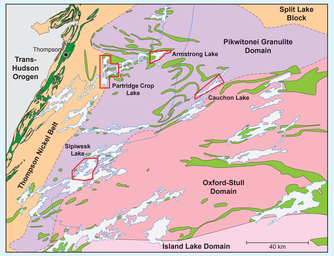
Mapping progress in the Pikwitonei Granulite Domain: updated tectonic model and economic considerations.

C.G. Couëslan

Regional geology

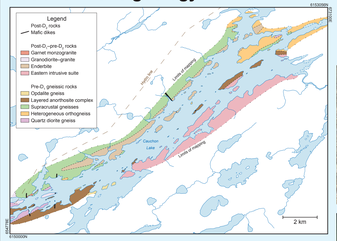


A project to re-map portions of the Pikwitonei Granulite Domain (PGD) with emphasis on protolith interpretation has been ongoing since 2012. The PGD is situated along the northwest margin of the Superior Province of Manitoba. It is bounded to the north and west by the Superior Boundary Zone, and to the southeast by the granite-greenstone belts of the Superior Province. The north and west boundaries are defined by the limit of tectonic and metamorphic overprint of the Paleoproterozoic Trans-Hudson Orogen, while the southeast boundary is defined by an orthopyroxene-in metamorphic isograd. The PGD is dominated by tonalitic gneiss with minor belts/domains of mafic granulite ±minor supracrustal rocks. Mapping has been conducted on Cauchon, Sipiwesk, Armstrong, and Partridge Crop lakes.

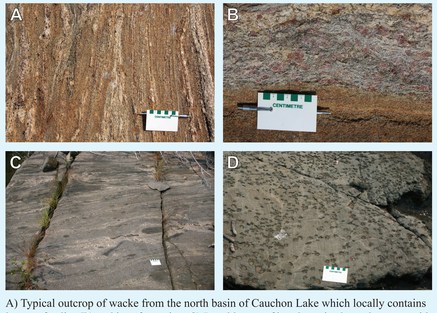
The oldest rocks in the PGD display an S_1 gneissosity. Gneissosity development was likely accompanied by M_1 metamorphic conditions of at least amphibolite-facies. M_1 metamorphism attained peak conditions of granulite-facies and resulted in the development of ubiquitous pods of orthopyroxene-bearing leucosome. The leucosome commonly transects S_1, and is in-turn folded by F_2 with well-developed S_2 quartz fabrics. This suggests D_2 post-dates, or occurred late during M_2. All Archean rocks in the PGD were affected by D_2 with the exception of rare, straight-walled granitic pegmatite dikes. Contrary to previous models which suggest a counter-clockwise P-T-t path and call for magmatic underplating or lithospheric delamination to drive metamorphism, textures observed in the field and in thin section suggest a clockwise P-T-t path as would be expected from crustal loading in a collisional environment.

Detrital zircon from sedimentary rocks on Sipiwesk Lake yielded dominant zircon populations at ca. 2900 and 2717 Ma, while ages of ca. 2721 and 2695 Ma were yielded by a wacke from Cauchon Lake and ca. 2695 Ma from a pelite on Partridge Crop Lake. Circa 2900 Ma is a period of known magmatism in the North Caribou terrane. Circa 2721–2717 Ma is similar to the timing of amalgamation of the North Caribou and Hudson Bay terranes. They could represent populations of metamorphic zircon related to the collisional event, or detrital material in syn-collisional sedimentary rocks. The populations at ca. 2696–2695 Ma are likely metamorphic and related to the D_2/M_2 event of the PGD. A tonalite on Sipiwesk Lake yielded a mean $^{207}Pb/^{206}Pb$ zircon age of ca. 2788 Ma, a known period of tonalite magmatism in the North Caribou terrane. A post-D_1, pre-M_2 enderbite from Cauchon Lake yielded a mean $^{207}Pb/^{206}Pb$ zircon age of ca. 2689 Ma, which is interpreted as the timing of intrusion. This age is in agreement with the study of Heaman et al. (2011) that suggests timings of ca. 2703–2692 Ma and ca. 2681–2672 Ma for M_1 and M_2, respectively.

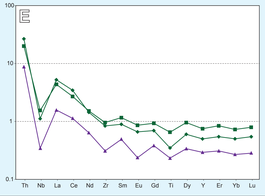
Cauchon Lake geology



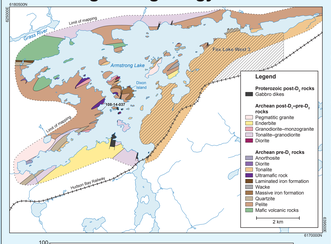
Intrusive rocks of a variety of ages occur on Cauchon Lake and consist of dioritic, tonalitic, and granodioritic bodies, as well as an anorthosite complex. Supracrustal rocks consist largely of wacke with local pelite, iron formation, and arc basalt. Boninitic volcanic rocks associated with iron formation and semipelite were also observed outside of the map area in the south basin of Cauchon Lake.



