Fluid History and Uranium Mineralization in the Hornby Bay Basin, Nunavut, Canada

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The Hornby Bay Basin, a Proterozoic terrestrial-to-marine sandstone and dolostone basin located in western Nunavut and eastern NWT, is an exploration prospect for unconformity-type and other styles of uranium deposits. The basin overlies granitoids and metavolcanics of the Wopmay Orogen dated at 1.85 Ga and is capped by the Coppermine Basalt that formed at about 1200 Ma. The sedimentary succession is up to 4 km deep in some areas, showing a changing depositional environment through time from terrestrial-fluvial conglomerate, sandstone and shale deposition changing to marine limestone, now dolostone (Ross, 1983). Sedimentary rocks in the basin are comprised of the Hornby Bay and Dismal Lakes Groups. Uranium mineralization is present in the Hornby Bay Group at and above a disconformity between the Lady Nye and Leroux formations above the basement-basin contact at a site called the Mountain Lake deposit (Hassard, 2005), at the Bog Showing in the basement granite in the eastern basin, and at the Gnaw-Bikini showing in the basement metavolcanics southwest of the Muskox Intrusion (Jensen et al., 1979) (Figure 1). This study involves determining a paragenesis of the diagenetic minerals both around the mineralized zones and in barren areas in the eastern end of the basin. Geochemical techniques including U-Pb dating, clay mineralogy and geothermometry, and stable isotope analysis are used to expand the paragenesis, which is applied in the context of the sequence stratigraphy of the basin and used to unravel the fluid history relating to alteration and uranium mineralization.

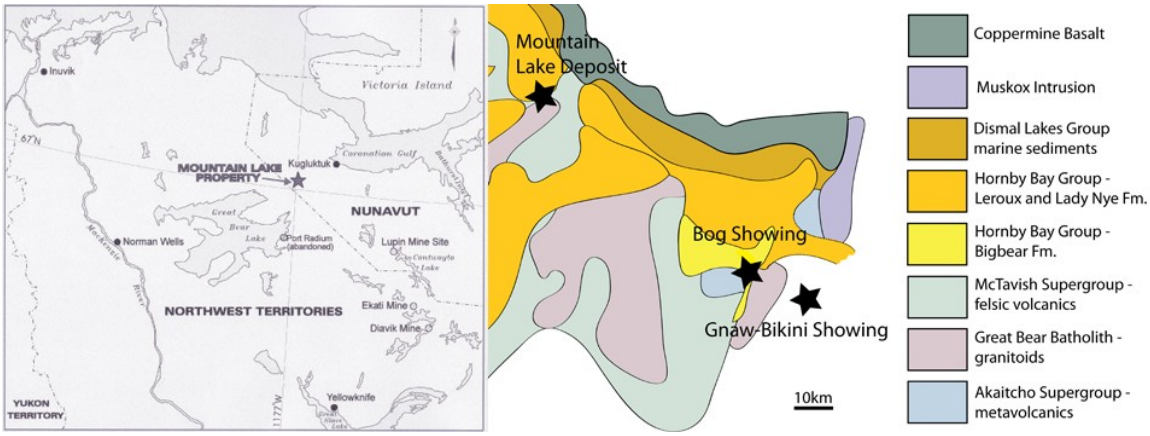

Figure 1. Geographic location and generalized geology of the eastern basin, including mineralized showings. After Jensen et al., 1979; Gandhi, 1986; Ross and Kerans, 1989; Hassard, 2005; Ramaekers, 2007.

Stratigraphy and Paragenesis

A generalized stratigraphic section for the Hornby Bay Group of the Hornby Bay Basin study area is shown in Figure 2a. The basement rocks underlying the Hornby Bay Basin are formed from the Wopmay Orogen; the Akaitcho metavolcanics are most common in the eastern end of the basin, while the Great Bear Batholith granitoids and McTavish felsic volcanics and

metasediments occur throughout the area. Notably, graphite commonly occurs in the Great Bear granites (Hassard, 2005; Kerans et al., 1980; Ross, 1983).

