Biogeochemical methods to explore for carbonatites and related mineral deposits: An orientation survey, Blue River area, British Columbia, Canada

Robert Fajber[1, 2, a], George J. Simandl[1, 3], Pearce Luck[1], and Michaela Neetz[1]

[1] British Columbia Geological Survey, Victoria, BC
[2] Present address: University of Toronto, Toronto, ON
[3] University of Victoria, Victoria, BC
[a] corresponding author: rfajber@physics.utoronto.ca

Recommended citation: Fajber, R., Simandl, G.J., Luck, P., and Neetz, M., 2015. Biogeochemical methods to explore for carbonatites and related mineral deposits: An orientation survey, Blue River area, British Columbia, Canada. In: Simandl, G.J. and Neetz, M., (Eds.), Symposium on Strategic and Critical Materials Proceedings, November 13-14, 2015, Victoria, British Columbia. British Columbia Ministry of Energy and Mines, British Columbia Geological Survey Paper 2015-3, pp. 241-243.

1. Introduction

Carbonatites host economic deposits of niobium (Nb), rare earth elements (REE), phosphate, baddeleyite (natural zirconia), vermiculite, and fluorspar, and historically, supplied copper, uranium, carbonate (for cement industries) and sodalite (Pell, 1994 and Simandl, this volume).

The Upper Fir carbonatite is in southeastern British Columbia, approximately 200 km north of Kamloops (Fig. 1). It is one of many known carbonatite occurrences in the British Columbia alkaline province, which follows the Rocky Mountain Trench and extends from the southeastern tip of British Columbia to its northern boundaries with the Yukon and Northwest Territories (Pell, 1994). The Upper Fir is a strongly deformed carbonatite with an indicated mineral resource of 48.4 million tonnes at 197 ppm of Ta_2O_5 and 1,610 ppm of Nb_2O_5, and an inferred resource of 5.4 million tonnes at 191 ppm of Ta_2O_5 and 1760 ppm of Nb_2O_5 (Kulla et al. 2013). The Nb, Ta, and vermiculite mineralization is described by Simandl et al. (2002, 2010), Chong, et al, (2012), and Chudy (2014).

In this document we present the results of an orientation survey designed to determine the biogechemical signature of a typical carbonatite in the Canadian Cordillera. This survey suggests that needles and twigs of White Spruce (Picea glauca) and Subalpine Fir (Abies lasiocarpa) are suitable sampling media to explore for carbonatites and carbonatite-related rare earth elements (REE), niobium (Nb), and tantalum (Ta) deposits.

2. Orientation Survey

2.1. Sampling and analytical procedures

All vegetation samples were collected on August 23, 2010. Sampling was completed in less than 3 hours on a single day to avoid seasonal and diurnal variations. Branch tips about 10 cm long were collected from trees 5 to 7 m tall at heights of about 1.7 m. The sample sites are a well-drained hillside. Samples were immediately placed in Kraft sample bags which were approximately 500 to 700 cm^3 in volume.

All samples were dried at 80°C for 24 hours. Needles were then separated from twigs. Twigs were milled using a Wiley mill, and a 1 g split was digested in nitric acid (HNO_3) and then in aqua regia, and analyzed using inductively coupled plasma mass spectrometry (ICP-MS) and inductively coupled plasma atomic emission spectroscopy (ICP-AES) methods to ultra-low detection limits. A 50 g quantity of dry needles was ashed using controlled ignition at 475°C for 24 hours. A 0.25 g quantity of the needle ash was then digested in HNO_3 and analyzed using the same ICP-MS/ICP-AES methods. Weights of samples before and after ashing were recorded.

Analyses were conducted at Bureau Veritas Minerals (formerly Acme Laboratories) in Vancouver, British Columbia. The same suite of elements was selected for both twig and needle samples: K, Na, Ca, Mg, Fe, Al, Mn, Cr, Ti, S, P, Ba, Mo, Cu, Pb, Zn, Cd, Ni, Co, Se, As, Sr, Zr, Au, Ag, Pd, Pt, Li, Be, B, V, Ga, Ge, Rb, In, Sn, Re, Sb, Te, Cs, Hf, W, Hg, Tl, Bi, Th, U, Nb, Ta, Sc, Y, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, and Lu.

