Biogeochemical Exploration Vectors in search of Carbonatite, Blue River, British Columbia

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Executive Summary

The objective of this orientation survey was to determine if coniferous trees represent suitable sampling media in the exploration for carbonatites and related rare earth elements (REE), Ta, Nb, phosphate and fluorspar mineralization referred to in the British Columbia "Carbonatite Deposit profile N01" (Birkett and Simandl, 1999).

Twenty four samples of twigs with needles from coniferous trees (Subalpine Fir and White Spruce) were collected over the Upper Fir Ta, Nb and apatite-bearing carbonatite. The results indicate that carbonatite is detectable by biogeochemical methods. Light rare earth elements (LREE), Y, Zr and P are good exploration vectors for REE and apatite mineralization; whereas Ta and Nb are direct indicators for their own ores. Ta is found in detectable concentrations only in White Spruce twigs (41% of samples), and mainly those directly overlying mineralization, concentrations range from 0.001 to 0.003 ppm Ta. Nb concentrations are higher than those of Ta; concentrations range from 0.02 to 0.24 ppm Nb in White Spruce twigs, 0.00496 to 0.070814 ppm Nb in White Spruce needles (ash values normalized to dry weights), and 0.012011 ppm to 0.030214 ppm in Subalpine Fir needles (ash values normalized to dry weights). Fluorine was not included in the analytical package; however, it should be considered for future surveys. The data also illustrate the difficulties that could arise when elevation (topography-related) changes in vegetation (sampling media) are encountered during the survey.

Location

The Upper Fir carbonatite is accessible by logging roads that connect to Highway 5 (Figure 1) at the Lempriere train station, approximately 40 km north from the municipality of Blue River (Simandl et al., 2002). The UTM co-ordinates of the Upper Fir carbonatite sampled and described in this document are 352875E and 5797209N (Zone 11U).

Figure 1. Location of the Upper Fir Carbonatite deposit area, Blue River Area, B.C.

Regional Setting

British Columbia carbonatites and fenite zones are part of an alkaline belt that follows the Rocky Mountain Trench (Pell, 1994). The Blue River carbonatites are a central part of this belt. They are located within the Shuswap Metamorphic Complex (Campbell,1967). Geology of the Blue River Carbonatite-bearing area was summarized by Diegel et al. (1989). These carbonatites are hosted by the semipelite-amphibolite unit of the Hadrynian Horsethief Creek Group (Mountjoy, 1992). Dominant lithologies in the Blue River area that host carbonatites are amphibolites and biotite-feldspar-quartz (±garnet, ±kyanite) gneisses. The carbonatites are strongly deformed, locally mylonitized and appear to follow the general trends observed in the host lithologies.

