# Whole-rock and mineral geochemistry as exploration tools for rare-element pegmatites in Manitoba: examples from the Cat Lake–Winnipeg River and Wekusko Lake pegmatite fields


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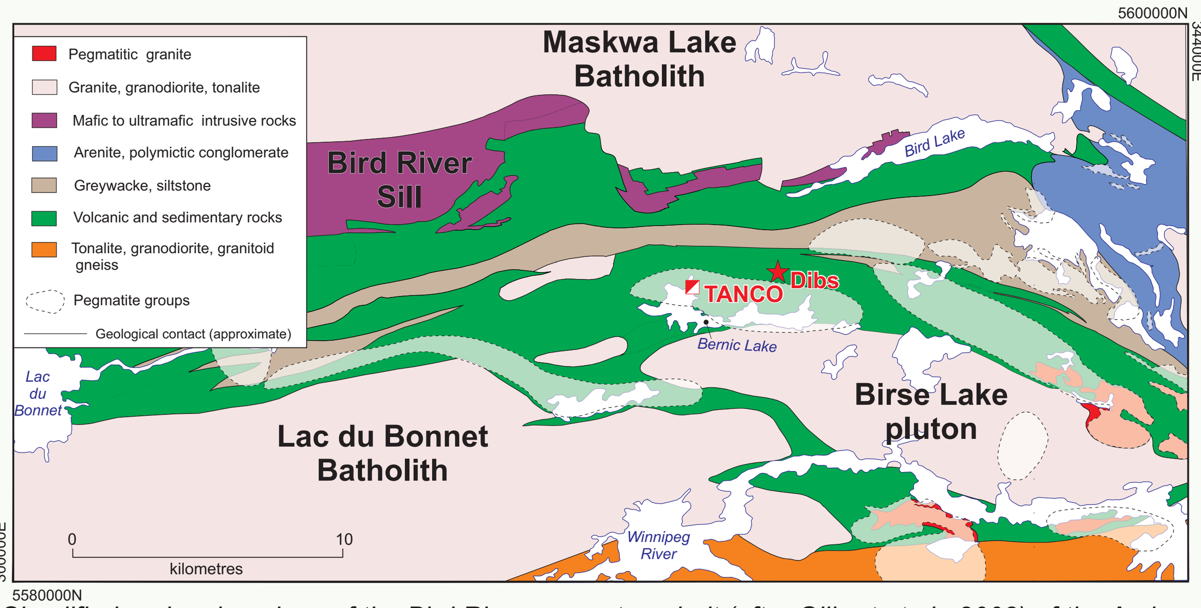
## Summary

Fieldwork was conducted in the Cat Lake–Winnipeg River pegmatite field in southeastern Manitoba and the Wekusko Lake field in west-central Manitoba. Both of these pegmatite fields are endowed with Li mineralization, but their geological settings and ages are different. Country rocks surrounding Li-bearing pegmatite in both fields were analyzed for major and trace elements, revealing anomalous values of highly mobile elements such as Li, Rb and Cs. This study indicates that whole-rock geochemistry can be a very useful tool in exploration programs for rare-element pegmatite. Holmsquistite-bearing assemblages, identified in the country rock to 'Dike 1' in the Wekusko Lake field, can also be used as an exploration tool for Li-bearing pegmatite. In addition, results from mineral-chemistry studies of muscovite and K-feldspar from Dike 1 indicate that it is possible to track pegmatite fractionation using these minerals.

