The search for uranium in the Great White North — similarities and differences amongst four Canadian Proterozoic settings

C.W. Jefferson, W. Davis, P. Ramaekers, R. Rainbird, S. Bosman, K. Chamberlain, T. Peterson, and W. Bleeker
Geological Survey of Canada, 601 Booth Street, Ottawa, ON, Canada K1A 0E8

Prospective intracontinental basins developed 100 to > 400 million years before local tectonic adjustments mobilized and precipitated uranium during the Proterozoic. Low-temperature hydrothermal alteration pervaded these basins, and regional layer-parallel flow has been modeled between hypothetical diagenetic aquitards, supported by some diagenetic features. Nevertheless, deposit-specific alteration is most obviously associated with fault systems that were active before, during, and after deposition of multiple, unconformity-bound, fluvial sequences. Reactivated steep faults, lateral thickness and facies changes, and basement uplifts clearly enhanced the vertical components of fluid flow, redox, and alteration. Telltale uraniferous phosphate cements formed at a range of sites just before uraninite deposition was focused where certain reactivated structures intersected geochemically favourable basement rocks, mafic dykes with contact metasomatic effects in sandstone, or stratigraphic facies changes. Such structural and temporal coincidences provide unique vectors and events for exploring each basin.

The largest, highest-grade deposits and potential are unchallenged in the Athabasca Basin, but at least three other basins offer viable potential. The Athabasca Basin was initiated ~1750 Ma with its fourth sequence still accumulating after 1541 ± 13 Ma (Re-Os isochron on oil shale). Local tectonic rejuvenation generated a regional angular unconformity between sequences 2 and 3 that is constrained by basin-transecting uranium-bearing fluorapatite cement (U-Pb ~1640 to 1610 Ma), and felsic tuff (U-Pb 1644 ± 13 Ma) above that unconformity. Pre-ore hydrothermal minerals near the basal unconformity were formed ~1670–1620 Ma. The principal uraninite ore deposits have so far yielded U-Pb ages as old as 1600–1500 Ma. Newly dated uraniferous fluorapatite in Thelon Basin (U-Pb 1667 ± 6 Ma) formed about 80 million years after basin initiation (< 1750 Ma) and prior to similar Athabasca cements. Thelon apatite has yet to be linked temporally to regional unconformities or uraninite, but is found in at least the lower two sequences, predates the Kuungmi shoshonite flows (U-Pb 1540 ± 30 Ma), and occupies a range of sites including altered basement, basal silicified breccia and higher soft-sediment faults. Brittle fault arrays are associated with basin margins, and with unconformity uranium deposits hosted by Archean or Paleoproterozoic strata and/or 1750 Ma granitic complexes. In Otish Basin > 440 million years separated basin initiation (U-Pb > 2170 Ma) from alteration (K-Ar and Sm-Nd 1730 Ma) associated with uranium deposits along fault offsets of the basal unconformity and northerly trending mafic dykes. In "Hornby Bay Basin" more than 450 Ma, dramatic basin reorganization, and volcanism at 1667 ± 8 Ma separated initiation of detrital sedimentation (< 1750 Ma) from deposition of the uranium host sandstone that contains local xenotime cement (U-Pb 1284 ± 11 Ma) in corrosive contact with detrital quartz and early quartz cement. Fluorapatite then cemented lower strata (U-Pb 1160 ± 80 Ma), not long before uraninite was disseminated in sandstone (U-Pb 1050 ± 50 Ma). Here the ore trap was an overlying carbonaceous unit within a graben superimposed on an older horst. In summary, each basin has its own structural, lithologic, and temporal coincidences to better quantify for exploration.

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