GS2024-4

Paragenetic relationships between zones 80 and 90 at the Tanco pegmatite, southeastern Manitoba (part of NTS 52L6)

by C.M. Breasley[1], T. Martins, R.L. Linnen[2] and L.A. Groat[3]

In Brief:

- A face map was created of the H-pillar at the Tanco pegmatite showing the complex crystallization history between the Cs-rich pollucite zone (zone 80) and Li-rich lepidolite zone (zone 90)
- Future work will involve creating thin sections of all aplite veins and representative mineralogical assemblages sampled to obtain micro-scale mineralogical information

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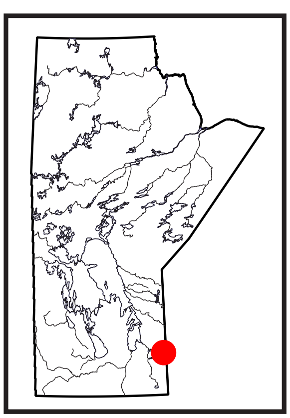
Summary

In May 2024, a map was produced of the underground face of the H-pillar in the Tanco pegmatite mine in southeastern Manitoba to investigate the relationships between the Cs-rich pollucite zone (zone 80) and Li-rich lepidolite zone (zone 90). Observations revealed a complex crystallization history recorded by multiple crosscutting relationships. The paragenetic sequence is interpreted to have initially involved the crystallization of primary blocky K-feldspar in zone 40 and pollucite in zone 80. During subsequent metasomatism, K-feldspar was nearly completely replaced with Li-rich micas. A meshlike veining pattern of lepidolite within the pollucite is found close to the contact between the two zones. A later-stage albitization event acted to form secondary aplite veins within a late-stage viscous siliceous residual liquid. A rapid depressurization of the system, potentially due to incompatible and volatile element crystallization, could have led to the flash quartz zone crystallization, which fractured the aplite bands and portions of the massive lepidolite zone. A final alteration stage of spodumene, recorded in green clays such as kaolinite and montmorillonite, occurred as a final paragenetic event.

Introduction

The economically important mineralization and complex crystallization styles of pegmatites make them a topical and fascinating field of study in economic geology. The Tanco pegmatite is a Li-Cs-Ta (LCT)–bearing deposit located in southeastern Manitoba, Canada. It is known to be one of the most evolved and economically important pegmatites in the world and has historically been mined for Cs from pollucite {$(Cs,Na)_2Al_2Si_4O_{12}\bullet(H_2O)$} and Ta from tantalite ({$(Fe, Mn)Ta_2O_6$}; Černý, 2005). It is currently the site of the largest Li mine in Canada, targeting spodumene {$LiAlSi_2O_6$}, dominantly in the form of spodumene and quartz intergrowths (SQUI). The Tanco pegmatite has been the basis of multiple pertinent studies that provide crucial insights into pegmatite geochemical evolution and mineralization (e.g., Černý et al., 1981, 1996; Bannatyne, 1985; van Lichtervelde et al., 2006; Brown et al., 2017; Breasley et al., 2022).

The current work is part of an ongoing Ph.D. project that began in August 2021, focusing on the lithium mineralization patterns in zones 45 and 50 of the Tanco pegmatite (Breasley et al., 2021, 2022, 2023). During sample collection in May 2024, an underground mine face of pollucite mineralization in contact with massive lepidolite was mapped in detail (the H-pillar) and paragenetic information was recorded. This project aims to add more information to the paragenetic sequence documented in literature for the Tanco pegmatite deposit, specifically with respect to the genetic relationship between the lepidolite and pollucite mineralized zones. This report includes a detailed map of the underground face of the H-pillar and interpretations regarding paragenetic relationships.



