Ultramafic Rocks in British Columbia: Applications in CO_2 Sequestration and Mineral Exploration

Danae A. Voormeij [1] and George J. Simandl [1,2]

[1] University of Victoria, [2] British Columbia Geological Survey and Development Branch

Geofile 2004-1

UNIVERSITY OF VICTORIA SEOS

BRITISH COLUMBIA Ministry of Energy and Mines

BRITISH COLUMBIA GEOLOGICAL SURVEY

CONTACT INFORMATION

Danae A. Voormeij: (250) 592-5401
voormeij@uvic.ca

George G. Simandl: (250) 952-0413
george.simandl@gems2.gov.bc.ca

INTRODUCTION

Based on the provincial mineral potential database, a detailed map of major dunite and/or serpentinite zones has been compiled. This map is essential for both CO_2 sequestration planning in British Columbia and in exploration for metal, industrial mineral and gemstone deposit types.

CO_2 SEQUESTRATION

In an effort to lower greenhouse gas levels, various geological CO_2 sequestration methods have been proposed worldwide (Voormeij and Simandl, in press). Major CO_2 emission sources (> 50kt/yr) for British Columbia have been identified (Voormeij and Simandl, 2003). The applicability of these methods is site specific and depends on the tectonic setting and geology in the proximity of major stationary CO_2 sources.

Ex situ mineral sequestration involves the binding of CO_2 emissions to Mg-silicates, such as olivine and serpentine, to form magnesite and silica:

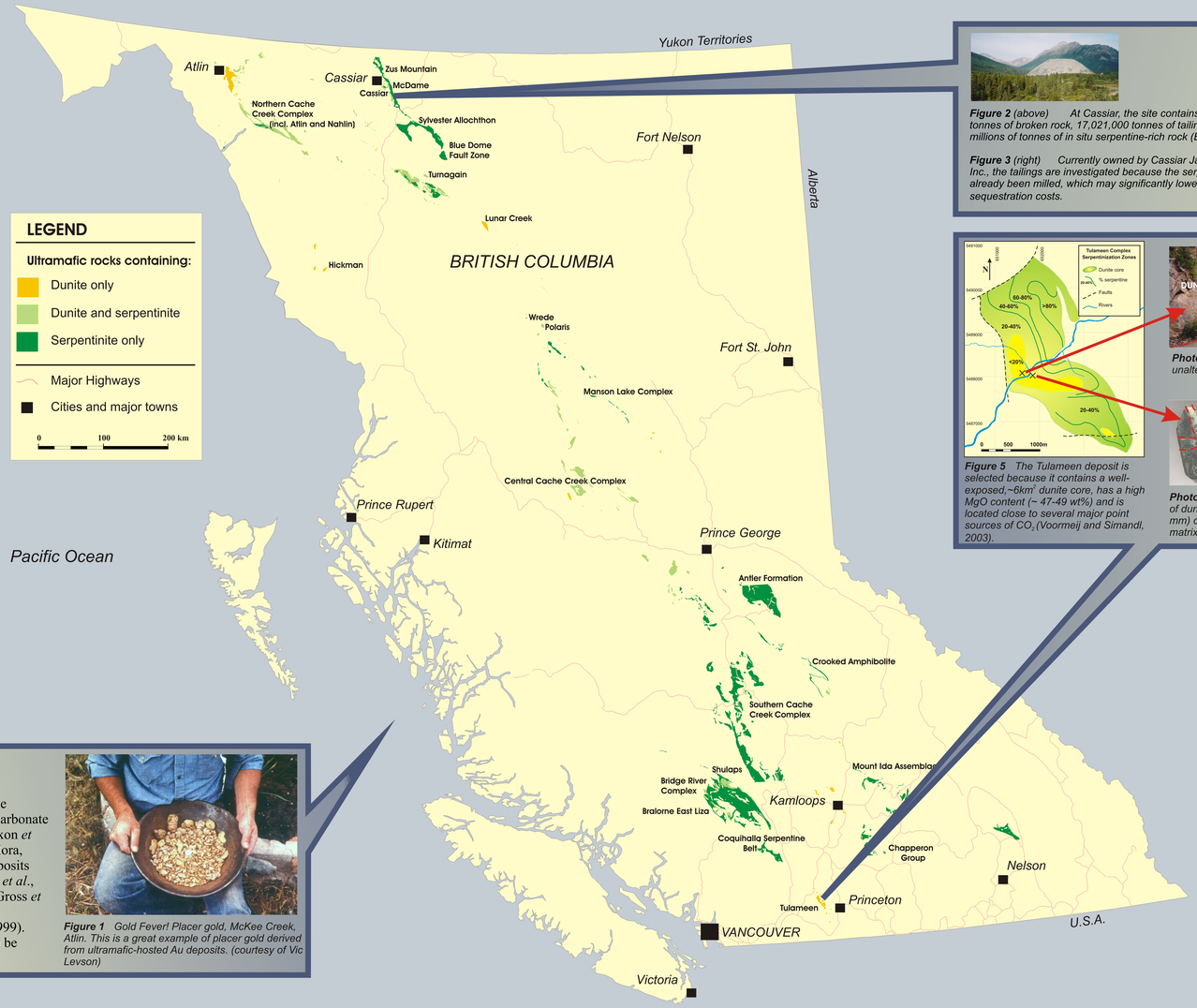
$$Mg_2SiO_4 + 2CO_2 \Rightarrow 2MgCO_3 + SiO_2$$
$$\text{[olivine]} \qquad \text{[magnesite]} \quad \text{[silica]}$$

