# Carbon capture and storage: ambitious targets for reductions in $CO_2$ emissions in Canada

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AWMA CPANS presentation, December 14, 2010


# CCS - why do it ?

Currently: ~84 million bpd

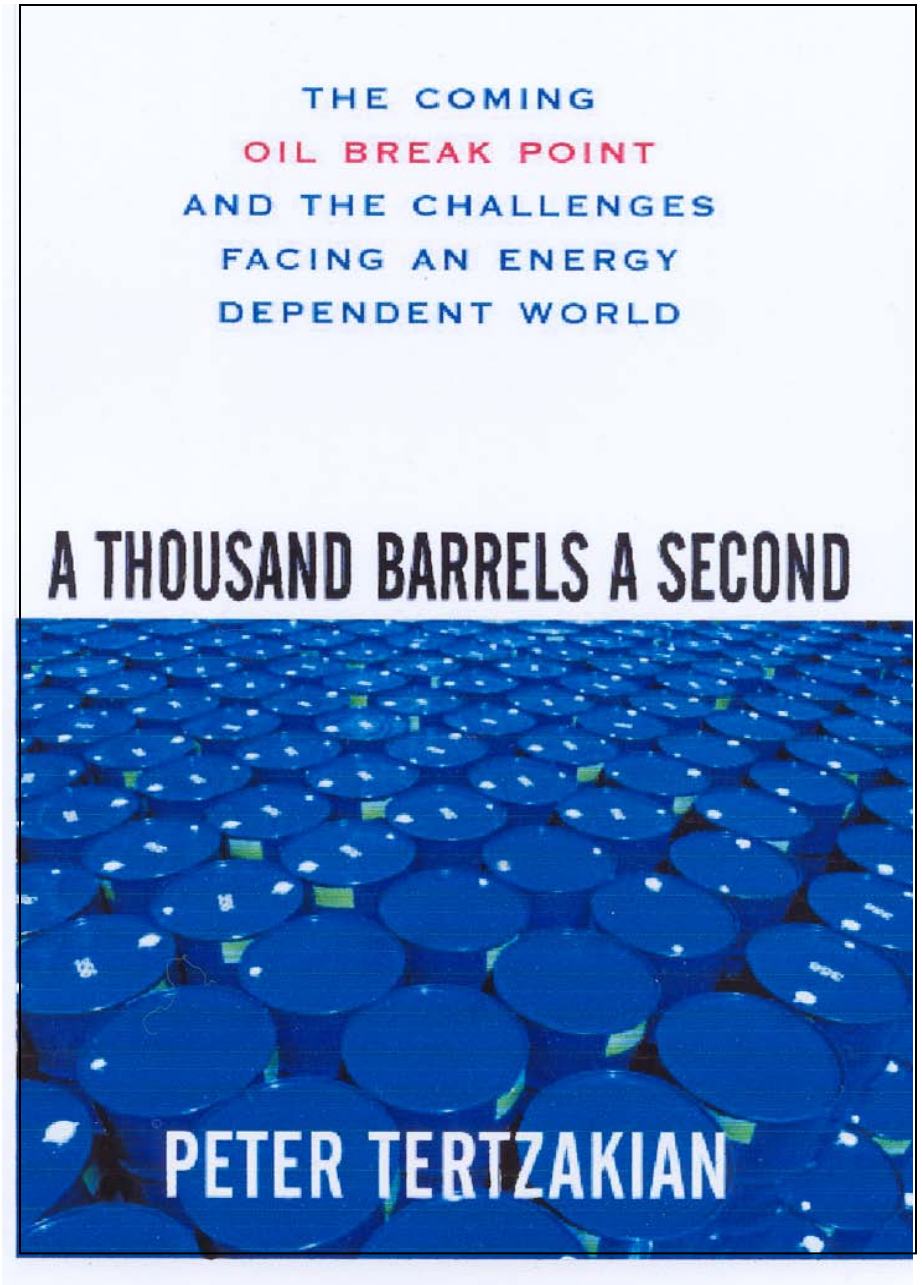
↓

86.4 million bpd

↓

Yields: ~ 35 million tpd $CO_2$

**Total worldwide emissions**
**30 Gt/yr $CO_2$**

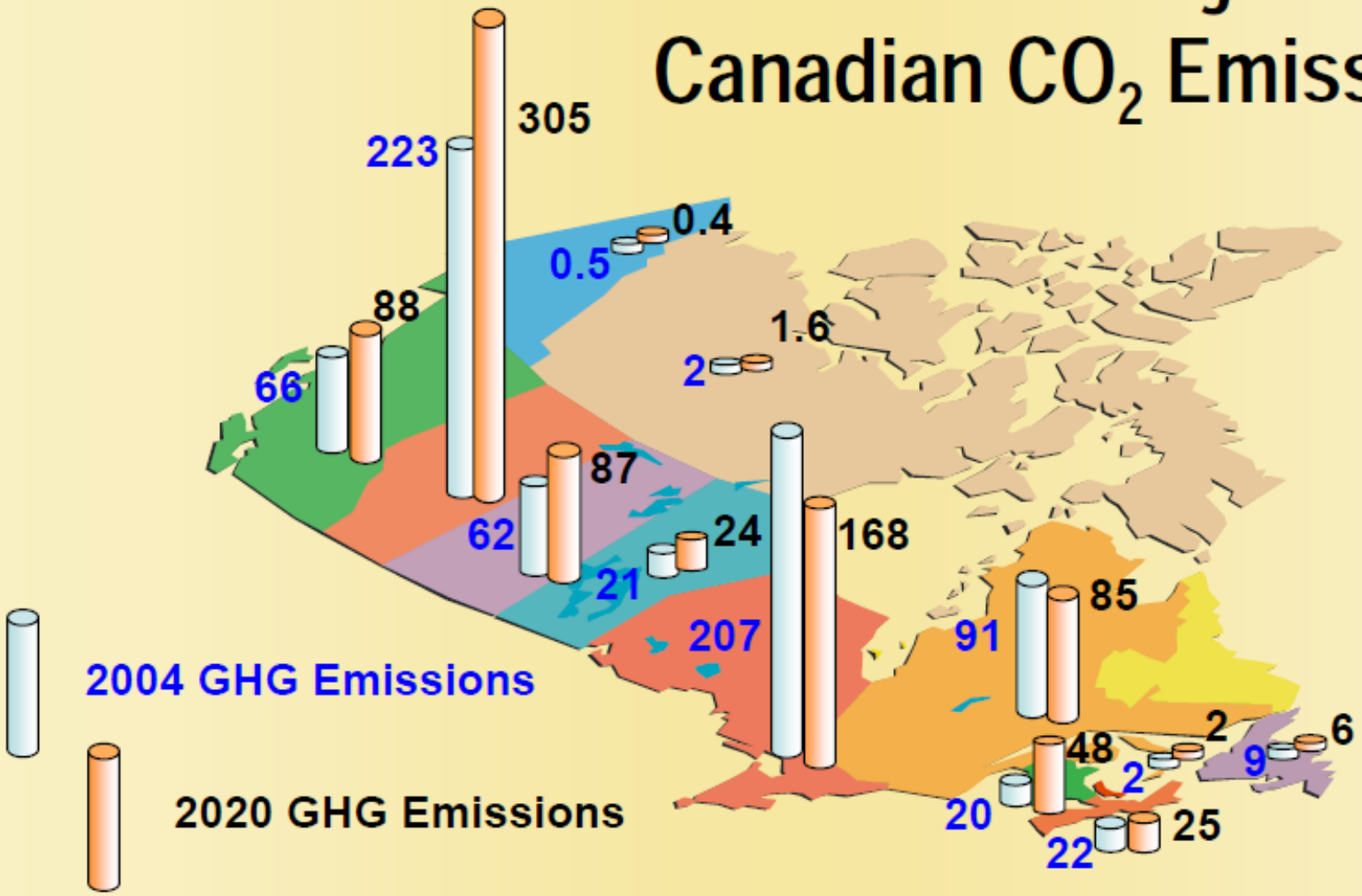


# GHG emissions

| Country | $CO_2e$ t/person/year |
|---|---|
| United States | 19 |
| Australia | 19 |
| Canada | 18 |
| China | 5 |
| Indonesia | 2 |
| India | 1 |

http://www.carbonplanet.com/country_emissions

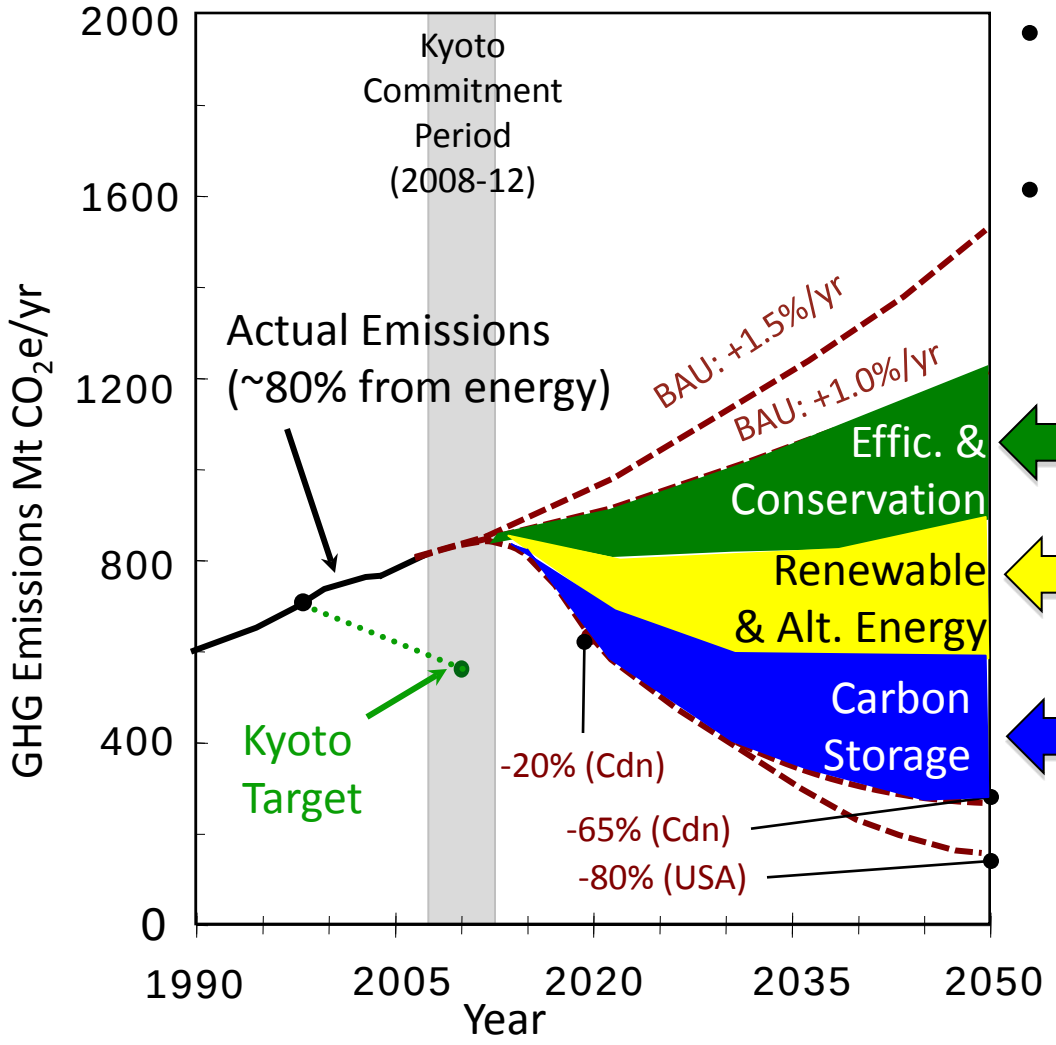
# Current and Projected Canadian $CO_2$ Emissions






Bachu, 2009

# Canada's 2050 target for emissions reductions



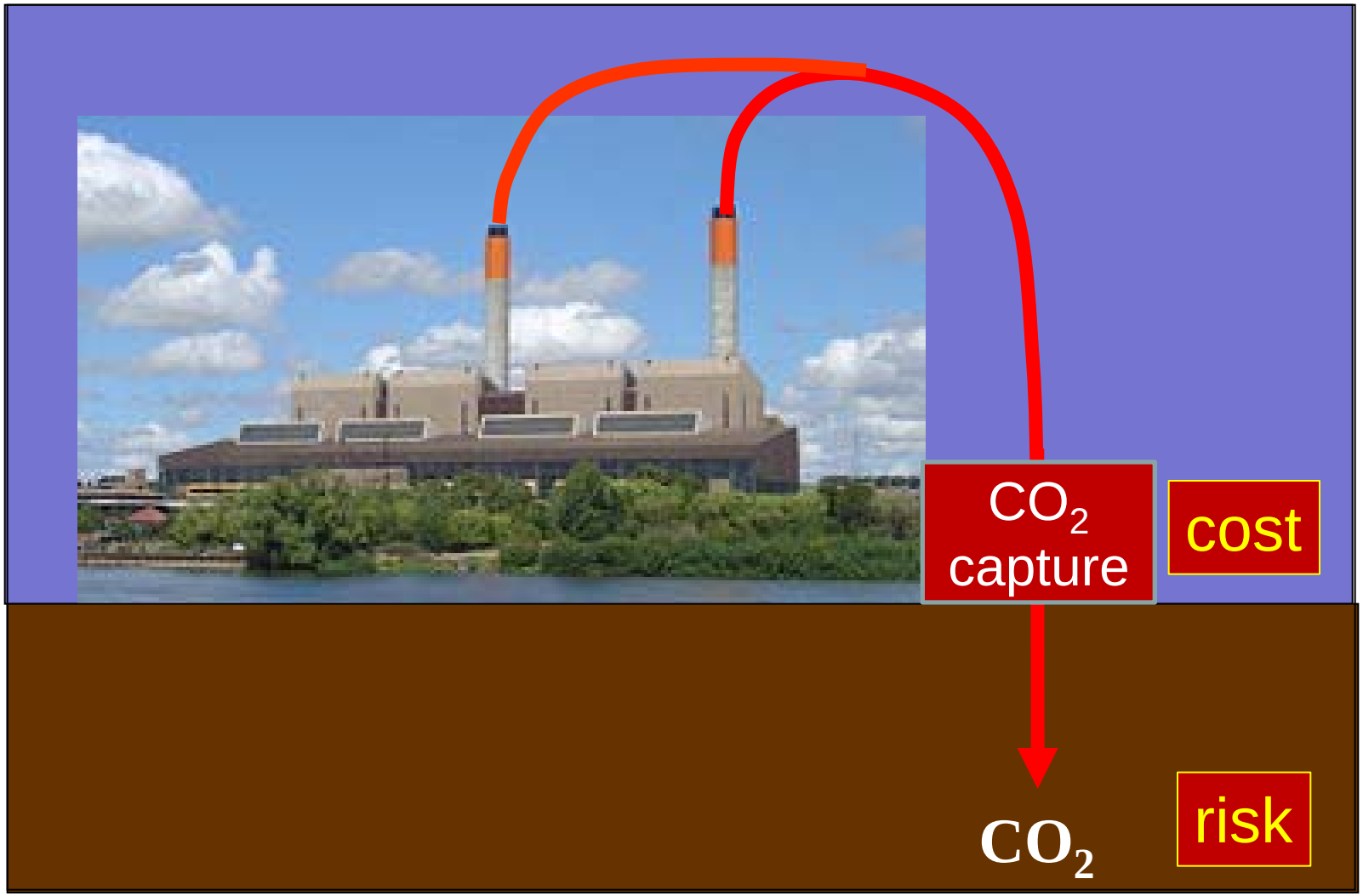

- Requires >850 Mt of GHG emission reductions by 2050
- Since fossil fuels account for 80% of emissions, meeting the target must entail:
  - Conserving and using fossil fuels more efficiently;
  - Substitution with alternative or renewable energy;
  - Keeping fossil carbon out of the atmosphere.

