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# BRITISH COLUMBIA'S $CO_2$ SEQUESTRATION OPTIONS: $CO_2$ SINKS AND MAJOR STATIONARY POINT SOURCES


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***SUGGESTED REFERENCE:***

**Voormeij, D.A. and Simandl, G.J. (2003): British Columbia's $CO_2$ Sequestration Options: $CO_2$ Sinks and Major Stationary Point Sources, *BC Ministry of Energy and Mines*, GEOFILE 2003-11**

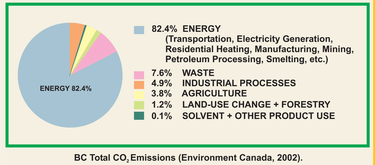
**The review that follows is an integral part of the senior author's M.Sc. thesis at the University of Victoria.**


## INTRODUCTION

**Canada has ratified the Kyoto Protocol on greenhouse gases (GHG). $CO_2$ is the greatest contributor to total emissions. Canada's equivalent $CO_2$ emissions are estimated at 692 Mt/yr.**

**Reduction of $CO_2$ emissions can be achieved by use of more efficient technology, use of energy fuels with low carbon content and increased use of alternative sources, such as wind, solar, geothermal and nuclear (Simandl, 2003). It is unlikely that the reduction of $CO_2$ emissions, required to meet the Kyoto agreement, could be reached by these measures alone. $CO_2$ sequestration will likely be an important component.**

**BC's $CO_2$ emissions total ~65.9 Mt/yr, of which 82.4% results from the combustion of fuels for energy generation .**



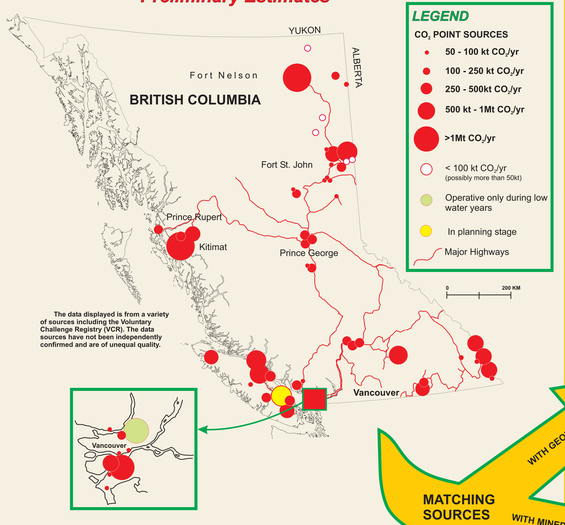

BC Total $CO_2$ Emissions (Environment Canada, 2002).

**$CO_2$ sequestration involves the capture and extraction of $CO_2$ from flue-gases or industrial streams, transportation of $CO_2$ and its disposal in an appropriate sink. There are several different methods for sequestering $CO_2$ that are potential options for BC (Voormeij and Simandl, 2003):**

- **In Oil and Gas Reservoirs**
- **In Deep Coal Seams**
- **In Deep Saline Aquifers**
- **In Deep Ocean**
- **Mineral Carbonation**

## STATIONARY $CO_2$ POINT SOURCES IN BC

### *Preliminary Estimates*




**LEGEND**

$CO_2$ POINT SOURCES
- 50 - 100 kt $CO_2$/yr
- 100 - 250 kt $CO_2$/yr
- 250 - 500kt $CO_2$/yr
- 500 kt - 1Mt $CO_2$/yr
- >1Mt $CO_2$/yr
- < 100 kt $CO_2$/yr (possibly more than 50kt)
- Operative only during low water years
- In planning stage
- Major Highways

MATCHING SOURCES WITH GEOLOGICAL SINKS

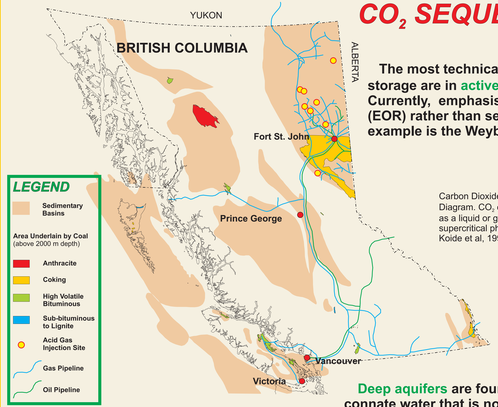
MATCHING SOURCES WITH MINERAL SINKS

**Stationary sources for $CO_2$ (greater than 50000 tonnes emitted per year) in BC include operations in:**

- Aluminum Manufacturing
- Cement Industry
- Chemical Manufacturing
- Coal Operations
- Gas Processing Facilities
- Glass Manufacturing
- Waste Incinerator
- Petroleum Refineries
- Pulp and Paper Mills
- Smelting Industry
- Thermal Power Plants