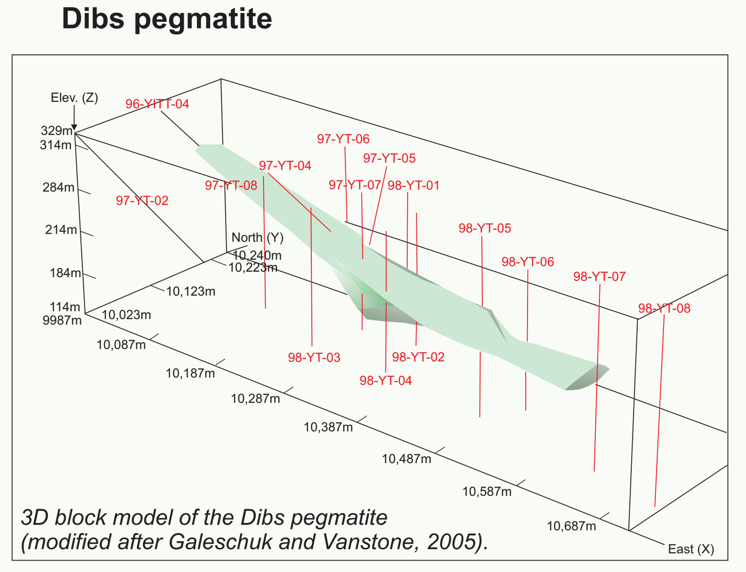

## Cat Lake–Winnipeg River pegmatite field




*Simplified regional geology of the Bird River greenstone belt (after Gilbert et al., 2008) of the Archean Superior province showing the location of the several groups of pegmatites that make up the Cat Lake-Winnipeg River pegmatite field Černý et al., 1981).*

The Bird River greenstone belt has been historically described as a large synclinal keel (e.g. Černý et al., 1981); however, recent mapping by the Manitoba Geological Survey has led to a reinterpretation of the stratigraphic framework of the belt, summarized by Gilbert et al. (2008). The Bird River belt has been subdivided into two distinct panels (North and South), both of which are composed of ca. 2.75–2.72 Ga, juvenile, arc-type metavolcanic and associated metasedimentary rocks. These two panels are separated by turbidites of the Booster Lake Formation (<2712 ±17 Ma; Gilbert, 2006).

### Dibs pegmatite



*3D block model of the Dibs pegmatite (modified after Galeschuk and Vanstone, 2005).*

The Dibs pegmatite is part of the Bernic Lake pegmatite group, which includes Tanco.

The hostrock for the Dibs pegmatite is a gabbroic to dioritic intrusion approximately 1.5 km by 3 km in size (e.g. Gilbert et al., 2008).

This gabbro was dated at 2723.1 ±0.8 Ma, contemporaneous with the age of volcanic rocks in the Bernic Lake Formation (2724.6 ±1.1 Ma) and with the Birse Lake granodiorite (2723.2 ±0.7 Ma), suggesting that these represent components of a single subvolcanic to volcanic system (e.g. Kremer, 2010).

The Dibs pegmatite is a horizontal body at least 500 m in length and up to 100 m in width, with a maximum thickness of approximately 65 m. Five different zones were identified in the Dibs pegmatite (Galeschuk and Vanstone, 2005):

1) the border zone, consisting predominantly of quartz, albite and local black tourmaline;

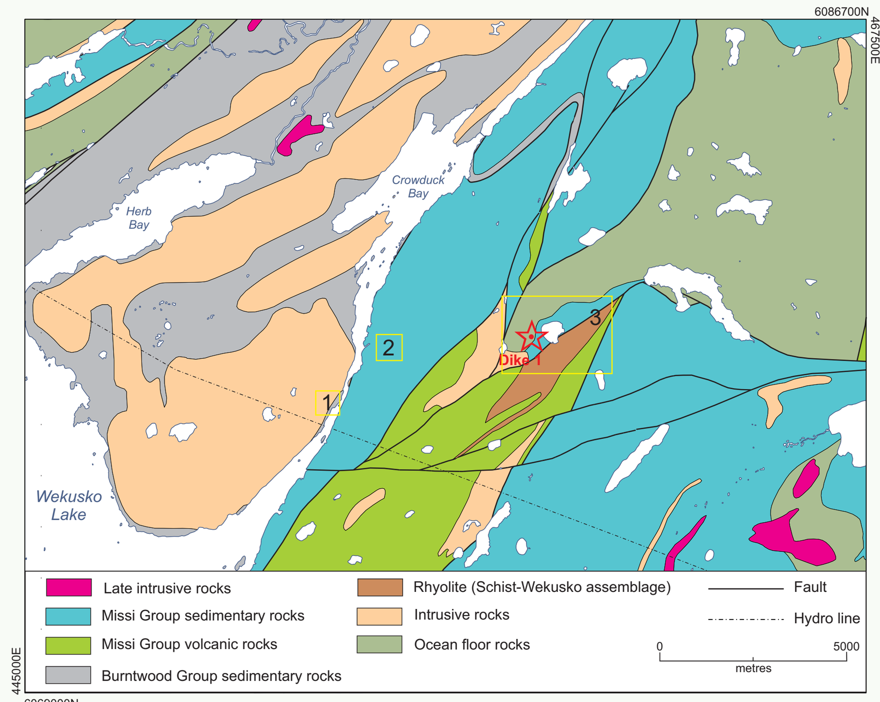
2) the wall zone, consisting of K-feldspar, quartz, cleavelandite, mica, petalite, tourmaline and minor amblygonite, triphylite, spodumene, lepidolite and smoky quartz;

