Lithium pegmatites: a mineral chemistry approach to understanding their formation

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Co-supervisors: Dr Tania Martins (Manitoba Geological Survey), Professor Stefanie Brueckner (University of Manitoba), Professor Lee Groat (University of British Colombia), Professor Robert Linnen (Western University, Canada).

Project Highlights:

- To research the rapidly developing topic of lithium-rich pegmatites with significant economic importance
- To work with an industry partner (Tanco Mine) on an active mine site in Manitoba, Canada
- To develop a wide range of desirable geochemical analytical skills, including new combined approached such as EDS and Raman spectroscopy with Oxford Instruments, UK.

Overview:

Achieving net-zero carbon emissions by 2050 will require a substantial and reliable supply of critical "battery metals" like lithium, as demand continues to grow with industrial expansion and the adoption of electric vehicles (EVs). Due to supply chain vulnerabilities, the UK, EU, and other nations have designated these metals as critical. Lithium demand alone is projected to increase by 26% annually through to 2030 (Bibienne et al., 2020). Li-Cs-Ta (LCT) pegmatites have emerged as a major global source of lithium hydroxide, yet fundamental questions remain about the processes involved in their formation.

The diversity in LCT pegmatites, from simple, homogenous forms to complexly zoned bodies, suggests a range of formation histories, including multi-stage magmatic and hydrothermal processes. Unlike granites, pegmatites pose unique dating challenges due to hydrothermal overprinting, metamict zircons, and high initial lead in some minerals. However, both major and accessory minerals crystallise at various stages of fractionation, capturing a sequential record of pegmatite genesis. Furthermore, later alterations in mineral compositions record the metasomatic stages of pegmatite evolution and reveal how these changes may affect primary Li-bearing minerals.

This study will analyse the trace element and novel isotopic compositions of key minerals – particularly white micas, but also tourmaline, monazite, quartz, and apatite - from the Tanco pegmatite in Manitoba, Canada (Černý, P.,2005), in collaboration with the mine owners, Tanco Mining Corp. The work will establish the origin and timing of individual zones in the Tanco pegmatite – currently one of only two lithium producing sites in Canada. Working with Oxford Instruments, the project will also develop innovative analytical techniques including combined EDS-Raman analysis with broad applications for wider pegmatite research.

The successful candidate will gain expertise from an internationally renowned supervisory team, build valuable industry connections, and develop advanced analytical skills with a global leader in instrumentation—preparing them for a strong career in industry, academia, and beyond.

Figure 1: Lithium-rich pegmatite with tourmaline (green) and lepidolite (pink)

Methodology:

The detailed objectives are to:

(1) Carry out underground geological mapping to improve understanding, distribution and relationships of the different zones of the Tanco pegmatite.
(2) Describe in detail the paragenesis and textural characteristics of all the different zones of the Tanco pegmatite.
(3) Carry out underground and drill core sampling of the different zones of the Tanco pegmatite with an emphasis on apatite (e.g. Sr isotopes), spodumene (e.g. Li isotopes) and other phosphate phases, tourmaline (e.g. B isotopes) and quartz (e.g. O isotopes)
(4) Document changes in the selected mineral composition within the zones of the pegmatite.
(5) Develop novel analytical approaches (e.g. combined EDS-Raman analysis) to analysing Li-bearing minerals in partnership with Oxford Instruments, UK.

To meet the objectives, the student will use a multi-analytical approach incorporating both fieldwork (underground mapping and sample collection) and laboratory analysis. Samples will be analysed in the lab by petrography of polished thin sections, X-ray powder diffraction (XRD), and scanning electron microscopy (SEM). To characterise the mineralogy of apatite and other phosphate phases particularly trace-element contents and fractionation indicators (Mg/Li, K/Rb), mineral compositions will be characterised using electron probe microanalysis (EPMA) and laser ablation-induction coupled plasma-mass spectrometry (LA-ICP-MS). O, Li and B isotopes will be determined by SIMS.

Possible Timeline

Year 1: Literature review; 3 months field work underground at the Tanco mine. Mapping and description of faces in the underground mine. Underground and drill core sampling; participation in the Maine pegmatite workshop in Maine, USA.