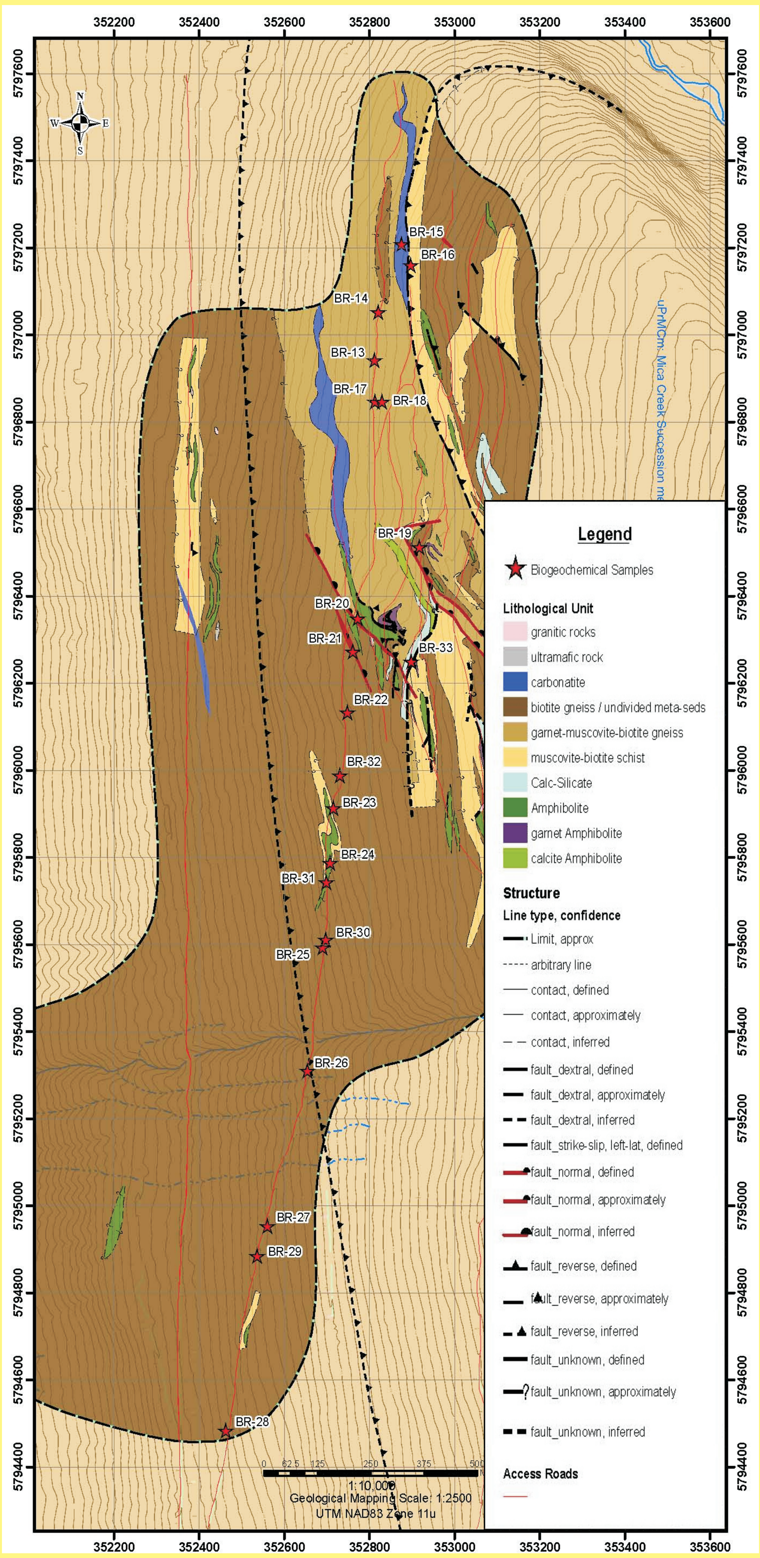


Figure 2: Geology Map of the Upper Fir carbonatite provided by Commerce Resources Corp., showing three carbonatite zones (in blue) and other lithologies. The northern most carbonatite zone is tested by samples BR-15 and BR-16 .

Carbonatites in the Blue River area

Carbonatites in the Blue River area are classified as calcio- and magnesio-carbonatites (as defined by Woolley and Kempe, 1989). The Ta, Nb, rare earth elements (REE) and vermiculite occurrences in the Blue River area (McCammon, 1953; White, 1982; Dahrouge, 2002; Simandl et al., 2002; Simandl et al., 2010; Stone and Selway, 2010) are related to carbonatites and fenitization.
Pyrochlore ($Na_{1.5}Ca_{0.5}Nb_2O_6(OH)_{0.75}F0_{.25}$), columbite-(Fe), previously known as ferrocolumbite ($Fe^{2+}Nb_2O_6$), and fersmite ($Ca_{0.7}Ce_{0.2}Y_{0.1}Na_{0.1}Th_{0.05}Nb_{1.7}Ta_{0.3}Ti_{0.02}O_5(OH)F_{0.1}$), are the recognized Nb and Ta ore minerals (Simandl et al. 2002, Mariano, 1982). The REE content of pyrochlore and columbite-(Fe) is relatively low. It is possible that a substantial proportion of the REE indicated in whole rock analyses is accounted for by other minerals.
Ce – La rich fluorocarbonate was tentatively identified by microprobe (Simandl et al. 2002). REE content of apatite was not investigated.

Figure 3: Bulk sample pit, Upper Fir Carbonatite, Blue River area.

Figure 4: White Spruce branch, Upper Fir, Blue River area.

Figure 5: Subalpine Fir branch, Upper Fir, Blue River area.