*Achieving 2050: A carbon pricing policy for Canada (2009), NRTEE*

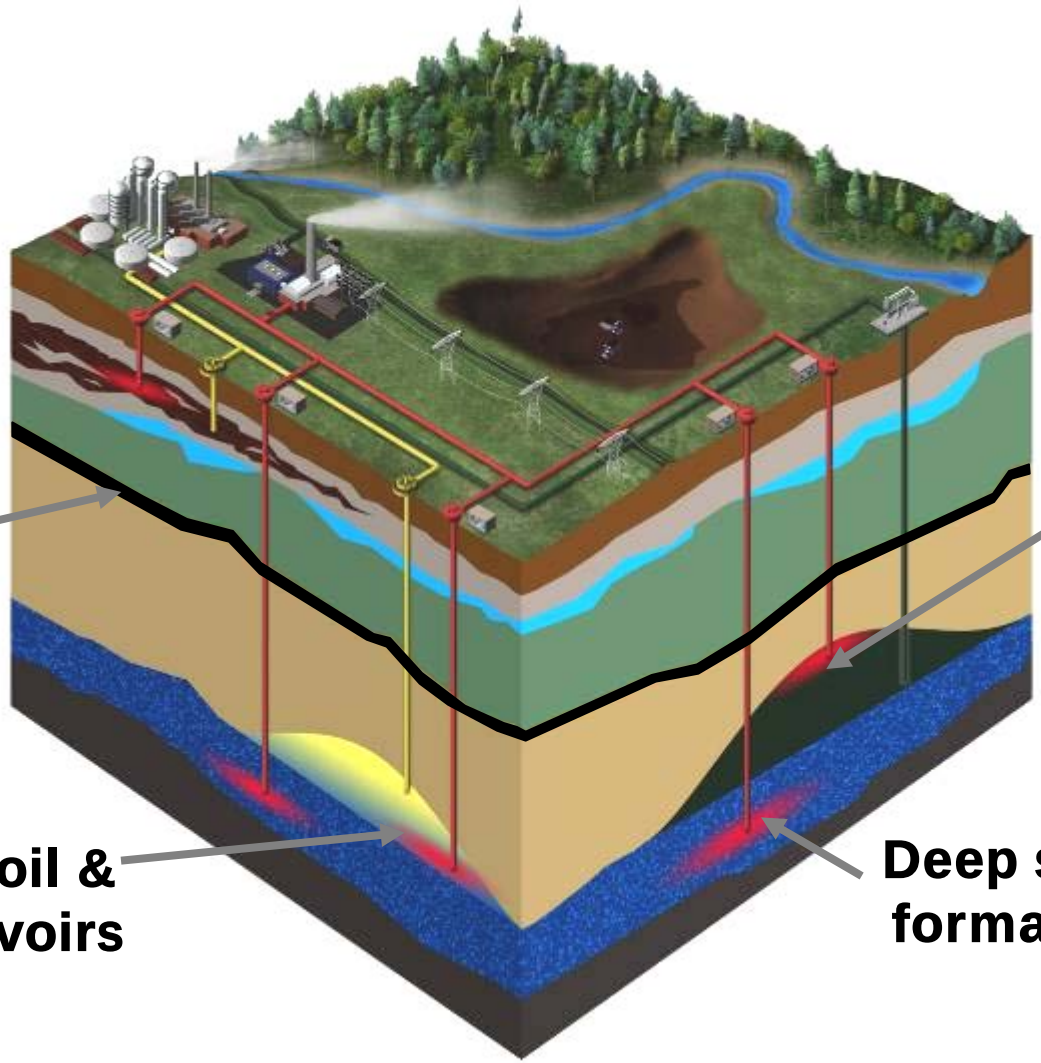


Carbon Management Canada
CMC-NCE

# CCS from large point $CO_2$ emitters



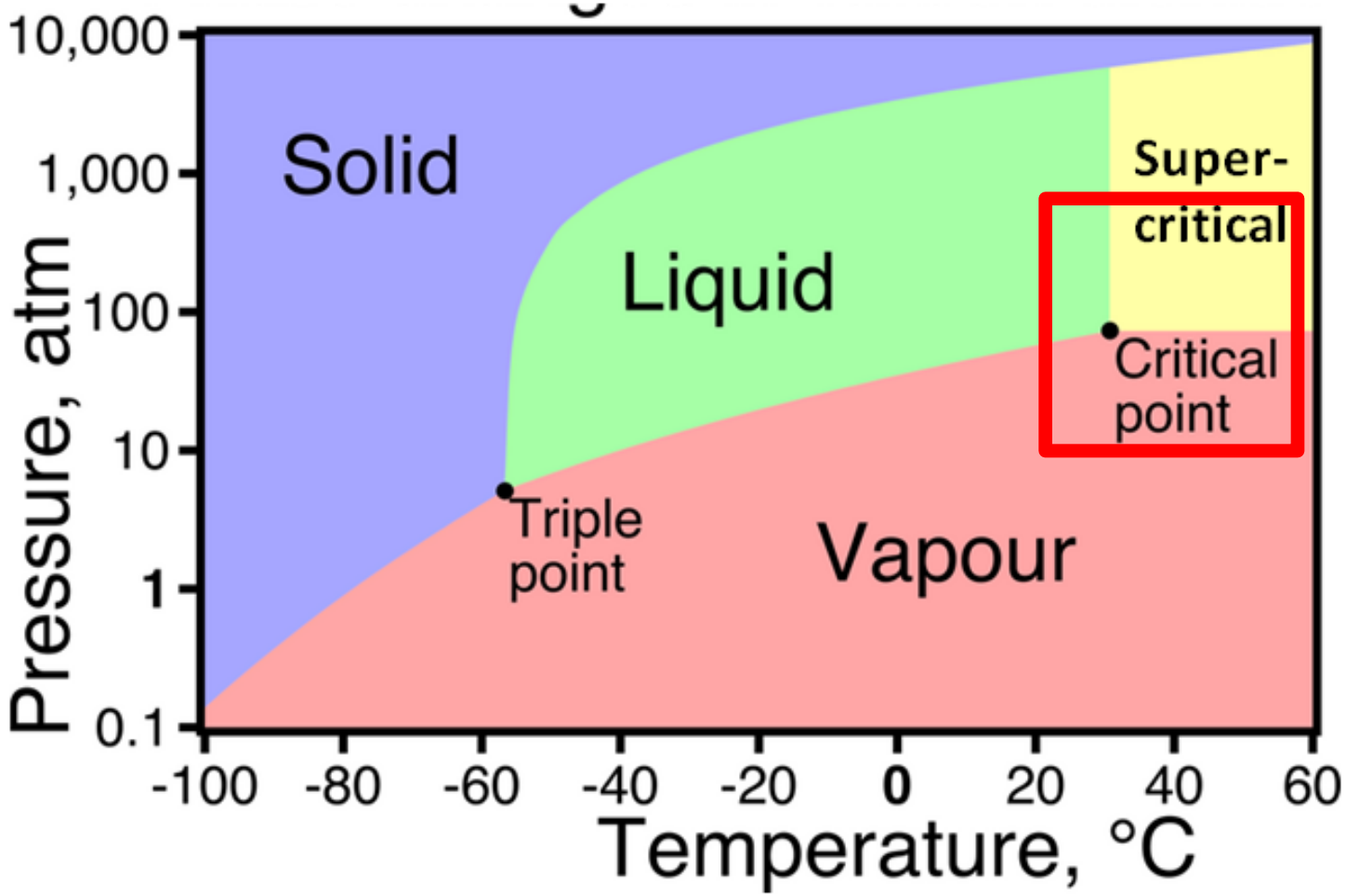
# Geological storage of $CO_2$






Courtesy Ian Potter, Alberta Research Council

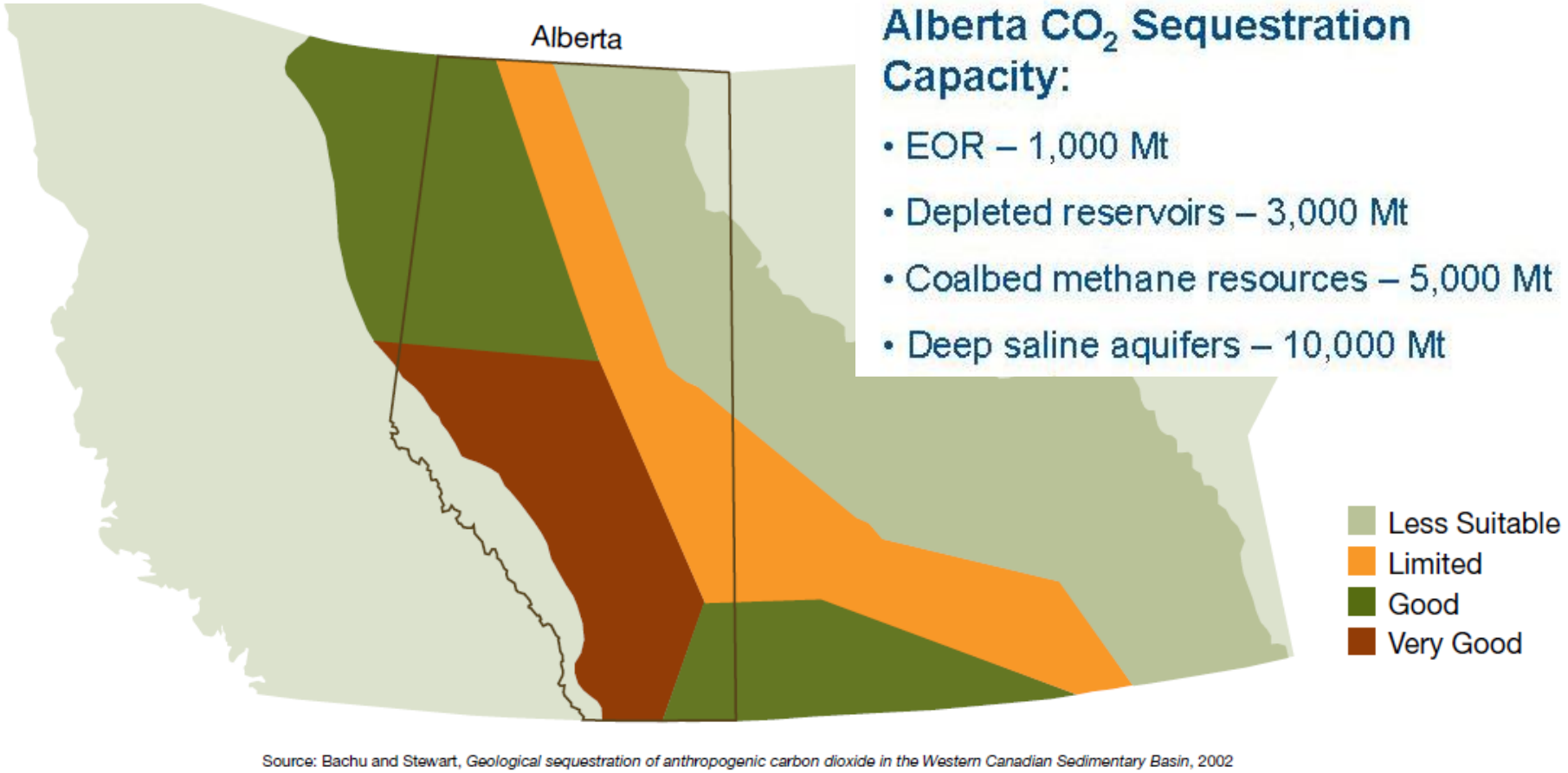
# Properties of $CO_2$






http://www2.warwick.ac.uk/ fac/sci/eng/cmd/research/civil/supercritical/

# CCS potential in Alberta

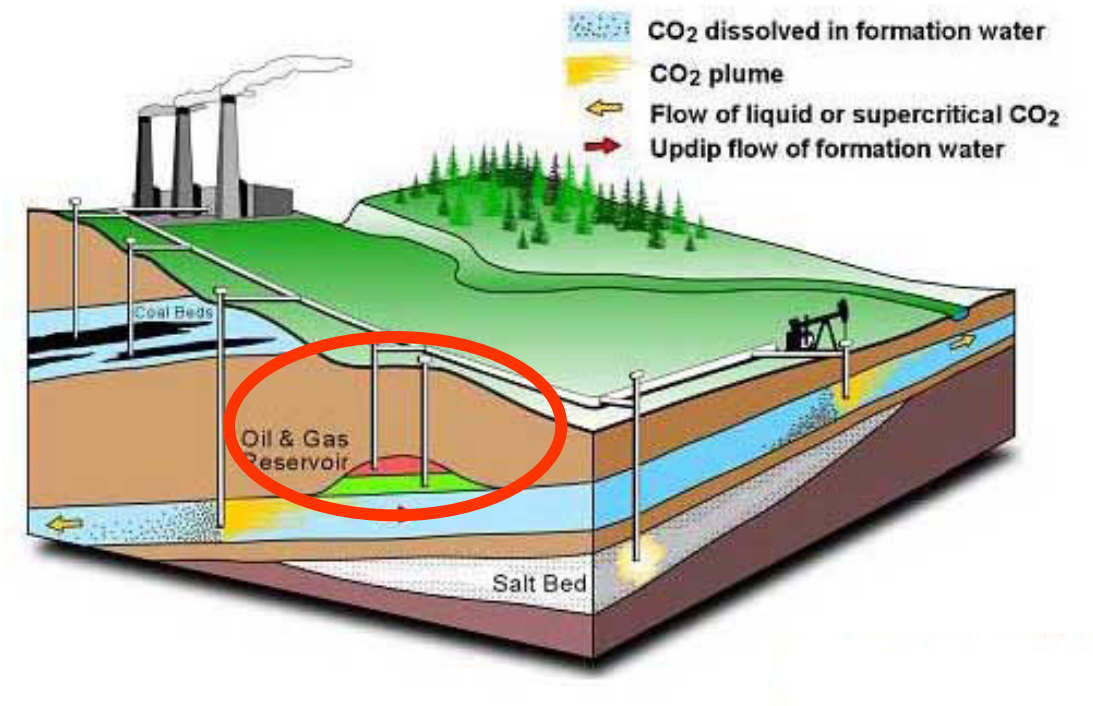



Source: Bachu and Stewart, *Geological sequestration of anthropogenic carbon dioxide in the Western Canadian Sedimentary Basin*, 2002

Capacity --- Injection rate --- Storage security --- Fate of $CO_2$

After Bachu and Stewart, 2002 http://www.oilsands.alberta.ca/FactSheets/FS-CES-CCS.pdf

