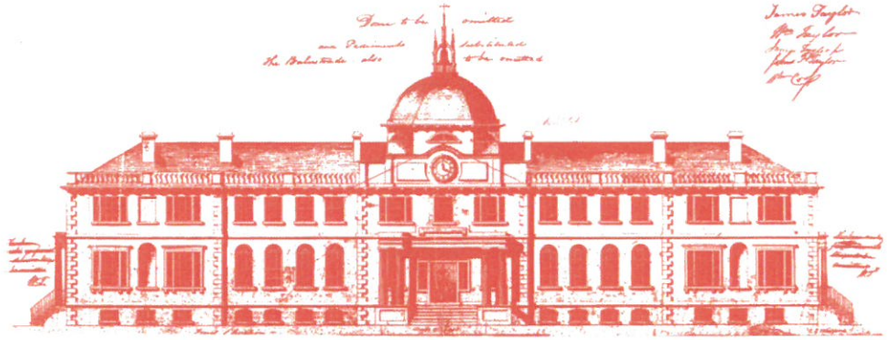
Using Mica Geochemistry as a Mineral Index to Differentiate Barren and Mineralized Granitoids in New Brunswick

Abstract

Acadian-related granites of New Brunswick cover the compositional spectrum from I- through S-, and A-types and are associated with several styles of granophile mineralization, including porphyry, Greisen, and vein-related of Sn, W, Cu, Mo, Au, and U. However, some of the intrusions are not known to have associated mineralization despite their highly fractionated nature. Two hundred and nineteen biotite grains from both barren and mineralized intrusions were selected for analysis with both electron microprobe analyzer (EPMA) and laser ablation inductivity coupled plasma mass spectrometry (LA-ICPMS) at the University of New Brunswick in order to investigate the ability of mica geochemistry as a mineral exploration tool.

The biotite colour varies from reddish-brown in intrusions related to Sn-W mineralization to brown and greenish-brown in intrusions associated with Cu-Mo, Mo and barren intrusion. The changes in colour reflect different oxygen fugacity for the host magma and correspond to a reduced environment for Sn-W hosting intrusions *versus* the more oxidized magmas associated with the other types of mineralization. The calculated oxygen fugacities for these intrusions fall between the quartz-fayalite-magnetite (QFM) and nickel-nickel oxide (NNO) buffers with values of 10-15.5 to 10-13.0 bar. The $Fe^{2+}/(Fe^{2+}+Mg^{2+})$ of biotite decreases from a high mean of 0.77 ± 0.16 in Sn-W related intrusions to Mo-related intrusions (mean of 0.69 ± 0.06), to barren intrusions (mean of 0.66 ± 0.06). Biotite from intrusions related to Cu-Mo occurrences have the lowest $Fe^{2+}/(Fe^{2+}+Mg^{2+})$ with a mean value of 0.56 ± 0.12. Biotite composition displays contrasting geochemical characteristics between barren intrusions and those associated with various types of mineral deposits.; Specifically, the compatible element content of biotite (e.g. Mg, Ti, Co, Ni, Cr, V, Sr, and Ba) increase, whereas incompatible element content (e.g. Sn, W, Mn Ta, Ga, Sc, Mo, Rb, and Cs), decrease from Sn-W-related intrusions to Mo, Cu-Mo and barren intrusions. These trends may reflect a more evolved nature of the Sn-W related intrusions. Barren intrusions have the lowest calculated water content of (1-3 wt.% H_2O), whereas biotite from Mo, and Sn-W-related intrusions have a much higher water content that ranges from 3 to 6 wt.%. The water content of intrusions related to Mo-mineralization is restricted to 4 to 4.5 wt.%. Biotite from Cu-Mo, barren, and Mo-related intrusions suggest a similar halogen fugacities for the parent magmas, i.e. biotite $fH_2O/fHCl$ and fH_2O/fHF range from 1.46 to 1.51 and 4.26 to 4.54, respectively. Conversely, biotite from Sn-W related intrusions have the lowest fH_2O/fHF (<3.56) and highest $fH_2O/fHCl$ (>1.59), indicating a high degree of halogen enrichment resulted from higher degree of fractional crystallization in these intrusions. Three metallogenic classification diagrams based on biotite mineral chemistry V-Na-Li, Li *versus* Si, and Sn+W *versus* Ga are proposed for the discrimination of barren and mineralized granitic systems.



