Geology and bedrock mapping of the Wekusko Lake pegmatite field, central Manitoba

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Abstract

Pegmatite dikes from the Green Bay group of the Wekusko Lake pegmatite field were examined in summer of 2018 through geological mapping and relogging drillcore from several diamond drill holes. The pegmatite dikes exhibit five zones: the border zone, the wall zone, the intermediate zone, the central zone and the core zone. The dikes vary in size and not all zones are present in all dikes. The zones vary in mineralogy and crystal size. An abundance of alkali feldspars is characteristic of the wall zone and the intermediate zone, whereas the abundances of albite and spodumene are characteristic of the central zone. The central zone also hosts rare-metal–bearing phases such as the columbite group minerals. Field mapping reveals that the pegmatites are folded and that the thickness of the pegmatite affects the degree to which it was folded during regional deformation. Future work will involve mineralogical studies (particularly of muscovite) to evaluate vectors for exploration. Uranium-Pb geochronological studies of the columbite-group minerals will also be carried out.

Regional Setting

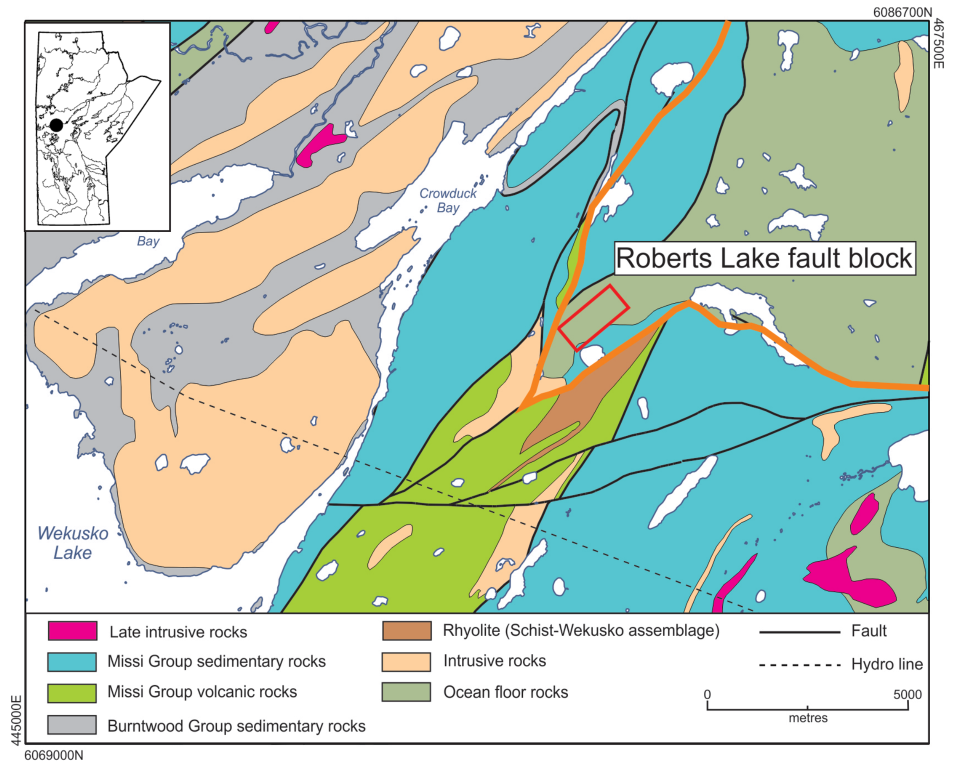


Figure 1: Regional geology of the east side of Wekusko Lake, central Manitoba. The red square outlines the mapping area, and the orange line outlines the Roberts Lake fault block (modified and simplified from NATMAP Shield Margin Working Group, 1998).

In Manitoba, Li is predominantly associated with Li-Cs-Ta (LCT) pegmatites, the best-known example being the world-class Archean Tanco deposit in southeast Manitoba (Černý, 2005). Trans-Hudson–aged LCT pegmatites are present in the Wekusko Lake pegmatite field (Černý et al., 1981; Martins et al., 2017), approximately 25 km east of Snow Lake in central Manitoba.

The Wekusko Lake pegmatite field (Černý et al., 1981) is located within the ca. 1.91–1.83 Ga Flin Flon–Glennie complex (Connors et al., 2002) of the Paleoproterozoic Trans-Hudson orogen (Figure 1; modified from the NATMAP Shield Margin Working Group, 1998; Bailes and Galley, 1999), an easterly trending belt approximately 140 km wide and 240 km long. Multiple mafic and felsic intrusive events, both syn-and late tectonic, occurred in the Flin Flon belt (Černý et al., 1981; Kraus and Williams, 1999). These events ranged from large granite plutons to smaller dikes, sills and stocks.