# Geologic storage of $CO_2$
# EOR and depleted oil & gas reservoirs



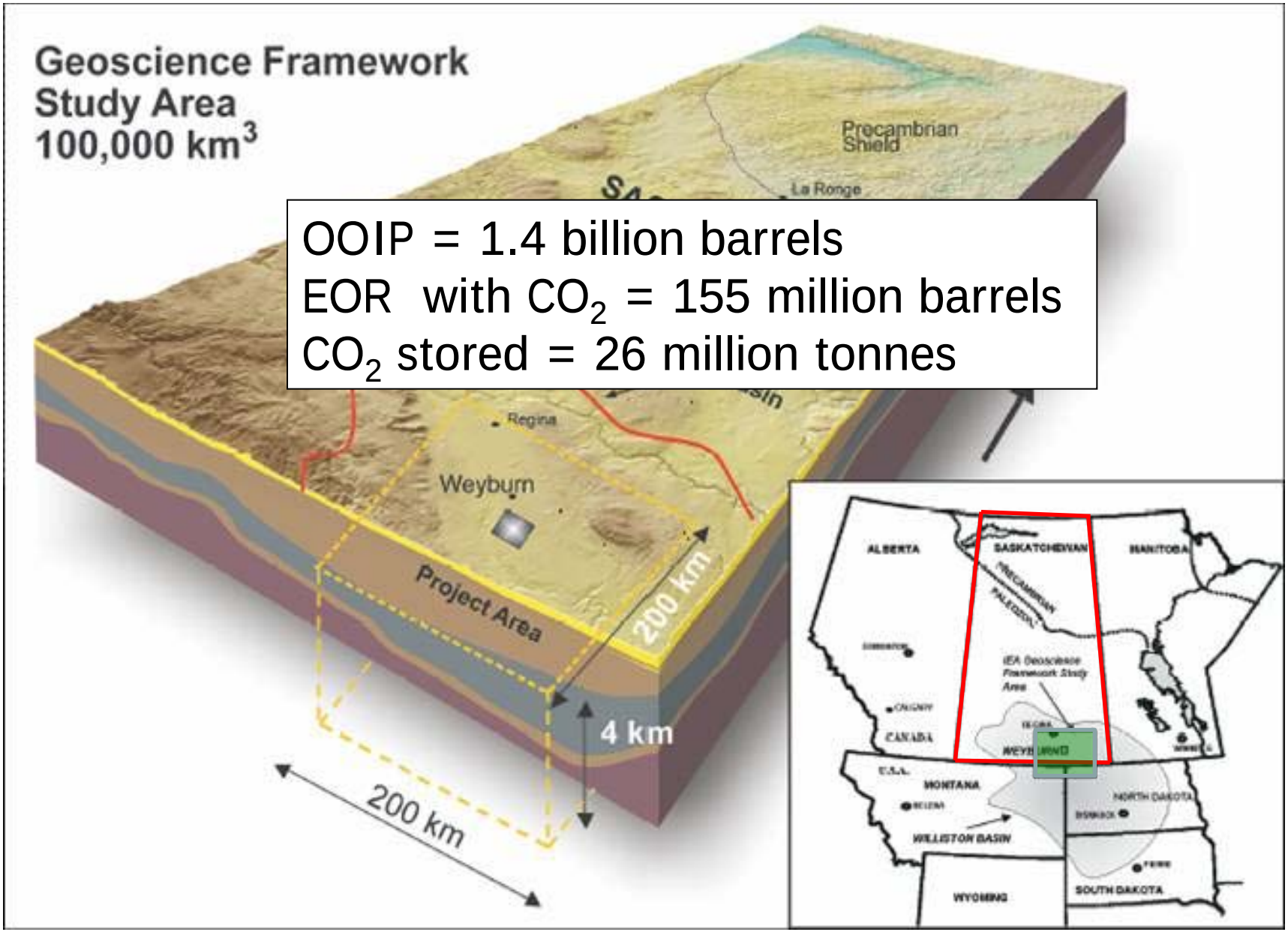

Various means of CO2 geological sequestration.

- Geometry of reservoir is well known
- Physical trapping mechanism
- Known caprock integrity
- History matched
- Leakage potential through old wells



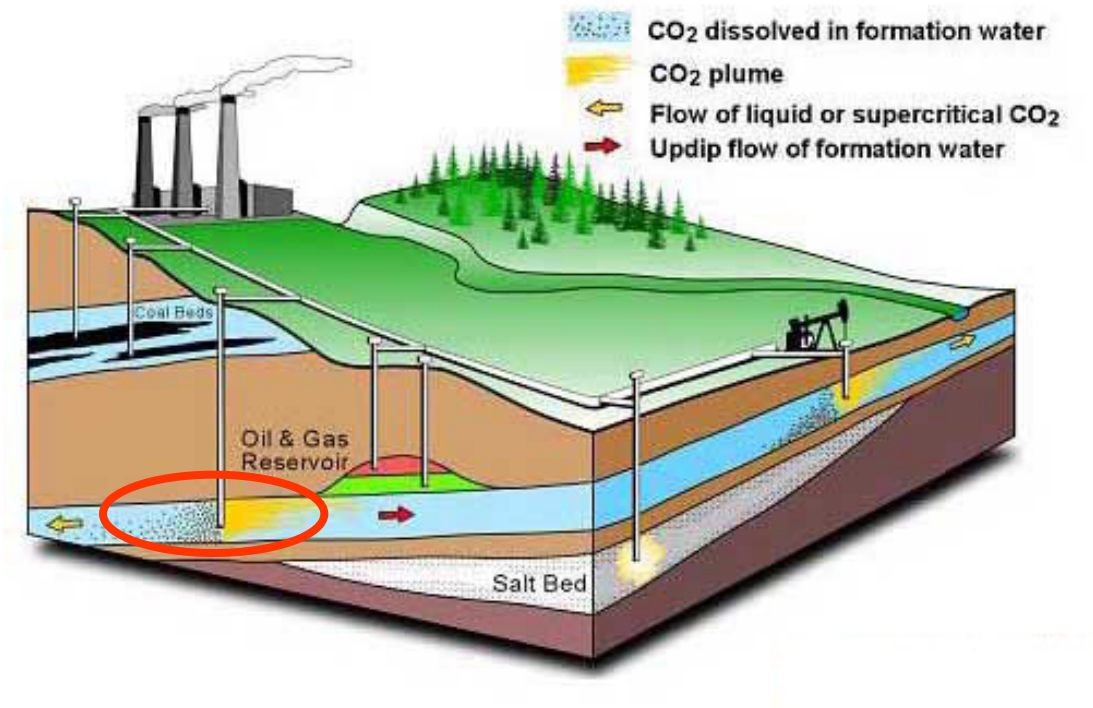
http://www.ags.gov.ab.ca/co2_h2s/means_of_storage.html

# Weyburn-Midale $CO_2$ Project, Saskatchewan




Don White, NRCan

# Geologic storage of $CO_2$ deep saline formations



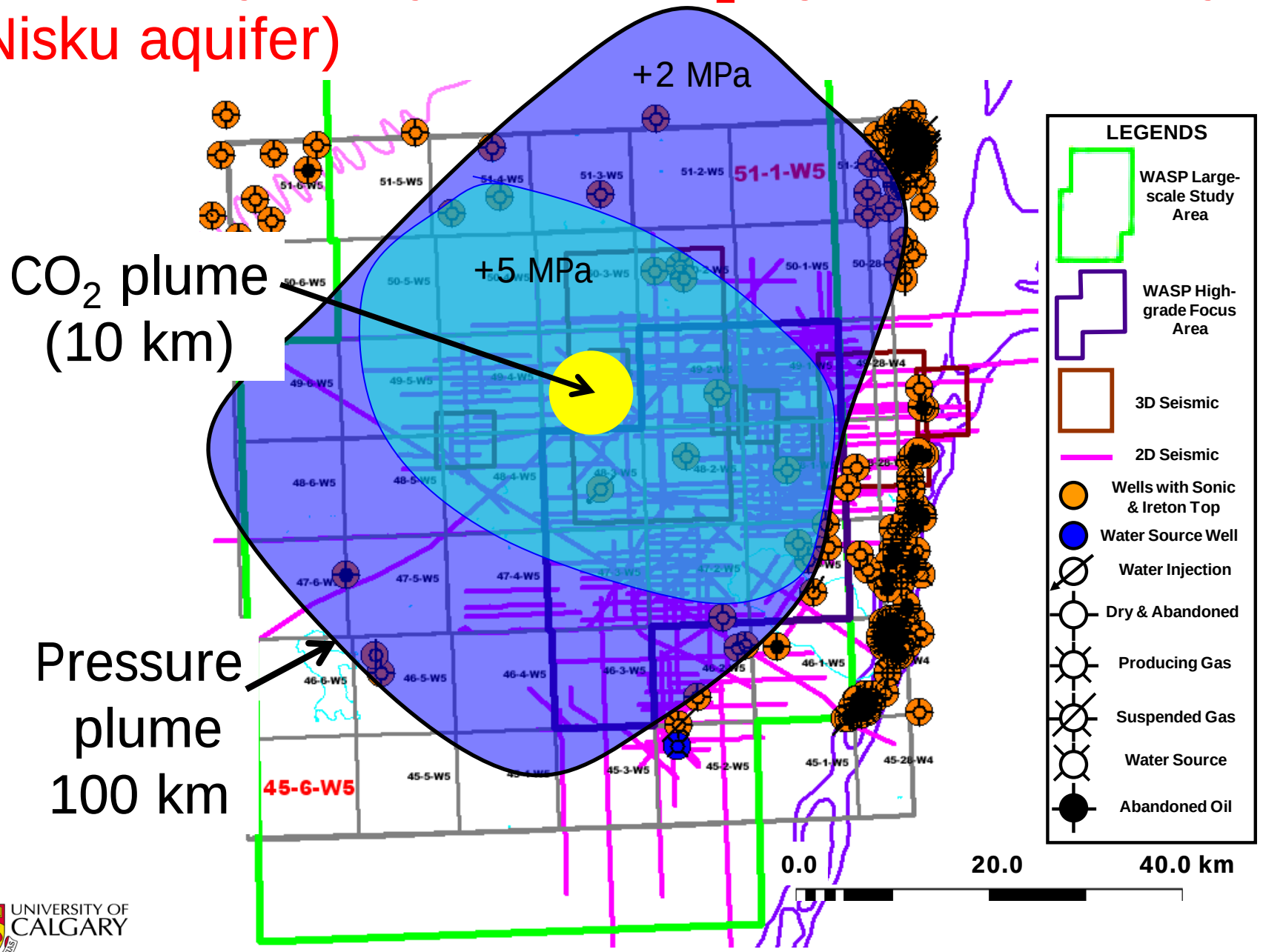

Various means of CO2 geological sequestration.

- Reservoir may not be confined
- Chemical/hydrodynamic trapping mechanism
- Seal integrity untested
- No history to match
- Deep, multiple seals
- Few wells for potential leakage pathways



http://www.ags.gov.ab.ca/co2_h2s/means_of_storage.html

# WASP study : 50 years of $CO_2$ injection at 1 Mt/year (Nisku aquifer)

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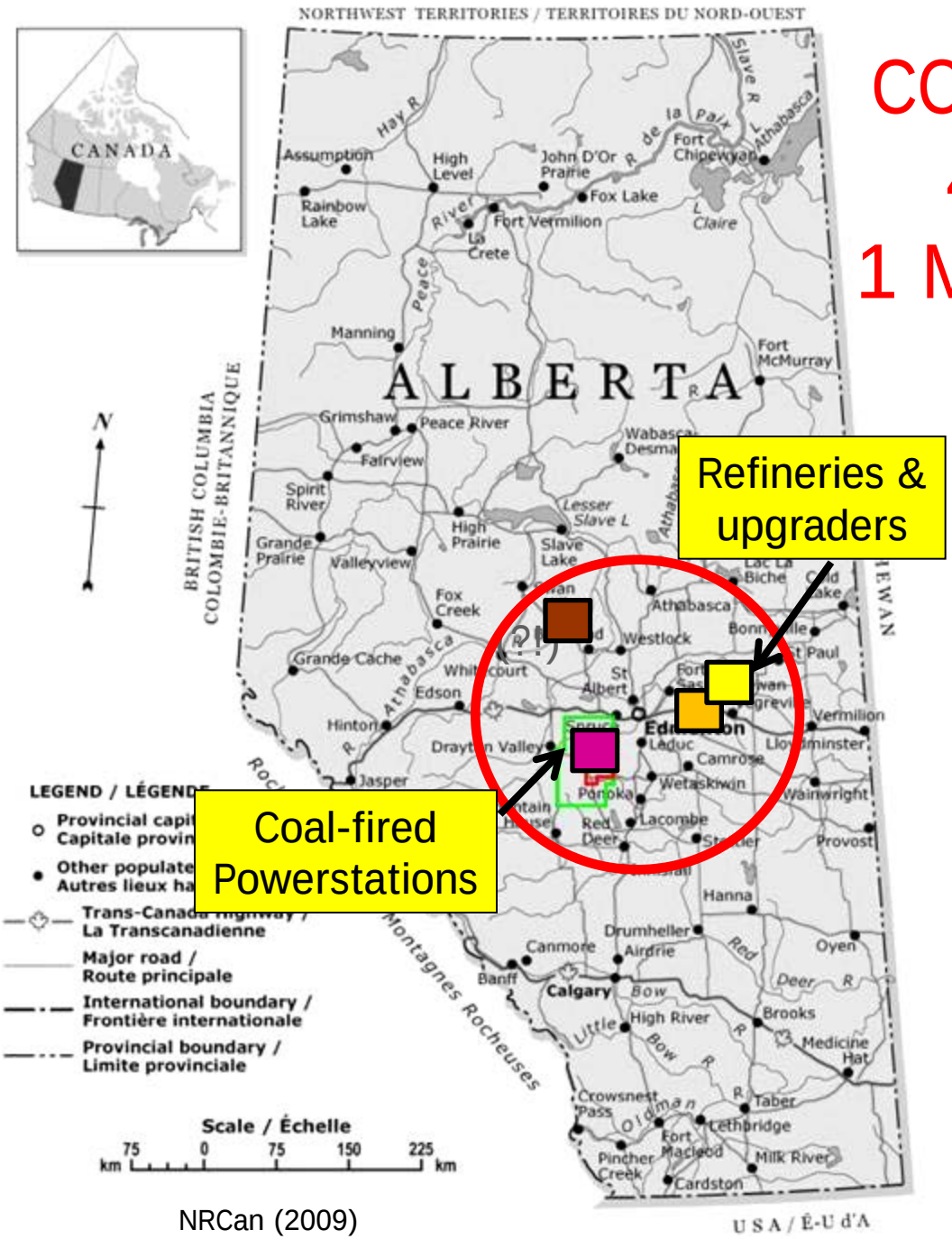
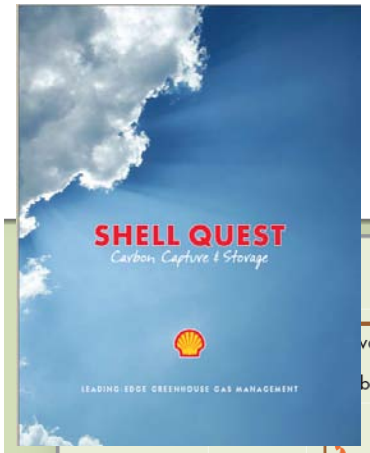
# CCS in Alberta
# 4 projects
# 1 Mt/y by 2015




NRCan (2009)

# Shell Quest Project





**Quest CCS Project is located next to Shell Scotford, in the Industrial Heartland Region, approximately five kilometres northeast of Fort Saskatchewan, AB.**