2.2. Summary of results

At Upper Fir, La, Ce, Pr, Nd, Sm, Dy, Fe, Nb, Ta, P, and Y were identified as the most promising pathfinder elements. Concentrations of Ta and heavy REE (with the exception of Dy and Y) are near or below the lower limit of detection in Spruce twigs that were not treated by ashing. In 2011, the ashing procedure concentrated most trace elements in needles to levels well above the lower limit of detection. Ashing of both twigs and needles before analysis is recommended for future surveys. All samples of twigs, with the exception of sample BR-18, in which Ta was detected in concentrations higher than 0.002 ppm are spatially related to carbonatite or related altered rocks, commonly referred to as fenites (Fig. 2; Fajber et al., 2015). Although Ta is described as an unreliable biogeochemical pathfinder by Dunn (2007), Ta concentration in sample BR-18

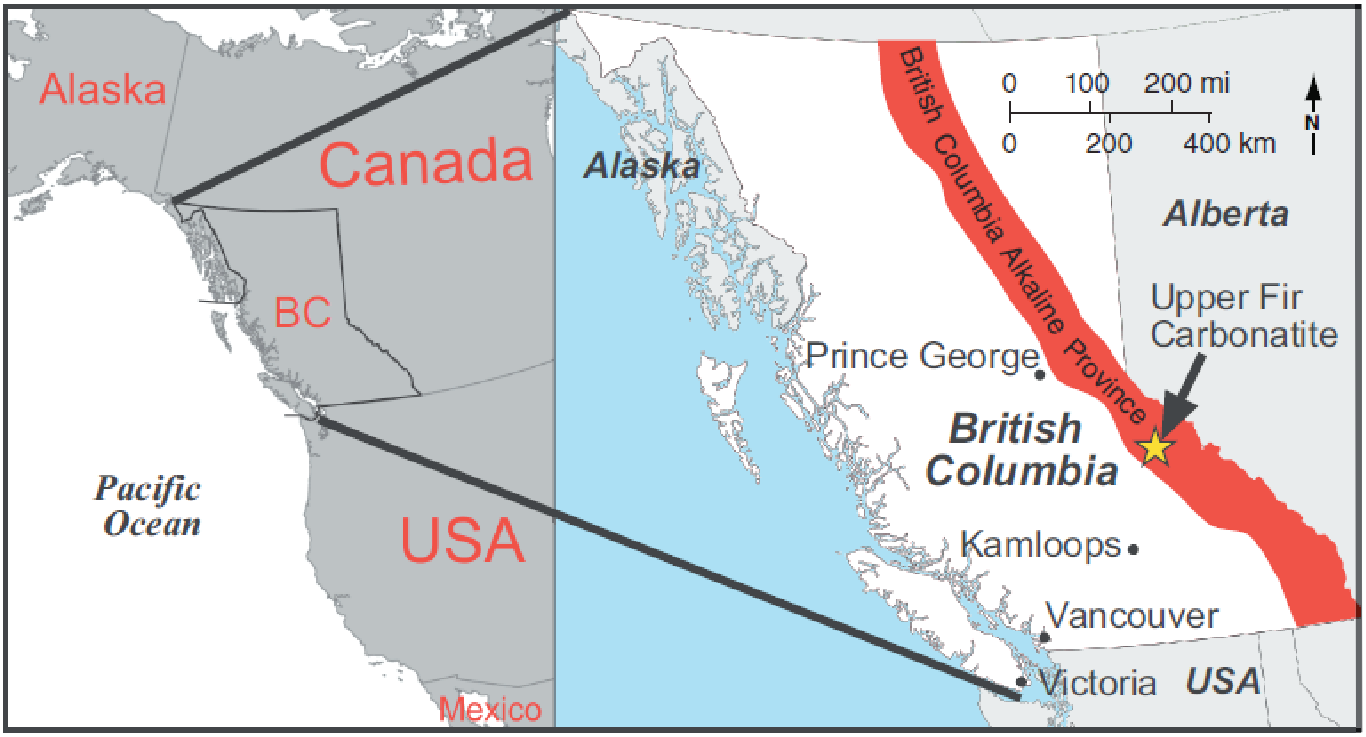

Fig. 1. Location of the Upper Fir carbonatite and British Columbia alkaline province, British Columbia, Canada.