The studied pegmatites are hosted primarily by a mafic volcanic assemblage. The mafic volcanic assemblage is unconformably overlain by Missi group metasedimentary rocks (Connors et al., 1999). These units make up the Roberts Lake fault block (Figure 1).

The region has undergone five deformation and folding events (D1 to D5; Kraus and Williams, 1999; Connors et al., 2002). The first three are linked to the thrusting of the Kisseynew basin over the Flin Flon belt (Kraus and Williams, 1999). This resulted in isoclinal folding and low angle shear zones. Deformation phase D4 is associated with east-west shortening during the underthrusting of the Superior plate, that resulted in north-northeast folds. Deformation event D5 is associated with the renewal of the north-south convergence (Kraus and Williams, 1999).

The emplacement of the granitic pegmatites is thought to be the last intrusive event (Černý et al., 1981; Kraus and Williams, 1999), although folding in the pegmatites (Figure 2) may indicate that these dikes could have been emplaced prior to some weakly or undeformed granitoid bodies.

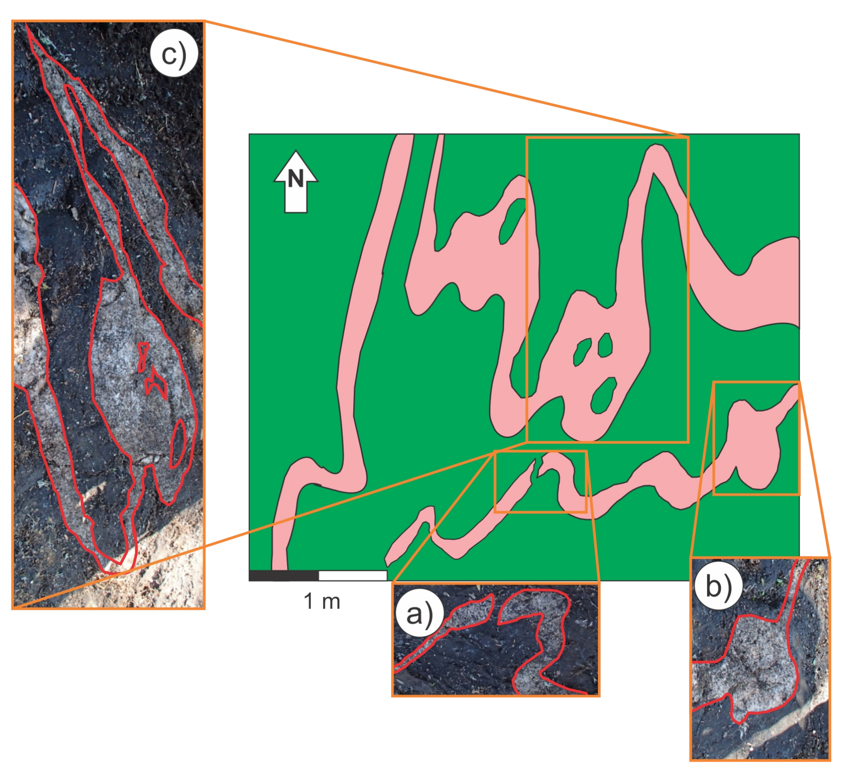
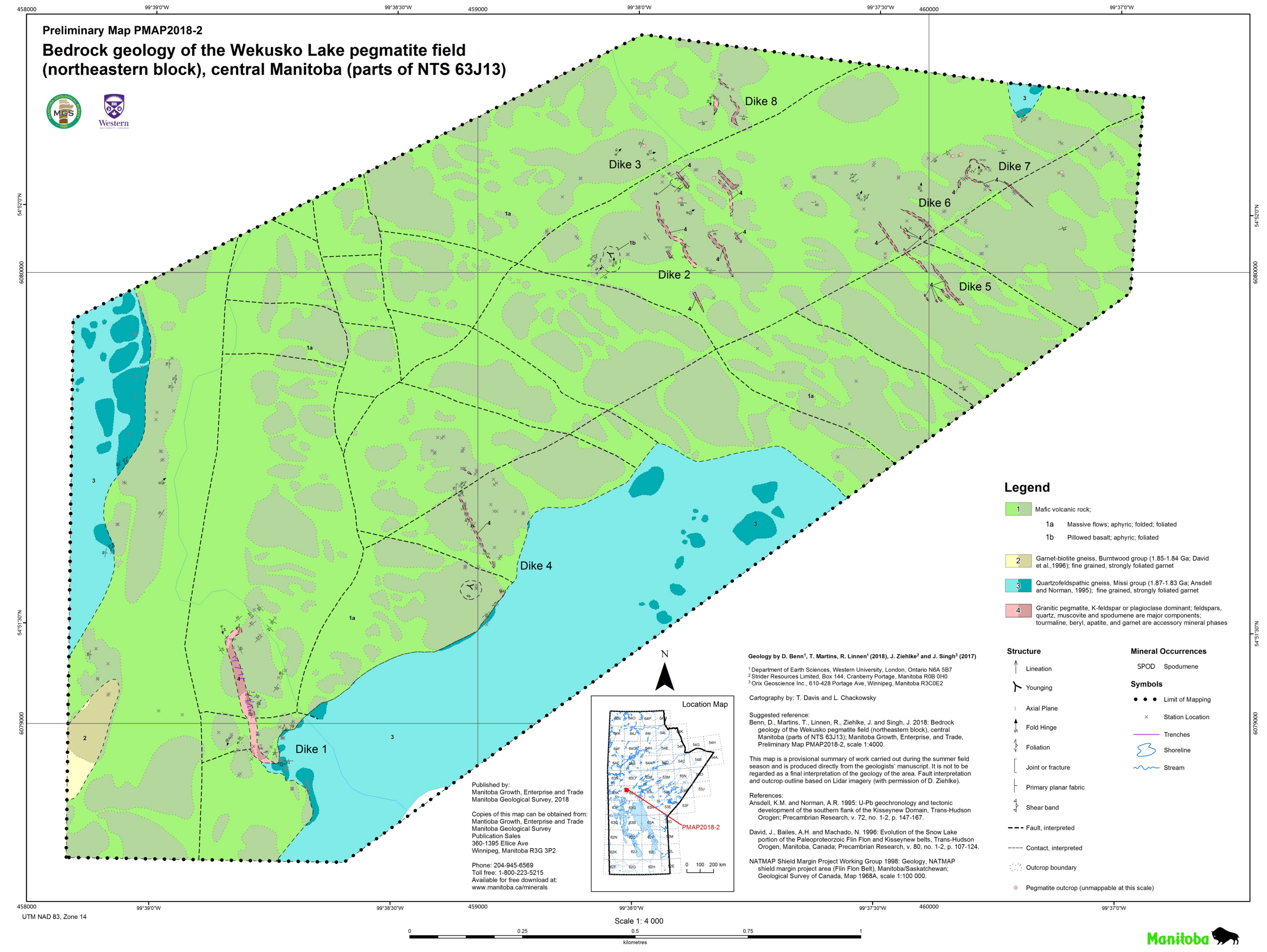