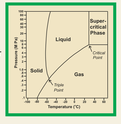
**Transportation is the major source of $CO_2$ emissions in British Columbia. Nearly all emissions growth is attributed to cars and trucks (Environment Canada, 2002). Based on current technology, sequestration of $CO_2$ from stationary sources is economically preferable (economy of scale).**

## $CO_2$ SEQUESTRATION IN GEOLOGICAL MEDIA

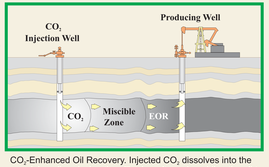



(Adapted from: Owsiacki and Payie, 2000)

**The most technically mature methods for $CO_2$ storage are in active and depleted oil and gas fields. Currently, emphasis lies on enhanced oil recovery (EOR) rather than sequestration potential. A good example is the Weyburn oil field in Saskatchewan.**




Carbon Dioxide ($CO_2$) Phase Diagram. $CO_2$ can be injected either as a liquid or gas or in a supercritical phase. (Adapted from Koide et al, 1996)

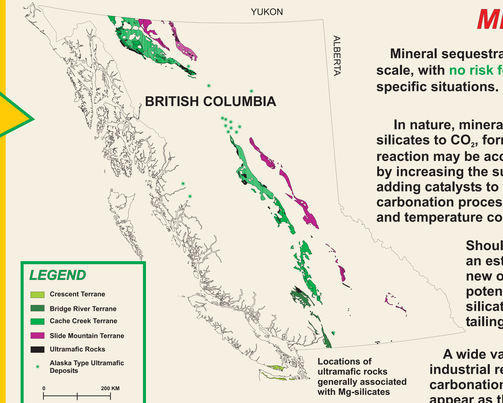



$CO_2$-Enhanced Oil Recovery. Injected $CO_2$ dissolves into the remaining oil, reducing the oil's viscosity and enabling the oil to migrate more readily to the producing well. (Modified from IEA R&D Programme, 2001)

**Deep Coalbeds are a promising storage medium for $CO_2$. British Columbia has abundant coal resources but some of them lie at depths too great to be considered for conventional mining. $CO_2$ sequestration in coal seams may also enhance coalbed methane (CBM) recovery.**

**Deep aquifers are found in most sedimentary basins. They typically contain high-salinity connate water that is not fit for human consumption or industrial and agricultural use. Deep aquifers offer huge storage potential for $CO_2$ sequestration, but are expensive to characterize due to a limited exploration database.**

## MINERAL SEQUESTRATION

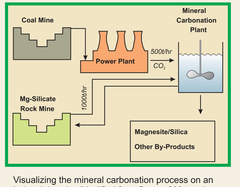



(Adapted from: Nixon, 2000)

**Mineral sequestration is the only method that truly disposes of $CO_2$ on a geological time scale, with no risk for an accidental $CO_2$ release. This method may be suitable only in very specific situations.**

**In nature, mineral carbonation binds Mg-rich silicates to $CO_2$, forming stable carbonates. This reaction may be accelerated in an industrial setting by increasing the surface area of the Mg-silicate, by adding catalysts to the slurry prior to the carbonation process and by controlling pressure and temperature conditions.**

**Should mineral sequestration become an established technology in BC, then new opportunities will arise for potential producers of magnesium silicates and owners of Mg-rich tailings.**




Visualizing the mineral carbonation process on an industrial scale. (Modified from Bauer, 2001 and Voormeij and Simandl, 2003)

Locations of ultramafic rocks generally associated with Mg-silicates

**A wide variety of Mg-rich minerals, such as asbestos tailings, fly ash and other industrial residues are investigated as potential starting material for the industrial carbonation process; However, in light of recent tests, olivine and serpentine appear as the most promising. Olivine is favored because it reacts better without the energy-intensive pretreatment that serpentine requires.**

## DISCUSSION

### MATCHING SOURCES TO SINKS:

**Deep saline aquifers and hydrocarbon reservoirs are located within sedimentary basins, which underlie point sources in northeastern and central BC and parts of Vancouver Island.**

**Coal beds underlie some point sources in southeastern and southcentral BC and on Vancouver Island.**

**Ultramafic rocks occur close to $CO_2$ point sources located in southwest, southcentral and central BC.**

### MAJOR COST FACTORS FOR SEQUESTERING $CO_2$:

**The costs of $CO_2$ sequestration are poorly known. Some major factors for determining the final cost are:**

- **Concentrations of $CO_2$ in gas streams.**

| Concentration of $CO_2$ (%) | 10 20 30 40 50 60 70 80 90 100 |
|---|---|
| Thermal Power Plants | |
| Petrochemical | |
| Ethane Processing | |
| Fertilizer Plants | |
| Hydrogen Production | |
| Gas Processing Plants | |
| Gas Pipelines | |
| Oil/Gas Field | |

Purity of Source $CO_2$. Differences in $CO_2$ content of flue gas by industrial source type. (Adapted from AnalysisWorks Project Team, 2002)

- **Distance from source to sink.**
- **Potential use of existing infrastructure for transportation and injection of $CO_2$.**
- **Cost of disposal of $CO_2$.**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