The Nature of Uranium Mineralization in the Paleoproterozoic Aillik and Post Hill Groups, Labrador Central Mineral Belt

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The Labrador Central Mineral Belt (LCMB) consists of six successive Proterozoic supracrustal sequences and associated Archean basement rocks that occupy a 260 x 75 km area in central to coastal Labrador (Wilton, 1996); the constituent Proterozoic sequences include the *ca*. 2.0 Ga Post Hill and Moran Lake groups, the *ca.* 1.86 Ga Aillik Group, the *ca*. 1.65 Ga Bruce River Group, the *ca*. 1.327 Ga Letitia Lake Group and the *ca*. 1.25 Ga Seal Lake Group. The eastern portion of the belt comprises the 1.78-1.9 Ga Makkovik Orogenic Zone, an accretionary orogen bounded to the northwest by the Archean Nain Province and to the south by the Mesoproterozoic Grenville Province. Kerr *et al.,*(1996) subdivided the orogen into three domains; *viz.,* the Kaipokok, Aillik and Cape Harrison domains; the Kaipokok Domain encompasses the Post Hill Group, its Archean basement and Paleoproterozic granitoids, and the Aillik Domain predominantly contains the Aillik Group and a variety of Paleoproterozoic granitoids.

Fronteer Development Corporation's wholly owned subsidiary, Aurora Energy Resources Inc. controls the mineral exploration rights to over 90,000 hectares in the LCMB, encompassing portions of both the Kaipokok and Aillik domains. Aurora has defined a significant uranium mineral resource at Michelin and Jacques Lake (both hosted by the Aillik Group), and four satellite deposits: Nash, Inda, Gear, and Rainbow (the former three are hosted by the Post Hill Group and the latter by the Aillik Group). Combined, these properties rank as one of the largest undeveloped primary uranium deposits in the world with a total measured and indicated resource of 83,842,000 lbs U_3O_8, and an inferred resource of 52,974,000 lbs U_3O_8. Other prospects in the Aurora inventory include the Melody Hill zone in a *ca*. 1.895 Ga granitoid, and the Otter Lake, White Bear, Aurora River and Lucky Girl zones hosted by the Aillik Group. All, except the Jacques Lake prospect, had been discovered prior to 2005 during earlier exploration in the LCMB stretching back fifty years. Though these various deposits and prospects are hosted by a range of lithologies with disparate ages, there are a number of common features.

The Post Hill Group is a highly strained, 2.7 km thick sequence of amphibolite-facies rocks including psammite and feldspathic paragneiss, schistose mafic metavolcanic , and well-bedded micaceous psammite (with minor pelite and graphitic paragneiss) units (Ketchum *et al.,* 2002). The 1.856-1.883 Ga Aillik Group is an assemblage of felsic volcanic and volcaniclastic sedimentary rocks with a minor mafic volcanic component (Hinchey and LaFlamme, 2009). The Aillik Group has been intruded by at least two granitoid suites at *ca*. 1.8 Ga and 1.65 Ga (Kerr *et al.,* 1992). Deformation and metamorphism associated with the Makkovikian Orogeny, ca. 1.8-1.84 Ga, affected the regional lithologies (Hinchey, 2007).

Mineralized lithologies at all the prospects are predominantly felsic and volcanic, volcaniclastic or intrusive in nature. There are also mafic hosts where the felsic lithologies are relatively impermeable; this includes mafic dykes at Michelin and other prospects, and an amphibolite host at Rainbow. Deposits in the Post Hill Group are hosted by both metasedimentary and metabasalt units. All host units are deformed and exhibit at least slightly schistose fabrics. At Michelin, and to a lesser extent White Bear, the host felsic volcanic rocks also exhibit an augen-like texture in coarser-grained porphyrytic varieties. These general ductile fabrics are overprinted by brittle fracturing especially at the Nash, Jacques Lake and Rainbow deposits. At the Melody prospect, the host granite is transected by ductile mylonites and brittle cataclastic fractures.

In all cases, the uranium-bearing zones exhibit, at least minor, chemical differences from unmineralized host rock, indicating that the uranium mineralizing event was epigenetic with respect to the host rocks. The most striking change is a Na_2O-enrichment and concomitant K_2O-depletion in the mineralized zones, this is particularly intense at Michelin (see Hicks and Wilton, 2010). At the Nash deposit there is a slight Na_2O depletion and K_2O contents are stable; at Gear there is a minor K_2O depletion; the host rocks at these latter two are Post Hill Group metasedimentary lithologies. At Michelin, Melody, and Otter Lake, U has a strong correlation with Zr. U and Pb contents correlate positively in all deposits and prospects, but there are some local deviations within individual samples indicating minor remobilization of one or the other elements. Detailed mass balance calculations at Melody, indicate that the uranium mineralizing event was basically a constant volume replacement with U, Pb, Zr, Mg, and Ba enrichments; the other elements (excepting a small decrease in Sr) were stable with respect to the mineralizing fluids.

Mineralogical analysis of Aurora's LCMB deposits was conducted using a Scanning Electron Microprobe equipped with Mineral Liberation Analyser (MLA-SEM) software (see Wilton *et al.,* 2010). The analyses indicated that uranium is present predominantly as uraninite with locally variable siderophile (*e.g.,* Si, Fe, Ca, Ti, *etc.*) element contents, minor uranium phases identified include uranophane (~$Ca(UO_2)2(SiO_3OH)_2{\cdot}5H_2O$)and brannerite ($UTi_2O_6$); uranophane is most common in samples from White Bear and Rainbow deposits in secondary fractures. The uraninite is in general intimately intergrown amphibole and associated with either magnetite or ilmenite/Ti-rich magnetite; a spinel is generally present in all samples, but magnetite and ilmenite themselves are mutually exclusive. Secondary zircon is intimately intergrown with U-phases, particularly at Michelin, Melody, and Otter Lake, to a lesser extent at Jacques Lake and White Bear, and not at all in the Nash deposit.

U-Pb isotope analyses were conducted by LAM-ICP-MS on: 1) secondary zircons from Michelin samples, 2) on zircons in samples from Jacques Lake of mineralized and unmineralized host rocks and mafic dykes cutting the host rocks, and 3) on detrital samples from a Nash metasedimentary unit. Some secondary zircons from Michelin were too U-rich for analysis, others defined $^{207}Pb/^{206}Pb$ ages (with large errors) ranging from 1.828 to 1.844 Ga. The zircons

from mineralized Jacques Lake samples defined *ca*. 1.84 Ga $^{207}Pb/^{206}Pb$ ages (also with large errors), the unmineralized host rock generated an $^{207}Pb/^{206}Pb$ age of 1.856 Ga (*i.e*., an Aillik Group age), and the $^{207}Pb/^{206}Pb$ age of a cross-cutting mafic dyke was calculated at 1.782 Ga. The Nash host metasedimentary unit defined an average $^{207}Pb/^{206}Pb$ detrital age of 1.907 Ga.

In summary, the uranium mineralization on the Aurora Energy Resources Inc. LCMB properties, though distributed through a variety of units and lithologies with different ages, appears to post-date deposition of the Post Hill and Aillik groups and 1.895 Ga granitoid magmatism. The mineralization is associated with ductile deformation and amphibole, hence may represent the products of regional metamorphism associated with the Makkovikian Orogeny. The uranium was also subject to local mobilization during later brittle deformation.

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