Figure 2: Sketch and outcrop photos showing folding in pegmatite near Dyke 7. a) boundinaged and folded pegmatite; b) ballooning in pegmatite; c) ballooning in pegmatite with mafic volcanic xenoliths.

Geological Map



Bedrock mapping at a scale of 1:4 000 was undertaken to investigate and document the zoning, morphology and structural controls of the emplacement of the pegmatite dikes. There are at least eight large (>1 m thick) dikes exposed in the map area, all oriented to the northwest-southeast. The dikes are folded and undulated over several metres (Figure 2). The largest dike known (Dike 1) varies from 1 to 15 m wide and is 300 m long at surface. The dikes are primarily hosted by the mafic volcanic rocks, except for southern tip of Dike 1, where it is hosted by a quartzofeldspathic gneiss.

Pegmatite Zonation

Based on observations of core from 29 drillholes, 5 zones for the Li-bearing pegmatite dikes were recognized: the border zone, the wall zone, the intermediate zone, the central zone and the core zone. These zones are not present in all eight dikes or at all depths within the dikes. Thin dikes, in particular, tend to lack the central or core zones, and the thickness of the different zones greatly varies between the dikes.

Border zone

The border zone is the outermost, thinest zone and is not always present. It is up to 1 cm thick along the outer edge of the pegmatite. The border zone is composed primarily of quartz, muscovite, feldspar and tourmaline. Grain sizes are between 0.5 and 2 mm.

Wall zone

The wall zone (Figure 3) is composed of K-feldspar, quartz, muscovite, albite and tourmaline with accessory beryl, spodumene and apatite and has a brick red colour. Muscovite is present as both primary and secondary phases. Tourmaline commonly form comb structures perpendicular to the pegmatite contact. Grain sizes are typically between 0.25 and 2 cm; however, it is not uncommon for larger crystals to be present in the wall zone.

