VARIATIONS IN THE U- AND Th - BEARING MINERALOGY OF THE GRENVILLIAN GRANITIC PEGMATITES OF FORT-COULONGE, QUEBEC, CANADA

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ABSTRACT

The Fort-Coulonge area is located in the Central Metasedimentary Belt (CMB) in the western part of the Grenville Province. For this study, two different types of uraniferous and thoriferous pegmatite, a white granitic and a pink granitic pegmatite. Thorium is frequently more abundant than U and Th/U ratio varies from 0.77 to 25.2, but is usually closer to 2 to 4, indicative of both extensive fractionation and magmatic hydrothermal processes. Thorium is mainly concentrated in thorite or uranothorite, thorogummite, allanite, zircon, monazite, and xenotime, whereas U is included in several minerals, such as uraninite, uranothorite, gummite, swamboite, allanite, zircon, and monazite.

INTRODUCTION

A petrological and mineralogical study of the U- and Th-bearing minerals of the white to pink granitic pegmatites in the Fort-Coulonge area in southwestern Quebec, Canada was initiated to get a better understanding of the characteristics these uraniferous and thoriferous pegmatites.

GEOLOGICAL SETTING

The Grenville Province is a major structural province included within the Canadian Shield and forms the sountheastern limit of the Laurentian craton. The Grenville Province varies in age from Archean to Late Mesoproterozoic (Rivers 1997). The Fort Coulonge area is located in the Central Metasedimentary Belt (CMB) in the western part of the Grenville Province and consists of five units: Bancroft terrane, Elzevir terrane, Mont Laurier terrane, Frontenac terrane, and Adirondack Lowlands. The study area is located within the Mont Laurier terrane characterized by high grade metasedimentary and metavolcanic rocks. Granitic, pegmatitic, tonalitic, or gabbroic intrusions of various dimensions and with variable degrees of metamorphism are common throughout the Mont Laurier terrane.

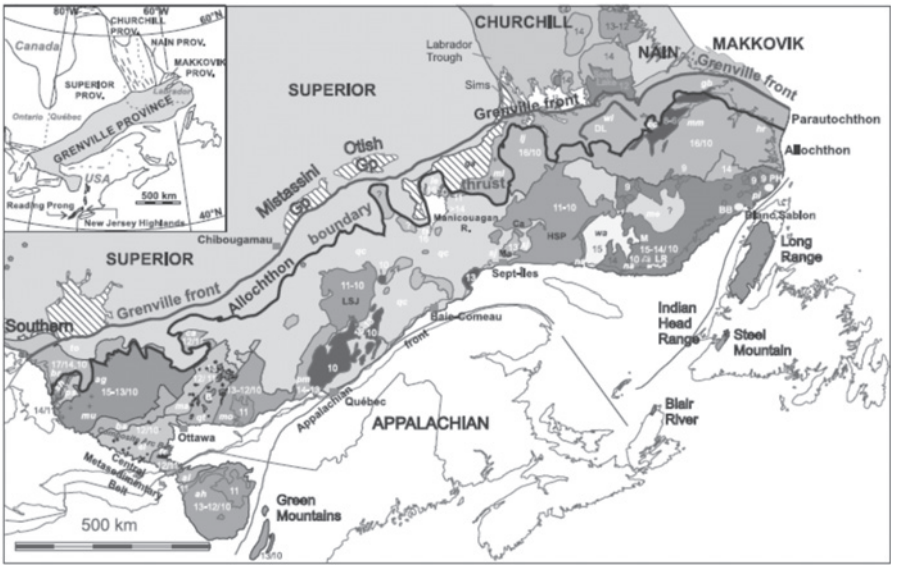

Figure 1- Regional geology of the Grenville Province in Canada, with geological subdivision (modified after Corriveau et al. 2007).

