Structural Characteristics of the Blue River Carbonatites in the Northern Monashee and Cariboo Mountains; British Columbia, Canada

McKinley W. Hiller

Abstract:

- Carbonatites are igneous rocks with >50% carbonate minerals. These rare rocks have been known to form near intracratonic rift and crustal-scale dome systems.
- Exploration for these petrogenic marvels has increased due to their host of abundant rare earth metals (specifically Niobium and Tantalum).
- The Blue River carbonatites lie in the Omineca Belt of the Canadian Cordillera and were emplaced periodically, at ca. 810-700, 500, and 360-330 Ma.
- The 360-330 Ma carbonatites are unusual. They were emplaced near the continental margin during subduction rather than previously emplaced carbonatites during the continental breakup of Rodinia (810-700, 500 Ma).
- This study aims to link the textural and structural characteristics of carbonatites in Blue River to better understand their entrapment and localization near collision-style tectonics.

Motivation:

- The Blue River deposits show high concentrations of Niobium and Tantalum which can be used in capacitors for automotive electronics, cell phones, personal computers, glass lenses, Ta-carbide in cutting tools, High-Strength Low-Alloy (HSLA) steels, and superalloys for the aerospace industry (Simandl, 2018; Roskill Information Services, 2016).
- The magmatic origin of carbonatites has been debated for decades due to the unusual processes and source rocks needed for these rocks to crystallize. Hence understanding the nature of the Blue River carbonatites and related rocks aids our understanding of their intrusion.
- Being composed largely of soluble carbonates, carbonatites are easily weathered and unlikely to be preserved in the geologic record making this outcrop unique.

Methods:

- Constructed geologic bedrock cross-sections that provide a two-dimensional interpretation of the fold and fault regimens present in the Monashee, Cariboo, and the Rocky Mountains that surround the Blue River area. Cross-sections are a two-dimensional representation of structural formation, thus keeping in mind the three-dimensional reality of orogenic structures and collision-style tectonics is necessary.
- Textural evidence of the Blue River Carbonatites and surrounding metamorphic rocks help distinguish the timing and crystallization patterns of these outcrops. Understanding the fabric nature helps constrain the metamorphic reworking that allowed these carbonatites to be located where they are today. Rukhlov et al. (2018) and Chudy (2013) provide an in-depth textural analysis of the Blue River outcrop which is used as primary evidence for this analysis.

References:

- Chudy, T.C., 2013. The petrogenesis of the Ta-bearing Fir carbonatite system, east-central British Columbia, Canada. Unpublished Ph.D. thesis, University of British Columbia, Canada, 316 p., 7 appendices.
- Kresten, P., 1983. Carbonatite nomenclature. GeologischeRundschau, 72 (1), 389-395.
- Murphy, D. C. (1990), Canoe River: British Columbia-Alberta Map 2110A, Natural Resource of Canada.
- Roskill Information Services (2016), Superalloys: an introduction: Tantalum–Niobium, International Study Center, Bulletin No. 167, p. 10 24, https://www.tanb.org/images/T_I_C_Bulletin_no_167_(October_2016).pdf
- Rukhlov, A.S., Chudy, T.C., Arnold, H., and Miller, D. (2018), Field trip guidebook to the Upper Fir carbonatite hosted Ta-Nb deposit, Blue River area, east-central British Columbia. British Columbia Ministry of Energy, Mines and Petroleum Resources, Geological Survey GeoFile 2018-6, 67 p.