Upper Fir Carbonatite

The geology of the area surrounding the Upper Fir carbonatite is shown on Figure 2. The Upper Fir mineralized zone (Figure 3) consists mainly of magnesio-carbonatite and calcio-carbonatite. Previous work is summarized by Stone and Selway (2010). The indicated resources of the Upper Fir carbonatite are estimated at 7 384 000 tonnes grading 217 ppm Ta_2O_5 and 1202 ppm Nb_2O_5. The inferred resources of the Upper Fir carbonatite deposit are estimated at 16 494 000 tonnes grading 213 ppm Ta_2O_5 and 1222 ppm Nb_2O_5. Both estimates are based on the 175 ppm Ta_2O_5 cut-off grade (Stone and Selway, 2010).

Methodology

Young (less than 3 years growth) twigs and needles of coniferous trees (approximately 5-7 metres in height), namely White Spruce (Figure 4) and Subalpine Fir (Figure 5) were selected as sampling media. All sampled trees were situated on the well drained hill site. Sample locations are shown on Figure 2.

Samples were placed into kraft sample bags (~500-750 cm^3 slightly compacted) and oven-dried. Twigs and needles were analysed separately. Nineteen samples of White Spruce twigs were milled using a Wiley mill. The pulps were digested in HNO_3, then Aqua Regia and then analysed by ICP-MS/ICP-ES.

Twenty four samples of needles were ashed and submitted for ICP-MS/ICP-ES analysis after Aqua Regia digestion. These analyses covered, 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.

Results

The results indicate that most of the analysed elements are incorporated in detectable concentrations into the White Spruce twigs and to a lesser extent into the White Spruce and Subalpine Fir needles. Subalpine Fir twigs were not analysed because there was insufficient mass for standard analyses.

White Spruce twigs contain above detection limit concentrations of K, Na, Ca, Mg, Fe, Mn, Cr, Ti, S, P, Ba, Mo, Cu, Pb, Zn, Cd, Sr, Ni, Co, Se, Zr, As, Au, Ag, Li, B, Hg, Cs, Rb, Th, Nb, Y, La, Ce, Nd, and Yb. For these elements, the quality and range of the data is sufficient to allow for exploration-type interpretation. Sb, Al, Tl, Hf are present in above detection concentrations in more than 50% of the samples. Ta is present above detection limit in samples associated with known mineralization or contamination (samples BR-15, BR-16, and Br-21).

White Spruce needles contain consistently detectable concentrations of K, Na, Ca, Mg, Fe, Mn, Cr, Ti, S, P, Ba, Mo, Cu, Pb, Zn, Cd, Ni, Co, Se, Zr, Au, Ag, Li, B, Rb, Cs, Nb, Y, Ce, Nd, and Sm.

Te, Gd, Th, Yb, Sb, Dy are detectable in more than 50% of the samples.

Subalpine Fir needles contain consistently detectable concentrations of 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, Li, B, V, Ga, Rb, Sn, Sb, Te, Cs, Th, Nb, Sc, Y, La, Ce, Pr, Nd, Sm, Gd, Dy, Ho, Er, and Yb

Bi, W, Tl, Ge are detectable in more than 50% of the samples.

Subalpine Fir and White Spruce Needles commonly contain Mn and K concentrations exceeding 10 000 ppm and 10% respectively. Ta was not detectable in any sample of needles.

F was not included in the analytical package. However, it should be considered for future surveys as an important constituent of pyrochlore and REE-bearing fluorocarbonates. F is found in apatite and fersmite and is important when considering the mobility of REE.

