Manitoba Geological Survey
B.G.C.M. Series
Caribou River, NTS 54M, 1:250 000

MARGINAL NOTES

Regional setting

The Caribou River map sheet (NTS 54M), which lies on the south flank of the Hearne Province of the Rae-Hearne Archean craton, comprises Archean continental crust and Paleoproterozoic cover strata that have together been affected by varying degrees of Paleoproterozoic plutonism and thermotectonism. These rocks, which are part of the Trans-Hudson Orogen (Hoffman, 1990), have been termed collectively the 'Cree Lake Ensialic Mobile Zone' by Lewry et al. (1978), Lewry and Sibbald (1980) and Lewry and Collerson (1990). There are several local domains relatively unaffected by Hudsonian overprint. One of these, the Ennadai Block (Lewry et al., 1985), outcrops in the extreme northwest corner of Manitoba and extends north of the Caribou River map sheet into Nunavut.

The Cree Lake Ensialic Mobile Zone, which dominates the map area, has been regionally subdivided into six geological domains in Saskatchewan and Manitoba: the Mudjatik, Peter Lake (present only in Saskatchewan), Wollaston, Seal River, Great Island and Nejanilini domains. The domains are defined by their cover rocks, the proportion or absence of basement rocks, and their dominant structural trends. Two of these domains, the Nejanilini and Great Island, occur in the Caribou River map area. They are separated from accreted juvenile Paleoproterozoic terranes to the south by the Wathaman-Chipewyan batholithic belt, the remnant of a continental magmatic arc.

Lithological units

The Nejanilini Domain occupies most of the map sheet. It comprises mainly foliated Archean granitic and granitoid rocks. A 20 km wide zone at the south margin of the map area is underlain by metasedimentary and metavolcanic rocks of the Great Island Domain. Both the Nejanilini and Great Island domains are intruded by Paleoproterozoic plutons. Rocks of both the Nejanilini and Great Island domains contain middle to upper amphibolite-facies Paleoproterozoic metamorphic mineral assemblages produced during Hudsonian thermotectonism.

The **Nejanilini Domain** in the map area is dominated by Archean orthogneiss and foliated granitic rocks, with enclaves of migmatized supracrustal rocks. The principal rock type is a foliated, hypersthene-bearing monzocharnockite (unit **Zh**), which shows varying degrees of alkali metasomatism and contains widely scattered, discontinuous inclusions of hypersthene-bearing, intermediate to mafic gneiss (unit **En**) and garnet-biotite migmatite (unit **N**). Clark and Schledewitz (1988) referred to this complex of Archean rocks (units **Zh**, **En** and **T**x occurring on NTS 64P) as the Nejanilini granulite massif. A sample of the monzocharnockite yielded a Rb-Sr age of 2577 ±42 Ma, with an initial $^{87}Sr/^{86}Sr$ ratio of 0.7057 (Clark and Schledewitz, 1988).

The central part of the Caribou River map area comprises foliated grey tonalitic to granodioritic gneiss (unit **Tn**). This unit forms clusters of low, flat outcrops that are typically light grey to buff on weathered surface and greyish white to pink on fresh surface. West of the map area, unit **Tn** extends into Nunavut, where it is considered to be equivalent to the Archean Kasba grey gneiss (Eade, 1973; Loveridge et al., 1988). It is also likely equivalent to the grey tonalitic gneiss (unit **Tn**) in the Mudjatik Domain of the Kasmere Lake map area (NTS 64N). The Kasba grey gneiss, which has yielded U-Pb zircon ages of 3274 ±18 Ma and 2777 +95/–66 Ma (Loveridge et al., 1988), is likely of mixed origin.

Metasedimentary gneiss (unit **N**), which occurs as remnants and inclusions in the hypersthene-bearing monzocharnockite (unit **Zh**) and foliated tonalite and granodiorite (unit **Tn**), is of uncertain age despite lithological similarity to lower parts of the Paleoproterozoic Wollaston Group. This is because it locally contains granulite-facies mineral assemblages (cordierite+sillimanite, hypersthene+cordierite+sillimanite+garnet+biotite and hypersthene+garnet+biotite) that are more compatible with their granulite-facies Archean host than the middle to upper amphibolite-facies grade typical of Paleoproterozoic thermotectonism. In the absence of dates, the age of these enclaves of metasedimentary rocks remains uncertain (Eade, 1973; Weber et al., 1975b; Cummings and Scott,1976).

