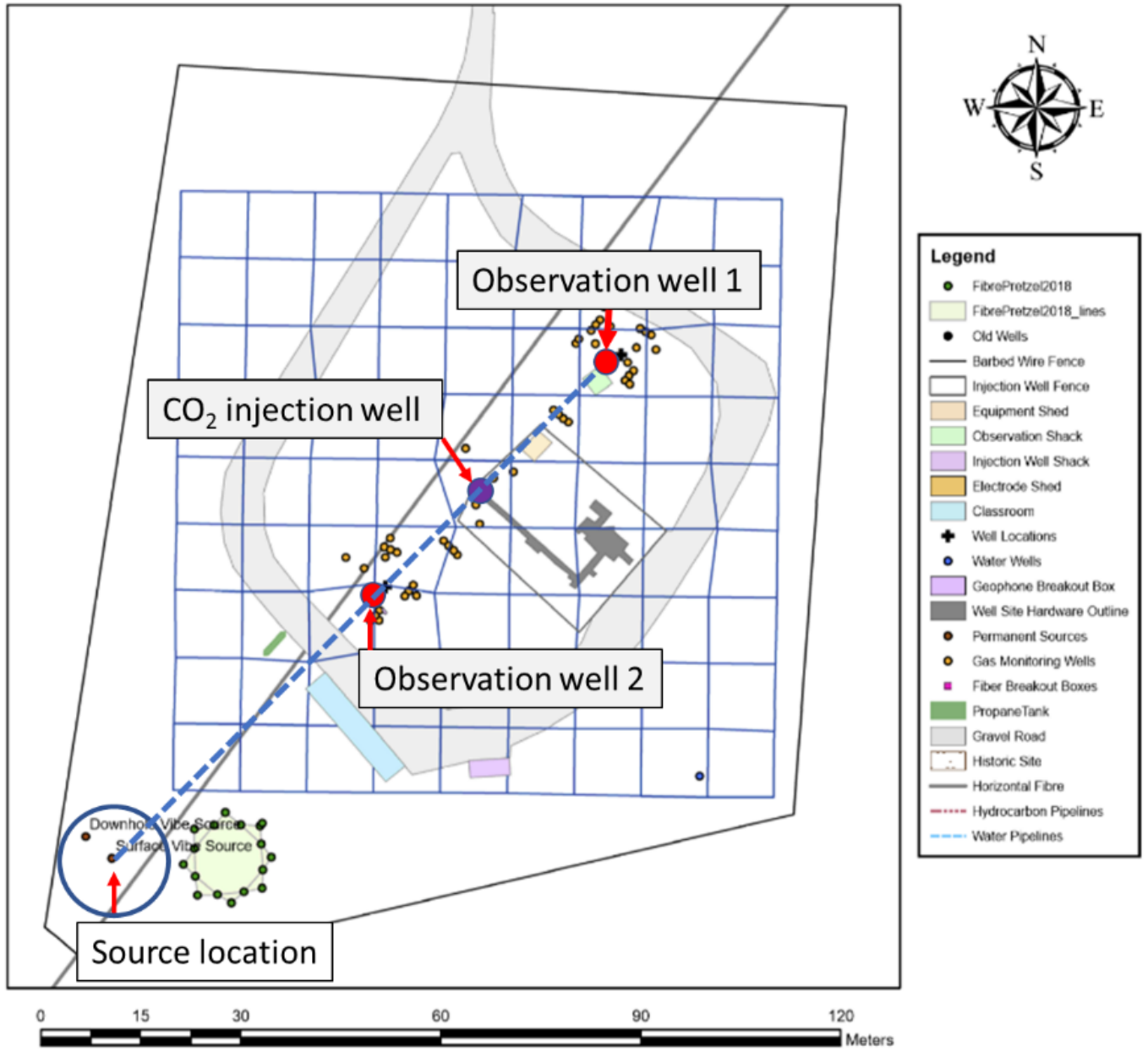
Southern Alberta shot gather

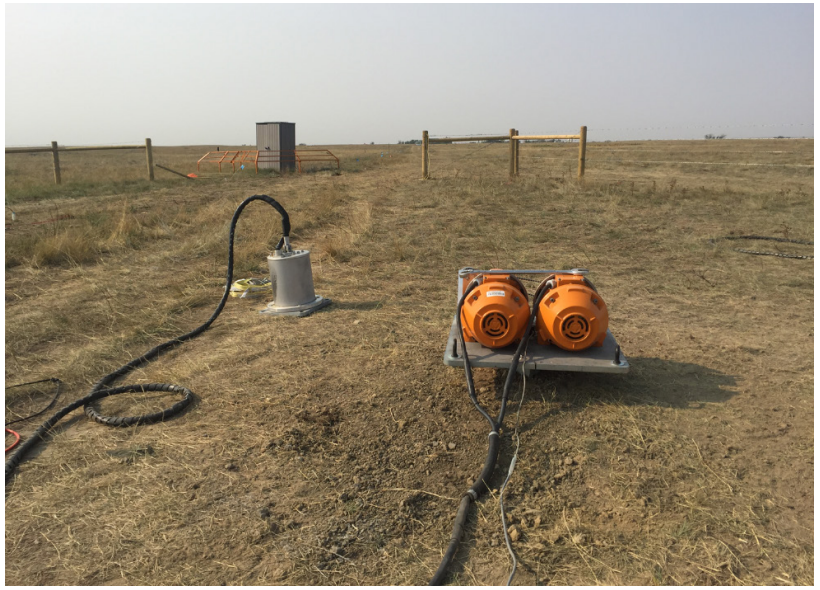


Shot gather illustrating optimum offset window



Permanent seismic sources





Conclusions

- Near-field VSP and ERT monitoring has established CO_2 detection thresholds at the CaMI Newell County Facility (< 40 tonnes) for CO_2 injection at 300 m depth → quantifiable leak detection.
- Sparse multi-physics monitoring will likely be key for gigatonne-scale CO_2 storage..
- A seismic source mounted on a helical pedestal and a buried receiver array show promise for highly repeatable surveys.
- Sparse monitoring will aim to:
  - Show conformance → CO_2 plume arrival (storage complex events)
  - Identity containment issues within plume (changes in shallow events)
- Receiver side can be used for microseismic monitoring between active source surveys, to monitor for induced seismicity.

Acknowledgements

Carbon Management Canada

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CREWES

PrairiesCan

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EMISSIONS REDUCTION ALBERTA

Accelerating CCS Technologies

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