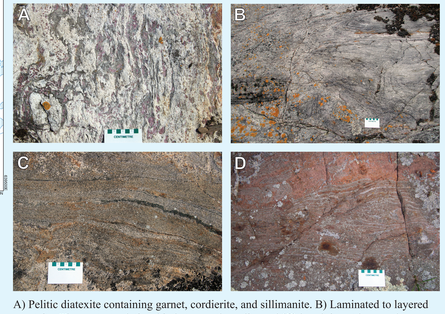
A) Typical outcrop of wacke from the north basin of Cauchon Lake which locally contains lenses of pelite (B) and iron formation. C) Local lenses of basalt are in sheared contact with the wacke. D) Olivine-phyric boninite from the south basin of Cauchon Lake (outside of map area). E) N-MORB-normalized trace-element patterns of basalt (green) and boninite (purple) are typical of arc magmatism.



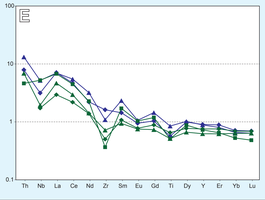
Armstrong Lake geology



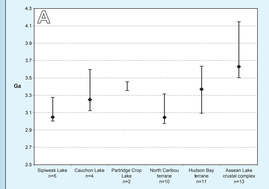
Intrusive rocks on Armstrong Lake consist of various ages of tonalite, granodiorite, and granite. Supracrustal rocks are dominated by pelite interbedded with quartzite and local wacke, arc basalt and iron formation. Dioritic and ultramafic rocks occur as lenses within the sediments, and it is uncertain if they represent flows or intrusions.

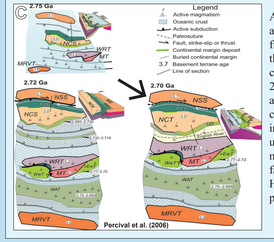


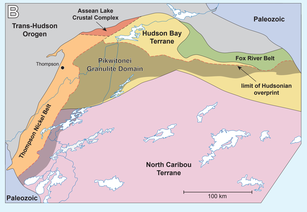
A) Pelitic diatexite containing garnet, cordierite, and sillimanite. B) Laminated to layered quartzite. The contact relationship between the pelite and (C) basalt is not known; however, lenses of dioritic rock similar to the basalt occur sporadically within the sedimentary rocks. D) Laminated, garnet-rich iron formation spatially associated with basalt. E) N-MORB-normalized trace-element patterns of the basalt (green) and diorite (blue) are similar and suggestive of an arc environment.



Tectonic model

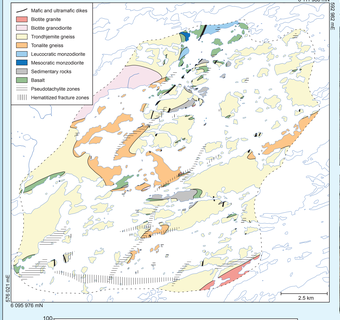




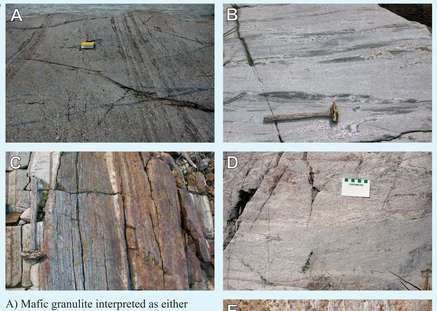


A) Neodymium model ages for rocks from the Sipiwesk Lake area are typical of the North Caribou terrane (B), while rocks from Cauchon and Partridge Crop lakes are older and typical of the Hudson Bay terrane. Model ages for the Assean Lake crustal complex and Hudson Bay terrane are from Böhm et al. (2000, 2003). C) An updated tectonic model for the PGD begins with amalgamation of the Hudson Bay and North Caribou terranes at ca. 2.72–2.71 Ga. The amalgamated terranes were then involved in a major collisional event from ca. 2.70–2.67 Ma with an unknown 'terrane' to the northwest (arrow). The high-grade metamorphism characteristic of the PGD could have been facilitated by the prior heating of the accreted North Caribou and Hudson Bay terranes during their amalgamation and the preceding arc magmatism.

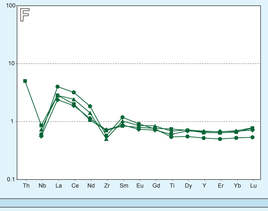
Sipiwesk Lake geology



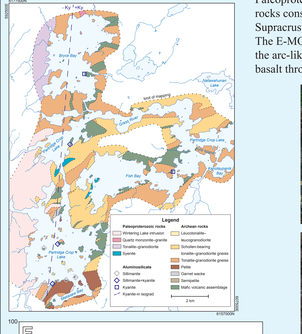
Mapping in central Sipiwesk Lake identified dominantly tonalitic and granodioritic intrusive rocks with minor monzodioritic and granitic intrusions. Supracrustal rocks consist of arc basalt, psammite, and wacke with lesser pelite and iron formation.



