## The petrology of the Lake George granodiorite stock, New Brunswick: implications for crystallization conditions, volatile exsolution, and W-Mo-Au-Sb mineralization

Xueming Yang[1], David R. Lentz[1], Douglas C. Hall[2], and Guoxiang Chi[3]

*1. Department of Geology, University of New Brunswick, P.O. Box 4400, Fredericton, NB E3B 5A3, Canada < m0qm4@unb.ca> ¶ 2. Electron Microscopy Unit, University of New Brunswick, P.O. Box 4400, Fredericton, NB E3B 6E1, Canada ¶ 3. Geological Survey of Canada (Quebec Division), 880 Chemin Ste-Foy, P.O. Box 7500 Sainte-Foy, QC G1V 4C7, Canada*

The Lake George Sb vein deposit is spatially and temporally associated with W-Mo-Au mineralization that is genetically related to a Middle Devonian granodiorite stock at depth. The fine- to medium-grained porphyritic granodiorite consists of quartz, plagioclase, orthoclase, biotite, and trace hornblende with minor titanite, zircon, apatite, ilmenite, magnetite, and pyrite. Detailed mineral compositions (EMPA) are employed to evaluate P, T, and fugacity conditions for magmatic-hydrothermal activity related to the granodiorite, based on various geothermobarometric calibrations.

Normally zoned plagioclase phenocrysts are oligoclase on average ($An_{58}$ to $An_{20}$), which is typically higher than those in the groundmass. K-feldspar phenocrysts and those in the groundmass have similar compositions (orthoclase; $Or_{93}Ab_{6.7}An_{1.9}$). Two-feldspar geothermometry yields temperatures lower than 500˚C, reflecting subsolidus recrystallisation. Early hornblende phenocrysts were followed by simultaneous crystallization of biotite and plagioclase, subsequently by quartz and orthoclase. Biotite has relatively consistent high Ti and Al contents, and average Fe/(Fe+Mg) ratios of 0.54 ± 0.10. However, calculated halogen fugacity ratios of log(fHF/fHCl) in equilibrating magmatic volatiles have a large range from -2 to 0 units at 400˚C, corresponding to a significant variation of log(XF/XCl) ratios in biotite, revealing that the halogens in biotite re-equilibrated with various Cl-rich magmatic fluids. Those fluids emanated from the granodiorite as it cooled at depth. Low calculated $Fe^{3+}/(Fe^{2+}+Fe^{3+})$ ratios in both amphibole (ave. 0.07) and biotite (ave. 0.06), the presence of ilmenite as predominant Fe-Ti oxide, and low magnetic susceptibility (ave. 6 x 10-5 SI), indicate reducing conditions of the magma, as well as associated magmatic fluids.

The calcic hornblende in the granodiorite has Σ(Ca+Na) in M4 ≥ 1.0 with Na < 0.5, Si/(Si+Al+Ti) > 0.775, average Fe/(Fe+Mg) of 0.53 ± 0.06, and moderate Al2O3 (<10 wt.%) and TiO2 (<2 wt.%) contents. Al-in-amphibole geobarometry yields crystallization pressures ranging from 3 to 5 kb; this is obviously higher than that of the final emplacement depth of the stock (<2 kb), based qualitatively on texture and Ab-Or-Q-H2O phase equilibria. This pressure discrepancy is interpreted as early amphibole crystallization prior to the final emplacement of the stock, implying the magma became water-saturated during ascent. According to amphibole-plagioclase geothermometry, temperatures calculated for co-genetic amphibole and plagioclase of five granodiorite samples indicate they crystallized between 729 – 772°C, which is near the wet granodiorite solidus (3 to 5 kb). However, the calculated apatite saturation temperatures (848 – 911°C), based on P content, infers much higher original supersolidus temperatures.