Geological setting

The Tanco pegmatite is located in southeastern Manitoba, Canada, where it forms part of the Bernic Lake group of pegmatites in the Cat Lake–Winnipeg River pegmatite district within the Bird River greenstone belt (Figure GS2024-4-1; Černý et al., 1981). The Bernic Lake formation is composed predominantly of mafic volcanic rocks, including the gabbro intrusion that hosts the Tanco pegmatite. The interpreted age of crystallization of the Tanco gabbro is 2723.1 ±0.8 Ma (U-Pb zircon dating; Černý, 2005; Gilbert, 2008; Kremer, 2010). The U-Pb tantalite dating of the Tanco pegmatite showed an intrusive age of 2641 ±3 Ma (Camacho et al., 2012) and U-Pb zircon dating revealed an age of 2647.4 ±1 Ma

[1] Department of Earth, Ocean and Atmospheric Sciences, The University of British Columbia, Vancouver, British Columbia, cbreasley@eoas.ubc.ca
[2] Department of Earth Sciences, Western University, London, Ontario
[3] Department of Earth, Ocean and Atmospheric Sciences, The University of British Columbia, Vancouver, British Columbia

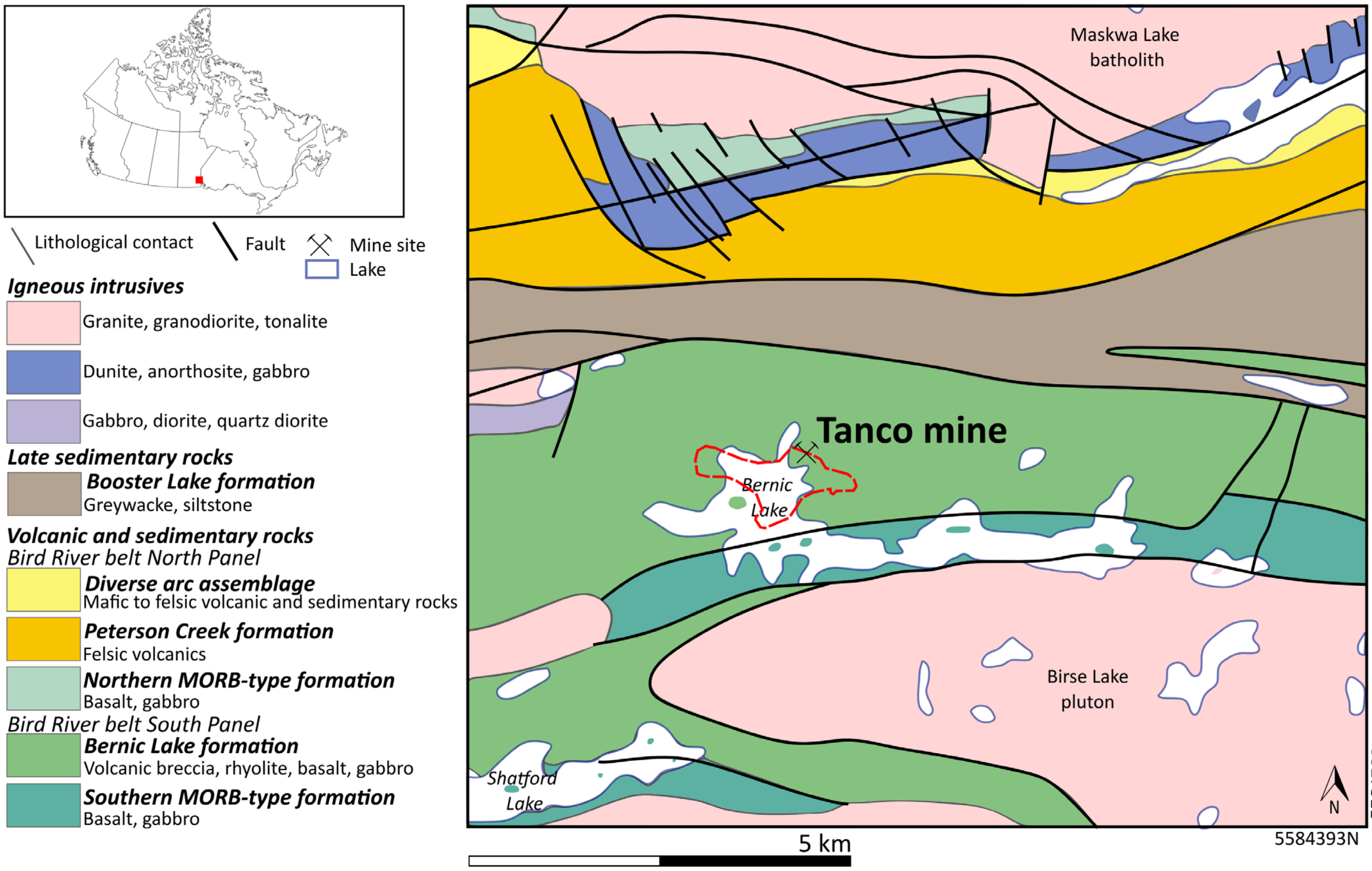


Figure GS2024-4-1: *Local geology surrounding the Tanco pegmatite (dashed red outline; Stilling et al., 2006) in southeastern Manitoba. All co-ordinates are in UTM Zone 15N, NAD83. From Breasley et al. (2021, 2022) and Gilbert (2008). Abbreviation: MORB, mid-ocean–ridge basalt.*

(Kremer, 2010). Multiple other pegmatites exist within the Bernic Lake group of pegmatites (Černý et al., 1981), however, the Tanco pegmatite is the largest, most fractionated and most enriched in Li, Cs and Ta.

The Tanco pegmatite

The Tanco pegmatite is a 1520 by 1060 by 100 m bilobate intrusion (Černý, 2005). It is classified as a petalite subtype, complex, LCT (Černý and Ercit, 2005) or Group 1 pegmatite (Wise et al., 2022). The pegmatite has been historically divided into nine major zones (10–90) based on varying geochemistry, textures and mineralogy (Černý et al., 1998; Černý, 2005; Stilling et al., 2006). A detailed review of the zonation of the Tanco pegmatite can be found in Breasley et al. (2022). A brief overview of the zones investigated in this study are reported below.