**The proposed pipeline route (shown above in orange) will travel aproximately 100 kilometres north of Shell Scotford to the chosen injection locations.**



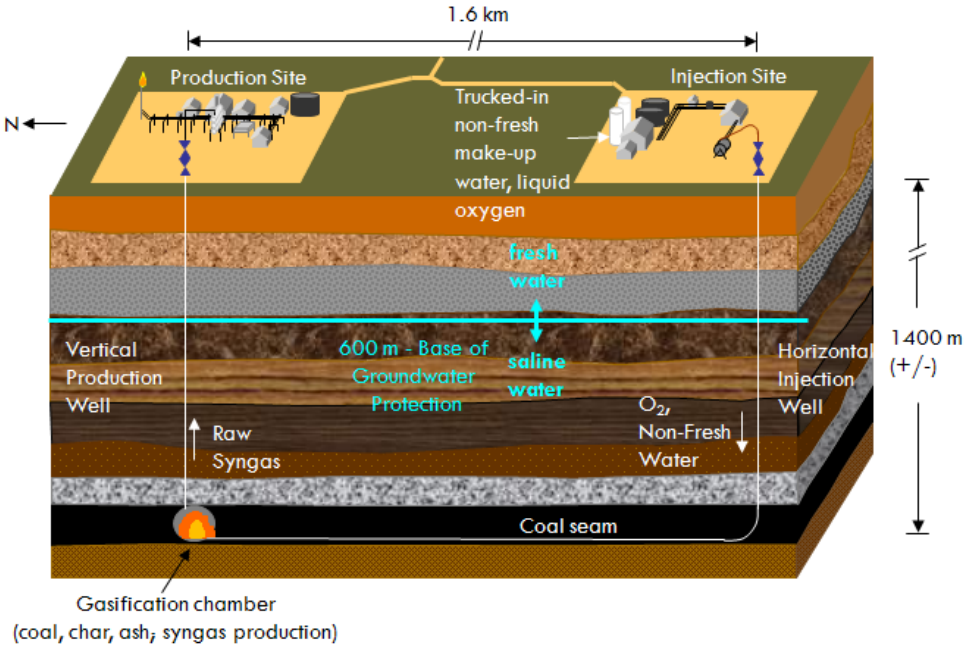
http://www-static.shell.com/static/investor/downloads/news_and_library/quest_ccs_project_overview.pdf

# Enhance Energy





# Swanhills Synfuels


http://swanhills-synfuels.com/iscg/overview/



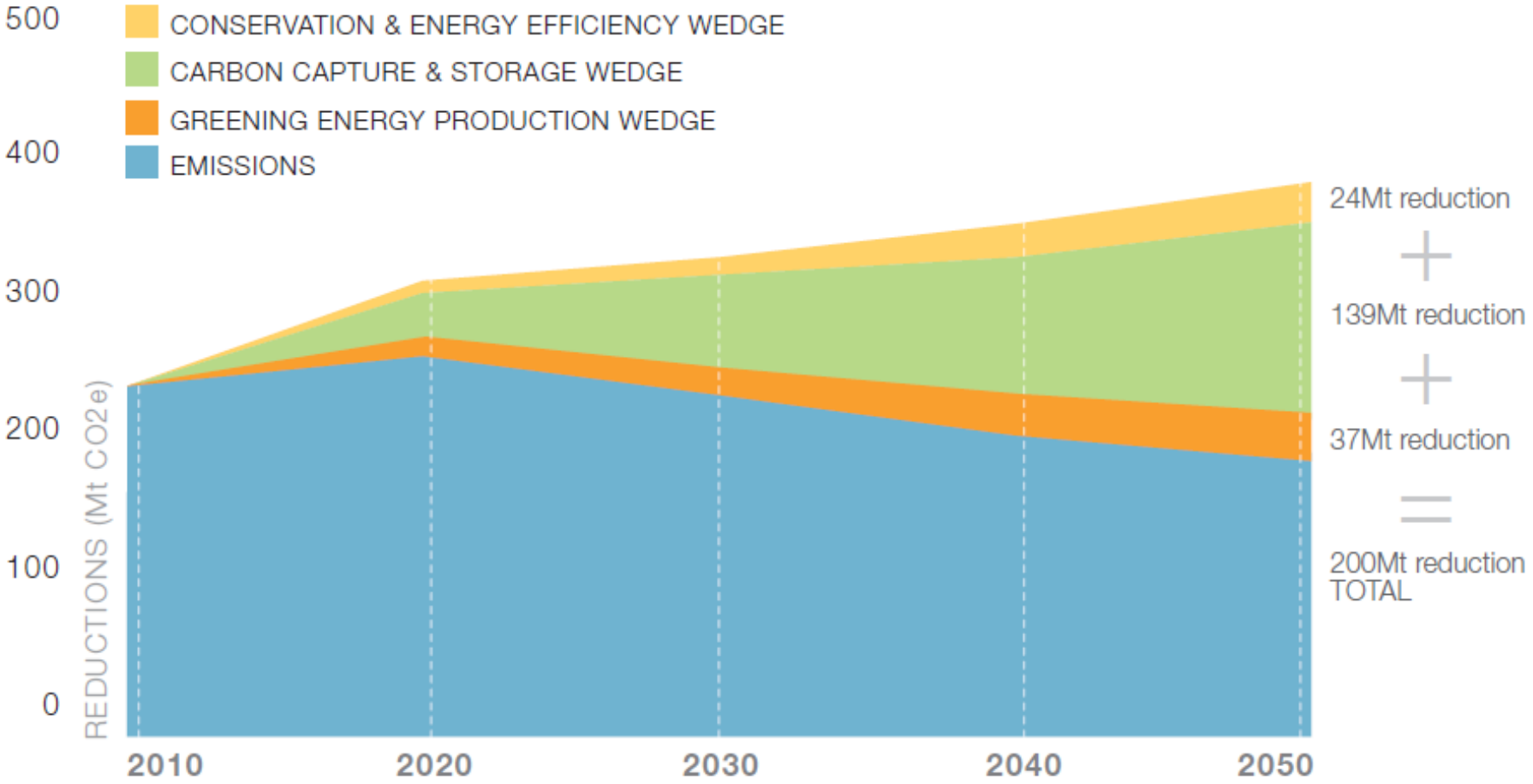
http://www.zeroco2.no/projects/alberta-carbon-trunk-line

# TransAlta Project Pioneer




http://projectpioneer.ca/about-pioneer/maps

# Alberta's 2008 $CO_2$ emissions reductions targets






http://environment.gov.ab.ca/info/library/7894.pdf

# CCS site selection

- Determination of $CO_2$ storage capacity in storage formation/complex
- Mapping and understanding seal quality and any containment risk for $CO_2$ storage
- Ability for sustained injectivity of $CO_2$ in the storage formation
- Understanding potential for unintended consequences (seismicity, pressure)
- Design and implementation of a monitoring program

# Risk from a regulatory perspective

- Pressure interference with existing hydrocarbon pools
- Pressure interference between adjacent CCS projects
- Brine migration through old wells
- Out of zone $CO_2$ migration to another storage formation (pore space)
- $CO_2$ migration to shallow aquifers through wells or natural pathways (faults, fractures)
- $CO_2$ escape into the atmosphere

# Risk concerns from a public perspective

- Will $CO_2$ leak back into the atmosphere?
- Are there any environmental or safety concerns associated with CCS? Now *and* in the future?
- What happens to the carbon dioxide once it is underground? Will it stay there?
- Will $CO_2$ leak and contaminate groundwater ?
- Will CCS cause earthquakes?
- Will CCS reactivate faults?

# Monitoring – risk identification/mitigation

- **Baseline geological characterization**

  site selection, static geological model, reservoir and seal properties, legacy wells

- **Containment monitoring**

  well integrity, caprock integrity, leakage at injection or observation well(s)

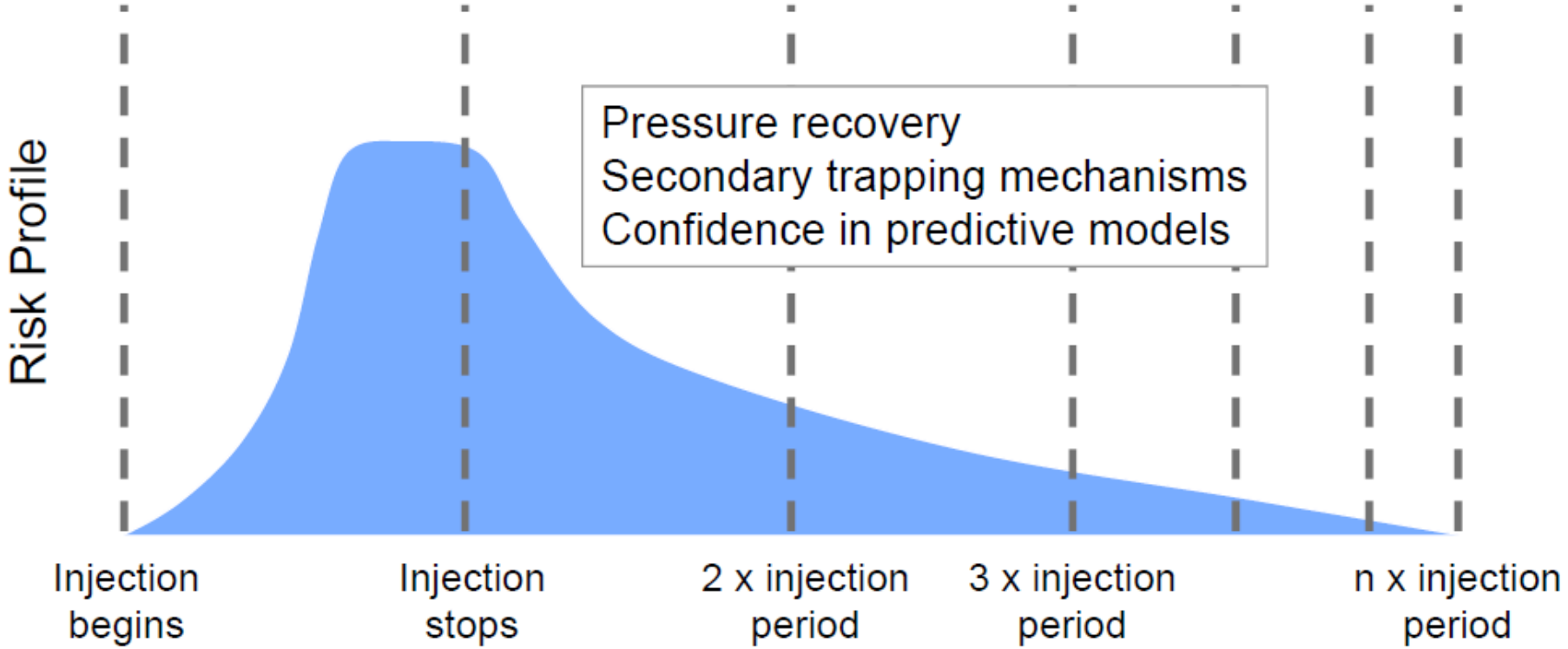
- **Conformance monitoring**

  $CO_2$ distribution in storage formation, out of zone migration, pressure distribution, consistency with modelling

