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 logging of drillcores 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. An abundance of alkali feldspars is characteristic of the wall zone and the intermediate zone, whereas the abundance of albite and spodumene are characteristic of the central zone. The central zone is hosted by iron-manganese ores of the same zone are present in adjacent nickel-copper deposits. 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-lead geochronological studies of the columbite-group minerals will also be carried out.

Regional Setting

In Manitoba, Li is predominately associated with Li-Ca-Ta (LCT) pegmatites, the best-known example being the world-class Archean Timmin deposit in southwestern Manitoba (Cerny 2005; Trans-Hudson-aged LCT pegmatites are present in the Wekusko Lake pegmatite field (Cerny et al., 1981; Martin et al., 2017), approximately 25 km east of Snow Lake in central Manitoba. The Wekusko Lake pegmatite field (Cerny et al., 1981) is located within the ca. 1.85 Ga Flin Flon-Gammon complex (Connors et al., 2002) of the Paleoarchaean Trans-Hudson orogen (Figure 1, modified from the NATMAP Shield Margin Working Group, 1996; Beales and Gallagher, 1999), an easternly trending belt approximately 140 km wide and 240 km long. Multiple mafic-ultramafic enclaves and double-layered intrusive complexes occurred in the Flin Flon belt (Cerny et al., 1981; Kraus and Williams, 1999). These enclaves range from large gabbroic 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 Misei Formation and the overlying Sonotse Formation (Connors et al., 1999). These units make up the Roberts Lake fault block (Figure 2). The regional setting is outlined in Figure 3a. 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 accretion of the Kisewaye belt to the Flin Flon belt (Kraus and Williams, 1999). This resulted in a deformed and folded low-angle shear zone. Deformation phase D4 is associated with east-west shortening during the upwarping of the Superior plate, that resulted in north-northeast fold. 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 (Connors 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 books.

Geological Map

Bedrock mapping at a scale of 1:4 000 was undertaken to investigate and document the zoning, morphology and structural control of the emplacement of the pegmatite dikes. There are at least eight large (1 to 5+ km thick) dikes exposed in the map area, all trending to the northwest-southeast. The dike is a greyish white colour due to the presence of albite and quartz. Spodumene occurs mostly as euhedral to subhedral crystals between 3 and 6 cm long. Muscovite is present in euhedral to subhedral coarse-grained books.

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 valuable sought-after element. Lithium is typically obtained either through mining pegmatites, such as the World’s largest Li deposit, the Tanco mine (e.g., Greenoughs, 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% Li2O (FAR Resources Ltd., 2017, 2018). A fifth round of drilling recently started at one of the zones (Figure 4), which contains a large euhedral to subhedral crystals up to 15 cm long. Spodumene is typically present as large euhedral to subhedral crystals up to 15 cm long. The core zone exploits the central zone in some tinmer sections of the dike, but this zone is not always present.

The classification of granitic pegmatites revisited (Černý et al., 2005). The Wekusko Lake pegmatite field (Figure 1) is one of the best-known examples of a large Li-bearing pegmatite deposit in central Manitoba. The Wekusko Lake pegmatite field is associated with Li-bearing pegmatite dikes that cut the 1.85 Ga Flin Flon-Gammon complex (Connors et al., 2002), which is part of the Trans-Hudson orogen (Figure 1; modified from the NATMAP Shield Margin Working Group, 1996; Beales and Gallagher, 1999). The first three are linked to the accretion of the Kisewaye belt to the Flin Flon belt (Kraus and Williams, 1999). This resulted in a deformed and folded low-angle shear zone. Deformation phase D4 is associated with east-west shortening during the upwarping of the Superior plate, that resulted in north-northeast fold. Deformation event D5 is associated with the renewal of the north-south convergence (Kraus and Williams, 1999).


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

Pegmatite Zonation

Based on observations of cores from 20 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. This is, in particular, tend to lack the central or core zones, and the thickness of the different zones greatly varies between the dikes.

Boundary zone

The border zone is the outermost, thinnest 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 range from 0.5 to 2 mm 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 community forms core structures perpendicular to the pegmatic 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.

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. There is a roughness of spodumene 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 finest-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 phosphates, but the central zone is not always present. The central zone contains the highest concentrations of spodumene ranging 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.

Core zone

The core zone is the innermost zone of the dikes 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 exploited the central zone in some thinner sections of the dike, but this zone is not always present.

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 drillcores with high Nb and Ta values were also targeted for geochemical studies. Li content will be determined by LA-ICP-MS. Peak shifts related to the muscovite molecular structure (muscovite to polythomite) 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. Geochemistry studies on pegmatite-mineral groups will help determine the timing of the pegmatite emplacement in relation to the peak metamorphism and deformation history of the region.