Petrography and Geochemistry of Granitic Pegmatite- and Leucogranite-hosted Uranium & Thorium Mineralization: Fraser Lakes Zone B, Northern Saskatchewan, Canada

Christine L. Austman and Kevin M. Ansdell
Department of Geological Sciences, University of Saskatchewan, 114 Science Place, Saskatoon, Saskatchewan, Canada S7N 5E2
christine.austman@usask.ca

and

Irvine R. Annesley
JNR Resources Inc., Suite 204 - 315 22nd St E, Saskatoon, Saskatchewan, Canada S7K 0G6

Summary

Located just outside of the Athabasca Basin, the Fraser Lakes uranium- and thorium-bearing granitic pegmatites/leucogranites are one example of igneous-hosted U and Th occurrences in the Wollaston Domain of northern Saskatchewan. The mineralized pegmatites/leucogranites intrude the highly deformed contact zone between Wollaston Group metasedimentary rocks and Archean orthogneisses. Geochemical analyses of Zone B drill core samples show the presence of multiple groups of granitic pegmatites that underwent igneous assimilation-fractional crystallization processes. They fall within Černý and Ecrit's (2005) AB-U pegmatite class, and include syn- and post-tectonic varieties. The granitic pegmatites are strongly peraluminous to weakly metaluminous, and formed by partial melting of Wollaston Group metasedimentary rocks at depth. Alteration of pegmatites may have led to the remobilization of uranium and the development of unconformity-type uranium mineralization in the Fraser Lakes area.

Introduction

The Fraser Lakes Zones A and B are located in northern Saskatchewan on the Way Lake Property, owned by JNR Resources Inc., and located approximately 55 km east of the Key Lake uranium mine (Fig. 1). Zone B contains significant U and Th mineralization accompanied by rare earth element (REE) and pathfinder element enrichment, and is the main focus of this work. The purpose of this study is to examine the geology and geochemistry of the Fraser Lakes Zone B granitic pegmatites and leucogranites in order to further the understanding of this type of mineralization and its relationship to the high-grade unconformity-type uranium deposits of the Athabasca Basin.

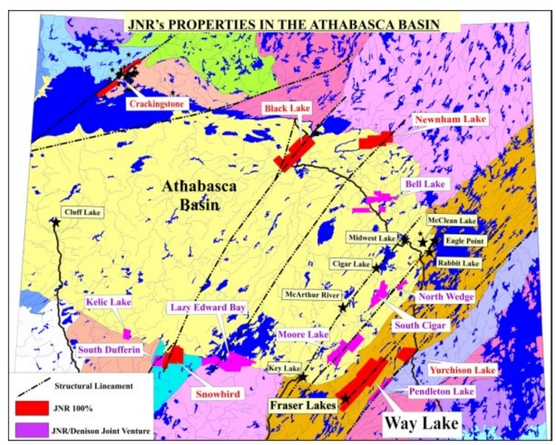

Fig. 1. Geological subdivisions of northern Saskatchewan, with the location of important uranium deposits, and JNR Resources Inc. properties, including Way Lake (JNR Resources Inc. 2010)

Local Geology

The Fraser Lakes area is underlain by strongly deformed Paleoproterozoic Wollaston Group metasedimentary rocks and Archean orthogneisses of the eastern Wollaston Domain (Annesley et al., 2009). The two mineralized zones (Zones A and B) are located in regional fold noses adjacent to a 5 km long section of a refolded 65 km long electromagnetic (EM) conductor (i.e. graphitic pelitic gneisses). The granitic pegmatites and leucogranites intruded into and in part were transported as crustal melts within the folded, protomylonitic to mylonitic contact zone between the Wollaston Group metasedimentary rocks and the underlying orthogneisses.

Zone B sits within a NE-plunging antiformal fold nose, and is cross-cut by a number of NE- and NW- trending brittle faults, which could have provided dilation zones for fluid flow at the now eroded Athabasca/basement unconformity (~ 200 - 250m above the present-day outcrop surfaces) (Annesley et al., 2009).

