Far North Geomapping Initiative: Bedrock geology of Manitoba's far northwest, with emphasis on uranium and rare-earth element mineralization in the Wollaston Domain

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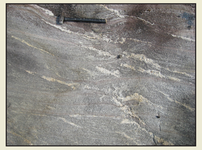
Introduction

Geological mapping of Manitoba's far northwest was conducted as part of the Manitoba Geological Survey's Far North Geomapping Initiative, a collaborative project with the Geological Survey of Canada's Geomapping for Energy and Minerals (GEM) program. The aim was to examine, document and characterize the southwestern margin of the Hearne craton and its Paleoproterozoic cover sequence(s), in an effort to upgrade the geological knowledge base and provide information on the styles and potential of mineral endowments in this part of the province.

Paleoproterozoic Intrusive Rocks

K-feldspar rich leucogranite to pegmatite (alaskite) dikes and sills are ubiquitous throughout the metasedimentary sequences of the Wollaston Supergroup. Geochemically, these rocks are characteristic of highly fractionated, peraluminous, S-type granitoids with elevated values of REE, Th, and Rb >>Sr. Dikes are injected along foliation planes and parallel to fold axial planes, are locally folded and boudinaged, and are interpreted to be derived from melting of metasedimentary rocks of the Wollaston Supergroup and emplaced during regional deformation associated with the Trans Hudson Orogeny.



Leucosome parallel to S_3 foliation, Lac Brochet

Leucogranite dike injected parallel to compositional layering in metasedimentary rocks, Snyder Lake

Wollaston Supergroup Rocks

Metasedimentary rocks of the Wollaston Supergroup are interpreted to have been deposited in an evolving basin with 3 distinct stages: a rift stage, passive margin stage, and foreland basin stage, separated by regional unconformities, and each with distinct detrital zircon profiles (Tran et al., 2008; Yeo and Delaney, 2007). Samples of metasedimentary rocks were collected for detrital zircon geochronology throughout northwestern Manitoba for comparison with the better established stratigraphy of the Wollaston Supergroup in Saskatchewan.

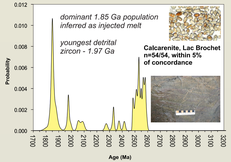
Quartzite from Kasmere Lake is dominantly sourced from Archean rocks and is consistent with data from the lower, rift stage. Psammitic gneiss from the Misty Lake area also has a dominant Neoarchean peak and a youngest detrital zircon ca. 1.94 Ga, likely sourced from advancing volcanic arc terranes in the Southern Indian/Rottenstone domains. This profile is similar to existing geochronology from the Souter and Daly Lake groups in Saskatchewan (Yeo and Delaney, 2007), interpreted as forming part of the passive margin stage. Psammitic rocks from the Putahow and Goose Lake areas, as well as calcarenite from Lac Brochet have a more diverse zircon population, including a greater abundance of Paleoproterozoic zircons, and are interpreted to be equivalent to foreland basin stage (Geikie River Group in Saskatchewan, Yeo and Delaney, 2007; Sequence 3 of Tran et al., 2008).

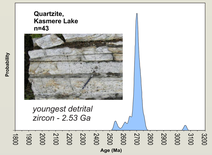
Folded marble and calcsilicate, Snyder Lake

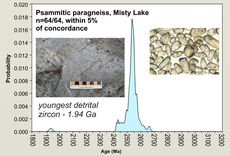
Layered psammitic and semipelitic gneiss, Lac Brochet

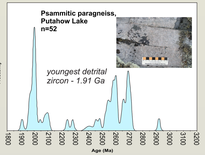
Folded semipelitic to pelitic gneiss, Misty Lake

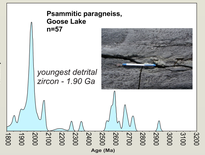
Cordierite-bearing arkosic gneiss, Misty Lake





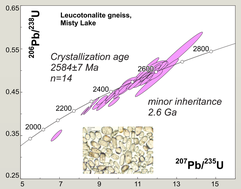




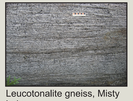


Archean Basement Rocks

Archean rocks of the Mudjatik Domain form part of the southwestern margin of the Hearne craton. They consist of tonalitic to granitic orthogneisses with lesser amounts of enderbite and charnockite. Within the Wollaston Domain, Archean gneisses form the cores of structural domes infolded within the metasedimentary rocks. A sample of leucotonalite to granodiorite gneiss collected from the Misty Lake area yielded a crystallization age of 2584 ±7 Ma, consistent with similar data collected in Saskatchewan for Archean rocks of the southwestern Hearne margin.