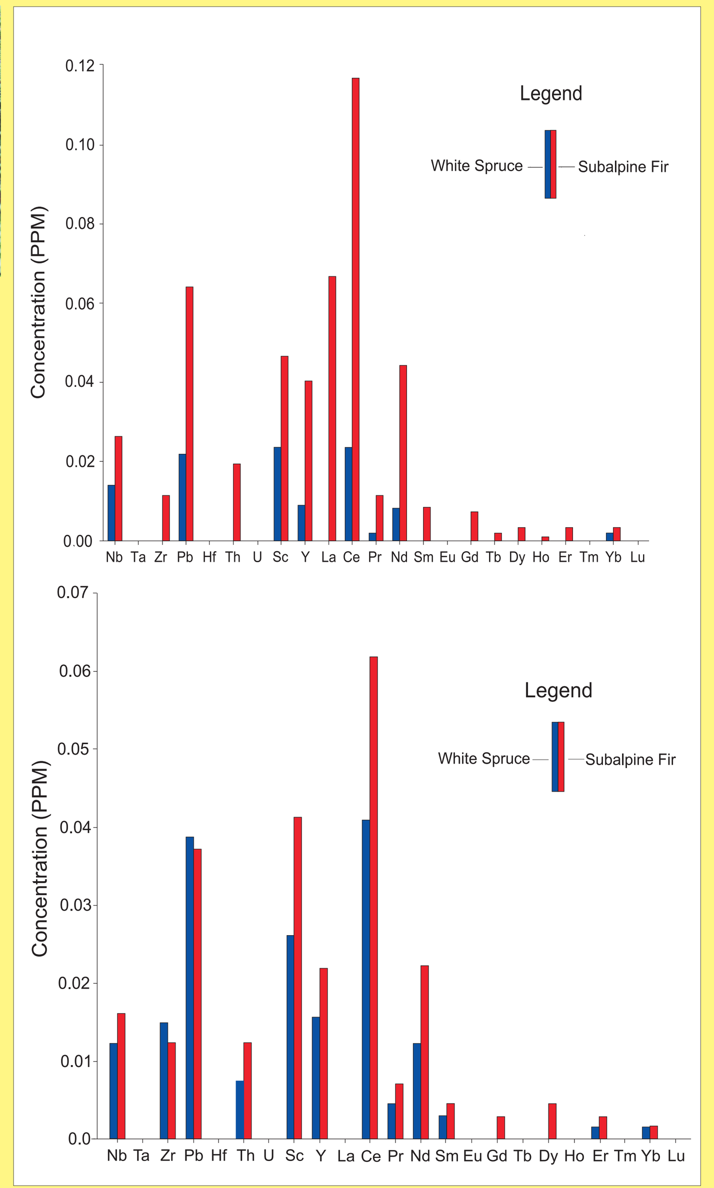


Figure 6: Concentrations of selected trace elements in needles of White Spruce and Subalpine Fir (ash values normalized to dry weights) at sites 32 (top) and 33 (bottom). Subalpine Fir needles are characterized by higher concentrations of trace elements than White Spruce needles. In both cases the adjacent Subalpine Fir and White Spruce are less than 3 metres apart. For locations see Figure 2.