Regional metamorphism of upper amphibolite to lower granulite facies accompanying deformation in the area was related to the Trans-Hudson Orogen (~ 1.8 Ga). The low to high-P, high-T metamorphic conditions led to partial melting (shown by migmatites in drill core) in the middle to lower crust, and the generation of the granitic pegmatites and leucogranites. Preliminary U-Pb chemical age dating of uraninite/uranothorite, monazite, and zircon from a mineralized granitic pegmatite within Zone B (Bonli 2010, pers. commun.) yielded a syn- to late-tectonic Hudsonian age, which corresponds well to contact relationships indicating that granitic pegmatite intrusions were syn-tectonic (mineralized and concordant to gneissosity) to post-tectonic (non-mineralized, discordant) with respect to the fabrics developed during the Trans-Hudson Orogen (Austman et al., 2009).

Petrography

Thin sections of the granitic pegmatites from one drill hole at Zone B (WYL-09-50) revealed the presence of varying amounts of quartz, feldspar, and biotite, and a primary accessory mineral assemblage including zircon, allanite, apatite, monazite, uraninite-uranothorite-thorite, magnetite, ilmenite, garnet, muscovite, fluorite, titanite, pyrite, sphalerite, molybdenite, and others. Of these, the main hosts for U and Th are zircon, allanite, monazite, and members of the uraninite-uranothorite-thorite solid solution series that are associated with biotite (Fig. 2). The granitic pegmatites also show evidence of post-crystallization hydrothermal alteration in thin section (Fig. 3). The hydrothermal mineral assemblage includes hematite, chlorite, fluorite, clay minerals, quartz, carbonate, and sausserite.

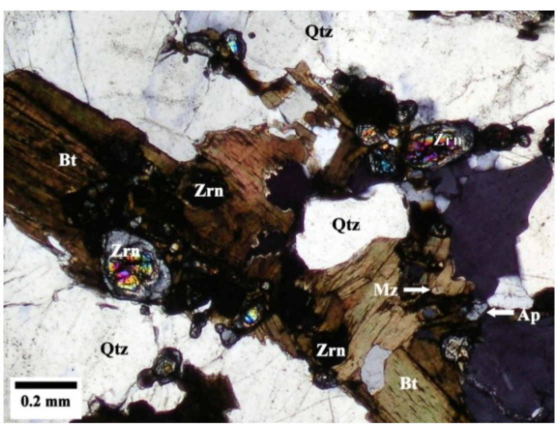

Fig. 2. Photomicrograph showing a granitic pegmatite with zoned zircons, apatite, and monazite within a cluster of biotite. Symbols after Kretz, 1983.

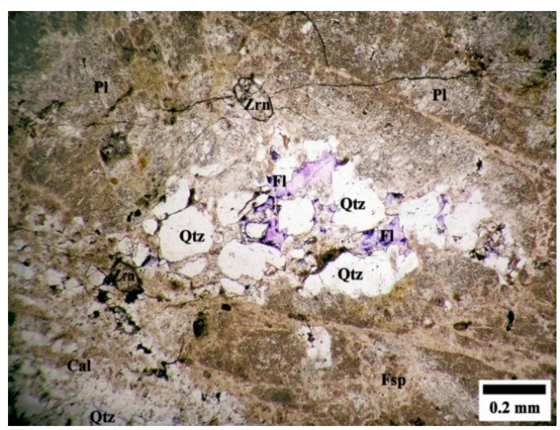

Fig. 3. Photomicrograph of a granitic pegmatite hydrothermally altered to fluorite, quartz, carbonate, hematite, and chlorite.

Geochemistry

Preliminary whole rock ICP geochemical analyses of ten granitic pegmatite samples from Zone B (WYL-09-50) were carried out at the Saskatchewan Research Council to provide initial constraints on the composition and origin of these rocks. The samples included both unaltered and moderately to strongly altered pegmatites, with some of the granitic pegmatites containing U and Th mineralization of up to 860 ppm U and 715 ppm Th. These samples also show enrichment, relative to typical crustal values, of the REEs, Co, Cu, Mo, Nb, Ni, Pb, V, Y, Zn, and Zr.