Large bodies of Paleoproterozoic medium- to coarse-grained granite (unit **G**), porphyritic granite (unit **Gp**) and lesser amounts of well-foliated biotite-magnetite granite gneiss (unit **G**b) make up the remainder of the Nejanilini Domain in the Caribou Lake map area. The presence of monzocharnockite (unit **Zh**) and garnet-biotite gneiss (unit **N**) inclusions and enclaves of gneissic tonalite (unit **Tn**) indicates that Archean rocks of the Nejanilini Domain formed the country rock prior to emplacement of these Paleoproterozoic intrusions. The Caribou Lake porphyritic quartz monzonite (unit **Gp**) has a Rb-Sr whole-rock isochron age of 1795 ±35 Ma (initial ratio 0.7084)). This age is considered to be a minimum age for crystallization, because Rb-Sr ages are consistently lower by 2–3% when compared to U-Pb zircon ages (Clark and Schledewitz, 1988). High $^{87}Sr/^{86}Sr$ initial ratios are characteristic of plutons in the Cree Lake zone. The Paleoproterozoic intrusions separate the Nejanilini Massif from the Great Island Domain.

The **Great Island Domain** comprises a lower succession of mainly volcanic and intrusive rocks, known as the Seal River volcanic rocks (unit **V**), and an unconformably overlying succession of metasedimentary rocks (units GI**Q**v and GI**P**), included in the Great Island Group (Schledewitz, 1986). An unconformable contact is inferred between these rocks because intrusive contacts in the Seal River volcanic rocks are truncated at their contact with the Great Island sedimentary sequence in the adjacent Nejanilini Lake map area (Manitoba Industry, Trade and Mines, 2002).

Rubidium-strontium radiometric ages, although far from definitive, indicate a possible Archean age for the Seal River volcanic rocks and a Paleoproterozoic age for rocks of the Great Island Group. A minimum age of 2052 ±41 Ma and an initial $^{87}Sr/^{86}Sr$ ratio of 0.7150 for a quartz-feldspar porphyry (unit **R**) that intrudes the Seal River metavolcanic rocks (NTS 64I) constrains the age of these volcanic rocks to Paleoproterozoic or older. In the Caribou River map sheet (NTS 54M), metavolcanic rocks form a narrow northeast-trending enclave, along the lower Seal River, within a granodiorite to porphyritic quartz diorite (unit **G**) that predates the Great Island Group sedimentary rocks. The metavolcanic rocks (unit **V**) comprise massive and pillowed basalt and andesite, interlayered tuffaceous rocks, lapilli tuff, siliceous sedimentary rocks and rhyolite to rhyodacite, all intruded by stocks of quartz-feldspar porphyry and gabbro.

Grey-green phyllite (unit GI**P**), with local occurrence of pyritic meta-argillite and overlain by quartzite and interlayered garnetiferous, pale green phyllite, outcrops as an outlier of the Great Island Group in the Caribou River map area. The grey-green phyllite is in contact with garnetiferous biotite metatexite and granodioritic diatexite (unit **G**) on the west side of the outlier and porphyritic quartz diorite (unit **G**) to the north and east. Primary layering in the rocks of the Great Island Group defines moderate closure folds about upright east-striking axial surfaces and moderate east-plunging axes. Available information suggests the structure to be the north end of a dumbbell-shaped, refolded and faulted, easterly-trending F_1 fold.

Grade of metamorphism in the Great Island Domain is defined by the mineralogy of the interlayered phyllite and quartz metasiltstone (unit GI**Q**). The mineral assemblage andalusite+chlorite+garnet+muscovite+biotite in phyllitic rocks of the basal Great Island Group at Great Island (NTS 64I) indicates lower to middle amphibolite-facies metamorphic conditions. Middle amphibolite-facies (low pressure and high temperature) metamorphism is defined by the mineral assemblage muscovite+cordierite+sillimanite+biotite, which occurs in outliers of the Great Island Group 100 km west of Great Island at Tadoule Lake (NTS 64J).

Relationships between the Hurwitz Group, Great Island Group, Wollaston Group and Seal River metavolcanic rocks

Between 2400 and 2100 Ma, Paleoproterozoic metasedimentary rocks and derived paragneiss of the Hurwitz Group, Great Island Group and Wollaston Group were deposited unconformably on Archean basement rocks of the Hearne Province. The Great Island Group (2100 Ma; Clark and Schledewitz, 1988) is interpreted to be the remnant of a cratonic basin, similar to one occupied by metasedimentary rocks of the coeval Hurwitz Group in Nunavut (2400–2100 Ma; Patterson and Heaman, 1991). The Hurwitz Group unconformably overlies the Archean Ennadai Lake metavolcanic belt.