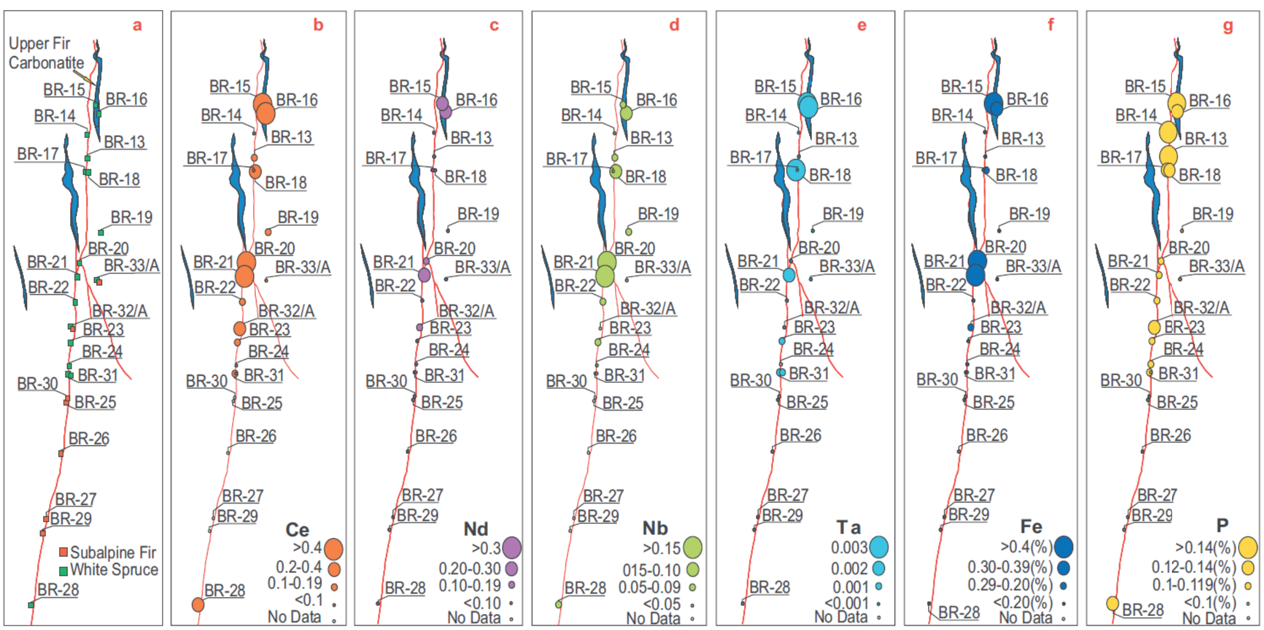

Fig. 2. Concentrations of selected carbonatite pathfinder elements in twigs (on dry weight basis), Upper Fir area. Samples BR-15 and BR-16 overlie the Upper Fir carbonatite; samples BR-20 and BR-21 overlie a zone of fenitization. **a)** sample media and concentrations of **b)** Ce, **c)** Nd, **d)** Nb, **e)** Ta, **f)** Fe, and **g)** P. All concentrations in parts per million unless otherwise indicated. From Fajber et al. (2015).

is unlikely to be spurious because it coincides with elevated concentrations of Nb, Ce and P (Fig. 2). It may correspond to a blind (near-surface, overburden-covered) extension of the carbonatite or an old drill site. Since 2011, when our samples were analyzed, the lower limit of detection for ash analysis has been reduced by half (Bureau Veritas Minerals, 2015). Because of this advancement, some of the elements we rejected in 2011 because of low concentrations may now be considered suitable pathfinders.