The presence of U, Th, Zr, and REE enrichment along with uraninite, uranothorite, thorite, zircon, and allanite in thin section is indicative of the abyssal-uranium (AB-U) subclass of Černý and Ecrit (2005). This also conforms to the upper amphibolite to granulite facies in the region and the relationship of the granitic pegmatites to anatectic leucosomes. In addition, HREE, Nb, Y, and Zr enrichment means that these granitic pegmatites fall into Černý's (1991) NYF family.

The granitic pegmatites exhibit wide compositional variation due to the sampling of different zones from multiple pegmatites. On Harker diagrams plotted for Al_2O_3 (Fig. 4a) and K_2O (Fig. 4b), three main clusters of analyses are apparent: high Al_2O_3-variable K_2O- high SiO_2 (Cluster 1 - blue triangles), low Al_2O_3-low-K_2O-high SiO_2 (Cluster 2 - red squares), and high Al_2O_3-low K_2O-low SiO_2 (Cluster 3 - green circle), which are thought to be from different zones. The distinct analysis in cluster 3 (low SiO_2) in cluster 3 represents a garnet-rich sample, as exemplified by high Y and Yb content. Trends are also apparent on the Harker diagrams for Al_2O_3 (Fig. 4a) and K_2O (Fig.4b), and are, along with the zoning seen in drill core, tentatively interpreted to be due to igneous fractional crystallization.

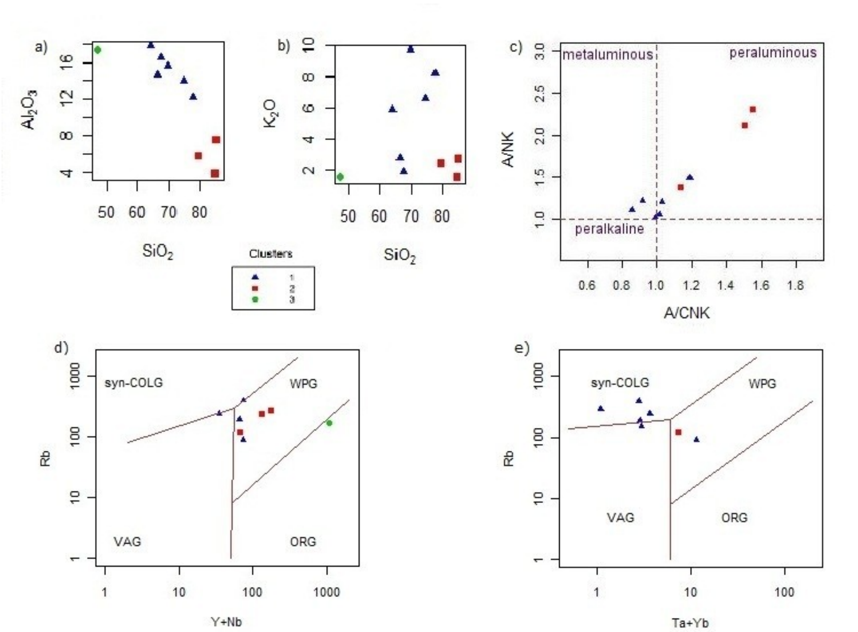

Fig. 4. Classification diagrams for the Fraser Lakes granitic pegmatites. a) Harker diagram for Al_2O_3 ; b) Harker diagram for K_2O. Three clusters are visible in the data on these diagrams, labeled Clusters 1, 2, and 3. ; c) A/NK vs. ASI after (Shand, 1943); d) Rb vs. Y + Nb, and e) Rb vs. Ta + Yb, with fields VAG =volcanic arc, syn-COLG = syn-collisional, WPG= within-plate, ORG = ocean-ridge (after Pearce et al., 1984).