- **Environmental monitoring**

  $CO_2$ migration to shallow aquifers, soils, or into the atmosphere

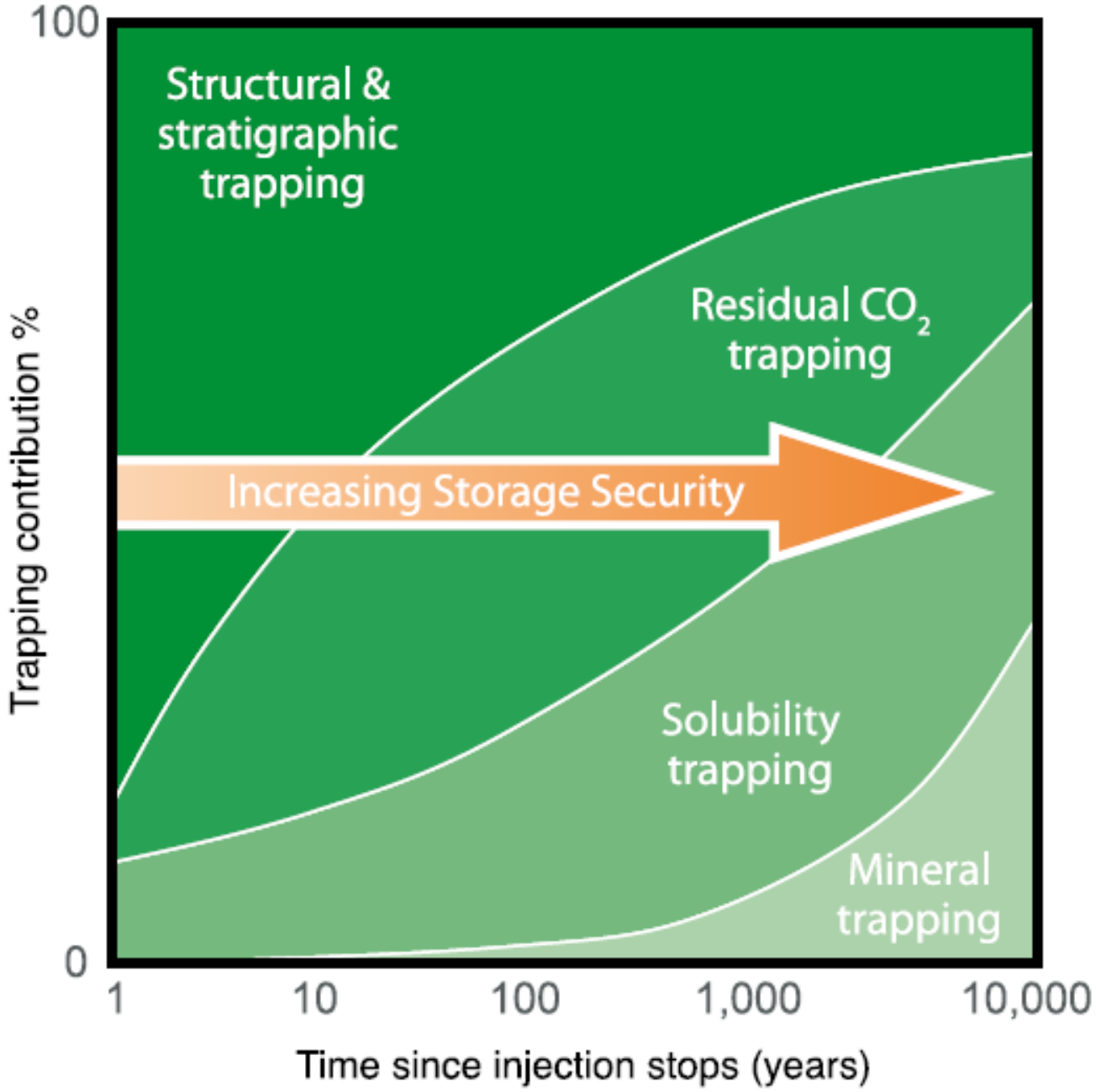
# CCS Risk





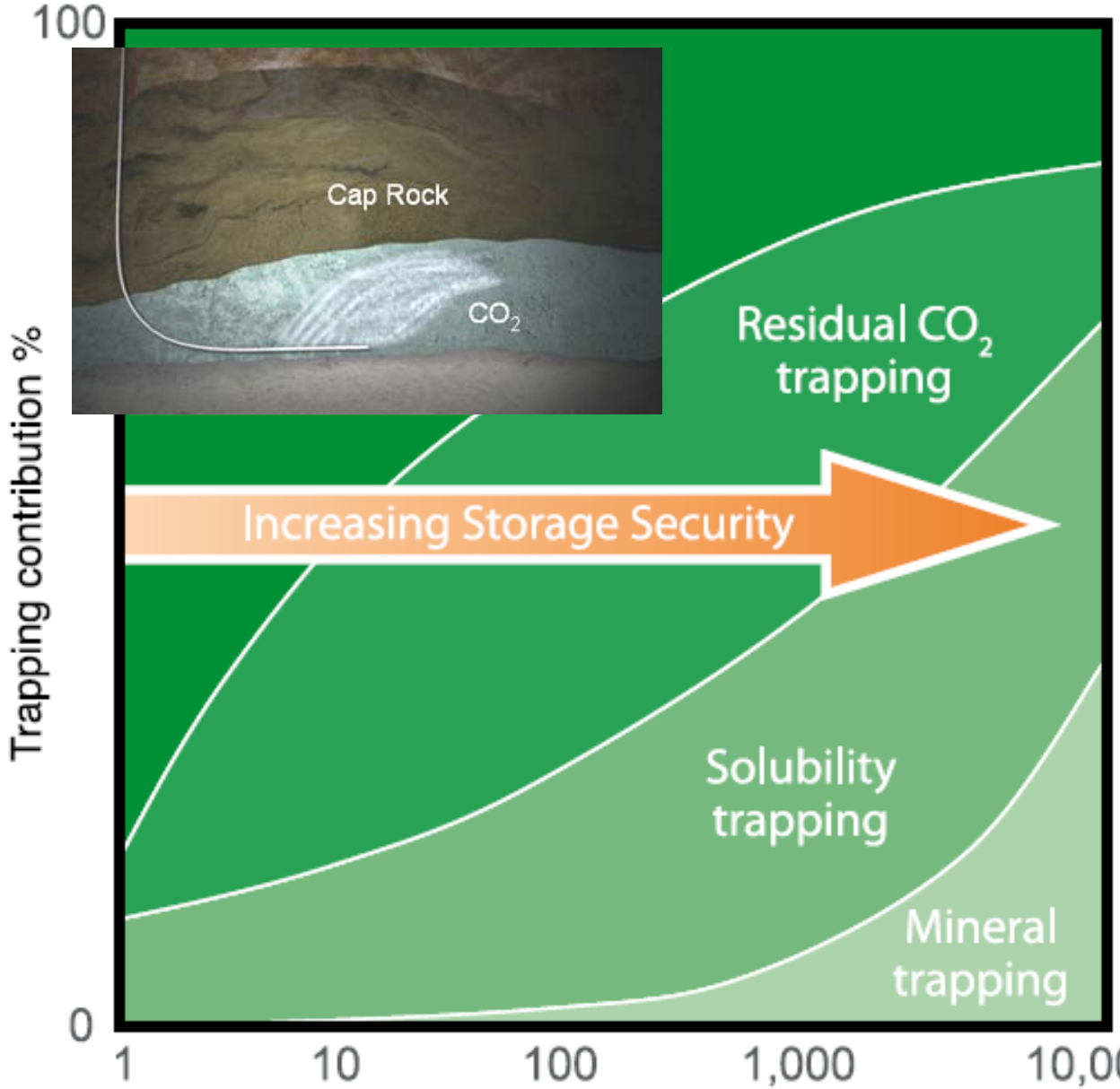

Benson, 2007

# $CO_2$ fate




IPCC, 2005

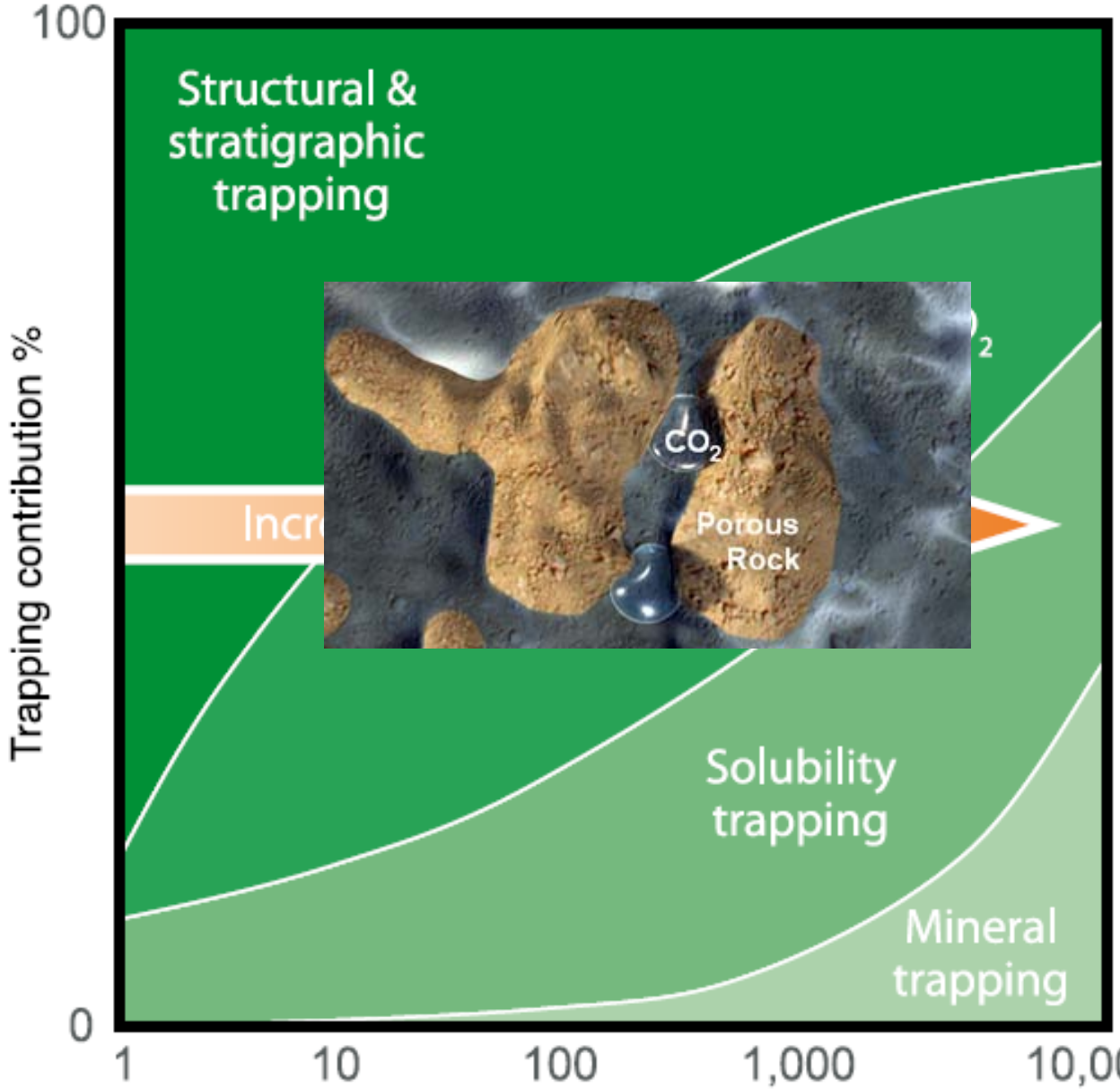
# Physical trapping




IPCC, 2005

After http://www.co2captureproject.org/co2_trapping.html

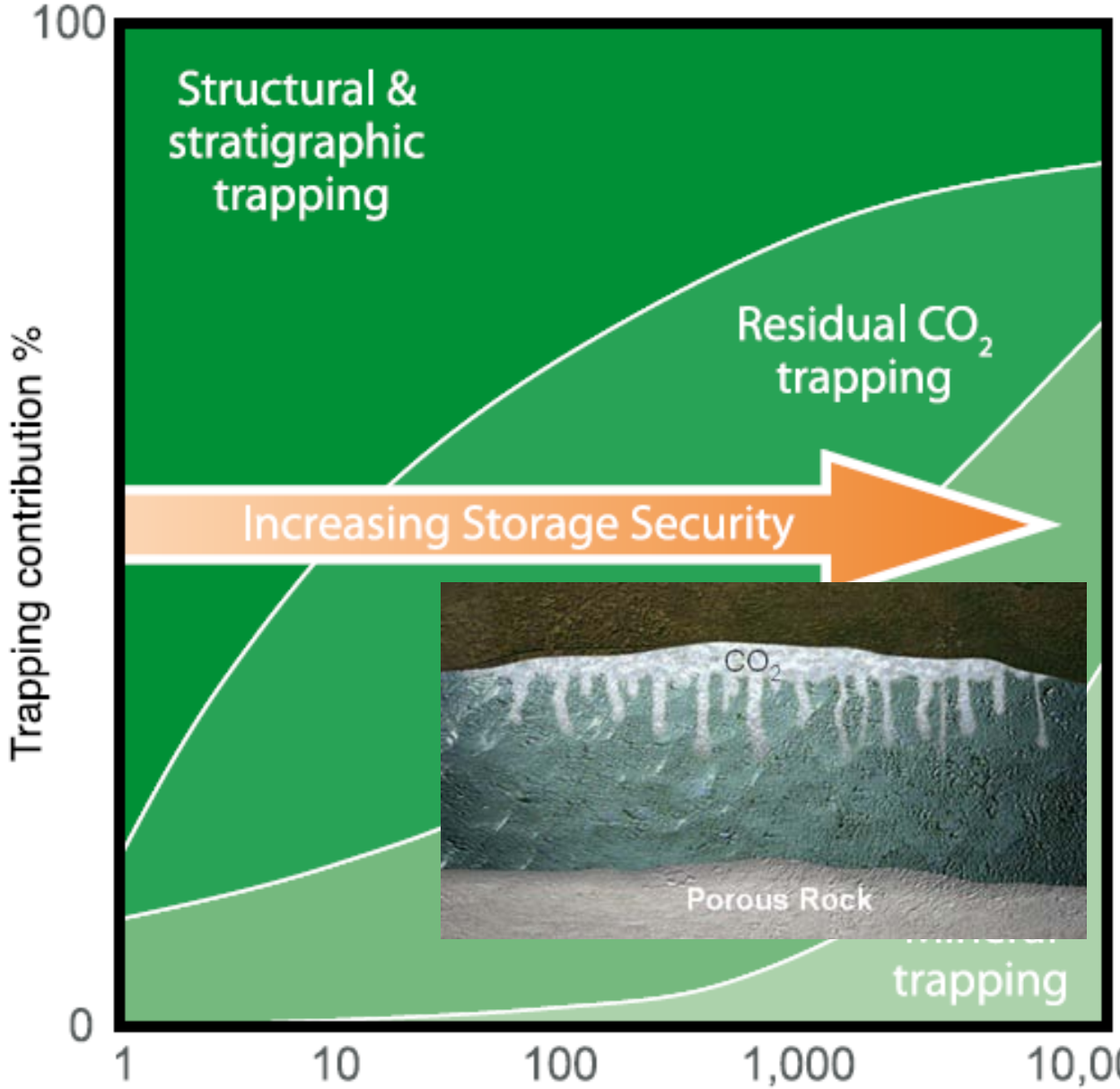
# Residual trapping




IPCC, 2005

After http://www.co2captureproject.org/co2_trapping.html

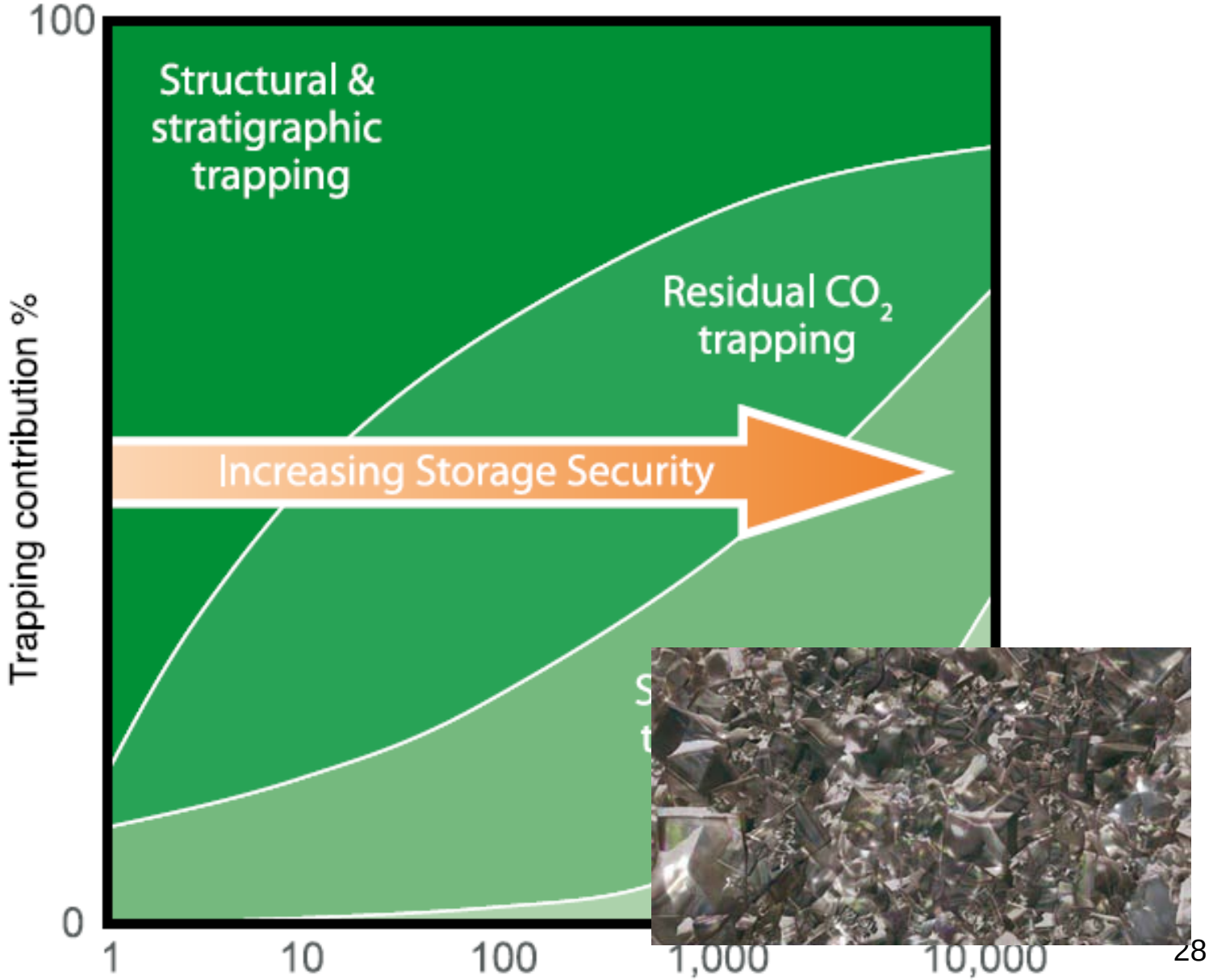
# Solubility trapping




IPCC, 2005

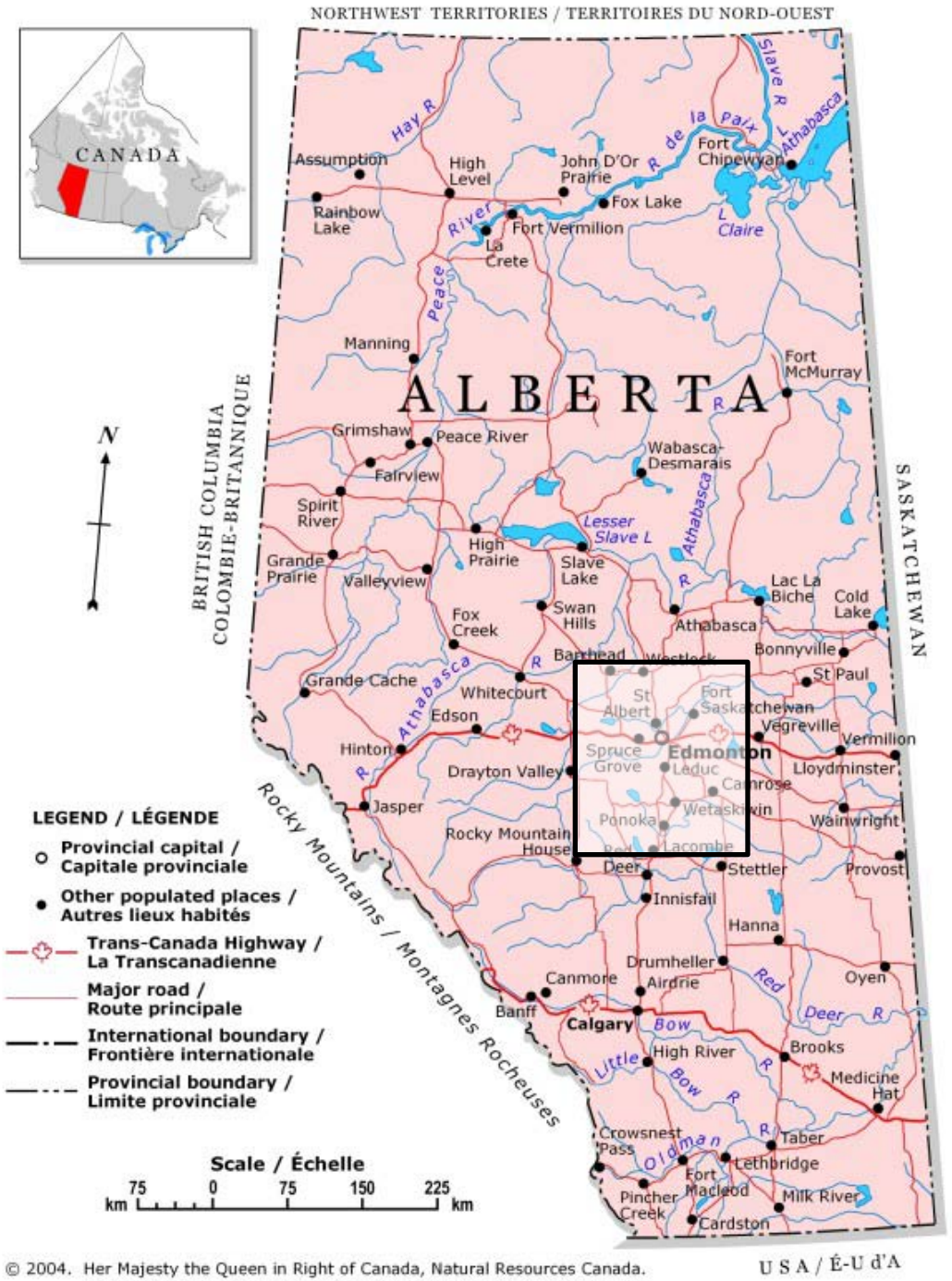
After http://www.co2captureproject.org/co2_trapping.html

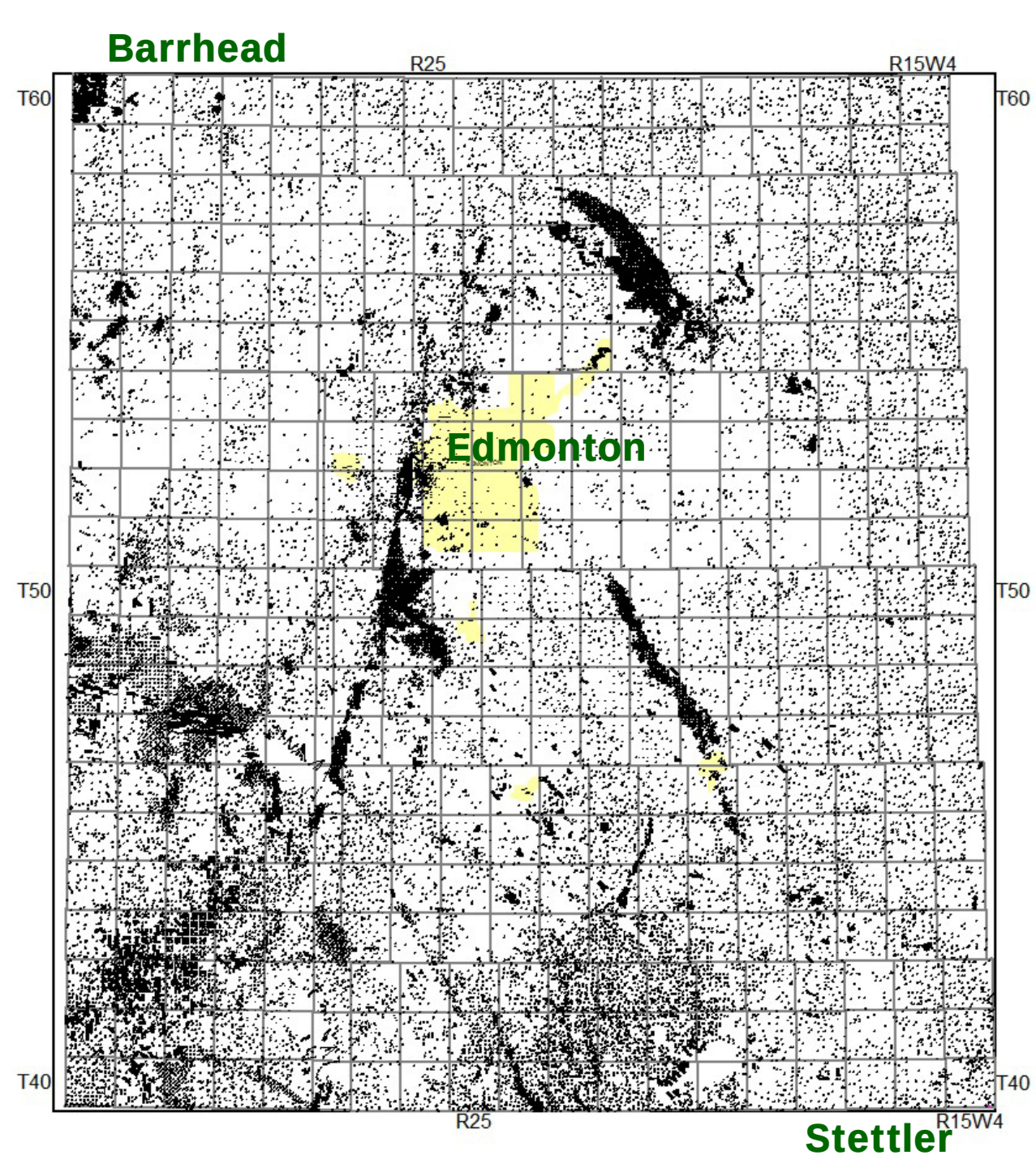
# Mineral trapping




IPCC, 2005

After http://www.co2captureproject.org/co2_trapping.html

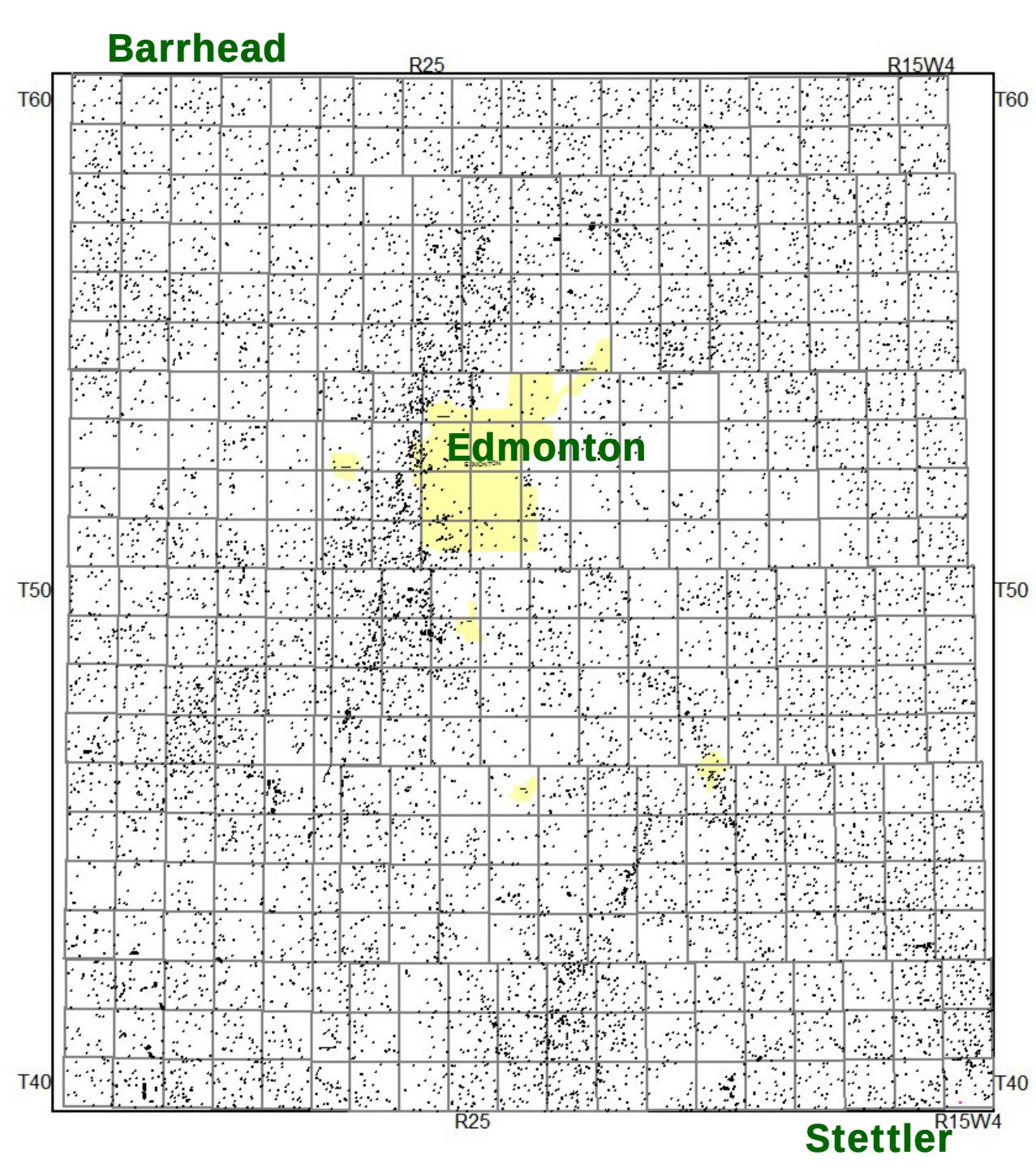

NORTHWEST TERRITORIES / TERRITOIRES DU NORD-OUEST
CANADA
ALBERTA
BRITISH COLUMBIA
COLOMBIE-BRITANNIQUE
SASKATCHEWAN
N
Assumption
High Level
John D'Or Prairie
Fort Chipewyan
Rainbow Lake
Fox Lake
Fort Vermilion
La Crete
Hay R.
Peace River
Slave R.
de la Paix R.
Athabasca L.
L. Claire
Manning
Fort McMurray