Twigs from a given sample contain consistently higher concentrations of pathfinder trace elements than the needles from the same sample, therefore twigs appear to be a better sampling medium. Based on our limited data (21 sample sites not counting duplicates) our survey suggests that a full-scale survey should provide comparable results to those obtained by the soil geochemistry carried out by the Commerce Resources Corp. and described in Dahrouge and Wolbaum (2004).

Unweathered carbonatite rocks and related REE mineralization typically have steep chondrite-normalized REE patterns lacking a Eu anomaly (Fig. 3a; Fig. 6 in Simandl, 2014). Soils and vegetation samples taken above the Upper Fir carbonatite show systematic negative Eu anomalies (Fig. 3b,c). This indicates that presence or absence of a negative Eu anomaly in soil and vegetation can't be used to distinguish an anomaly caused by buried carbonatite from those caused by peralkaline intrusion, peraluminous granite, or rare metal-bearing pegmatite.

Acknowledgments

This project was supported by the Targeted Geoscience Initiative 4 (2010–2015), a Natural Resources Canada program. The Specialty Metal component of this program was carried out collaboratively between the Geological Survey of Canada and the British Columbia Geological Survey. Early comments from Colin Dunn (Consultant Geochemist, Victoria, British Columbia) and later detailed explanation regarding the laboratory procedure by John Gravel (Bureau Veritas Minerals, Vancouver) are appreciated. John Gorham, Janine Brown, and Brad Ulry from Dahrouge Geological Consulting Ltd. provided guidance in the field and constructive comments. Commerce Resources Corp. is thanked for sharing its expertise related to Upper Fir carbonatite and the Illinois Geological Survey for the permission to use figures 1, 2 and 3 that were previously published.

