CO$_2$ storage in Canada

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Outline

- CO₂ storage projects: then and now
- Aquistore CO₂ storage project
- Time-lapse monitoring
- Microseismic monitoring
Figure 6: Map of Phanerozoic sedimentary basins in Canada that are recommended for evaluation in regard to their potential and capacity for CO₂ storage.¹²
Planned or Operating CCS Projects

2011

- SPECTRA
- PIONEER
- QUEST
- WEYBURN
- AQUISTORE
Operating CCS Projects 2017

- **QUEST**: 2 Mt
- **WEYBURN**: 30 Mt
- **CaMI**: Not mentioned
- **AQUISTORE**: 120 kt
2. AQUISTORE CO$_2$ STORAGE PROJECT
CO₂ Injection

Monitor 1 (36 kT)

Monitor 2 (102 kT)
PTRC Injector

Injection into 3 zones

Porosity: 6-7%
Permeability: < 20 mD

10% Black Island
45% Winnipeg FM
45% Deadwood B
45% Deadwood C
45% Deadwood D
45% Deadwood A
45% Precambrian
3. 3D TIME-LAPSE SEISMIC
Aquistore: 3D Time-Lapse Seismic

Baseline survey (March-2012)
- 3D Surface seismic

Monitor I (May-2013)
- 3D Surface seismic

Monitor II (Nov-2013)
- 3D Surface seismic
- 3D DAS VSP test

CO2 injection started (Q4 2015)

Monitor III (Feb 2016) 36 kT
- 3D Surface seismic
- 3D DAS VSP

Monitor III (Nov 2016) 102 kT
- 3D Surface seismic
- 3D DAS VSP
M1-BL nRMS results

Mean nRMS=13%
4D Seismic Inline Slice

Monitor 3 (36 ktonnes CO₂)

Monitor 4 (102 ktonnes CO₂)
M3-BL: 30m RMS @3280 m
Deadwood C

36 Ktonnes

300 m
M4-BL: 30m RMS @3280 m
Deadwood C

102 Ktonnes

300 m
Deadwood Sand Height Above Dipping Plane

(Roach et al., 2018; White et al., 2018)
4. 3D TIME-LAPSE DAS VSP
DAS VSP

(Harris et al., 2015, 2017)
Time-Lapse VSP: 36 kT

(Harris et al., 2018)
3D Time-Lapse Seismic: Deadwood nRMS

3D DAS-VSP

Surface 3D

(Harris et al., 2017)
Summary

- **Repeatability (GnRMS):**
  - Surface 3D: ~10%, DAS VSP: ~30%. Allow detection of relatively small changes in reservoir.

- **1st Monitor Survey (36 kT):**
  - Time-lapse amplitude anomaly in the Deadwood at ~3260 m.
  - Extends <200 m from the injection well, likely corresponds to ~15 kT CO$_2$.
  - The anomaly extends to the NNW (up dip) from the injection well following NNW basement fabrics.
  - CO$_2$ levels in the upper reservoir (Winnipeg) and Lower Deadwood are below seismic detection threshold at this stage.

- **2nd Monitor Survey (102 kT):**
  - Time-lapse amplitude anomaly in the Deadwood at ~3260 m now extends ~300 m to NNW from the injection well.
  - Anomaly developing in the lower Deadwood, but still nothing in the upper reservoir (Winnipeg formation).

- **Geological model:**
  - History-matched flow simulations don’t match time-lapse seismic. Models will have to be modified accordingly.
5. MICROSEISMICITY
Microseismic Monitoring

(Stork et al., 2018)
Monitoring Period

CO₂ Injection

1C (20m)
3C (6m)
Broadband (3)
Broadband (+2)
Downhole

Jul '12  Jan '13  Jul '13  Jan '14  Jul '14  Jan '15  Jul '15  Jan '16  Jul '16  Jan '17  Jul '17

(Stork et al., 2018)
Regional Event: Mine Blast

(Stork et al., 2018)
Summary

- No induced seismicity to date
- Minimum detectable magnitude for 3.2 km depth:
  - BB: $M_L = -0.8$
  - Array: $M_L = -1.6$ to $-0.6$
- Magnitude of completeness (STA/LTA):
  - BB: $M_W = 1.3$
  - Array: $M_W = 0.6$

(Stork et al., 2018)
CO$_2$ Injection in Basal SS

- **Quest** (Oropeza Bacci et al., 2017)
  - Minimal seismic response
  - 3 locatable basement events, Mw -1.8 to -0.6
  - 9-14 months after injection start; >750 kT

- **Decatur** (Bauer et al., 2016)
  - ~5000 events M -3.0 to 1.2; 94% < M 0.0)
  - onset 2 months after injection start; ~56kt

- **Aquistore** (Stork et al., 2018)
  - Is injection aseismic or just early in injection history?