PETROLOGY

The two types of pegmatites (white and pink) are late orogenic granitic pegmatites intruding ductily deformed and high-grade metamorphic rocks. The pink pegmatites are more abundant and widespread than the white pegmatite. They are heterogeneous, have hypidiomorphic to allotriomorphic inequigranular texture, and vary in grain size from aplitic to pegmatitic (20-50 mm). They mainly constitute quartzo-feldspathic material, with an average composition of 25-35% quartz, 40-70% K-feldspar, and 0-25% plagioclase. The most common mafic minerals are magnetite (1-5%) and biotite (0-10%). Minor components also include hornblende and zircon. Accessory minerals are titanite, epidote/allanite, muscovite, uranothorite, pyrite and rarely chalcopyrite. The pink pegmatites are foliated and locally sheared. Graphic (Fig. 2) and granophyric intergrowths are common (Lentz 1996).

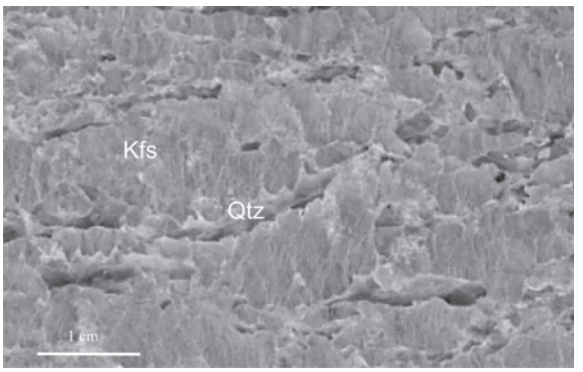

Figure 2 - Photograph showing coarse graphic texture in the pink pegmatite (sample FC07-TJCR-258).

The white pegmatite is the least common of the two types of pegmatites occurring in the Fort-Coulonge area and is unzoned with a hypidiomorphic equigranular texture (Fig. 3). Grain size varies from aplitic to pegmatitic (20 to 50 mm) and grains locally show seriated texture. The white pegmatites are mainly constituted of quartz, feldspars, and biotite. When plagioclase and K-feldspar are present, both are white to light grey. The average composition of the white pegmatite is 35% quartz, 62% feldspars, and 3% biotite. Zircon, black tourmaline, titanite, apatite, molybdenite, muscovite, epidote/allanite, clinopyroxene, and hornblende are the main accessory minerals.

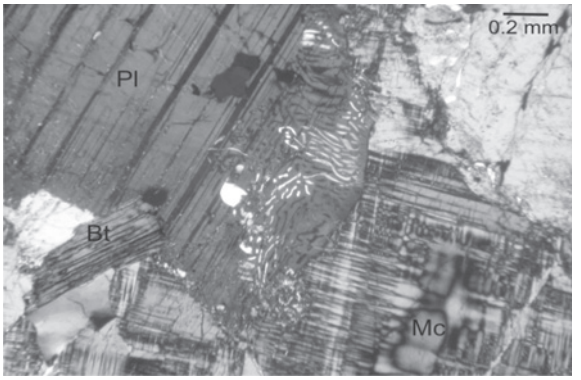

Figure 3 - Photomicrograph of an equigranular white pegmatite with myrmekite growing at the margin between a plagioclase and a microcline (sample FC07-CR-0025), cross polarized transmitted light.

GEOCHEMISTRY

The pegmatites of the Fort-Coulonge area are classified as NYF pegmatite, abyssal uranium (AB-U) subclass (Černý & Ercit 2005). The two types of pegmatite are peraluminous and have low CaO, MgO, TiO_2, P_2O_5 and high silica and alkalis contents, with SiO_2 ranging from 63-80 wt.% and total K_2O+Na_2O varying from 5.1-10.2 wt.% (Richer & Lentz 2008). Thorium values (10-468 ppm) and U values (<1-613 ppm) vary widely. Their Th/U ratios range from 0.77 to 25, but are typically between 2 to 4 indicative of coupled extensive fractionation and magmatic hydrothermal processes during emplacement. Secondary mobilization of uranium is partly responsible for variations in uranium abundance and U/Th ratios (Lentz 1991). A total of six samples, four from the pink pegmatite and two from the white pegmatite show enrichment in total REE, with values between 530-712 ppm. The white pegmatite has lower Sr values (155-254 ppm) compared to the pink pegmatite (199-659 ppm). The data from oxygen isotope quartz-feldspar diagram of the white pegmatites shows an array with a constant per mil difference (Δ) between the two minerals, indicative of constant temperature crystallization of minerals of different $^{18}O/^{16}O$ ratio. The wide range of Δquartz–biotite (from +3‰ to +6‰) and Δquartz-feldspar values (from -0.6‰ to +3‰) could result of isotope exchange between minerals and magmatic fluids in a system opened to fluid, or of infiltration of a small quantity of external fluids (Richer & Lentz 2009).