Cluster 1 granitic pegmatites are metaluminous to weakly peraluminous (Fig. 4c), and are within-plate to syn-collisional (Fig. 4d, 4e), and contain variable amounts of quartz, feldspar (plagioclase, k-feldspar, and perthite), ± biotite, ± amphibole, ± pyroxene, ± muscovite, ±tourmaline, ± zircon, ± allanite, and ± monazite. There is some overlap in composition with the granitic pegmatites of cluster 2, which are peraluminous (Fig. 4c) within-plate granitoids (Fig. 4d, 4e.). The cluster 2 granitic pegmatites contain variable amounts of quartz (typically more than in cluster 1), biotite, ± feldspar (plagioclase, k-feldspar, and perthite), + tourmaline, ± garnet, ± zircon, ± allanite, and ± monazite. Cluster 3 is a garnet-rich pegmatite and thus is extremely peraluminous, low SiO_2, and high Y and Yb. The pegmatite contains quartz, feldspar, biotite, tourmaline, and zircon, in addition to garnet. The field interpretation of the pegmatite is that it is also syn-tectonic.

The initial geochemical and petrological analyses suggest there are a number of different granitic pegmatites in the Fraser Lakes area. This agrees with drill core observations showing multiple pegmatite groups with different mineralogy, and relative age relationships.

Geochemical trends in the pegmatite diagrams also show the possibility of igneous AFC processes influencing the composition of the granitic pegmatites, which clearly show up in drill core in the form of zonation in pegmatites. Some of the samples showed varying degrees of hydrothermal alteration indicating the potential for hydrothermal fluids to have altered the geochemical signatures of the granitic pegmatites.

Conclusions

The Fraser Lakes Zone B mineralization is structurally controlled, basement-hosted, and associated with granitic pegmatites and leucogranites generated by partial melting of the middle to lower crust. The granitic pegmatites and leucogranites are enriched in U, Th, and other high field strength elements, and fall within the abyssal-uranium granitic pegmatite subclass of Černý and Ecrit (2005). The granitic pegmatites are mineralogically (and thus geochemically) zoned, and their development was likely controlled by igneous AFC processes. Their geochemical composition may also have been affected by hydrothermal fluids, which may have led to remobilization of the U and Th. Further petrochemical work to examine the potential relationship between these granitic pegmatites and unconformity uranium deposits of the Athabasca Basin is ongoing.

Acknowledgements

The authors acknowledge the financial support of JNR Resources Inc., NSERC (Discovery Grant to Ansdell) and the University of Saskatchewan (Graduate Scholarship to Austman). Thanks to Blaine Novakovski for preparing the thin sections, to Kimberly Bradley from JNR Resources Inc. for her assistance with petrography, and the Saskatchewan Research Council for the geochemical results.

References

Annesley, I. R., Cutford, C., Billard, D., Kusmirski, R. T., Wasyliuk, K., Bogdan, T., Sweet, K., and Ludwig, C., 2009, Fraser Lakes Zones A and B, Way Lake Project, Saskatchewan: Geological, geophysical, and geochemical characteristics of basement-hosted mineralization. Proceedings of the 24th International Applied Geochemistry Symposium (IAGS), Fredericton, NB. Conference Abstract Volume 1. p. 409-414.

Austman, C.A., Ansdell, K.M., and Annesley, I.R., 2009, Granitic pegmatite- and leucogranite-hosted uranium mineralization adjacent to the Athabasca basin, Saskatchewan, Canada: A different target for uranium exploration. Geological Society of America Abstracts with Programs, Vol. 41, No. 7, p. 83.

Černý, P., 1991, Rare-element granite pegmatites. I. Anatomy and internal evolution of pegmatite deposits. Geoscience Canada, Vol. 18, 49-67.

Černý, P., and Ecrit, T., 2005, The classification of granitic pegmatites revisited. The Canadian Mineralogist, 43, 2005-2026.

JNR Resources Inc., 2010, —Home Page— Jan. 5, 2010, Saskatoon, 01/05/2010, http://www.jnrresources.com.

Kretz, R., 1983, Symbols for rock-forming minerals. American Mineralogist, Vol. 68, 277-279.

Pearce, J., Harris, N., and Tindle, A., 1984, Trace element discrimination diagrams for the tectonic interpretation of granitic rocks. Journal of Petrology, Vol. 25, 956-983.

Shand, S., 1943, The Eruptive Rocks, 2nd ed., New York: John Wiley, 444 pp.