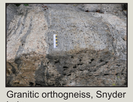


Multiphase granitic gneiss, Grevstad Lake



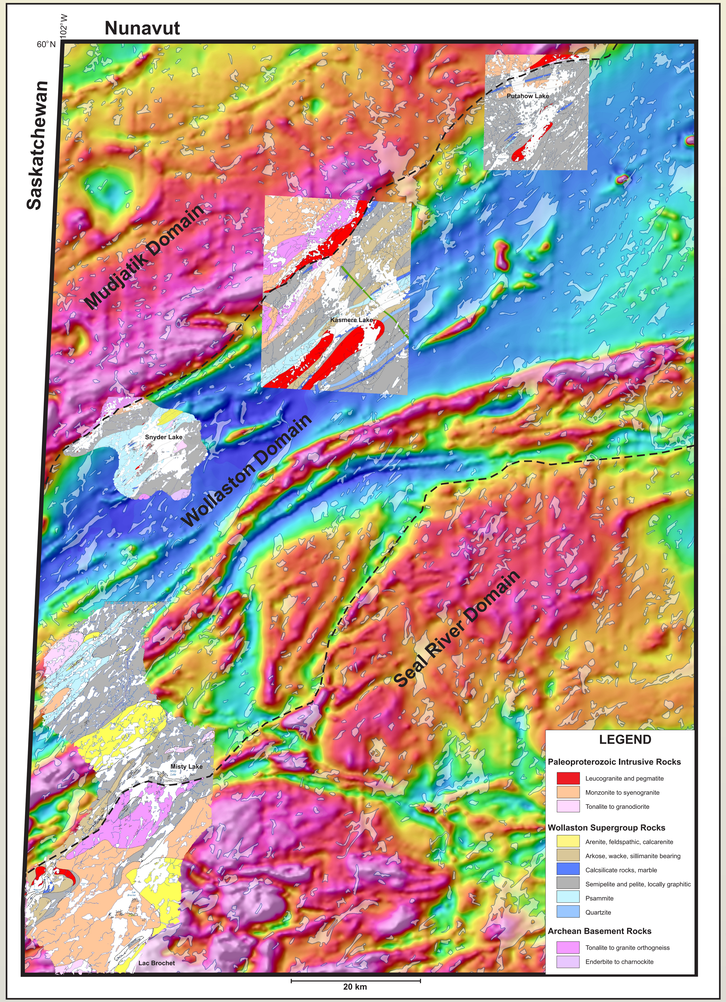
Leucotonalite gneiss, Misty Lake

Granulite grade orthogneiss, Snyder Lake



Granitic orthogneiss, Snyder Lake

MGS bedrock geological maps (2006, 2010, 2011) on total field magnetic relief



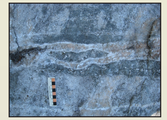
Uranium and rare-earth element mineralization

The Wollaston Supergroup and underlying Hearne craton margin form the basement sequence to the Athabasca Basin in Saskatchewan, and are locally host to unconformity-related, basement-hosted uranium deposits. Discrete zones of U and/or REE mineralization identified by CanAlaska Uranium Ltd. (2009) in the Snyder Lake area of northwestern Manitoba were investigated in the summer of 2011 to provide a geological context for U and REE mineralization within the Wollaston Domain in Manitoba. On the basis of field mapping, the following obervations were made:

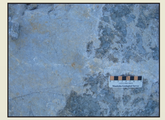
1) U, Th and REE enrichments are associated with calcareous and/or graphitic horizons within the Wollaston Supergroup, which act as chemostratigraphic traps that allow for the precipitation of U, Th and/or REEs from a fluid phase.
2) Within these horizons, secondary metasomatic veining and alteration associated with late brittle-ductile deformation appear to be important controls on the localization of mineralization
3) Two mineralogically distinct vein phases were observed: megacrystic calcsilicate veining and alteration, and calcite-diopside veining and alteration.

Megacrystic calcsilicate veins and alteration

Secondary alteration in calcsilicate rocks resulted in textural recrystallization to megacrystic calcsilicate rock consisting of varying amounts of tremolite, diopside, feldspar and scapolite. Veins of this type in the Snyder Lake area (Pitchblende Ridge and Snyder Island) range from narrow fracture veins with alteration haloes <1 cm to large veins >5 m in width. Preliminary geochemistry indicates that megacrystic calcsilicate veins are enriched in U and Th (values up to 64 ppm Th and 56 ppm U), relative to adjacent "unaltered" fine- to medium-grained calcsilicate. Megacrystic calcsilicate veins show no REE enrichment.