3) the central intermediate zone, consisting of K-feldspar, quartz-rich sections with masses of muscovite, minerals of the columbite group, and cassiterite;

4) the lower intermediate zone, consisting mainly of K-feldspar, albite, quartz, muscovite, accessory beryl, 'ball peen' mica, petalite, cookeite, amblygonite and smoky cleavable quartz;

5) the quartz±K-feldspar zone or core, composed mainly of massive quartz, K-feldspar and minor petalite, amblygonite and muscovite.

## Wekusko Lake pegmatite field




*Simplified regional geology of the area surrounding the Wekusko Lake pegmatite field (modified and simplified from NATMAP Shield Margin Working Group, 1998).*

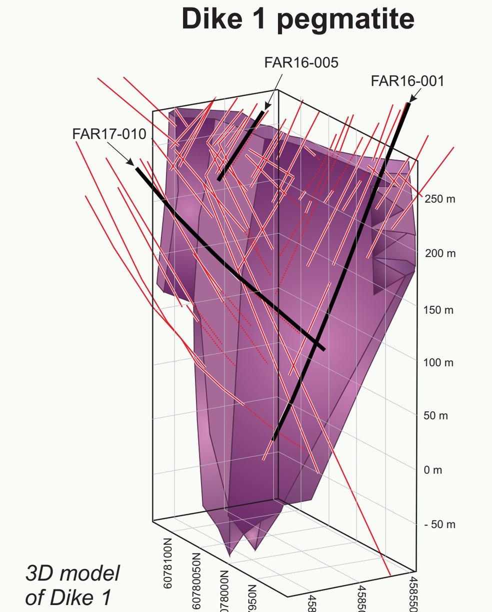
*Numbers indicate the different pegmatite groups that are known to have Li mineralization (Černý et al., 1981):*

*1- Sherritt Gordon*
*2- Violet-Thompson*
*3- Green Bay*

The Wekusko Lake pegmatite field is located east of Wekusko Lake within the Flin Flon–Glennie complex of the Paleoproterozoic Trans-Hudson orogen.

Bedrock exposures east of Wekusko Lake are dominantly Paleoproterozoic metavolcanic and metasedimentary rocks of the Missi group intruded by granitoid rocks (NATMAP Shield Margin Working Group, 1998; Gilbert and Bailes, 2005a). Surface exposures and drillcore indicate that the hostrocks for the Dike 1 pegmatite are ocean-floor mafic volcanic rocks likely deposited between 1.92 and 1.87 Ga (NATMAP Shield Margin Working Group, 1998). Locally in drillcore, the country rock to the Dike 1 pegmatite can also be metasedimentary biotite-garnet-muscovite schist, possibly belonging to the Missi group (NATMAP Shield Margin Working Group, 1998).