The Great Island Group rocks display an abrupt change from cratonic-basin and platform sedimentation (silicate iron formation [unit GI**IF** on NTS 64P], dolomitic marble [unit GI**K** on NTS 64I] or an interlayered quartzite-phyllite sequence [unit GI**Q** on NTS 64P]) to deposition of an immature metagreywacke (unit GI**W** on NTS 64P). The timing of this change is uncertain but may coincide with continental rifting recorded in the Wollaston Group and the Hurwitz Group. The rifting event in the Hurwitz Group is constrained by U-Pb zircon and baddeleyite ages of 2094 +26/–17 Ma (Patterson and Heaman, 1991) from gabbro sills in the lower to middle Ameto Formation of the Hurwitz Group. This defines a minimum depositional age of ca. 2100 Ma for the lower to middle Ameto Formation. The Ameto and post-Ameto formations define a change from cratonic-basin sedimentation in the underlying Padlei and Kinga formations to a period of crustal subsidence and tectonic destabilization in the Hurwitz Group.

A minimum geological age of 2100 Ma has been established for the Wollaston Group by dating an igneous intrusion cutting rocks of the Courtenay Lake Formation of the Wollaston Group (Annesley et al., 1992). The date of 2076 ±3 Ma, interpreted to be an igneous crystallization age, was obtained from samples of mylonitic quartzofeldspathic gneiss in the rocks of the Courtenay Lake Formation. Courtenay Lake Formation conglomerate, arkose and quartzite are interlayered with mafic volcanic rocks characterized by within-plate lithogeochemistry, thus favouring emplacement in a continental-rift setting (Fossenier et al., 1995; MacNeil et al., 1997).

Economic geology

The North Caribou Lake area was flown at a line spacing of 5 km, using a high-sensitivity gamma-ray spectrometer, as part of the federal-provincial Uranium Reconnaissance Program (URP). This survey was carried out in 1975 and 1976 by the Geological Survey of Canada, with participation from Manitoba. The survey included concurrent lake-centre sediment sampling, with an approximate density of one sample per 13 km^2. Lake-sediment samples were analyzed for U, Zn, Cu, Pb, Ni, Co, Ag, Mn, Fe, Mo, As, Hg and loss-on-ignition.

The URP, which was intended to define broad regions with higher-than-average uranium contents, delineated such zones of uranium enrichment in the Kasmere Lake map area (NTS 64N) and, to a lesser extent, the Munroe Lake map area (NTS 64O). In the Caribou Lake map area (NTS 54M), airborne radiometric uranium and coincident potassium anomalies, with uranium greater than 2.8 ppm uranium equivalents (eU), coincide with areas of Paleoproterozoic porphyritic monzogranite (unit **Gp**), based on geological mapping by the Manitoba Mineral Resources Division subsequent to the release of the URP survey. Ground follow-up was also carried out by mining companies and the Geological Survey of Canada. This activity was summarized by Schledewitz (1986).

Indications of base- and precious-metal concentrations occur in the Seal River metavolcanic rocks and the unconformably overlying Great Island Group. Extensive exploration in the Seal River metavolcanic and igneous rocks on the Seal River, 66 km downstream from Great Island (NTS 54L and M), indicates the presence of volcanogenic massive sulphide–type mineralization. The Seal River metavolcanic rocks, forming a 5 km by 20 km domain, were the focus of a six-year exploration program by Manitoba Mineral Resources Ltd., initiated in 1972–1973. The investigation included airborne electromagnetic (EM) surveys and follow-up geological mapping, ground EM, trenching and diamond-drilling.

Gold mineralization in the Caribou River and adjacent map areas appears to have a multi-age history. Gold occurs in trace amounts in volcanogenic massive sulphides hosted by Seal River metavolcanic rocks. In addition, a younger, structurally controlled phase of gold mineralization is associated with iron formation in both the Seal River metavolcanic rocks and the overlying Great Island Group rocks. The structural control of the younger gold deposits is suggested by localization of gold mineralization along an easterly-trending shear zone at the northwest corner of Great Island (NTS 64I), and by a northeasterly-trending shear zone in Seal River metavolcanic rocks (NTS 54L and M).

Regional tectonic synthesis

Rocks of the Nejanilini Lake map area are part of the Trans-Hudson Orogen and were involved in the Paleoproterozoic tectonics and thermotectonism that dominated this orogen. Rocks of the area evolved as a terrane of Archean basement and Paleoproterozoic sedimentary basins that constituted the foreland zone of the Ray-Hearne craton.

The Trans-Hudson Orogen extends for approximately 5000 km from the north-central United States, through the Churchill Province in Canada and ultimately to Greenland (Lewry and Collerson, 1990). In Manitoba and Saskatchewan, two major elements of the Trans-Hudson Orogen, the Cree Lake Ensialic Mobile Zone of the Archean Hearne Province and the juvenile Paleoproterozoic arc-related terranes, are separated by the Andean-type Wathaman-Chipewyan continental magmatic arc. The latter has a minimum strike length of 900 km and a width of 15 to 150 km.

Radiometric dating of pre-Hudsonian rocks

Radiometric dating has allowed delineation of Archean to Paleoproterozoic pre-Hudsonian sedimentary and igneous rocks that were subsequently involved in several discrete tectonic events resulting from multistage subduction and collision processes.