Year 2: Sample preparation and beginning of analytical work, conference participation; beginning of writing first reviewed paper; follow up visit to the mine if needed.

Year 3: continue and finalise analytical work; participation in conferences and finalizing peer reviewed publication and thesis.

Training and skills:

TARGET researchers will participate in a minimum of 40 days training over the 3.5 years of study composed of:

- an annual one-week workshop dedicated to their year group, and tailored to that cohort's needs in terms of skills development – *for the first three years of their study*;
- an annual all-TARGET workshop with cross-year interactions, advanced training and opportunities to specialise in particular areas – *all years of study*;
- a number of one-day workshops;
- additional online events and in-person workshops attached to relevant conferences.

The successful candidate will work with partners in Canada, with the option of working in Canada for a period of time. They will benefit from their experience in mineralogy, mineral systems, geochemistry and geochronology together with their experience in analytical methods. Full training will be provided for analytical techniques and fieldwork.

Partners and collaboration (including CASE):

The applicant will benefit from the extensive expertise of the supervisory team:

- **Andrew Miles:** An igneous petrologist with over 10 years' experience in granite petrology, copper porphyry deposits, and mineral chemistry.
- **Tania Martins:** An internationally recognised expert on granitic pegmatites.
- **Stefanie Brueckner:** An authority in economic mineral systems and micro-analytical techniques.
- **Lee Groat:** With over 30 years of experience in pegmatite research.
- **Robert Linnen:** A globally recognised specialist in pegmatite studies, including work on the Tanco pegmatite.

The student will work closely with the industry partner at the Tanco mine site for up to three months, where accommodation, meals, and training will be provided. Additionally, they will collaborate with analytical specialists at Oxford Instruments in the UK, gaining experience in innovative analytical techniques valuable to both industry and academia.

Further reading:

Bibienne, T., Magnan, J.-F., Rupp, A. and Laroche, N. (2020) From Mine to mind and mobiles: society's increasing dependence on lithium. Elements, 16, 265–270, https://doi.org/10.2138/gselements.16.4.265

Černý, P. (2005) The Tanco rare-element pegmatite deposit, Manitoba: regional context, internal anatomy, and global comparisons; in Rare-Element Geochemistry and Mineral Deposits, R.L. Linnen and I.M. Samson (ed.), Geological Association of Canada, Short Course Notes, 17, 127–158.

Linnen, R.L., Van Lichtervelde, M., and Černý, P. (2012) Granitic Pegmatites as sources of strategic metals. Elements, 8, 275–280.

Martins, T., Roda-Robles, E., Lima, A., and de Parseval, P. (2012) Geochemistry and evolution of micas in the Barroso-Alvao pegmatite field, northern Portugal. Canadian Mineralogist, 50, 1117–1129.

Roda-Robles, E., Pesquera, A., Gil-Crespo, P.P., Vieira, R., Lima, A., Garate-Olave, I., Martins, T., and Torres-Ruiz, J. (2016) Geology and mineralogy of Li mineralization in the Central Iberian Zone (Spain and Portugal). Mineralogical Magazine, 80, 103–126.

Stilling, A., Ćerný, P., and Vanstone, P.J. (2006) The Tanco pegmatite at Bernic Lake, Manitoba, XVI – Zonal and bulk compositions and their petrogenetic significance. Canadian Mineralogist, 44, 599–623.

U.S. Geological Survey (2024), Mineral commodity summaries 2024: U.S. Geological Survey, 212 p., https://doi.org/10.3133/mcs2024.

Van Lichtervelde, M., Grégoire, M., Linnen, R.L., Béziat, D. and Salvi, S. (2008) Trace element geochemistry by laser ablation ICP-MS of micas associated with Ta mineralization in the Tanco pegmatite, Manitoba, Canada. Contributions to Mineralogy and Petrology, 155, 791–806.

Further details:

Please visit https://target.le.ac.uk/ for additional details on how to apply. Please contact the lead supervisor, Dr Andrew Miles, with specific questions about the project: ajm131@le.ac.uk