### Dike 1 pegmatite



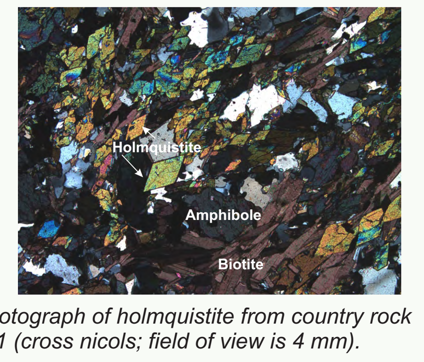

*3D model of Dike 1*

*(work in progress)*

Dike 1 is part of a swarm of at least seven pegmatite dikes that make up the Green Bay group of the Wekusko Lake pegmatite field (Černý et al., 1981).

This pegmatite is north-trending, near-vertical body that extends for at least 280 m along strike, with a maximum thickness of approximately 35 m, and is the largest and best known dike of the Green Bay group.


*Photo of halved drill core of Dike 1 showing abundant spodumene (green mineral).*




*Microphotograph of holmquistite from country rock of Dike 1 (cross nicols; field of view is 4 mm).*

Results from this study identified **holmquistite** in the mafic-volcanic country rock of Dike 1, indicating metasomatic alteration associated with Li-bearing pegmatite intrusion.

**Holmquistite** assemblages reflect greenschist-facies metamorphic conditions and are only found in amphibolitic wallrock, usually replacing hornblende, pyroxene or biotite (e.g. London, 1986).

Based on historical (A.F. 93562) and recent drill-log descriptions, the zonation in the Dike 1 pegmatite can be defined as follows:

1) the wall zone, composed predominantly of quartz, microcline and muscovite, with accessory tourmaline, hornblende, biotite and rare beryl and spodumene;

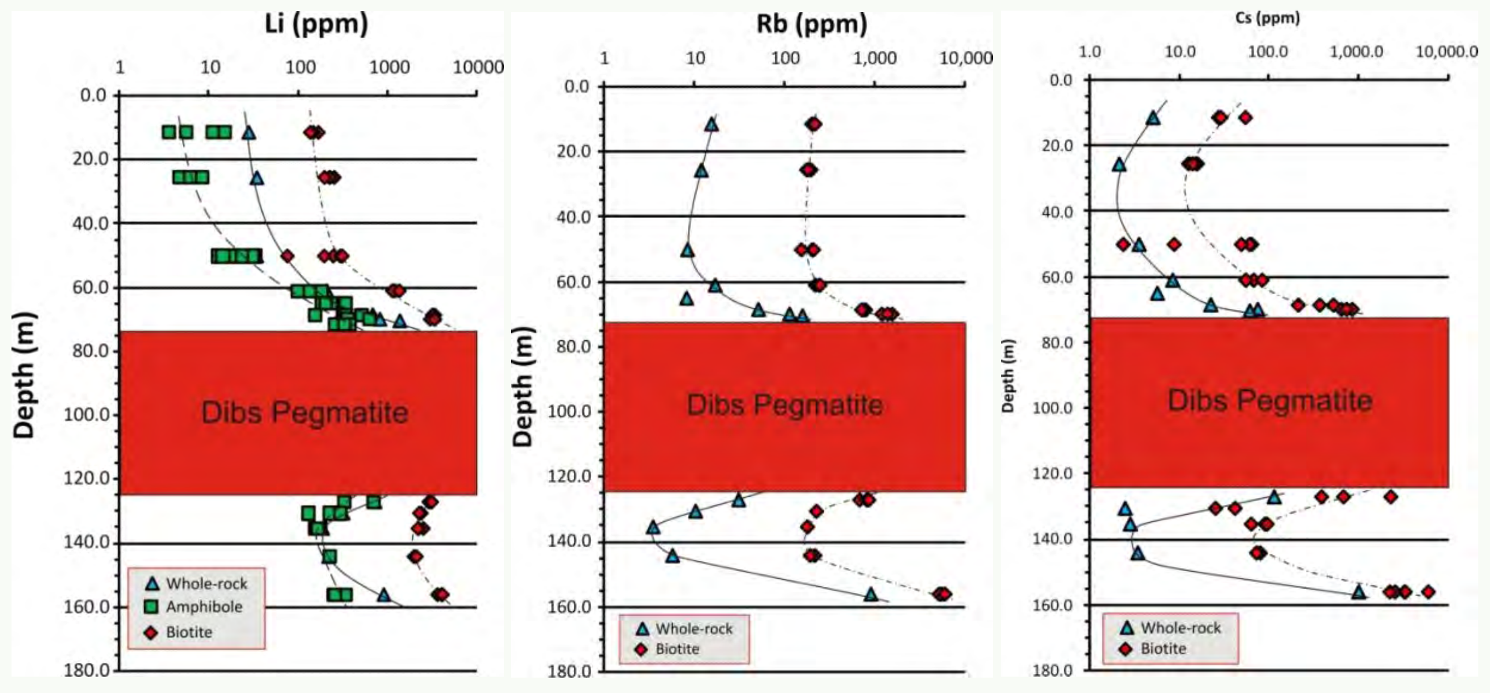
2) the intermediate zone, with medium-sized crystals of microcline, albite, quartz, muscovite and spodumene (<5%);