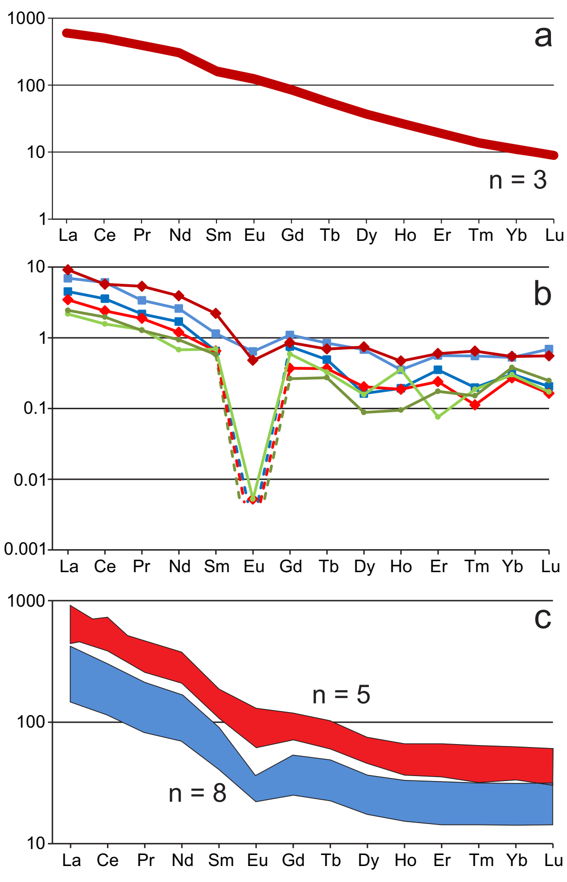

Fig. 3. Chondrite-normalized REE plots. **a)** Absence of negative Eu anomaly in Upper Fir carbonatite rocks. Envelope of three Upper Fir carbonatite analyses. **b)** Presence of negative Eu anomaly in Spruce needle ash overlying Upper Fir carbonatite (red diamonds; BR-15 and BR-16), fenite (blue squares; BR-20 and BR-21), and metasedimentary rocks (green circles; BR-13 and BR-17). Dotted lines represent projections where Eu concentrations were below the lower limit of detection. **c)** Soils overlying carbonatites (red, envelope of 5 analyses) contain higher concentrations of REE than those overlying schists and gneisses (blue, envelope of 8 analyses). All soil samples display negative Eu anomalies. Analysis of soil from Dahrouge and Wolbaum (2004). Chondrite normalization according to McDonough and Sun (1995). From Fajber et al. (2015).

References cited

Bureau Veritas Minerals, 2015. Schedule of services and fees (CDN). Bureau Veritas Minerals, 44 p., <http://acmelab.com/wp-content/uploads/2009/03/2015-Fee-Schedule.pdf>.accessed July 22, 2015.

Chong, A., Postolski, T., Mendoza, R.R., Lipiec, T., and Omidvar, B., 2012. Blue River Tantalum-Niobium Project, British Columbia. Vancouver, Canada, Commerce Resources Corp., NI 43-101 Technical Report on Mineral Resource Update, June 22, 2012, 450 p., <http://www.commerceresources.com/i/pdf/TechnicalReport-BlueRiverResourceUpdate.pdf>. accessed July 22, 2015.

Chudy, T.C., 2014. The petrogenesis of the Ta-bearing Fir carbonatite system, east-central British Columbia. Ph.D. dissertation, University of British Columbia, Vancouver, Canada, 585p.

Dahrouge, J., and Wolbaum, R., 2004. 2003 Exploration at the Blue River property, Commerce Resources Corp. Fort St. John, British Columbia Ministry of Energy and Mines, Assessment Report 27412, 11 p., <http://aris.empr.gov.bc.ca/search.asp?mode=repsum&rep_no=27412> accessed July 22, 2015.

Dunn, C., 2007. Biogeochemistry in mineral exploration. Elsevier, Amsterdam, 462p.

Fajber, R., Simandl, G.J., and Luck, P., 2015. Exploration for carbonatite-hosted niobium-tantalum deposits using biogeochemical methods (orientation survey), Blue River Area, British Columbia, Canada. In: Lasemi, Z., (ed.), Proceedings of the 47th Forum on the Geology of Industrial Minerals: Illinois State Geological Survey, Circular 587.

Kulla, G., Postolski, T., Mendoza, R.R., Lipiec, T., and Omidvar, B., 2013. Blue River Tantalum-Niobium Project, British Columbia, Canada. Vancouver, Canada, Commerce Resources Corp., NI 43-101 Technical Report on Mineral Resource Update, June 21, 2013 (Project No. 171542), 238p., <http://www.commerceresources.com/i/pdf/2013-06-21_NI43-101.pdf>. accessed July 22, 2015.

Pell, J., 1994. Carbonatites, nepheline syenites, kimberlites and related rocks in British Columbia. Victoria, British Columbia Ministry of Energy, Mines and Petroleum Resources, Bulletin 88, 133 p.

Simandl, G.J., 2014. Geology and market-dependent significance of rare earth element resources. Mineralia Deposita, 49, 889–904.

Simandl, G.J., 2015. Carbonatites and related exploration targets. In: Simandl, G.J. and Neetz, M., (Eds.), Symposium on Strategic and Critical Materials Proceedings, November 13-14, 2015, Victoria, British Columbia. British Columbia Ministry of Energy and Mines, British Columbia Geological Survey Paper 2015-3, pp. 31-37.

Simandl, G.J., Paradis, S., Simandl, L., and Dahrouge, J., 2010. Vermiculite in the Blue River area, east central British Columbia, Canada. Victoria, British Columbia Ministry of Energy and Mines, Geological Fieldwork 2009, Paper 2010-1, pp. 83–92.