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Chemical characteristics and composition of magmatic biotite from the Nashwaak Granite and related dikes, west-central New Brunswick

Wei Zhang*, David R. Lentz, Chris McFarlane, and Kathleen Thorne

*e-mail, zhangwei-china@live.cn

The Sisson Brook W-Mo-Cu deposit, situated in west-central New Brunswick, is hosted by Cambro-Ordovician volcanic and sedimentary rocks of the Miramichi and Tetagouche Groups. These rocks have been intruded by the Early Devonian Howard Peak diorite-gabbro, Nashwaak Granite, a phaneritic felsic dike swarm, and a distinctively younger Late Devonian porphyritic felsic dike. In order to understand the composition and circulation of fluids during or after emplacement of the magmatic rocks and associated hydrothermal mineralization, the chemical composition of biotite in each of these felsic units was analyzed by electron-microprobe and LA-ICP-MS. The four intrusive granitic units in the Sisson Brook deposit area include: (1) medium-grained, equigranular two-mica granite with brown biotite that is slightly altered to chlorite along the rim and foliation; (2) biotite granite with approx. 20% greenish-brown biotite and accessory zircon, apatite, monazite, magnetite, titanite, sulfides and ilmenite; (3) biotite granite dikes with similar mineralogical features to the biotite granite, except these dikes are more highly evolved (higher Zr/TiO_2) and have apatite as the main accessory mineral as inclusions in the greenish-brown biotite; and (4) porphyry dikes with phenocrysts consisting of approximately 23% plagioclase that are up to 1 cm in length, 10% quartz up to 7 mm, 8% greenish-brown biotite up to 0.3 mm in length, and 7% K-feldspar.

The Al and Ti contents of biotite are controlled by their host granite bulk composition and temperature. The atoms per formula unit of manganese in the biotite increase with Fe/(Fe+Mg) in each group except in the two-mica granite. Potassium, Na, F, and Cl contents show no systematic variations. Metallic elements (Cu, Zn, Mo, W, Sn) in biotite were analyzed by LA-ICP-MS and the biotite in dikes is relatively rich in W and Sn, and depleted in Zn and Cu. Molybdenum is below detection limit. Mineral stability experiments have shown that the fO_2 of granite is controlled by biotite-phlogopite solid solution series and gas coexisting with sanidine-magnetite-gas at 207 MPa. The fO_2 of the biotite granite and the two-mica granite increases with the magma evolution (T decrease), and that in the biotite granite dikes and the porphyry dikes have no systematic variation trend. The geochemical attributes of the two-mica granite indicate a strongly contaminated, reduced I-type signature, whereas the other groups are close to the contaminated oxidized I-type features. The log (XCl/XOH) versus XMg and log (XF/XOH) versus XFe plots show that the two-mica granite equilibrated with fluids at higher T than the biotite granite. However, the samples from the granitic dikes are scattered and this may indicate that they have continually equilibrated with fluids over a range of temperatures and fluid compositions. The HF/HCl ratio (IV(F/Cl)) values of the biotite in these dikes are similar to other Sn-W-Be deposits and their slightly oxidized state are also typical for the formation of W-Mo deposits. With the aid of other types of data, the composition of biotite may serve as a useful tool to identify the progenitor granitic rocks responsible for the mineralizing fluids at the Sisson Brook deposit.