Grimshaw
Peace River
Fairview
Wabasca-Desmarais
Spirit River
Lesser Slave L.
Athabasca R.
Grande Prairie
Valleyview
High Prairie
Slave Lake
Lac La Biche
Cold Lake
Fox Creek
Swan Hills
Athabasca
Bonnyville
Grande Cache
Whitecourt
St Albert
Fort Saskatchewan
St Paul
Edson
Vegreville
Vermilion
Hinton
Spruce Grove
Edmonton
Leduc
Drayton Valley
Lloydminster
Camrose
Jasper
Wetaskiwin
Ponoka
Wainwright
Rocky Mountain House
Lacombe
Deer
Stettler
Provost
Innisfail
Hanna
Rocky Mountains / Montagnes Rocheuses
Drumheller
Canmore
Airdrie
Red Deer R.
Oyen
Banff
Calgary
Bow R.
High River
Brooks
Little Bow R.
Medicine Hat
Crowsnest Pass
Oldman R.
Taber
Fort Macleod
Lethbridge
Pincher Creek
Milk River
Cardston
LEGEND / LÉGENDE
Provincial capital / Capitale provinciale
Other populated places / Autres lieux habités
Trans-Canada Highway / La Transcanadienne
Major road / Route principale
International boundary / Frontière internationale
Provincial boundary / Limite provinciale
Scale / Échelle
75 0 75 150 225
km km
© 2004. Her Majesty the Queen in Right of Canada, Natural Resources Canada.
Sa Majesté la Reine du chef du Canada, Ressources naturelles Canada.
U S A / É-U d'A