3) the central zone, with abundant spodumene, albite, quartz and locally pollucite, and accessory apatite, tourmaline, pyrrhotite, lepidolite, columbite-group minerals and Fe-Mn–phosphate minerals;

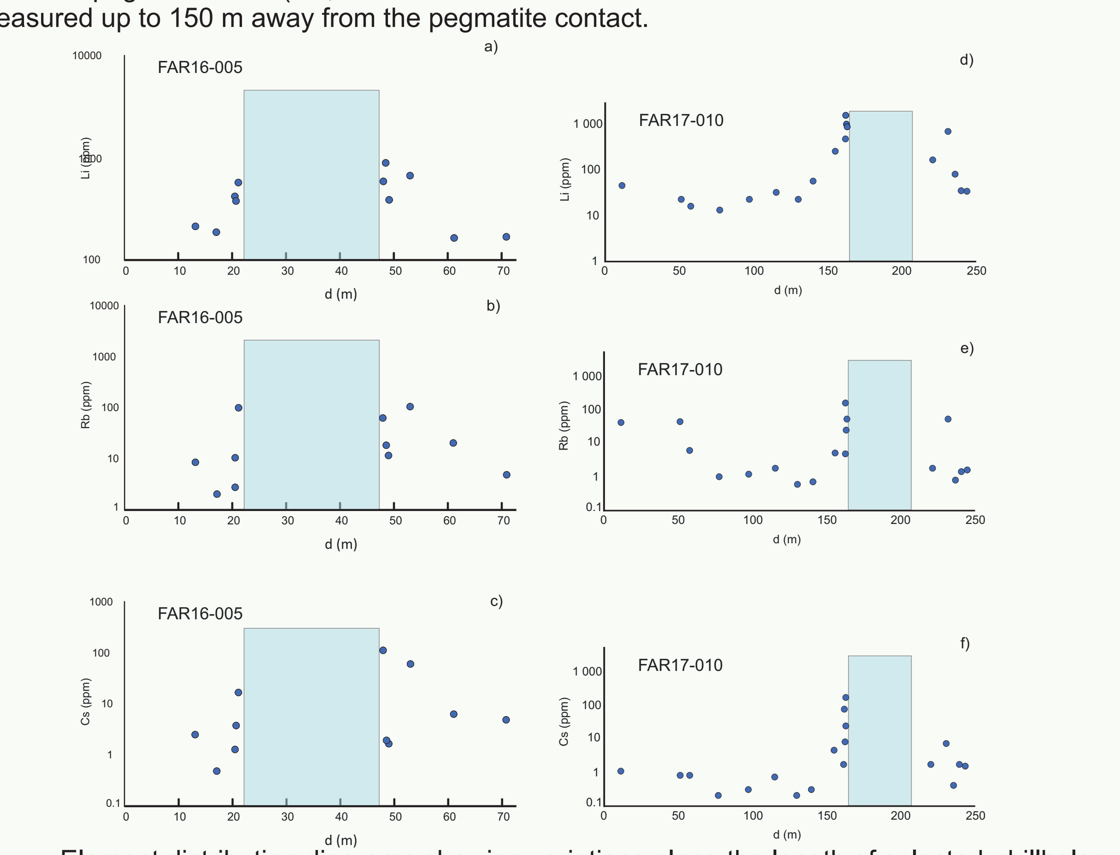
4) the core zone, composed mainly of quartz with small- to medium-grained spodumene crystals in a quartz matrix, with minor tourmaline and muscovite.