Mineral carbonation is considered the only method that disposes of CO_2 on a geologic time-scale and with minimum risk of leakage (Lackner *et al*., 1997; O'Connor *et al*., 2000).

Dunites (olivine-rich rocks) and serpentinite zones within ultramafic complexes are considered as the most promising sources of raw materials for the mineral sequestration process. Tailings derived by past extraction of chrysotile from serpentinites may also provide a source of starting material. Should mineral sequestration of CO_2 emissions become a reality, then these materials will become essential as sources of high magnesia silicates (Voormeij and Simandl, in press).

SELECTING RAW MATERIALS FOR CO_2 SEQUESTRATION

1. Suitable targets should be located within the proximity of a major CO_2 point source. **2.** Size of resource should be sufficient to sequester 10 kt CO_2/day for ~ 10yrs (on the order of 70-100 Mt of ore). **3.** Dunites should have low degree of serpentinization (i.e.high density and low FeO_t). **4.** Major element analysis should show high MgO, low CaO, low LOI and low CO_2 (indicating minimum amount of mineral impurities).



MINERAL EXPLORATION

British Columbia's ultramafic complexes represent metallotects for Cyprus-type massive sulphide (Höy, 1995), Au-quartz veins (Ash and Alldrick, 1996), silica-carbonate mercury (Ash, 1996a), podiform chromite (Ash, 1996b), stratiform chromite (Nixon *et al*., 1997), talc and magnesite (Simandl and Ogden, 1999), chrysotile asbestos (Hora, 1999) and nephrite jade (Simandl *et al*., 2000). Furthermore, BC's ultramafic deposits are potential metallotects for platinum group elements (Rublee, 1986; Evenchick *et al*., 1986; Nixon, 1990; Nixon, 1996; Nixon *et al*., 1997), Ti and Fe oxide deposits (Gross *et al*., 1999), nickel (Hancock, 1990), vermiculite (Simandl *et al*., 1999a), emeralds (Simandl *et al*., 1999b) and corundum group gemstones (Simandl and Paradis, 1999). Exploration for these primary deposits and their related placers (see figure 1) can be focused using this map.

Figure 1 *Gold Fever! Placer gold, McKee Creek, Atlin. This is a great example of placer gold derived from ultramafic-hosted Au deposits. (courtesy of Vic Levson)*

CASSIAR ASBESTOS TAILINGS

Figure 2 *(above) At Cassiar, the site contains 5,457,000 tonnes of broken rock, 17,021,000 tonnes of tailings and 48 millions of tonnes of in situ serpentine-rich rock (Budinski, 2000).*

Figure 3 *(right) Currently owned by Cassiar Jade Contracting Inc., the tailings are investigated because the serpentine has already been milled, which may significantly lower the CO_2 sequestration costs.*

Figure 4 *(right) Chrysotile vein in massive serpentine. The fibrous nature of this mineral, which is considered a health concern (Hamel, 1998), may be effectively disposed of during the mineral carbonation process.*

TULAMEEN ULTRAMAFIC COMPLEX

The dunite at Tulameen ranges from fresh olivine in the core of the complex, to highly serpentinized at the outer edges of the body (Findlay, 1963).