The Bigbear Formation of the Hornby Bay Group was investigated as part of the barren sandstone study, but has limited lateral extent in the basin, ocurring only in the easternmost end (Maclean and Cook, 2004). A mineral paragenesis of the sandstones for the Leroux and Lady Nye formations based on textural relationships is shown in Figure 2b. The Leroux and Lady Nye formation sandstones are well sorted to moderately sorted quartz arenites with rounded to subrounded quartz grains and diagenetic or hydrothermal minerals in the matrix, as well as detrital zircons with varying degrees of roundness. Exceptions include mud rip-up clasts, detrital muscovite and obvious clay pseudomorphs after feldspar that are preserved at the boundary between the units and throughout the Lady Nye Formation. Early coating of hematite (F1) on quartz grains is the first diagenetic mineral observed, closely followed by quartz overgrowths (Q1) and compaction causing stylolites in some samples. Early kaolin group clays (K1) have been predominantly altered to muscovite (M1). The muscovite also corroded the edges of quartz overgrowths. Patches of apatite cement (P1) in the matrix formed pre- or syn-early muscovite alteration. Later hydrothermal alteration phases include sulphide minerals such as pyrite and arsenopyrite (S1), barite (B1), and uranium arsenates including trogerite and metazeunerite (LR-U). The age of apatite cements is interpreted to be the age of fluid movement and mineralization at Mountain Lake (Davis et al., 2008.) Because apatite (P1) occurs intergrown with muscovite alteration in thin section, the syn-mineralization hydrothermal phases are placed later than the apatite cement. The Fort Confidence Formation has many lithic fragments, detrital micas and very early diagenetic matrix minerals well preserved in the sandstones between shale intervals, indicating the shales acted as an effective aquitard to fluids circulating in the units below.

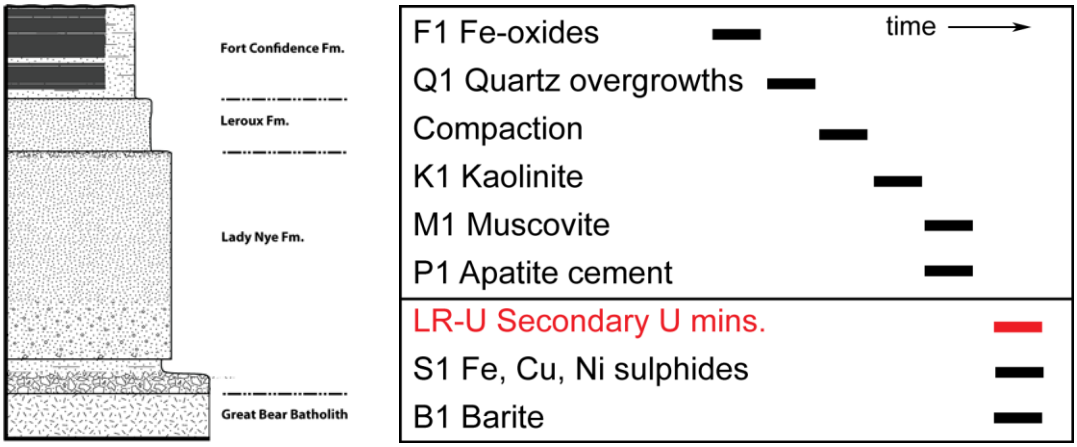

Figure 2. (a) Generalized stratigraphic section of the study area. (b) Mineral paragenesis in the Leroux and Lady Nye Fms.

In the Great Bear Batholith basement unit underlying the eastern end of the basin, uraninite veins were found on the edges of larger quartz veins and were altering to coffinite on the outside margins. Mineralization in the Akaitcho metavolcanic basement unit southwest of the Muskox Intrusion occurs in a fracture comprised entirely of hematite and carbonate. Uraninite grains have a sharp contact with the matrix and a distinctive scalloped edge on contact with carbonate veins, indicating the uraninite pre-dates the carbonate. A serpentine mineral crosscuts uraninite grains and the matrix in several places as a long, thin vein.