## Country rock: whole rock geochemistry

For both examples, the maximum concentrations for each element occur mostly in the country rock adjacent to the pegmatite contacts. However, the increase in concentration approaching the contact might not always be a steady one. Within the same drillhole (FAR17-010), values at 11 m for Li, Rb and Cs are 48, 39.1 and 1.1 ppm, respectively (see FAR-010 f). These values close to surface are higher than at roughly 70 m downhole (14 ppm Li, 1 ppm Rb, 0.2 ppm Cs). Deeper than 70 m there is a steady increase of Li, Rb and Cs until the pegmatite intrusion at 163 m (922 ppm Li, 51 ppm Rb, 23.9 ppm Cs). This downhole variation in concentration of Li, Rb and Cs could be related to the presence of fractures, the size or shape of the pegmatite (and consequently the metasomatic halo), and the zonation of the pegmatite itself (i.e., location of the Li or Cs mineralization and Rb enrichment within the pegmatite). The data also indicate that above-background concentrations of Li, Rb and Cs in the country rock of Dike 1 can be measured up to 150 m away from the pegmatite contact.



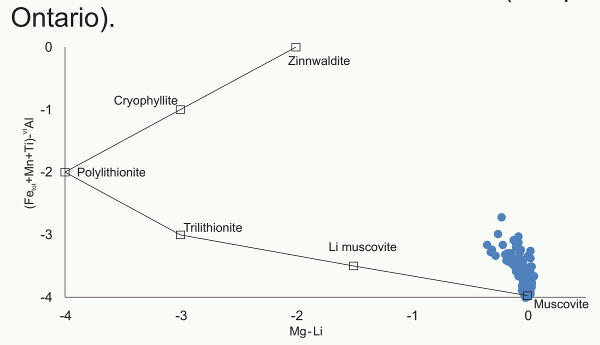

Element distribution diagrams showing variations along drill hole 98-YT-02 for both country rock and mineral chemistry (biotite and amphibole). Mobility of Li>Rb>Cs, similar to previous studies (e.g. Halden et al, 1989). At the top of the hole enrichemnt is ~30 ppm Li, ~15ppm Rb and ~5 ppm Cs. Note enrichemnt at the bottom.




Element distribution diagrams showing variations along the length of selected drillholes from Dike 1. a) Li for drillhole FAR16-005; b) Rb for drillhole FAR16-005; c) Cs for drillhole FAR16-005; d) Li for drillhole FAR17-010; e) Rb for drillhole FAR17-010; f) Cs for drillhole FAR17-010. Shaded areas mark the location of the pegmatite.

## Mineral chemistry of Dike 1 pegmatite (muscovite and K-feldspar)

Results for mineral-chemistry data for both muscovite and K-feldspar indicate a moderate level of fractionation for Dike 1 (compared to Tanco and pegmatites in Ontario).

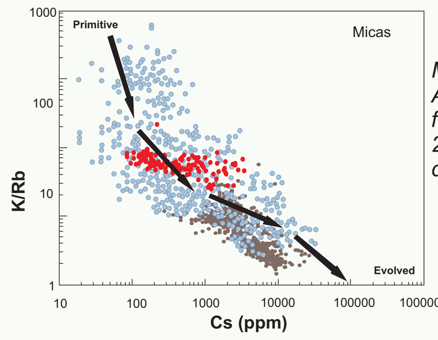



*Classification diagram proposed by Tischendorf et al. (1997) for micas (plotted values in atoms per formula unit; squares indicate the ideal locations for mica end-members of this section of the diagram).*

Micas have compositions close to end-member muscovite; diagram shows a trend toward the Li-enriched muscovite end-member.