Zone 40 (lower intermediate zone) is dominantly composed of blocky microcline-perthite crystals with SQUI, quartz, albite, mica and amblygonite as minor phases (Černý et al., 1996).

Zone 50 (upper intermediate zone) is often found with a gradational contact to zone 40 and is the most lithium enriched, containing abundant SQUI, amblygonite and pollucite (Černý et al., 1996).

Zone 80 (pollucite zone) is genetically part of zone 50, however, due to the massive nature of pollucite mineralization, it is better described as a discrete ore zone. Zone 80 is commonly crosscut by veins containing micas, feldspars and quartz (Černý et al., 1996). Pollucite at the Tanco pegmatite is typically grey to white in appearance and internally heterogenous. It is commonly found braided with sericite, spodumene and adularia. The microscopic internal structure reveals that analcime is intruded by multiple generations of increasingly Cs- and Al-enriched veins until almost Na-free end-member pollucite occurs (Černý and Simpson, 1978; Černý et al., 1998). The zone's 'tapioca'-like texture is attributed to Cs-analcime aggregates and late-stage adularia (Černý, 2005).

Zone 90 (lepidolite zone) is thought to be metasomatic in origin, having replaced blocky feldspar crystals. The mineralogy is mostly massive purple lithian muscovite with minor amounts of albite, quartz and microlite (Černý et al., 1996). Lithian muscovite and lepidolite form the bulk of zone 90 (Figure GS2024-4-2a). The typical interlocking massive micas in this zone are pale to dark purple in appearance (Rinaldi et al., 1972).

Summary of fieldwork

During field work in May 2024, a map of the underground face of the H-pillar was produced and a representative sample