Results:

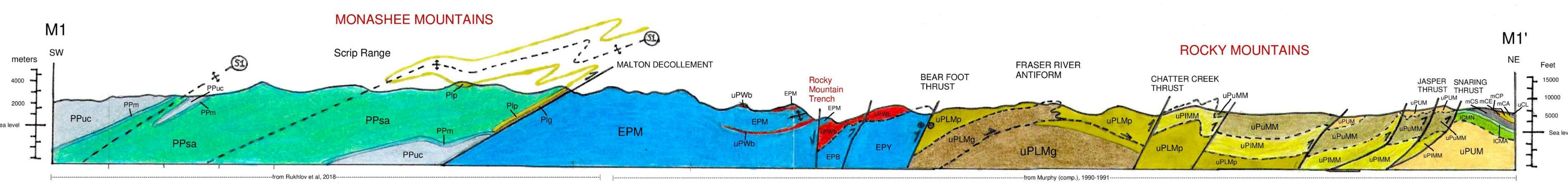


Figure 2a.

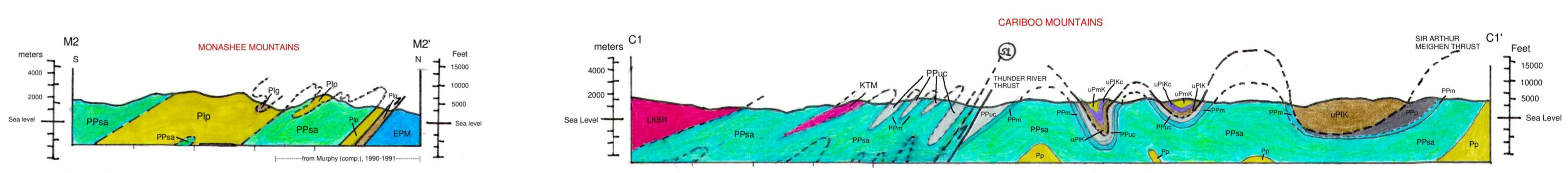


Figure 2b.

Figure 2d.

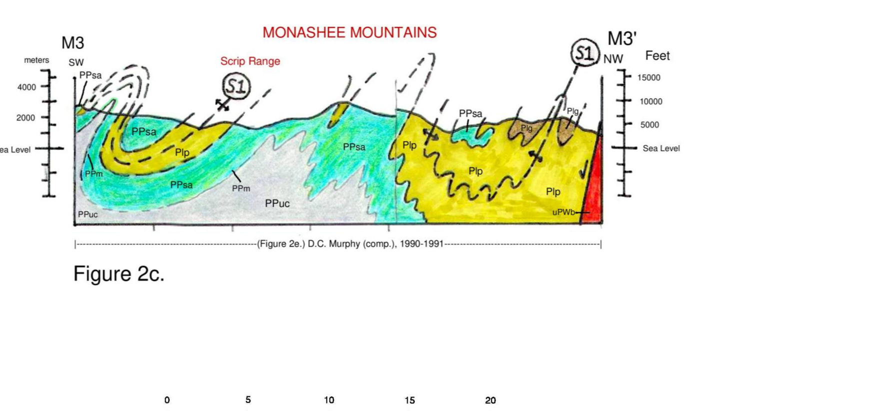


Figure 2c.

Figure 2. Interpretive vertical cross-sections

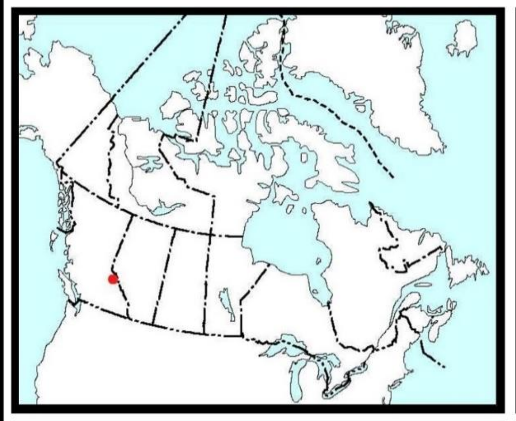


Figure 1a:
Location Map from Murphy (1990-1991). Red dot indicates the location of Blue River, British Columbia.