Figure 3: Drillcore sample displaying the brick red colour of the wall zone, coin for scale.

Pegmatite Zonation

Intermediate zone

The intermediate zone (Figure 4a) is composed of albite, K-feldspar, quartz, muscovite and spodumene (5%). Grain sizes range from 0.5 to 5 cm with rare crystals up to 10 cm in length. Three textural phases of spodumene are present in this zone. The albite to K-feldspar ratio is approximately 1:1, which gives the zone a salmon pink colour. The K-feldspar forms fine-grained (<0.5 cm) masses, whereas albite occurs as larger subhedral crystals (3–5 cm).

Central zone

The central zone (Figure 4b) is composed of albite, spodumene, quartz and muscovite with accessory apatite, columbite-group minerals and Fe-Mn phosphate minerals, but the central zone is not always present. The central zone contains the highest concentrations of spodumene varying from 10 to 30 modal percent and locally up to 50 modal percent. The average grain size ranges from 3 to 10 cm, with some crystals up to 15 cm long. The central zone has a greyish white colour due to the presence of albite and quartz. Spodumene is occurs mostly as euhedral to subhedral crystals between 3 and 6 cm long. Muscovite is present in euhedral to subhedral coarse-grained books.

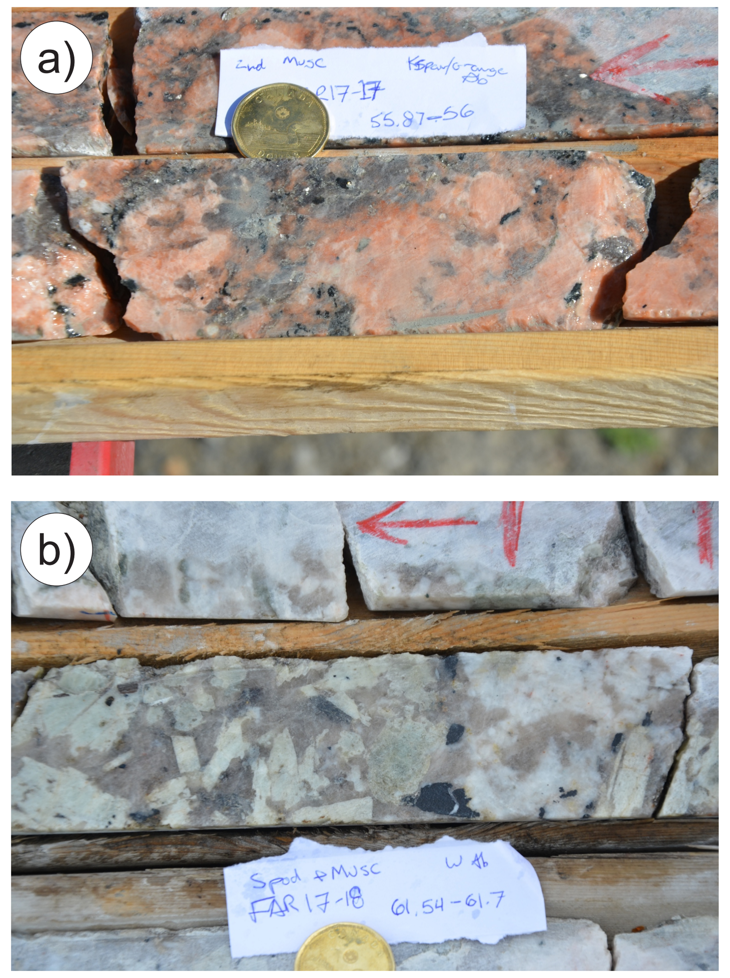


Figure 4: Drillcore sample displaying a) the salmon pink transition zone and b) the white central zone, coin for scale.