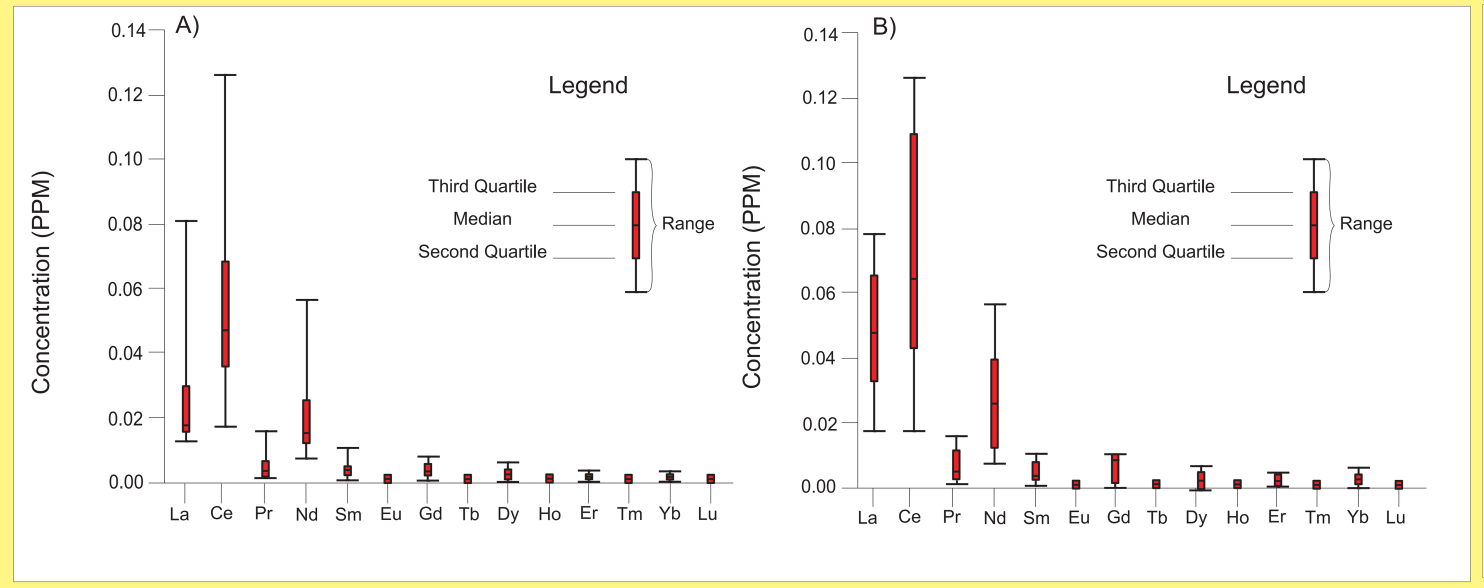


Figure 8: Concentration of trace elements (ash normalized to dry weights) in needles