Figure 5 *The Tulameen deposit is selected because it contains a well-exposed,~6km² dunite core, has a high MgO content (~ 47-49 wt%) and is located close to several major point sources of CO_2 (Voormeij and Simandl, 2003).*

Photo 6 *Roadcut through unaltered dunite ~180m long.*

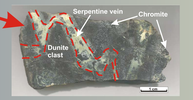


Photo 7 *Dunite Breccia consists of dunite clasts and large (~1.5 mm) chromite grains in serpentine matrix.*

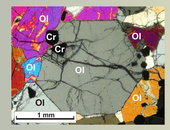


Figure 8 *Fresh dunite (xpl). Euhedral olivine (Ol) surrounded by smaller subhedral olivine grains and accessory chromite (Cr). Olivine grains in the dunite range in size from <0.1mm to >2mm.*

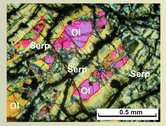


Figure 9 *Serpentinized dunite (xpl). This sample displays ~65% serpentinization. Serpentine (Serp) requires heat-treatment prior to the carbonation process, thus dunite with the least amount of serpentinization is favoured.*

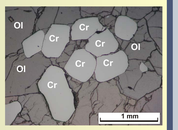


Figure 10 *Chromite (Cr) grains in dunite. It is a common accessory mineral, ranging in size from <0.1mm to >1.5mm and is one of the potential by-products (Voormeij and Simandl, in press) for the CO_2 sequestration process.*

SUMMARY

This map:

1. Highlights areas with the potential to contain raw materials for CO_2 mineral sequestration

2. Represents an important metallotect.

ACKNOWLEDGMENTS

Dr. Don McIntyre was essential in manipulating the BC's Mineral Potential database . New Ventures Branch of the BC Ministry of Energy and Mines provided financial support.

SELECTED REFERENCES

Budinski, D. (2000): Chrysotile Resources at Cassiar Mine, *Orcan Consulting Report*, February 15th, 2000.

Findlay, D.C. (1963): Petrology of the Tulameen Ultramafic Complex, Yale District, British Columbia. Ph. D. Thesis, *Queens University*, 415 pp.

Hamel, D. (1998): Utilization of Chrysotile Asbestos; Lessons from Experiences, *In:* Proceedings of the 33rd Forum on the Geology of Industrial Minerals, *Canadian Institute of Mining and Metallurgy Special Volume* 50, p. 121-129.

Lackner, K.S., Butt, D.P. and Wendt, C.H. (1997): Magnesite Disposal of Carbon Dioxide, *Proceedings of the 22nd International Technical Conference on Coal Utilization & Fuel Systems*, Clearwater Florida, p. 419-430.

Nixon, G.T. (1990): Geology and Precious Metal Potential of Mafic-Ultramafic Rocks in British Columbia: Current Progress, *Geologic Fieldwork, 1989*, Paper 1990-1, p.353-358.

O'Connor, W.K., Dahlin, D.C., Nilsen, D.N., Walters, R.P. and Turner, P.C. (2000): Carbon Dioxide Sequestration by Direct Mineral Carbonation with Carbonic Acid, *Proceedings of the 25th International Technical Conference on Coal Utilization & Fuel Systems, Coal Technology Association*, Clearwater, Florida.

Voormeij, D.A., and Simandl G.J. (in press): Geological and Mineral CO_2 Sequestration Options: A Technical Review, *Geoscience Canada*.

Voormeij, D.A. and Simandl, G.J. (in press): Ultramafic Rocks in British Columbia: Delineating Targets for Mineral Sequestration of CO_2, Energy-Resource Development and Geoscience Branch, BC Ministry of Energy and Mines, Summary of Activities 2004.

Voormeij, D.A. and Simandl, G.J. (2003): CO_2 Sequestration Options for B.C.: Matching Sinks and Sources, *Geological Survey Branch*, Geofile 2003-11.

For mineral exploration references please refer to: *Selected BC Mineral Deposit Profiles, Volumes I, II and III, BC MEM, 1995-1999.*
Complete list of references available from authors.