Timing of Mineralization

U-Pb isotoptic compositions were measured on mineralized samples using laser ablation high-resolution multi-collector ICP-MS. A U-Pb concordia for the Gnaw-Bikini Showing hematite fracture-hosted uraninite has an upper intercept of 1221 ± 83 Ma and a lower intercept of 410 ± 45 Ma (Figure 3a). ^{207}Pb-^{206}Pb ages range from 1012 Ma to 783 Ma. The upper intercept age is interpreted as the age of mineralization, and coincides with the Mackenzie dyke swarm (1250 Ma). The lower intercept age is interpreted as a resetting age, supported by SEM images of the uraninite that show fine-scale alteration within individual grains. The uraninite-coffinite vein in granite at the Bog Showing has a U-Pb age of 973 ± 130 Ma determined by HR-MC-LA-ICP-MS (Figure 3b). It was partially reset by an event at 456 ± 130 Ma, similar to the disseminated uraninite's lower intercept of 410 ± 45 Ma. ^{207}Pb-^{206}Pb ages range from 911 Ma to 731 Ma. Fluid events occurring after the initial uranium deposition at 1220 Ma either remobilized uranium from the original deposit or scavenged more uranium from nearby U-rich rocks, and deposited it along the edges of quartz veins. Mineralization in the sandstones at Mountain Lake could not be dated due to the very small grain size of uranium arsenates and possible mass interference from Pb-S.

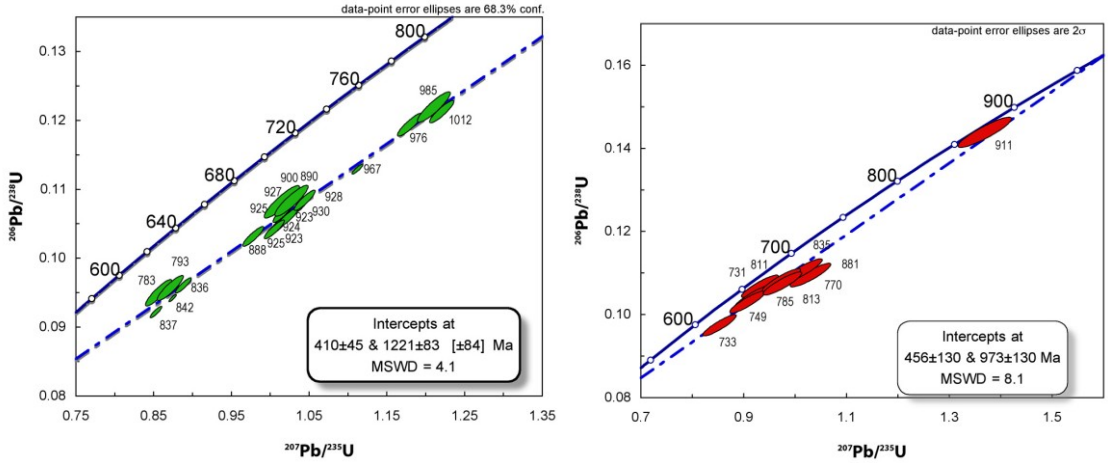

Figure 3. U-Pb concordia diagrams for (a) metavolcanic-hosted uraninite and (b) granite quartz vein-hosted uraninite/coffinite.

Discussion

Despite the apparently favourable conditions for unconformity-style uranium in the Hornby Bay Basin, including a relatively confined aquifer in the Lady Nye and Leroux formations and the availability of uranium to late hydrothermal fluids circulating through the sandstones and basement, no uraninite has been observed in the sandstone and no basement-hosted deposits are of the appropriate age. The young age of the uraninite in the metavolcanic basement compared to unconformity-style uranium deposits in the Athabasca Basin (Alexandre et al., 2009), and it's location in a hematite-filled fracture, indicates that it is closer to IOCG hematite fracture-style uranium mineralization caused by Muskox Intrusion-era hydrothermal fluid movement. Weak acid leach technique (Holk et al., 2003) can be used to investigate the amount of radiogenic lead present in the sandstones and to postulate whether the minor amounts of uranium arsenates in the basin rocks are sourced from late basement mineralization or an earlier event.

References

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