of A) White Spruce and B) Subalpine Fir.

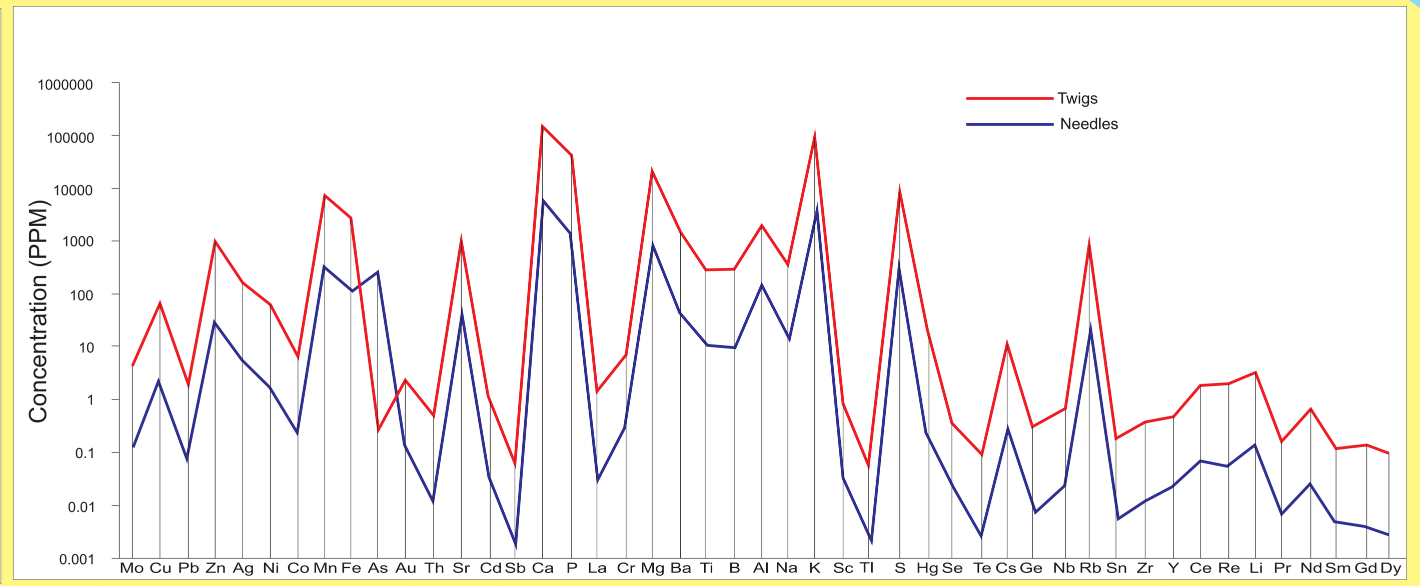
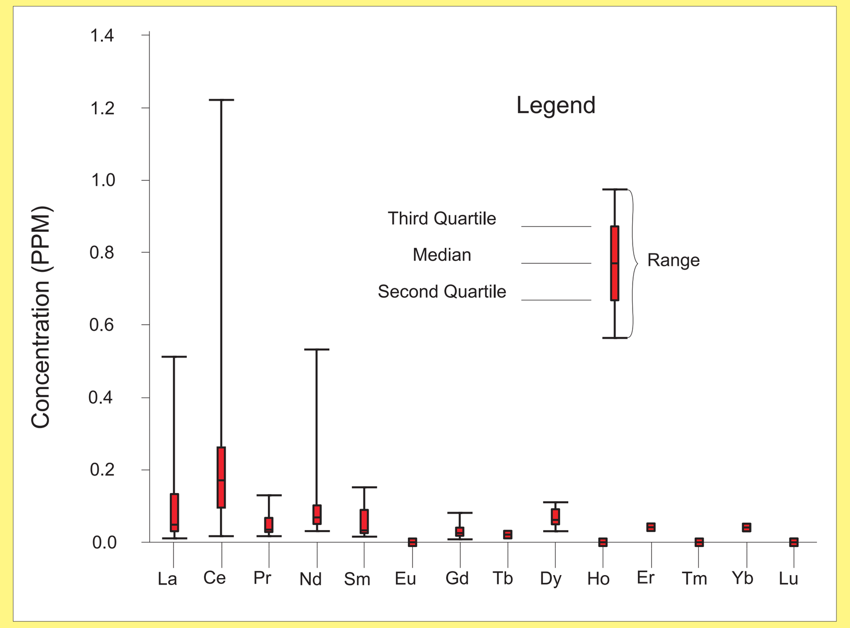