# South-central Alberta wells

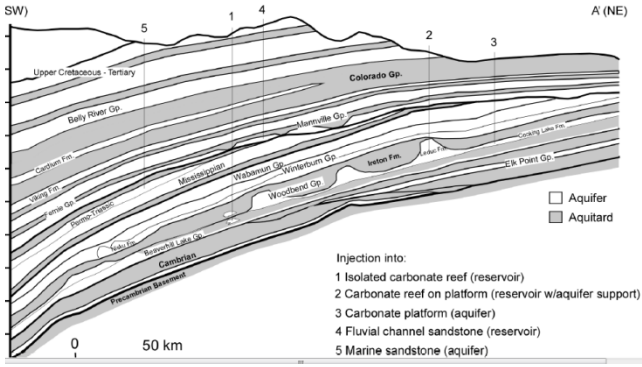
Total wells
49,880

Area
200 x 180 km
36,000 $km^2$



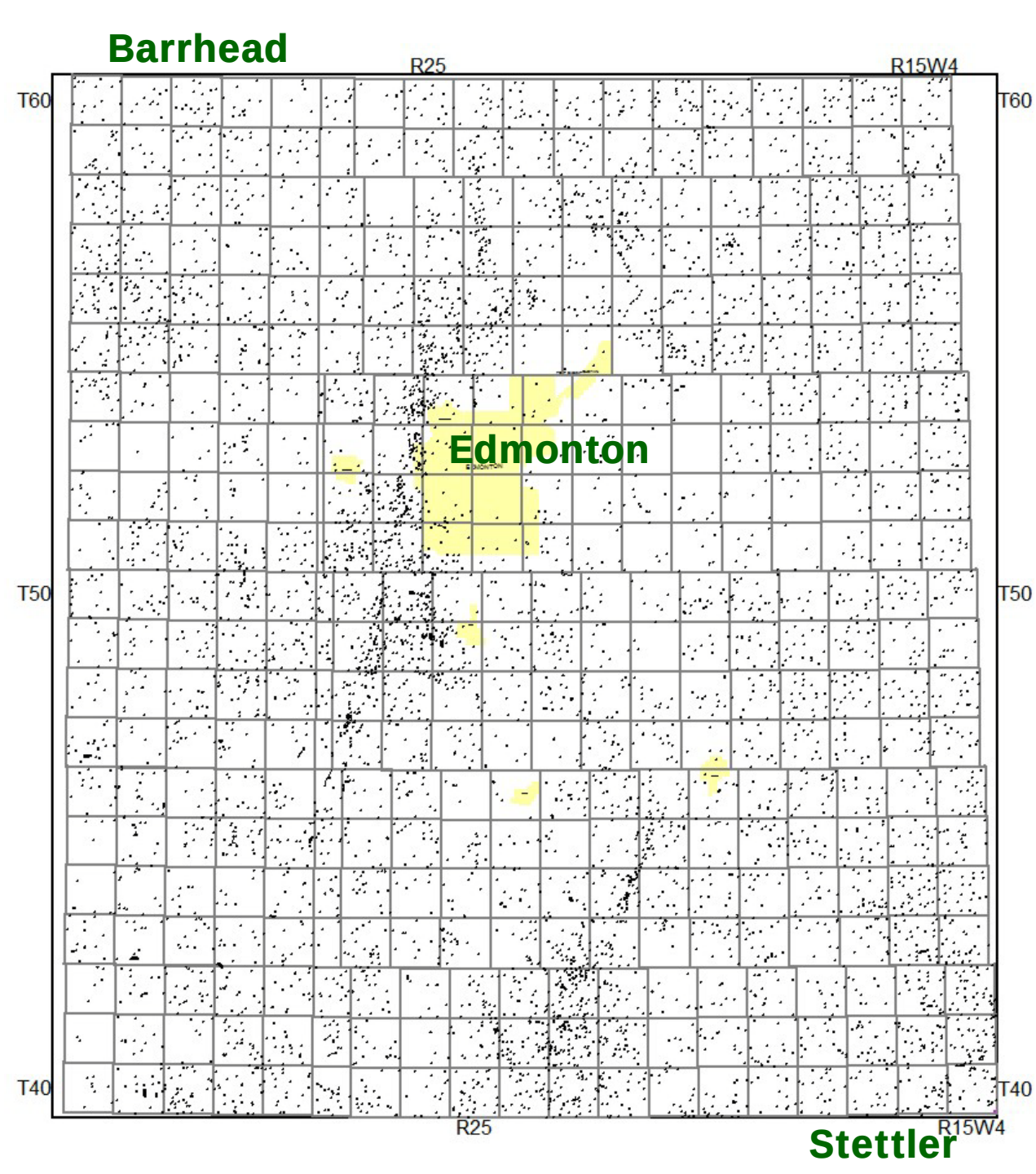

# South-central Alberta wells

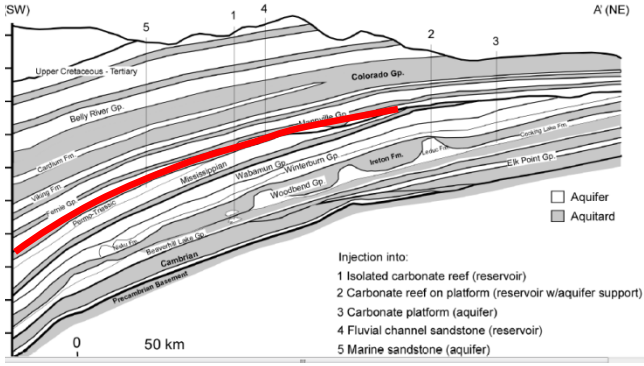
## Abandoned wells
## All depths
## 9,587



# South-central Alberta wells

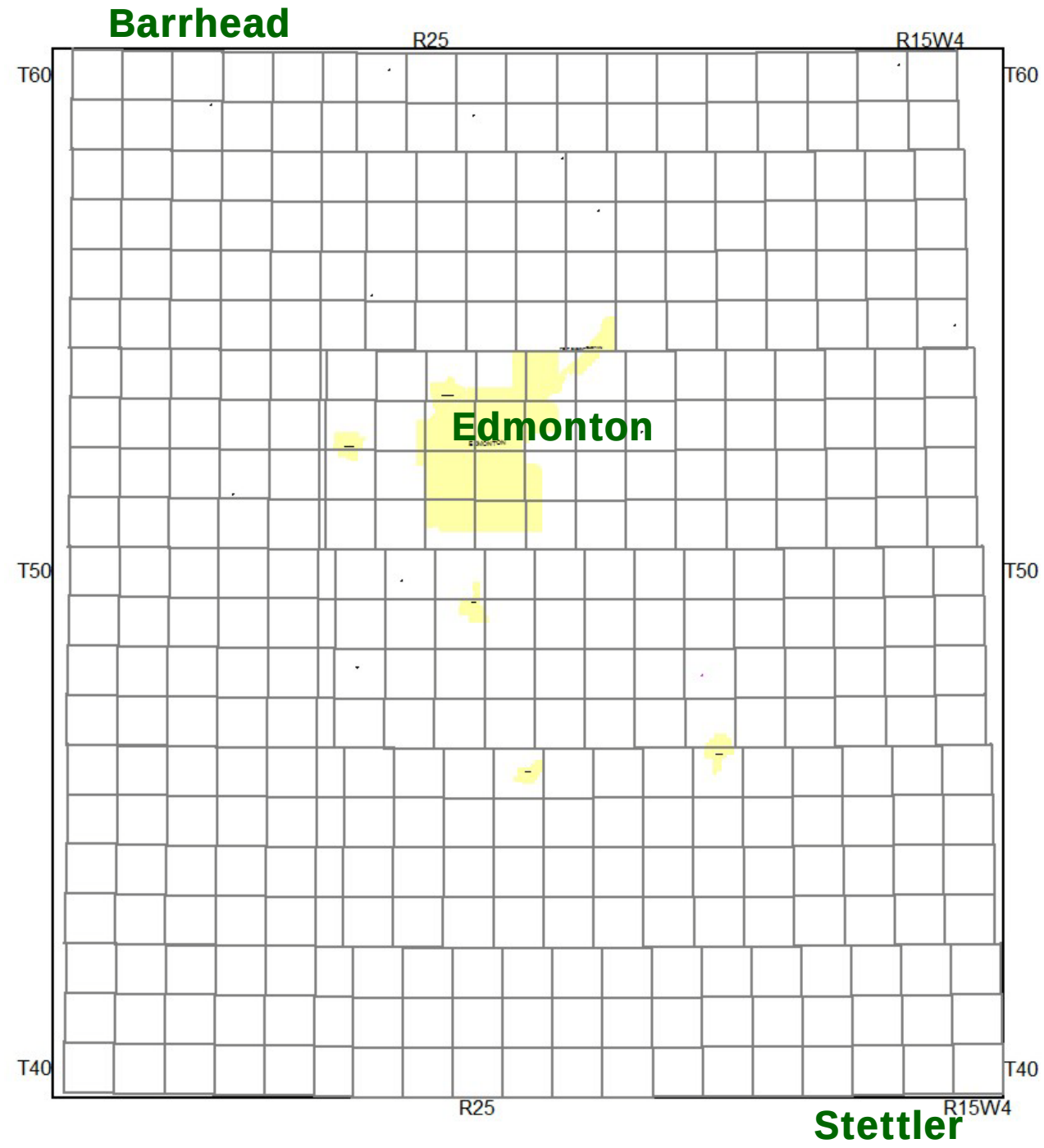
Abandoned wells
> Mississippian
6,665

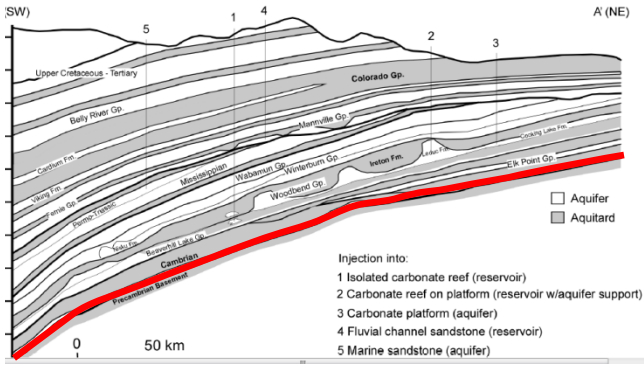


# South-central Alberta wells

## Abandoned wells Precambrian 10



# Measurement, Monitoring and Verification (MMV) - methods

- **Baseline geological characterization**

  regional geology and hydrology; geophysical data, wells, cores, logs, seismicity.

- **Containment monitoring**

  pressure/temperature/geomechanics logs, fluid sampling, seismic & microseismic.

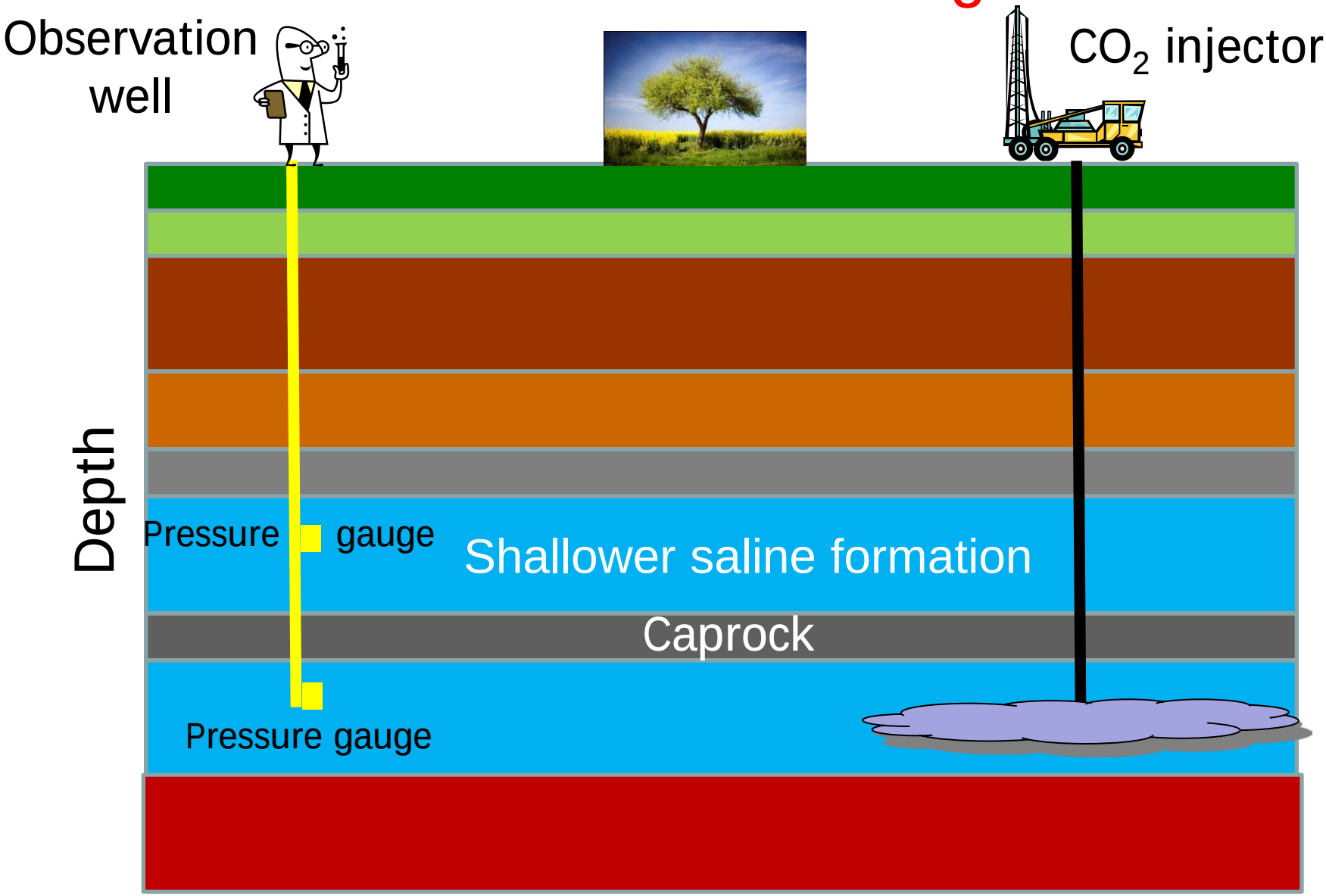
- **Conformance monitoring**

  geophysical/geochemical/geomechanics surveys, pressure/temperature

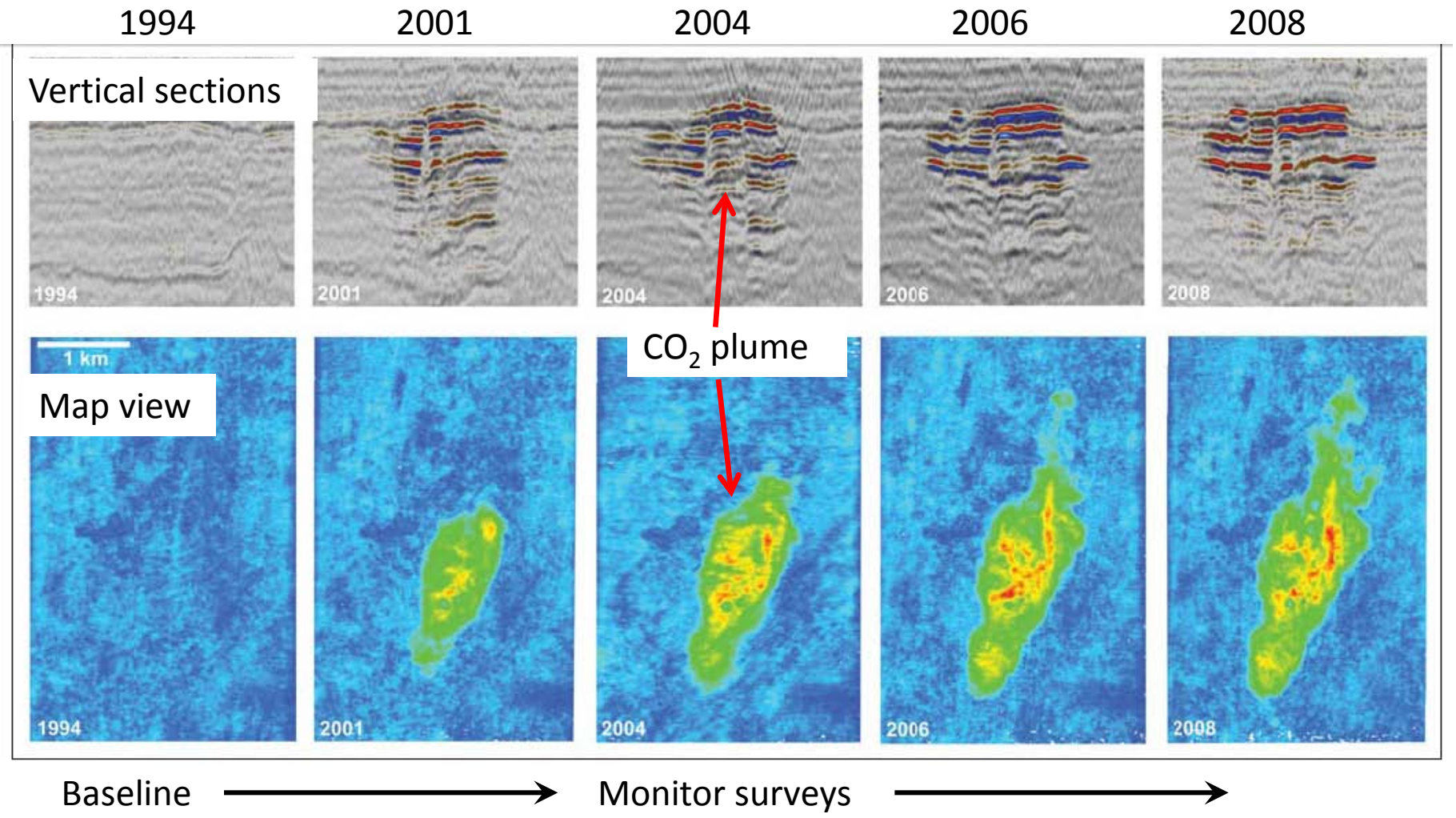
- **Assurance (environmental) monitoring**

  soil and atmospheric surveys, water well surveys, shallow geophysics.