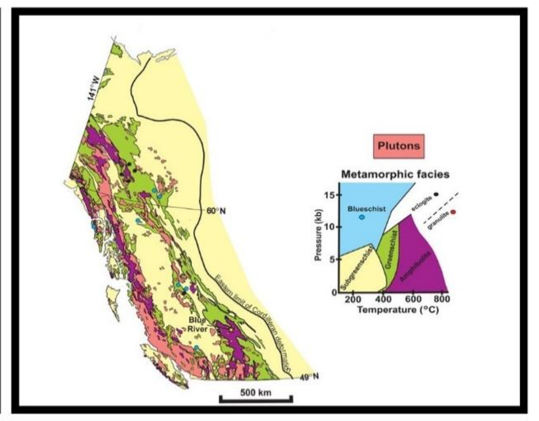


Figure 1b:
Metamorphic and plutonic rocks from Rukhlov et al. (2018) (after Monger and Hutchison, 1971; Read et al., 1991; Monger, 2014:).

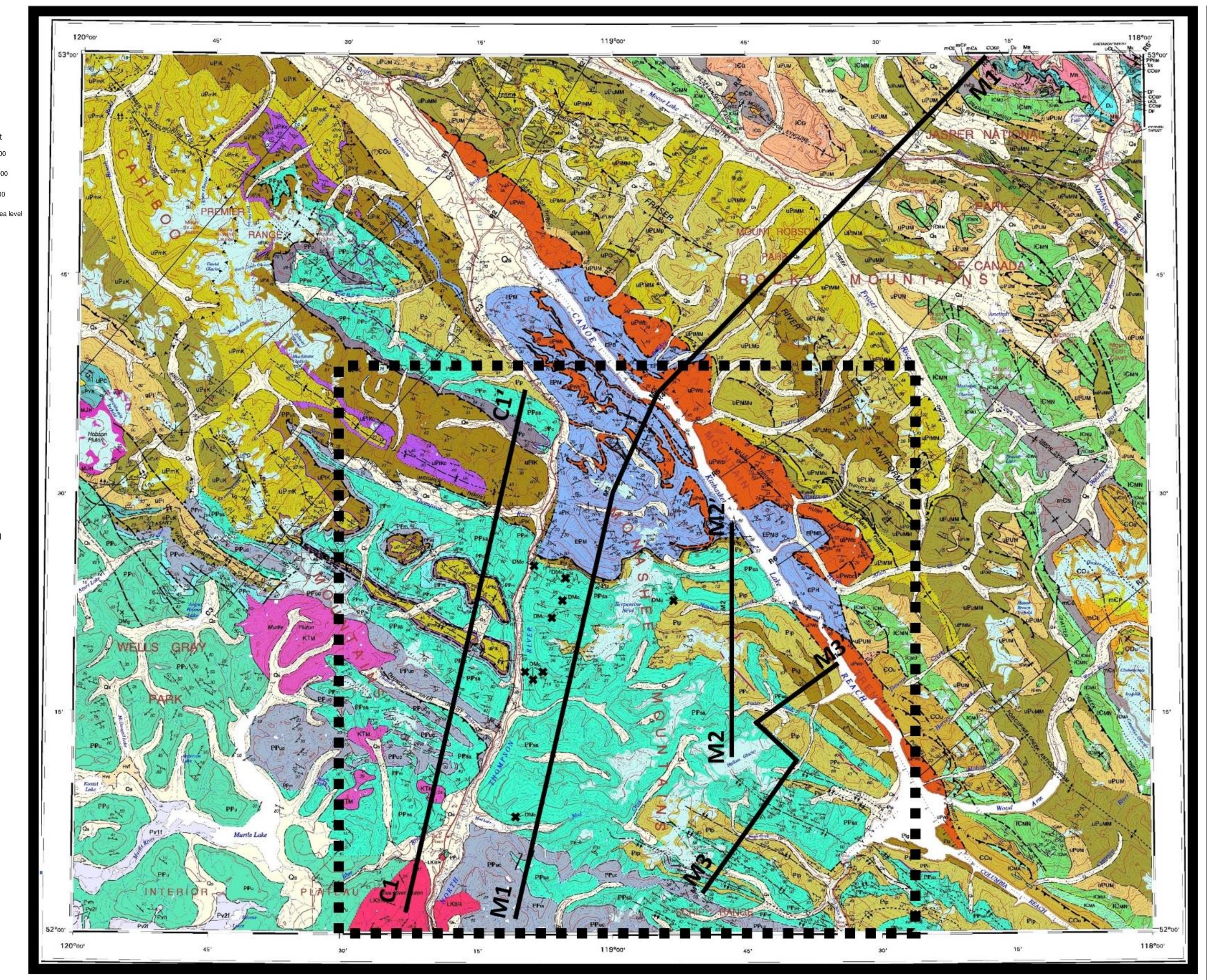


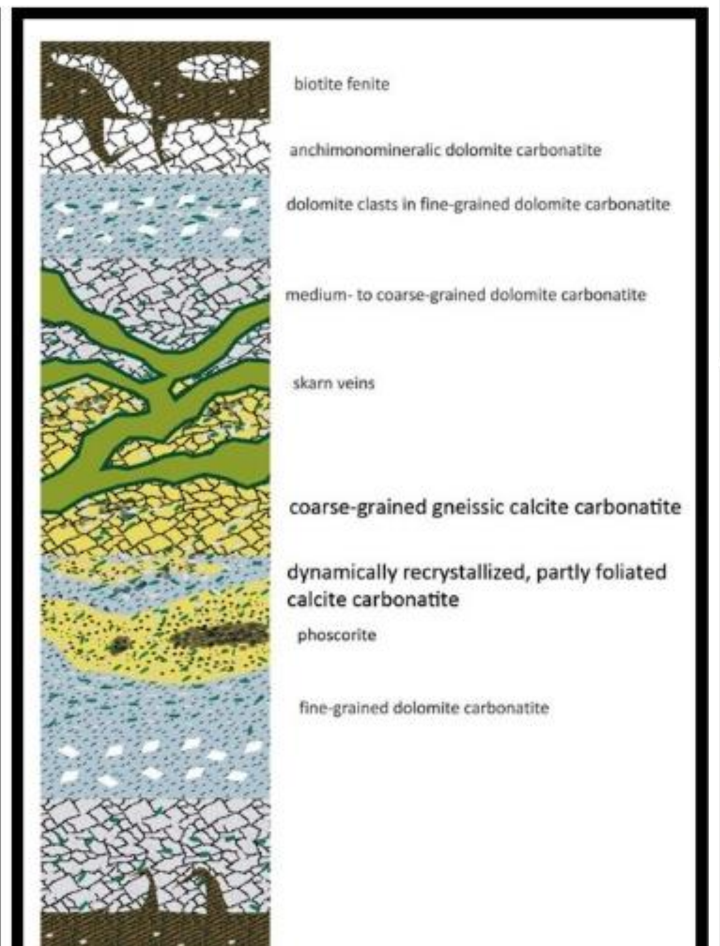
Figure 3a:
Canoe River, British Columbia-Alberta Geology Bedrock Map. Compilation by D.C. Murphy, Geologic Survey of Canada (1990-1991). The dotted line indicates the region where carbonatites are known to be located marked with the black x-marks. The solid lines with annotations indicate the cross sections. M1, M2, and M3 lie in the Monashee Mountains with M1 extending into the Rocky Mountains, and C1 lies in the Cariboo Mountains.

Figure 3b:
Legend and Scale for Figure 3a, from Murphy (1990-1991).

Results:

- A continuum of fabrics ranging from porphyroclastic to very fine-grained foliated rocks exist (Fig 4). Note that the skarn veins occur in coarse-grained calcite and dolomite carbonatite (Fig. 4).
- Shape-preferred orientation of dolomite grains gives the rock a gneissic appearance and a lack of preferred orientation gives them a granoblastic texture (Fig. 5a, b) (Rukhlov et al, 2018).
- Rocks with a porphyroclastic texture display medium to coarse-grained dolomite grains set in very fine-grained blue-gray matrix (Fig. 5c).

