

Magmatic biotite and its use to distinguish barren and mineralized granitic systems in New Brunswick, Canada

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Abstract: Forty-two different Devonian granitoid intrusions in New Brunswick were studied for this project. They formed by crustal growth processes during the Acadian orogeny, post-Acadian uplift, and Neocadian orogeny and most are associated with granophile element deposits, such as Sn, W, Mo, Cu, Bi, In, Sb, Au, and possibly Ta and Li, as well as base-metals and U mineralization. These intrusions were emplaced pre-, syn-, late-, and post-tectonically between 423 and 360 Ma with affinities ranging from primitive to highly evolved A-, S-, and I-types granitoids.

The aim of this study is to find a way to differentiate barren and mineralized granitic systems using biotite compositional systematics since it is highly sensitive to physico-chemical changes of its host, and continuously re-equilibrates with host and derivative fluids. Therefore, core to rim studies of this mineral and analysis of its compositional zoning may reveal the origin and evolution history of the hosting granitoid and the different types of associated mineralization. Mineralized and barren granitoids are characterized by different chemical variations in biotite. For instance, biotite from a mineralized granitoid is characterized by lower Mg and Ti, and higher Al content relative to biotite from a barren granitoid. A combination of electron microprobe (EPMA) and laser ablation ICP-MS (LA-ICP-MS) was used to identify major, minor, trace elements, and halogen contents of biotite; these results were used to calculate fluoride and chloride activity of aqueous fluids associated with these intrusions, based on F and Cl contents in the mineral.

Microprobe studies indicated homogeneous intragranular major element composition; crystallization temperature was calculated using Ti-In-biotite geothermometer, which gave a range of 670 to $750 \pm 25^\circ\text{C}$. However, hydroxyl exchange biotite-apatite thermometer confirmed sub-solidus processes disturbed these systems resulting in a lower temperature around 300 . Biotite grains from the highly fractionated bodies of the Pleasant Ridge, Mount Pleasant, and Kedron granites show the highest fluorine contents, ranging from 4.5 wt.% to 6.5 wt.%.

Trace element changes within the biotite lattice were measured using LA-ICP-MS. Interestingly, almost all of studied grains show Cs, Ba, and Rb zoning relative to K. These patterns were followed by Co, Cu, K, Li, Be, Sn, W, Ti, Sc, Ni, B, and V. Large ionic charge and radius make it difficult for elements to join or leave any crystalline structure; therefore, any Cs or Ba zoning could be of an igneous origin. As a result, any other elemental pattern following those could be a result of magmatic evolution, which has been recorded by the biotite crystal growth.

Based on the results of this project, the concept of using biotite composition to help identify fertile Acadian magma systems has been established; however, more work needs to be done to define characteristics of different magmatic processes.

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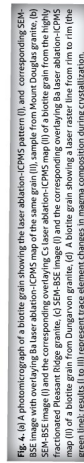


TGI⁴
Ore Systems

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Fig. 3. Tectonographic diagram of New Brunswick Devonian gneissos (data from Pearce et al. (1984) as modified by Christensen and Berman (1984)). The description is annotated in figure 2. (i) 1-6; (ii) 7-9; and (iii) 10-12.

Fig. 3. Tectonomagmatic geochemical discrimination diagrams of New Brunswick Devonian granitoids (data from Whalen (1993)); field boundaries are from Pearce et al. (1984) as modified by Christiansen and Keith (1996); colour code and description is annotated in figure 2. (I) 1-16, (II) 17-28 and (III) 29-42.



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Rosenfeld, M., Winkler, K., and Jurek, D.B. (2010) The Sarcheshmeh pyroclastic deposit: Kerman, Iran. *Journal of Volcanology and Geothermal Research*, 199, 105–117.

Schumacher, C.H., and Jurek, D.B. (2010) Trace-element systematics in silicic rhyolites: a metallogenic perspective. In *Trace Element Geochemistry of Volcanic Rocks* (eds J. D. M. Martin, J. D. Blundy, and J. N. Miller), pp. 105–124. Cambridge University Press, Cambridge.

Shaw, H.R. (1968) *Volcanic Ashes and Tuffs*. Geological Society of America, Washington, D.C.

Stout, M.Z. (1993) Composition and color of biotite from granites: two useful properties in the characterization of granitoid rocks. *Contributions to Mineralogy and Petrology*, 113, 115–116.

Stout, M.Z. (1996) Biotite from the helium intrusion zone of Hopalong cinder, Northwest Territories, Canada. *Mineralogical Magazine*, 60, 131–133.

Varma, J.G., Nigam, B.W., and Tirdat, A.C. (1984) Trace Element discrimination diagrams for the tectonic interpretation of granitic rocks. *Journal of Petrology*, 25, 956–963.

Winkler, K., and Jurek, D.B. (2010) Geochemistry of Apulian Granites in New Brunswick and Quebec, Canada. *Journal of Geological Research*, 2010, 1–10.