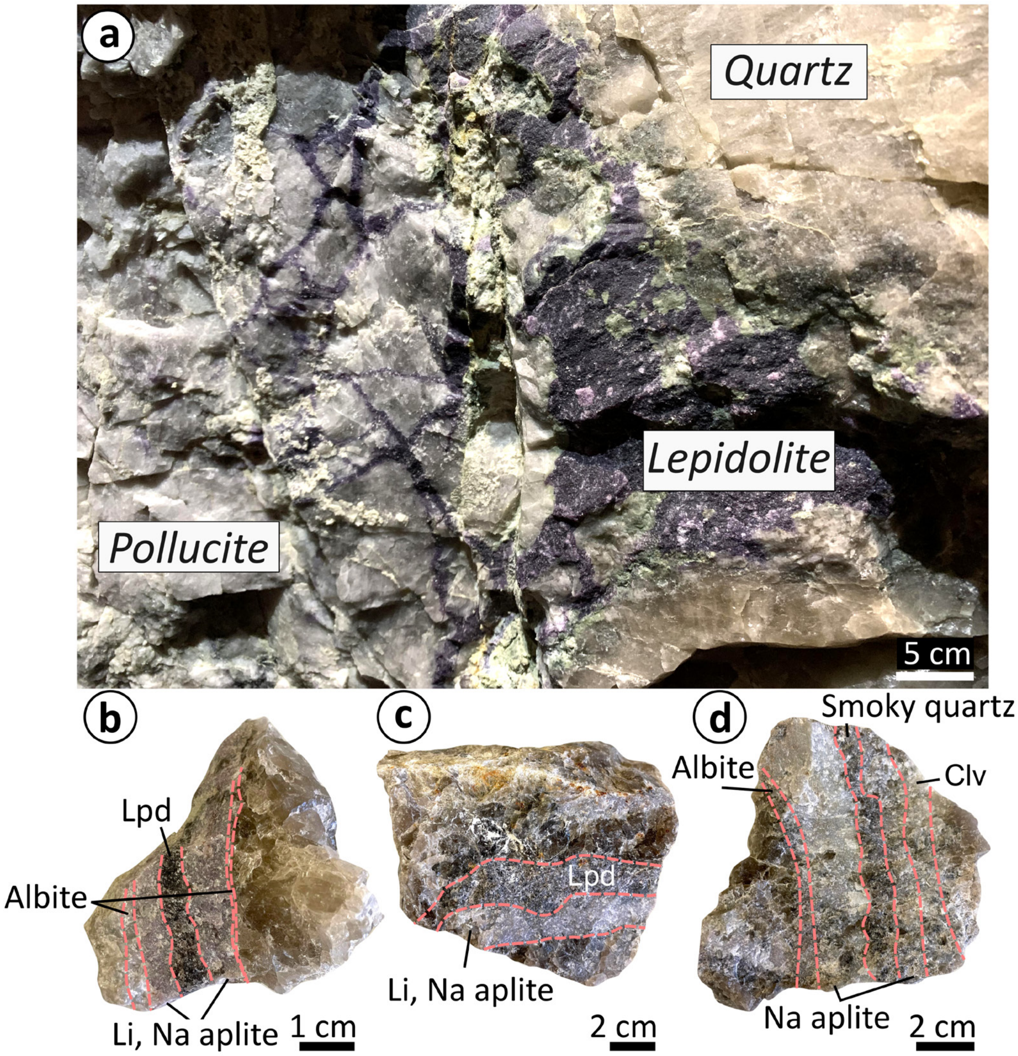


Figure GS2024-4-2: a) *The pollucite and lepidolite zone contact evident on the H-pillar face, Tanco mine. Rock samples from the H-pillar show* ***b)*** *type I purple aplite vein with concentric zonation,* ***c)*** *type II purple aplite vein and* ***d)*** *type III blue aplite vein. See Figure GS2024-4-3 for rock sample locations. Abbreviations: Lpd, lepidolite; Clv, cleavelandite.*

set was collected. This pillar was selected due to the interesting textural features it shows in relation to the Cs and Li mineralization and to the pristine exposures. This section was deemed to be promising in revealing information regarding the paragenetic crystallization sequence of the multiple zones in the Tanco pegmatite.