Figure 9: Average concentration of selected elements in White Spruce twigs and needles (ash values normalized to dry weights) in the Upper Fir deposit area, Blue River. Vertical scale is logarithmic.



Concentrations of selected trace elements in White Spruce twigs, Upper Fir deposit area, Blue River.

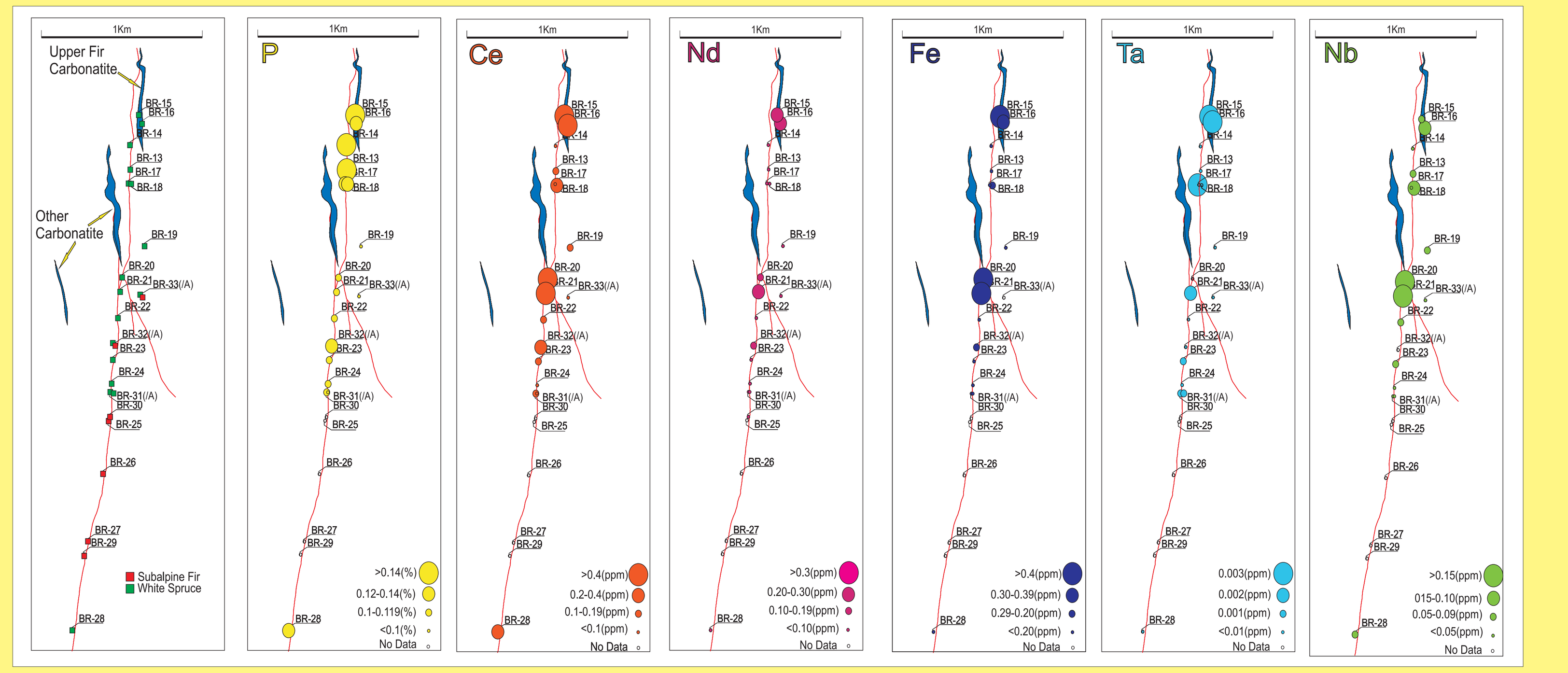


Figure 10: Concentration of selected trace elements in White Spruce twigs. Samples BR-15 and BR-16 are taken over the Upper Fir carbonatite. Sample BR-21 corresponds to a staging area containing carbonatite-fenite blocks.

Interpretation

In the Upper Fir area, White Spruce grows at higher elevations than Subalpine Fir (Figure 3). There is a narrow overlap between Spruce and Fir domains. Two pairs (32/32A and 33/33A) of both tree varieties growing ~3 metres apart were found. In both cases, the Subalpine Fir needles concentrate more of all of the trace elements (except Zr and Pb) than the White Spruce needles (Figure 6). Concentration of lanthanides in White Spruce twigs, White Spruce needles and Subalpine Fir needles are shown on Figures, 7, 8 a and 8 b. Ce, La and Nd are present in higher concentrations than other REEs. White Spruce twigs contain higher concentrations of REE than White Spruce and Subalpine Fir needles.

Our data indicate that White Spruce twigs concentrate most of the trace elements in higher concentrations than corresponding needles (Figure 9). Analyses of twigs and needles display the same pattern, indicating that both sets of data are amenable to exploration-related interpretation.

The contrast in concentration of selected elements (P, Ce, Nd, Fe, Cd and Nd) in White Spruce twigs over the upper Upper Fir carbonatite relative to the surrounding lithologies is depicted on Figure 10. Host rock ithologies are shown on Figure 2. The multi-element anomaly (sample BR-21) coincides with a shallow excavation containing blocks of carbonatite and fenite. This area was used in 2008 to prepare a bulk sample for shipping. These blocks may have contaminated the soil and explain the anomalies in elements associated with carbonatites in this area.

Statistical Analyses

Statistical analysis of White Spruce twig data indicates that moderate to strong positive correlation exists between Fe, REE and Zr. Nb correlates positively with Fe, Ti, Ce, and Nd.

Analysis of White Spruce needles suggests good positive correlation between P, Mg and Ti. A moderate to strong positive correlation exists between P and Ca. There is also strong positive correlation between Nb and REE, Zr and Fe.

There are not enough Subalpine Fir samples to statistically analyse the correlations between most elements. However, strong correlations exist between Fe and REE, Fe and Ti and also P and Zr.

Conclusions

REE (especially Ce), Zr, P, Nb, Ta and Fe, possibly in combination with Mg and Ti could be used as biogeochemical exploration vectors to search for carbonatite deposits. F is another possible exploration vector that remains to be evaluated.

Ta concentrations in needles of both Subalpine Fir and White Spruce are below detection limit. Ta and most of the heavy rare earth elements (HREE) in White Spruce twigs are present in concentrations below or near detection limit. Detectable Ta concentrations are mineralization-related.

Nb is present at higher concentrations than Ta. Precision for Nb and Ta analysis in vegetation is reported to be poor at low concentrations and may cause false anomalies (Dunn, 2007). The highest Nb concentrations detected in White Spruce twigs are accurate however, since the high concentrations were also detected in the needles of the same sample.

Good positive correlation exists between individual LREE. The relative abundance of REE in coniferous trees tested largely mimics concentrations of REE in carbonatites, where the first four lanthanide elements typically account for over 80% of the total REE.

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