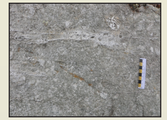
Megacrystic calcsilicate vein, Pitchblende Ridge



Metasomatic alteration around narrow vein, Pitchblende Ridge

Large megacrystic calcsilicate vein (bottom of photo) cutting medium-grained calcsilicate rocks, Pitchblende Ridge

Uraninite crystal in megacrystic calcsilicate boulder, Pitchblende



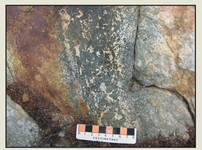
Zone of megacrystic calcsilicate alteration around narrow vein, Snyder Island

Calcite-diopside veins and alteration

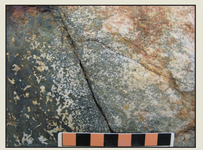
Calcite-diopside veins are most prevalent on the southwestern exposures of the Snyder Island occurrence. Calcite-diopside veins form late, discrete, brittle-ductile structures with diffuse, gradational contacts. Calcite-diopside veins generally trend north-south and crosscut the regional structural grain of the Wollaston Domain. In contrast to megacrystic calcsilicate veining, calcite-diopside alteration veins are characterized by enrichments in REE (>2700 ppm total REE) but low Th and U values.

Trenched calcite-diopside vein cutting calcsilicate rocks, Snyder Island

Close-up of trenched calcite-diopside vein, Snyder Island



Narrow calcite-diopside vein, Snyder Island



Margin of calcite-diopside vein showing gradational contact and grain coarsening towards centre of vein, Snyder Island

Possible sources of U, Th, REE

Granitic gneisses of the Mudjatik Domain have peraluminous geochemical affinities with high Ba, Sr, Zr ±REE. Oxidative continental weathering of these rocks could have provided primary enrichments of U, Th, and REE to the Wollaston Supergroup. Highly fractionated, peraluminous S-type leucogranitic dikes and sills that intrude sedimentary rocks of the Wollaston Supergroup are interpreted to be derived from partial melting of the sedimentary pile during high grade metamorphism (upper amphibolite to lower granulite facies). These dikes have elevated values of REE, Th and Rb>Sr, and are interpreted to have remobilized and concentrated U, Th and REE from the sediments into calcareous and graphitic horizons.

Regional implications

Calcareous and graphitic horizons are significant components throughout the stratigraphy of the Wollaston Supergroup, and by extension, may contain similar enrichments in U, Th and REE as seen in the Snyder Lake area. In the Misty Lake area (approximately 60 km south of Snyder Lake), metasomatic veining and zones of megacrystic calcsilicate recrystallization similar to that documented at Snyder Lake were found at 3 separate locations. These zones have strong enrichments in Th (up to 117 ppm), and minor enrichments in U and REE. These data suggest that the Wollaston Domain potentially contains numerous occurrences of U, Th and REE throughout its stratigraphy. These occurrences may have been re-enriched during a low temperature hydrothermal event to form the unconfomity-related uranium deposits associated with the Athabasca Basin.

References

CanAlaska Uranium Ltd., 2009: CanAlaska Uranium Details Extensive Rare Earth Mineralization at NE Wollaston; CanAlaska Mining Corporation Ltd., press release, October 20, 2009, URL < http://www.canalaska.com/s/News.asp?ReportID=367962> [October 2010].

Tran, H. T., Ansdell, K. M., Bethune, K. M., Ashton, K. and Hamilton, M. A. 2008: Provenance and tectonic setting of Paleoproterozoic metasedimentary rocks along the eastern margin of Hearne Craton: constraints from SHRIMP geochronology, Wollaston Group, Saskatchewan, Canada; Precambrian Research, v. 167, no. 1–2, p. 171–185.

Yeo, G. M. and Delaney, G. 2007: The Wollaston Supergroup, stratigraphy and metallogeny of a Paleoproterozoic Wilson cycle in the Trans-Hudson Orogen, Saskatchewan; in EXTECH IV: Geology and Uranium EXploration TECHnology of the Proterozoic Athabasca Basin, Saskatchewan and Alberta, C. W. Jefferson and G. Delaney (eds.), Geological Survey of Canada, Bulletin 588, (also Saskatchewan Geological Society, Special Publication 17; Geological Association of Canada, Mineral Deposits Division, Special Publication 4) p 89–117.