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The University of New Brunswick recognizes that the university sits on traditional Wolastoqey territory. The river that runs right by our university – the St. John River – is also known as Wolastoq, along which live the Wolastoqiyik -- the people of the beautiful and bountiful river.

UNIVERSITY OF NEW BRUNSWICK

SCHOOL OF GRADUATE STUDIES

ORAL EXAMINATION

Zeinab Azadbakht

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

Ph.D. Candidate

Zeinab Azadbakht

Graduate Academic Unit

Earth Sciences

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April 26, 2019

1:00 p.m.

Forestry/Geology Bldg.
Room 202

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Examining Board:

Dr. David Lentz (Earth Sciences)	Supervisor
Dr. Chris MacFarlane (Earth Sciences)	Supervisor
Dr. Chunzeng Wang, HRA (Earth Sciences)	
Dr. James Walker, HRA (Earth Sciences)	
Dr. Shawn MacLellan (Chemistry)	

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The Oral Examination will be chaired by:
Dr. Kevin Englehart, Acting Associate Dean of Graduate Studies

BIOGRAPHY

Universities attended (with dates & degrees obtained):

2012 – present	PhD candidate, University of New Brunswick
2006 – 2009	MSc Economic Geology, Islamic Azad University of Tehran, Iran
2002 – 2006	BSc Geology, Islamic Azad University of Tehran, Iran

Publications:

Peer-Reviewed Publications:

Azadbakht, Z., Lentz, D., and and McFarlane, C.R.M., 2018, Apatite chemical compositions from Acadian-related granitoids of New Brunswick, Canada: implications for petrogenesis and metallogenesis. Minerals, 8, 598.

Azadbakht, Z., McFarlane, C.R.M., and Lentz, D.R., 2016, Precise U-Pb ages for the cogenetic alkaline Mount LaTour and peraluminous Mount Elizabeth granites of the South Nepisiguit River Plutonic Suite, northeastern New Brunswick, Canada. Atlantic Geology, 52, 188-211.

Non-Peer Review Articles:

Azadbakht, Z., Rogers, N., Lentz, D., and and McFarlane., 2019, Petrogenesis and associated mineralization of Acadian-related granitoids in New Brunswick; in Targeted Geoscience Initiative; 2018 report of activities, (ed.) N. Rogers; Geological Survey of Canada, Open File, 30 p.

Azadbakht, Z., Lentz, D.R., and McFarlane, C.R.M., 2017, Geochemical characteristics of magmatic mica as a monitor of metal fertility in Devonian intrusions of the New Brunswick Appalachians [ext. abs]: Society of Geology Applied to Mineral Deposits (SGA), 14th, Quebec City, Quebec, Canada, 4 p.

Selected Conferences Presentations:

Research Talks

Azadbakht, Z., Lentz, D., and McFarlane, C.R.M., 2018, Apatite chemical composition from Acadian-related granitoids of New Brunswick, Canada: implication for petrogenesis and metallogenesis: Resources for future generations (RFG), 1st, Vancouver, Canada, 2018, Program with Abstracts, number 2128.

Mohammedi, N., Lentz., **Azadbakht, Z.**, and McFarlan, C.RM., 2017, Biotite geochemical analysis in the Sn-W-Mo-Bearing Mt. Douglas leucogranite, southwestern New Brunswick, Canada: Analysis of metallogenic indices: Society of Economic Geologists (SEG), Beijing, China, 2017, Program with Abstracts, p. 46.

Azadbakht, Z., Lentz, D., and McFarlane, C.R.M., 2017, Geochemical characteristics of magmatic mica as a monitor of metal fertility in Devonian intrusions of the New Brunswick Appalachians: Society of Geology Applied to Mineral Deposits (SGA), 14th, Quebec City, Canada, 2017, Program with Abstracts, p. 1065-1068.

Several other Conference Presentations