Core zone

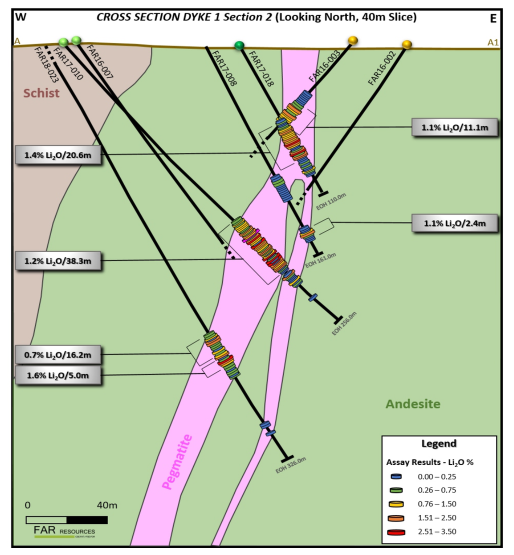
The core zone is the innermost zone of the dike and is composed predominantly of quartz and albite, with minor spodumene (<5%). The grain sizes range from 3 to 10 cm, locally with crystals up to 20 cm long. Spodumene is typically present as large euhedral to subhedral crystals up to 15 cm long. The core zone replaced the central zone in some thinner sections of the dike, but this zone is not always present.

Economic Consideration

With the rise of interest in renewable energy and electric cars, batteries have become increasingly more important. Many new battery technologies use Li as a main component. For this reason, Li has become a widely sought-after element. Lithium is typically obtained either through mining pegmatites, where spodumene is the most common Li ore mineral (e.g., Greenbushes, Australia), or extraction from brines (e.g., Salar de Atacama, Chile).

Manitoba is highly prospective for Li pegmatites. This includes the Green Bay group of the Wekusko Lake pegmatite field, which contains at least eight large Li-bearing pegmatite dikes. Of those, two contain central zones with more than 2 wt.% Li_2O (FAR Resources Ltd., 2017, 2018). A fifth round of drilling is currently ongoing. It is anticipated that variations of Li between mica grains within pegmatite can act as a vector to identify the central zone.

Some dikes contain increased abundances of Ta and Nb, hosted in columbite-group minerals.



Future Work

During this study, samples were collected from all zones and pegmatites at varying depths. Sampling focused on obtaining both primary and secondary muscovite crystals to determine their Li content and to evaluate whether muscovite chemistry is related to the proximity of spodumene or the Li grade of a pegmatite zone. Samples of drillcore with high Nb and Ta values were also targeted for geochronology studies.

Lithium content will be determined by laser-ablation inductively coupled plasma–mass spectroscopy (LA-ICP-MS). Peak shifts related to the muscovite molecular structure (muscovite to polylithionite) will be measured by portable Raman spectroscopy and calibrated by LA-ICP-MS to evaluate the utility of portable Raman spectroscopy in Li pegmatite exploration. The portable Raman spectrometer will also be used to determine feldspar compositions (albite versus K-feldspar) and this instrument will be evaluated as a more general tool for use in pegmatite exploration. Geochronology studies on columbite-group minerals will help determine the timing of the pegmatite emplacement in relation to the peak metamorphism and deformation history of the region.

References: Bailes, A.H. and Galley, A.G. 1999: *Evolution of the Paleoproterozoic Snow lake arc assemblage and geodynamic setting for associated volcanic-hosted massive sulphide deposits*; Černý, P. 2005: *The Tanco rare element pegmatite deposit, Manitoba: regional context, internal anatomy and global comparisons*; Černý, P. and Ercit, T.S. 2005: *The classification of granitic pegmatites revisited*; Černý, P., Trueman, D.L., Zeihlke, D.V., Goad, B.E. and Paul, B.J. 1981: *The Cat Lake–Winnipeg River and the Wekusko Lake pegmatite fields, Manitoba; Connors, K.A., Ansdell, K.M. and Lucas, S.B. 1999: Coeval sedimentation, magmatism, and fold-thrust development in the Trans-Hudson Orogen: propagation of deformation into an active continental arc setting, Wekusko Lake area, Manitoba*; Connors, K., Ansdell, K. and Lucas, S. 2002: *Development of a transverse to orogen parallel extension lineation in a complex collisional setting, Trans-Hudson Orogen, Manitoba, Canada*; FAR Resources Ltd. 2017: *Phase 3 drilling*; FAR Resources Ltd. 2018: *Phase 4 drilling*; Kraus, J. and Williams, P.F. 1999: *Structural development of the Snow Lake allochthon and its role in the evolution of the southeastern Trans-Hudson Orogen in Manitoba, central Canada*; Martins, T., Linnen, R.L., Fedikow, M.A.F. and Singh, J. 2017: *Whole-rock and mineral geochemistry as exploration tools for rare-element pegmatite in Manitoba: examples from the Cat Lake–Winnipeg River and Wekusko Lake pegmatite fields (parts of NTS 52L6, 63J13)*; NATMAP Shield Margin Project Working Group 1998: *Geology, NATMAP shield margin project area (Flin Flon Belt), Manitoba/Saskatchewan*;