U- AND Th-BEARING MINERALS

Uraninite was only identified in the white pegmatites and often contains impurities from substitution or radiogenic

disintegration. The composition of the uraninites from the Otter Lake area ranges as follows: 66.51-79.58 wt% UO_2, 7.58-9.84 wt% ThO_2, 9.54-11.24 wt% PbO, 0.53-0.9 wt% CaO, 11.18-2.04 wt% Y_2O_3. Uraninite varies in size from 25 to 250 µm, is massive (Fig. 4) and locally fractured (Fig. 5), and is mostly found in K-feldspar. The composition of the uraninites from the Todd Lake South varies as follow: 57.07-76.7 wt% UO_2, 1.39-13.45 wt% ThO_2, 3.07-8.01 wt% PbO, 0.48-4.84 wt% CaO, 0.13-2.11 wt% Y_2O_3.Uraninites in this area are smaller (5-35 µm) and form inclusions in zircon.

Uranothorite was identified in both types of pegmatites. The composition for uranothorite in the white pegmatite varies as follow: 31.29-59.96 wt% ThO_2, 8.56-19.92 wt% UO_2 , 7.23-20.25 wt% SiO_2, 0.58-4.83 wt% Y_2O_3, 0-4.39 wt% ZrO, 0.17-2.2 wt% REE_2O_3, 0.22-5.29 wt% CaO, 0.22-7.68 wt% FeO, 0.46-4.04 wt% Al_2O_3, 0.37-4.31 wt% P_2O_5. The composition for uranothorite in the pink pegmatite ranges as follow: 48.23-50.21 wt% ThO_2, 21.65-26.18 wt% UO_2 , 16.61-17.59 wt% SiO_2, 0.94-2.1 wt% Y_2O_3, 0-1.11 wt% REE_2O_3, 1.1-1.55 wt% CaO, 0.51-1.78 wt% FeO, 0.34-1.12 wt% Al_2O_3. Uranothorite is found as an inclusion in monazite, zircon, magnetite, and K-feldspar. Major compositional impurities in thorite/uranothorite involve the substitution of U, Fe, or REE (Speer 1982). The uranothorites from the white pegmatites have between 8.56-19.92 wt% UO_2, which is close the data reported by Robinson and Abbey (1957). On the other hand, the uranothorites from the pink pegmatites have U values between 21.65-26.18 wt% UO_2. Those concentrations are higher than the average and suggest that uranothorite contains inclusions of uraninite.

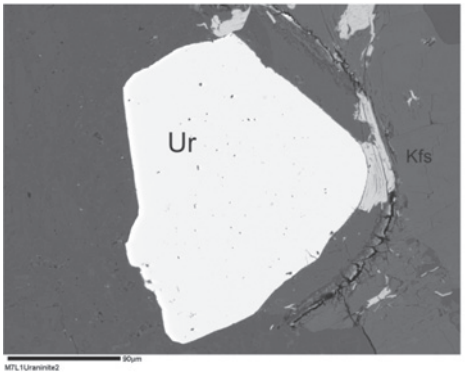

Figure 4 - SEM back scatter electron image showing a non fractured uraninite crystal from a white pegmatite of the Otter Lake area (sample FC07-CR-M7-L1).