# Pressure monitoring



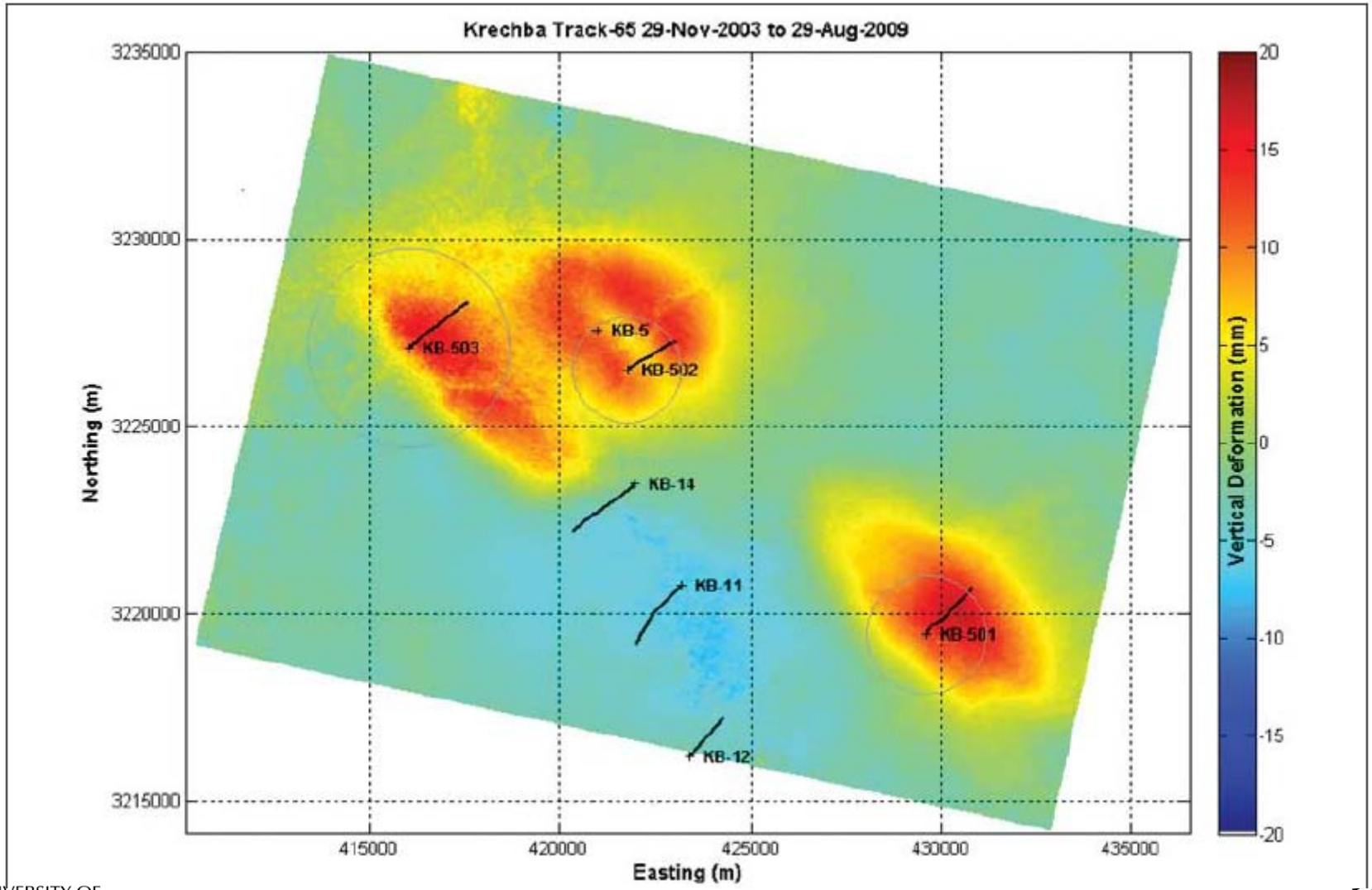
# Seismic monitoring example, Sleipner, Norway






After Chadwick et al., TLE, February, 2010

# Surface deformation monitoring from satellite data, Krechba, Algeria

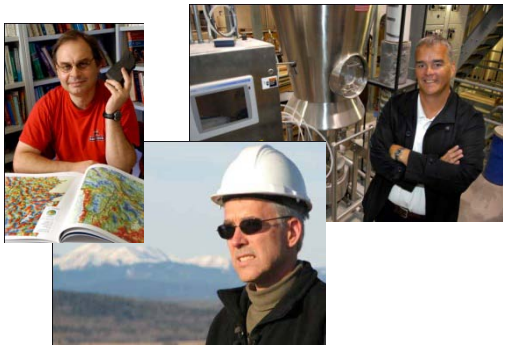



Mathieson et al., TLE, February 2010

# Observation well - operational monitoring

# Carbon mitigation research

Carbon Management Canada
CMC-NCE



**NCE**
- National Network of Centres of Excellence
- De-Carbonize Upstream Fossil Energy
- Started December 2009

**Funded**
- $25M Federal
- $25M Alberta
- >$1M Industry (to date)

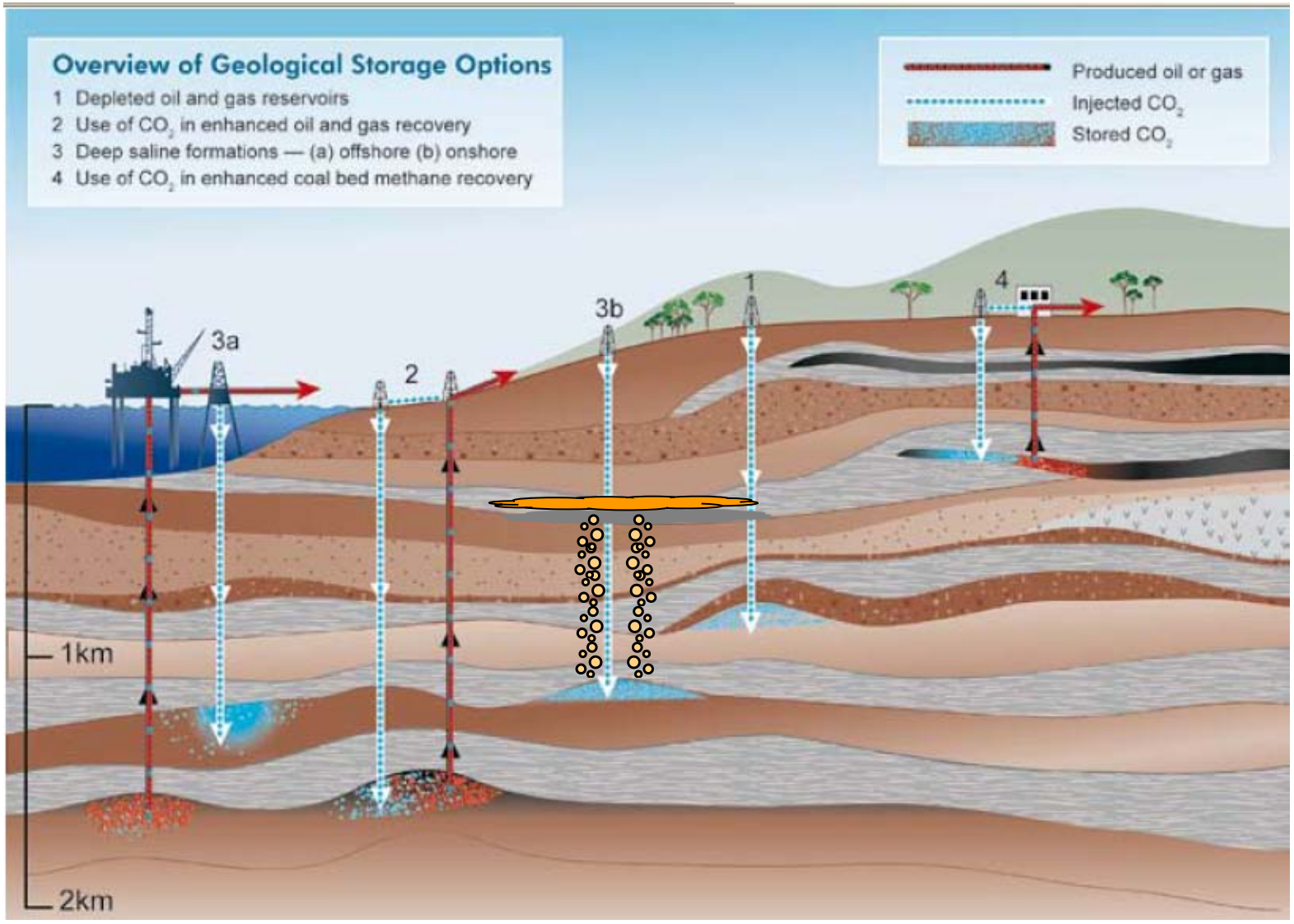
**Duration**
- 3 x 5 year terms (funded first term)
- Challenge: Sustainable model

Carbon Management Canada
CMC-NCE

## CMC research themes

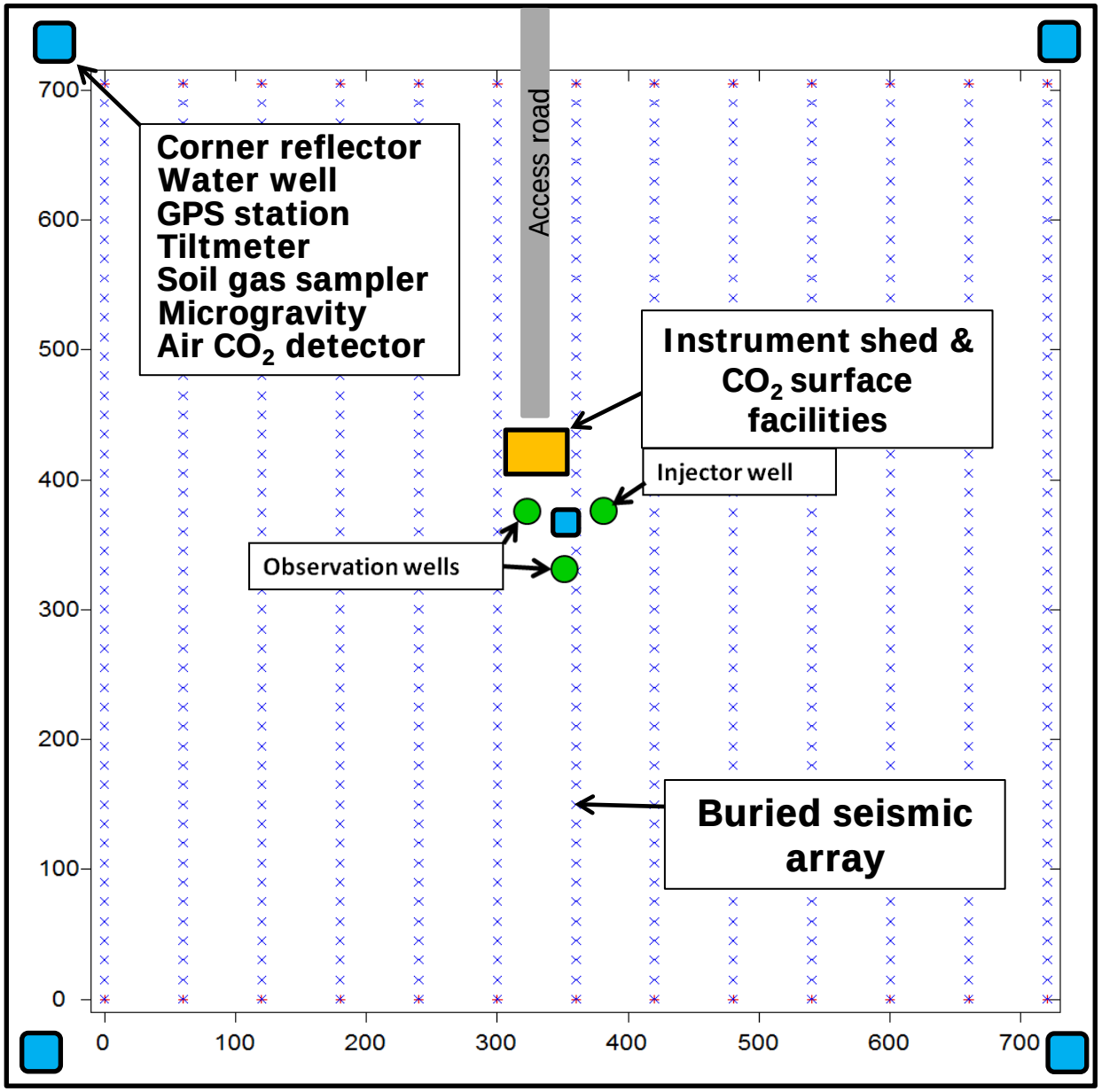
A. Recovery, processing & capture
B. Emerging & enabling technologies
C. Secure carbon storage
D. Accelerating appropriate deployment

# Shallow monitoring – $CO_2$ detection threshold




IPCC Summary for Policy Makers, Special Report of Working Group III, 2005

# CCS monitoring research & training centre

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Institute for Sustainable ENERGY, ENVIRONMENT AND ECONOMY

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¼ section footprint

Need a site !

# Goals of CCS monitoring research centre

- Assess monitoring methods for $CO_2$ detection threshold at shallow to intermediate depths for CCS risk assessment
- A field site for development, testing and implementation of new CCS monitoring technologies
- A hub for hands-on field research for multiple ISEEE & CMC-supported research programs in CCS
- Training in CCS MMV for students and industry
- Information to regulators for CCS conformance metrics
- A site for public education about CCS
- Novel $CO_2$ capture on-site from a solid oxide fuel cell
- International partnerships

# Conclusions

- CCS is a viable and pragmatic means of reducing $CO_2$ emissions
- Western Canada Sedimentary Basin has a large potential to store $CO_2$
- CCS is a bridging technology towards new energy paradigms
- Canadian activities have focused on $CO_2$ EOR
- Scale-up to meet targets will be a challenge.
- Secure $CO_2$ storage is critical to public acceptance
- Monitoring technology programs are being developed for verification of storage.

# Acknowledgements


- ISEEE, University of Calgary
- Carbon Management Canada
- CREWES, University of Calgary.
- Helen Isaac, Abdullah Alshuhail, Taher Sodagar
- NSERC, AERI
- PennWest Petroleum
- Alberta Research Council (now AITF)
- ARC Resources.
- GG Veritas, Schlumberger, Divestco, Geoscout