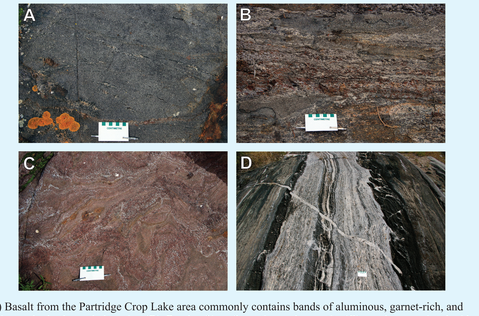
A) Mafic granulite interpreted as either metabasalt or metagabbro. B) Basalt with local bands of iron formation (C). D) Quartz-rich psammite with variable amounts of garnet. E) Garnet-bearing pelite with variable amounts of orthopyroxene and sillimanite ±cordierite. F) N-MORB-normalized trace-element patterns of basalts are typical of arc-related rocks. Pervasive partial melting/migmatization has likely resulted in thorium becoming mobile and concentrations are below detection limits in several samples.



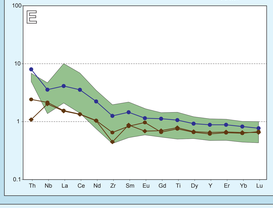
Partridge Crop Lake geology



The geology at Partridge Crop Lake is further complicated by at least two additional generations of Paleoproterozoic deformation and variable degrees of middle amphibolite-facies retrogression. Intrusive rocks consist of Archean tonalite and granodiorite, and Paleoproterozoic tonalite, granite and syenite. Supracrustal rocks are dominated by arc-like basalt with minor E-MORB basalt, pelite, and iron formation. The E-MORB basalt typically occurs as isolated lenses in tonalite and its temporal/spatial relationship to the arc-like basalt is not known. Bands of intense, pre-metamorphic hydrothermal alteration are present in basalt throughout the Partridge Crop Lake area.

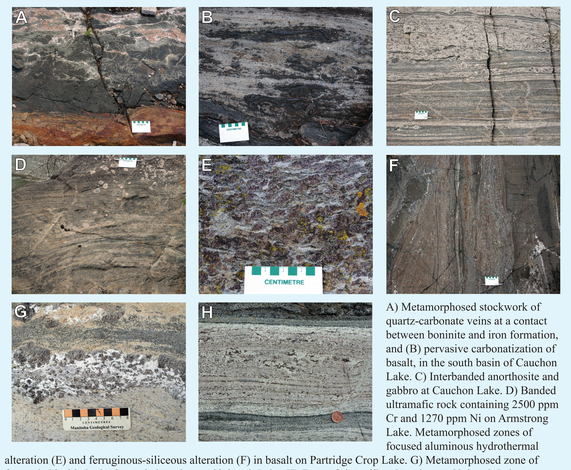


A) Basalt from the Partridge Crop Lake area commonly contains bands of aluminous, garnet-rich, and siliceous hydrothermal alteration (B). Bands of iron formation and garnetite (C) are also associated with the basalt. Sedimentary rocks are most common in the southern-most bay of the map area. D) Some sedimentary sequences include semipelite, calcsilicate, marble, iron formation, and sulphidic pelite, similar to the Ospwagan Group sequence of the Thompson Nickel Belt; however, their migmatitic texture and Nd-model age suggest that they are Archean. E) N-MORB-normalized trace-element patterns of basalt (green) and a possible syn-volcanic gabbro (blue) suggest an arc environment. The patterns of two isolated basalt samples (brown) are suggestive of E-MORB magmatism.



Economic considerations

Although the grade of metamorphism and degree of deformation in the PGD make mineral exploration difficult, VMS-, Au-, Ni-, and Sedex-deposits are known from granulite terranes world-wide including the Broken Hill deposit of Australia, the largest Pb-Zn deposit in the world. The occurrence of arc-type basalt associated with hydrothermal alteration and exhalative sedimentary rocks in all four study areas suggests a potential for both VMS and Au mineralization. Archean ultramafic rocks with elevated Cr and Ni on Armstrong and Partridge Crop lakes indicate a potential for magmatic Ni-Cu-PGE mineralization. The anorthosite complex on Cauchon Lake indicates a potential for Ti-V-Fe mineralization.



A) Metamorphosed stockwork of quartz-carbonate veins at a contact between boninite and iron formation, and (B) pervasive carbonatization of basalt, in the south basin of Cauchon Lake. C) Interbanded anorthosite and gabbro at Cauchon Lake. D) Banded ultramafic rock containing 2500 ppm Cr and 1270 ppm Ni on Armstrong Lake. Metamorphosed zones of focused aluminous hydrothermal alteration (E) and ferruginous-siliceous alteration (F) in basalt on Partridge Crop Lake. G) Metamorphosed zone of focused chloritic hydrothermal alteration on Sipiwesk Lake. H) Zone of skarn-like alteration on Sipiwesk Lake.

Acknowledgements

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