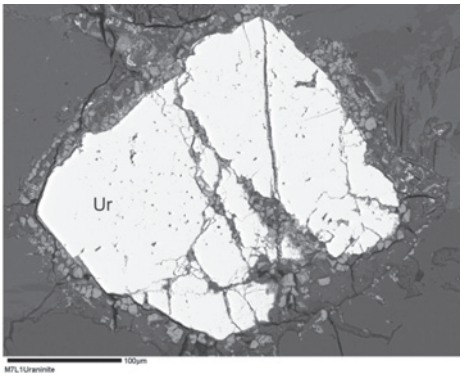

Figure 5 - SEM Backscatter electron image from a white pegmatite from the Otter Lake area showing a fractured uraninite crystal (sample FC07-CR-M7-

Several other minerals contain U as a minor substituent, particularly in Th-bearing minerals as they can freely substitute for one another. In the white pegmatites, several accessory U- and Th-bearing minerals were observed: monazite, xenotime, allanite, apatite, and zircon. Zircon analyses show high U (between 0.16-0.76 wt% UO_2), which is similar to previous studies in western Grenville (Tremblay 1974, Rimsaite 1980, and Habib 1982). Xenotime was found as a possible inclusion in thorogummite. Two alteration product of U- and Th-bearing minerals were identified in the pink pegmatite: gummite and possibly swamboite. The only alteration mineral identified in the white pegmatite is thorogummite, an alteration product of thorite or uranothorite. The U-Th mineralization is typically related to biotite-rich and oxidized areas, or with magnetite and strong hematization areas.

CONCLUSIONS

The petrological and mineralogical study of the white to pink granitic pegmatites showed that the two types have evolved differently. The U- and Th-bearing minerals of the white pegmatites are more diversified than those of the pink pegmatites. On the other hand, the pink pegmatites were more affected by weathering as showed by the larger amount of alteration products.

Acknowledgments

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REFERENCES

Černy, P. & Ercit, T.S. 2005. The classification of granitic pegmatites revisited. *The Canadian Mineralogist*, 43: 2005-2026.

Corriveau, L. *et al. 2007*. Prospective metallogenic settings of the Grenville Province. In *Mineral Deposits of Canada: A synthesis of major deposit-types, district metallogeny, the evolution of geological provinces, and exploration methods: Geological Association of Canada,* Special Publication, 5: 819-847.

Habib, M.K. 1982. Structural fabric and uranium distribution in shear zones near Cardiff, Ontario. Ms. Thesis, University of Ottawa, Ottawa, Ont.

Lentz, D. 1991. Radioelement distribution in U, Th, Mo, and rare-earth-element pegmatites, skarns, and veins in a portion of the Grenville Province, Ontario and Quebec. *Canadian Journal of Earth Sciences*, 28: 1-12.

Lentz, D. 1996. U, Mo, and REE mineralization in late-tectonic granitic pegmatites, southwestern Grenville Province, Canada. *Ore Geology Reviews*, 11 : 197-227.

Richer, C. & Lentz, D.R. 2008. Geochemistry and geochronology of the Grenvillian granitic pegmatites of the Fort-Coulonge area, Québec: Complexity of the origin of the magma *Geochimica et Cosmochimica Acta,* Volume 76, Number 12S, p.793.

Richer, C. & Lentz, D.R. 2009. Petrological, geochemical, and isotopic evaluation of the Grenvillian uraniferous pink and white granitic pegmatites, Fort-Coulonge, Quebec, IAGS 2009 extended abstract volume, 4 p.

Rimsaite, J. 1982. Mineralogical and petrological properties of heterogeneous granitoid rocks from radioactive occurrences in the Grenville Structural Province, Ontario and Quebec. *In* Uranium in granites, *Edited by* Y.T. Maurice, Geological

Survey of Canada, Paper 81-23, pp. 19-30.

Rivers, T. 1997. Lithotectonic elements of the Grenville Province: review and tectonic implications. *Precambrian Research*, 86: 117–154.

Robinson, S.C, & Abbey, S. 1957. Uranothorite from eastern Ontario. *The Canadian Mineralogist*, 6: 1-15.

Speer, J.A. 1982. The actinide orthosilicates. Mineralogical Society of America, Reviews in Mineralogy, 5: 1l3-135.

Tremblay, P. 1974. Mineralogy and geochemistry of radioactive pegmatites of Mont Laurier area, Quebec. M.Sc. thesis, Queen's University, Kingston, Ont.