Figure 4:
Illustration by Chudy (2013) showing the distribution of various textures in dolomite and calcite carbonatite from the Blue River carbonatite system; the dynamically recrystallized and foliated calcite carbonatite as well as the coarse-grained calcite carbonatite are described in the text.



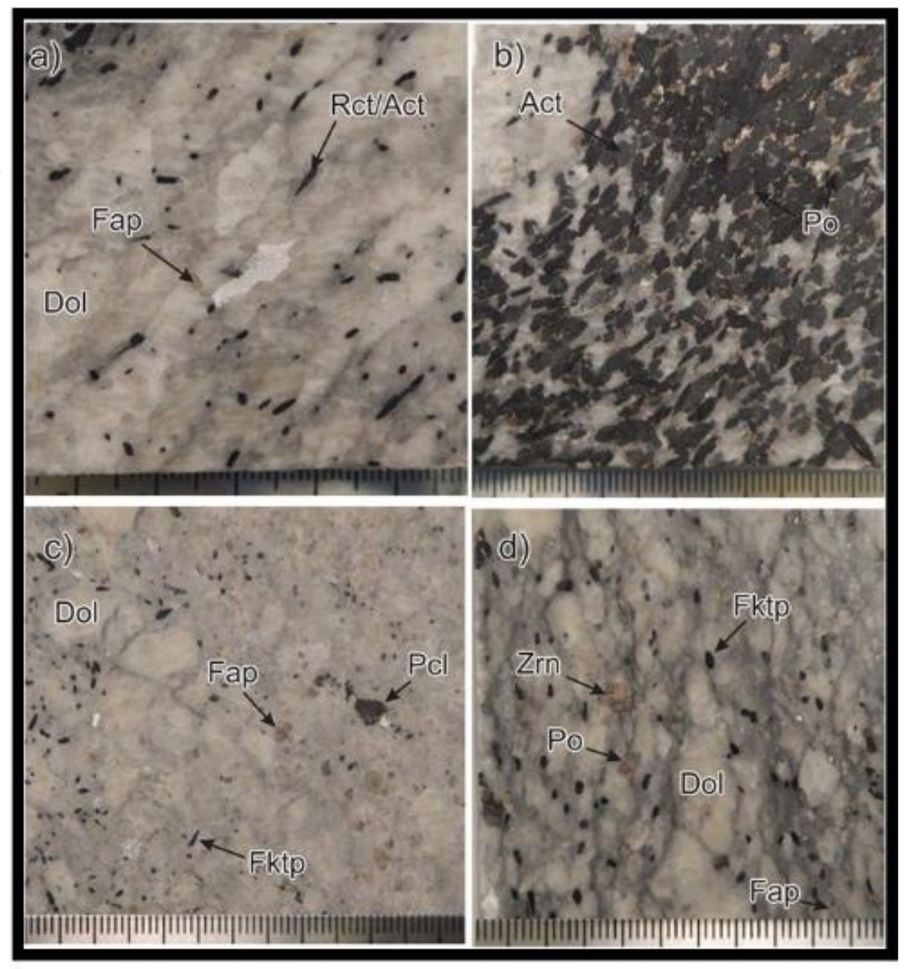


Figure 5:
Typical fabrics in the Blue River dolomite carbonatites from Rukhlov et al. (2018): **a)** Foliated, coarse-grained granoblastic or gneissic texture **b)** Foliated, coarse-grained pyrrhotite-actinolite segregation in a). **c)** Porphyroclastic texture. **d)** Foliated, fine-grained porphyroclastic texture. **Act** = actinolite, **Dol** = Fe-rich dolomite, **Fap** = fluorapatite, **Fktp** = ferrikatophorite, **Pcl** = pyrochlore, **Po** = pyrrhotite, **Rct** = richterite, **Zrn** = zircon. Scale in mm and cm.