Observations

Several mineralogical and zonation relationships were seen at the H-pillar (Figures GS2024-4-2, -3a). The pollucite is crosscut by multiple meshlike veins of lepidolite (Figure GS2024-4-3a). Aplites and lepidolites are fragmented and interstitially infilled with massive quartz. The various aplites seen in the H-pillar show variable layering with three major aplite veins. The first aplite vein type (I; Figures GS2024-4-2b, -3b) has concentric layering with a central portion of monomineralic lepidolite, surrounded by a pale lavender aplite and finally coated by a thin rim of white albite, which locally shows cleavelandite textures. The second (II) and third (III) major aplite vein types are also present in the H-pillar (Figures GS2024-4-2c, d, -3c). The second aplite type (II) shows an upper portion of monomineralic lepidolite with a lower zone of pale purple aplite similar to the mineralogy in the type I aplite (Figures GS2024-4-2c, -3c). Finally, the third aplite type (III) hosts multiple layers. Looking at Figures GS2024-4-2d and -3c, curved blue aplite bands have a pure white albite rim on the left and it coats pale purple aplite to the right. This purple aplite has a gradational contact with the light blue aplite to its right and then a central portion of smoky quartz is found. The blue aplite to the right of the quartz hosts radial cleavelandite textures. It can be noted that the aplites are generally more purple in appearance toward the left and bluer toward the right.

Paragenetic interpretation

The following paragenetic sequence of events was interpreted from underground pillar face and hand sample observations:

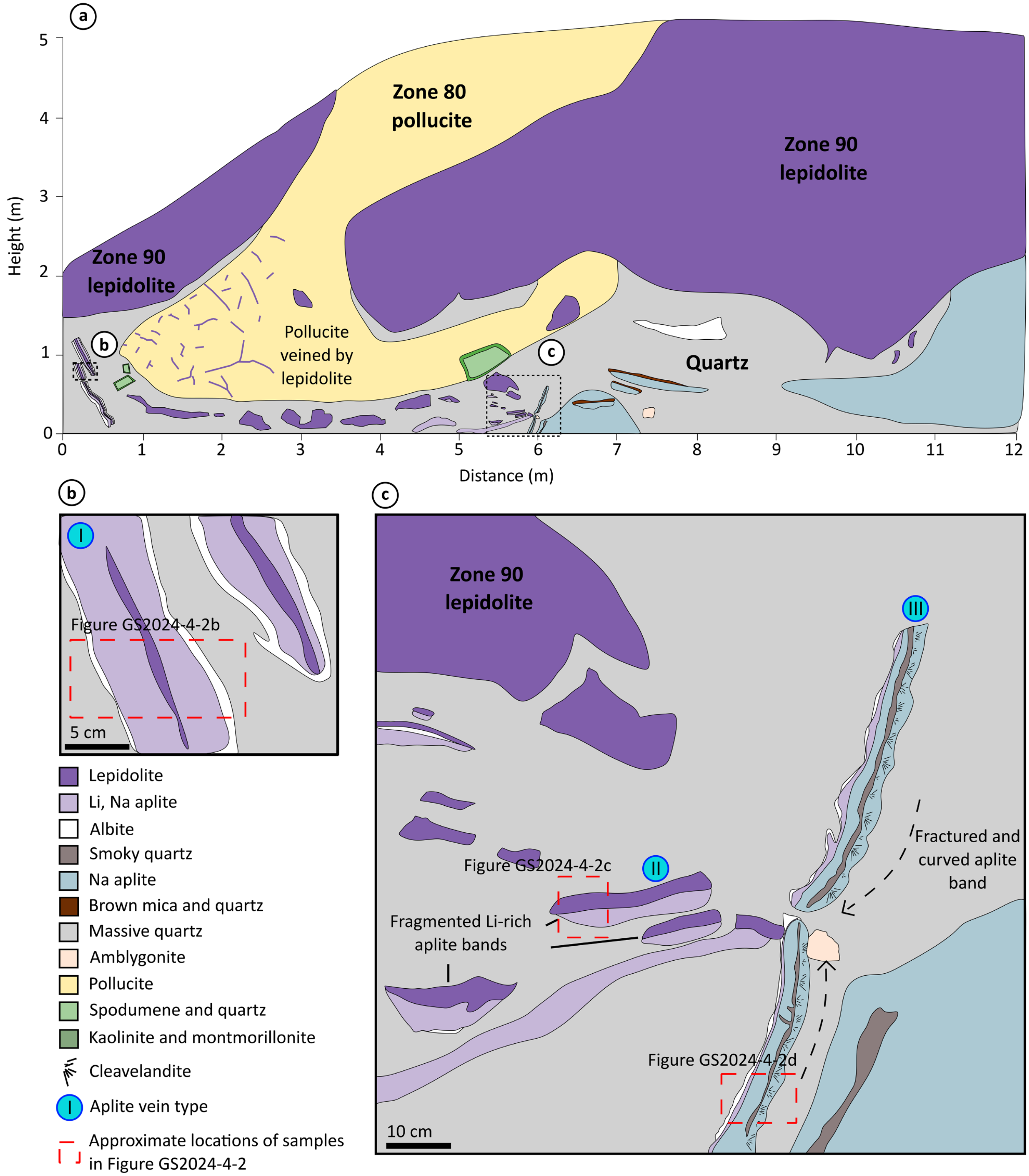


Figure GS2024-4-3: a) *Mineralogical relationships between the pollucite zone (80) and the lepidolite zone (90) evident on the H-pillar face, Tanco mine;* ***b, c)*** *details of the textural and mineralogical features shown in a), including the crosscutting relationships.*

1) The first crystals that formed in the H-pillar were blocky K-feldspars, which are attributed to zone 40 with a gradational contact to zone 50 and paragenetically linked to the primary pollucite, minor SQUI and amblygonite in zone 80. This acted to deplete the melt in Cs, Na and K.
2) Subsequently, the massive zone 90 lepidolite (Figure GS2024-4-3) formed via the pervasive alteration of blocky K-feldspars, removing K from the system and crystallizing Li and F into lithian muscovite and lepidolite.
3) An albitization phase followed this event, which formed the blue aplitic albite (Na aplite) and complex veins of aplites. These veins cut through a massive quartz unit and are fragmented and locally curved (Figure GS2024-4-3). They are associated with increased amounts of Na and local Li when purple in appearance due to the assumed presence of lithian muscovite. It is interpreted that the aplite veins originally formed in a late-stage hyperviscous siliceous residual liquid, which was subsequently crystallized rapidly.
4) A final massive quartz unit is interpreted to be the last to crystallize. Due to the fragmented nature of the aplite veins, it is interpreted that a localized depressurization of the system fragmented the veins (London, 2008; Roda-Robles et al., 2015). This could have been triggered by the precipitation of incompatible elements from the liquid, such as Li, in the albitization phase, which triggered the siliceous residual liquid to crystallize rapidly. This hypothesis could explain the fragmented nature of the lepidolite zone and the aplites, which are crosscut with late-stage quartz (Figure GS2024-4-3c).
5) At a later stage, a sericitization event altered the pollucite and a final late-stage clay alteration of SQUI produced vivid green kaolinite and montmorillonite rims.

Future work

Future work will involve creating thin sections of all sampled aplite veins and representative mineralogical assemblages to obtain microscale mineralogical information. Electron probe microanalyses will also be performed to gain geochemical insights into the various phases of aplite formation at the H-pillar. These results will help constrain the geochemistry of the different paragenetic stages.

Economic considerations

Pegmatites contain multiple minerals that can be extracted for economic purposes (Linnen et al., 2012). Studying the paragenesis through textural relationships of various minerals can enhance the understanding of pegmatite systems, improving the ability to target economically mineral-rich areas effectively. Cesium and lithium, both of which can be found in pegmatites, were identified as critical minerals by the Government of Canada (Natural Resources Canada, 2021). Cesium is an essential element with diverse applications. A primary use of Cs is the production of cesium formate, a very dense liquid that is used to stabilize drills, which is particularly useful in environmentally sensitive areas (Martins et al., 2024).

As the world transitions to a decarbonized economy, the demand for Li for batteries has been increasing making the study of pegmatite mineralization sequences that host Li topical and important (Zubi et al., 2018). Future work will help understand the textural and geochemical relationships between the lepidolite and pollucite zones at the Tanco pegmatite, which will aid in understanding pegmatite crystallization dynamics and zone geochemical interactions.

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