Major-element compositions show minor variation; trace-elements with the greatest variation are F, Rb and Cs:
* F varies from below detection limit to 1.53 wt. % F;
* Rb ranges from 0.18 to 0.81 wt. % $Rb_2O$;
* Cs varies from below detection limit to 0.36 wt. % $Cs_2O$.

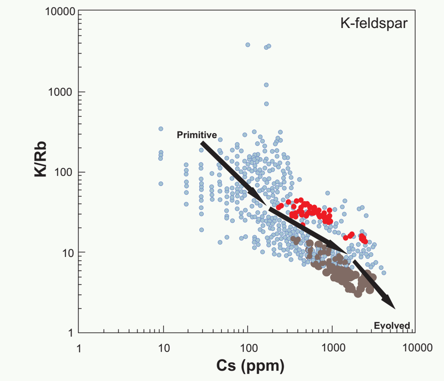
K/Rb (10.99 - 28.73) in micas are comparable to moderately evolved pegmatites from Ontario but higher than the highly evolved Tanco pegmatite; these results indicate that the Dike 1 pegmatite is less fractionated than the Tanco pegmatite.




*Mineral-chemistry results for muscovite from Dike 1 in red dots. Also shown is general fractionation trend (arrows) for micas from Ontario pegmatites (blue dots; data from Selway et al., 2005) and from Tanco (brown dots; S. Margison, unpublished data)*

Results for K-feldspar indicate little to no variation of the major elements; trace elements Rb and Cs show the greatest variation.

K/Rb (13.45 - 43.92) indicate a moderate level of fractionation. These values are typical for feldspar from spodumene-type pegmatites in Ontario but higher than the values listed for Tanco feldspar but, corroborating the lower degree of fractionation of Dike 1 (compared to Tanco).




*Mineral chemistry results for K-feldspar from Dike 1, pegmatites from Ontario (data from Selway et al., 2005) and Tanco (data from Brown, 2001; symbols as before).*

## Economic considerations

The results from this work corroborate the conclusion from other studies that using lithogeochemistry of country rocks is a viable and relatively inexpensive tool to explore for rare-element pegmatites (Halden et al., 1989; Linnen et al., 2009, 2015).

This is valid for metavolcanic rocks, but has not been sufficiently tested for other types of wallrock and should therefore be used with caution.

The presence of holmquistite-bearing assemblages in the amphibolitic country rock to the Dike 1 pegmatite indicates interaction of Li-enriched fluid sourced from the Li-bearing pegmatite. Hence, identification of these assemblages could also be a very useful and inexpensive tool in exploration for Li-bearing pegmatite because they can occur up to 20 m away from pegmatite contacts (Černý et al., 1981).

Mineral-chemistry results for muscovite and K-feldspar indicate that Dike 1 is a moderately fractionated pegmatite; this kind of information could be a useful tool for understanding fractionation trends within a pegmatite field. According to Selway et al. (2005), compositions of K-feldspar and muscovite are excellent exploration tools because these minerals are common in barren and fertile granites as well as rare-element pegmatites, allowing for an understanding of fractionation trends.

Collectively, the techniques presented in this poster provide effective exploration tools for identifying and characterizing Li-bearing pegmatite dikes.

## Proposed future work

Expand the mineral-chemistry study to other pegmatite dikes in the area will help understanding fractionation paths in the Wekusko pegmatite field and establishing areas of higher probability of finding pegmatite other mineralised dikes;

Further petrographic studies of mineralogy and zonation would give a better idea of the degree of fractionation of the Dike 1 pegmatite and a better understanding of the Li mineralization and its associations.

Carry out detail mapping, rock, vegetation or soil geochemical surveys and selective-extraction analytical techniques area around the Dike 1 pegmatite could help establishing mineralization controls.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