Discussion:

• The Blue River Carbonatites are localized in Semipelite-Amphibolite (PPsa) in the Northern Monashee and Cariboo mountains. These pelitic rocks are metamorphosed mafic mudstone that was exposed at the surface during the Proterozoic to Paleozoic era.

• Figure 2 shows the syntectonic fold regimens in these Pelitic (PPsa) regions. Overturned synclinal formations shown in Figures 2a and 2c are defined by the S1 foliation in the Lower Pelite Unit (Plp) on the southwest side of the Malton Decollement (Rukhlov et al, 2018; Murphy, 1990-1991). Similar structures exist in Figures 2b (SW side of the Malton Decollement) and 2d (SW side of Thunder River Thrust) with overturned synclines dipping towards the South-West.

• The textural diversity of the Blue River carbonatites records prolonged tectono-metamorphic reworking and different styles of intrusion phases (Rukhlov et al, 2018).

• Following the peak of metamorphism, continued ductile to brittle deformation resulted in the development of localized shear zones that formed a continuum of fabrics ranging from porphyroclastic to very fine-grained foliated dolomite and calcite carbonatite (Rukhlov et al, 2018).

• Fine-grained dolomite carbonatites with no or minor dolomite clastics (Fig. 5d) represent zones of localized retrograde strain (Rukhlov et al, 2018).

•Despite the large degree of deformation, microstructures can be interpreted as remnants of the primary fabric which can be preserved in some gneissic carbonatite portions (Chudy, 2013). The gneissic fabric is the result of re-equilibration under metamorphic conditions (Rukhlov et al, 2018).

• The dolomite carbonatites with granoblastic texture (Fig. 5a) suggest that the primary igneous fabric was likely a coarse-grained or pegmatitic rock (Rukhlov et al, 2018).

•The porphyroclastic fabric overprints the gneissic fabric due to dynamic recrystallization.

•Calcite carbonatites are for the most part moderately to strongly deformed and dynamically recrystallized (Fig. 4).

Conclusions:

- Syntectonic pegmatites, syenites and leucogranites crosscutting the Blue River carbonatites and related metasomatic rocks constrain the timing of retrograde shearing (Rukhlov et al, 2018). The shearing occurred after the emplacement of the syntectonic pegmatites because shear zones contain fragments of skarn typically found at pegmatite contacts with the dolomite carbonatite (Rukhlov et al. 2018).
- Syntectonic intrusion has been found to stabilize carbonatites during shearing (Rukhlov et al, 2018). Syntectonic structures are clearly marked in Figure 2. Reverse thrusting caused by the Malton Decollement and Thunder River Thrust localize the carbonatite deposits and likely protected them from sustained weathering since their Devonian-Mississippian intrusion.
- It is likely that after the subduction of the Cache Creek Accretionary Complex (what is now the Coastal Belt) formed a back-arc rift in the Omineca Belt allowing upper mantle carbonatite melts to intrude and later thrusted into the synclinal fold structures seen today.
- The primary microstructure is either metamorphic or magmatic in origin but cannot be confidently decided without further petrographic investigation (Chudy, 2013). Analysis of the mineral composition is necessary for future investigations which can provide information about the equilibrium temperature of these carbonatite systems which may provide more important clues about their petrogenesis.

Acknowledgements:

- Dr. Peter Davis primary advisor for this project.
- Dr. Mike Turzewski secondary advisor.

References:

- Simandl, G., R. Burt, D. Trueman, and S. Paradis (2018), Economic Geology Models 2. Tantalum and Niobium: Deposits, Resources, Exploration Methods and Market – A Primer for Geoscientists, Geoscience Canada, 45(2), 85-96, doi:10.12789/geocanj.2018.45.135.