Pre-Hudsonian sedimentation:

- The Kinga and Padlei formations of the Montgomery Group and Hurwitz Group, and the overlying Ameto Formation (Nunavut) range in age from 2400 to 2100 Ma (Patterson and Heaman, 1991) and possibly represent cratonic-basin sedimentation (Aspler and Bursey, 1990).
- The Courtenay Lake Formation of the Wollaston Group (Saskatchewan), with a minimum age of 2100 Ma (Annesley et al., 1997), unconformably overlies garnet-biotite gneiss (age uncertain).
- Wollaston Group calcsilicate rocks (Manitoba) overlie garnet-biotite gneiss (age uncertain).
- Pre-Hudsonian mafic igneous and volcanic rocks have a geochemistry that favours a continental-rift setting.
- Mafic sills and flows, dated at 2094 +26/–17 Ma (Patterson and Heaman, 1991), intrude the lower Ameto Formation and underlying Kinga Formation of the Hurwitz Group (Nunavut).
- Mafic pillowed and massive flows in the Courtenay Lake Formation (Saskatchewan) have a minimum age of 2100 Ma (Fossenier et al., 1995; Annesley et al., 1997). This mafic igneous activity at ca. 2100 Ma may be related to opening of the Manikwan Sea (Aspler and Bursey, 1990; Patterson and Heaman, 1991).
- Synorogenic magmatism, as early as 1.91 Ga and related to the Trans-Hudson Orogen, was reported by Baldwin et al. (1987) in felsic volcanic rocks at Lynn Lake.

Hudsonian collisional tectonics

Incorporation of the entire Paleoproterozoic cover sequence, the juvenile synorogenic volcanic and intrusive rocks, and the Archean 'basement' into the Trans-Hudson Orogen:

- Early arc-continent collision possibly occurred at 1888 to 1860 Ma (Bickford et al., 1990).
- Deformation occurred in cratonic-basin and passive-margin (?) successions, forming fold and thrust belts, including overthrusting of foredeep deposits (?).
- Deformation and metamorphism occurred in the Rottenstone Domain (Saskatchewan; minimum age 1867 ±8 Ma on synkinematic tonalitic gneiss that postdates some phases of deformation [Lewry et al., 1987]).
- Accretion added a complex collage of Paleoproterozoic volcanic island-arc, back-arc to ocean-floor rocks and intrusive rocks (Rottenstone Domain and La Ronge belt in Saskatchewan and Southern Indian, Lynn Lake and Leaf Rapids domains in Manitoba) to the Rae-Hearne craton, possibly via southeast-directed subduction (Bickford et al., 1990).
- Emplacement of the Wathaman-Chipewyan plutonic complex occurred between 1865 and 1855 Ma (Van Schmus and Schledewitz, 1986; Meyer et al., 1992), possibly as a continental-margin magmatic arc related to a northerly subduction flip. This magmatic arc lies between the Archean Rae-Hearne craton and an accreted terrane consisting of the Rottenstone Domain, the Southern Indian Domain and the La Ronge and Lynn Lake greenstone belts. The magmatic arc effectively stitched together the craton and the Paleoproterozoic accreted-arc terranes.

Continent-continent collision, deformation and emplacement of nappe sheets (1830–1800 Ma; Bickford et al., 1990):

- At 1855 to 1800 Ma (Stauffer and Lewry, 1993), the northwestern margin of the Wathaman-Chipewyan magmatic arc was deformed along the Needle Falls Shear Zone (an oblique collision structure), along its boundary with the Wollaston Domain and along shear zones at the boundary with the Peter Lake Complex (Reindeer Lake, Saskatchewan).
- At ca. 1820 to 1812 Ma, the Wollaston Group, the underlying Archean basement and the early-formed Hudsonian intrusions were affected by peak thermal metamorphism (Annesley et al., 1997) that was synchronous with the age of peak metamorphism in the internal juvenile zone of the Trans-Hudson Orogen.

Late- to postcollisional deformation:

- Ductile-brittle deformation continued along the Needle Falls Shear Zone and the mostly sheared boundary of the Peter Lake Complex (Ray and Wanless, 1980; Van Schmus et al., 1987).
- Folds tightened and ductile-brittle shearing occurred in the Wollaston and Mudjatik domains.
- Northeast-, north- and east-trending ductile-brittle shear zones were superimposed on the east-trending structures of the Wathaman-Chipewyan magmatic arc, Seal River Domain and Nejanilini Domain.
- Postcollisional granite bodies (1753 +3/–2 Ma; Loveridge et al., 1987), characteristically fluorite bearing and with rapakivi texture and high uranium background, occur most commonly in parts of the Hearne Province where negative gravity anomalies exceed –60 mGal (Schledewitz, 1986).

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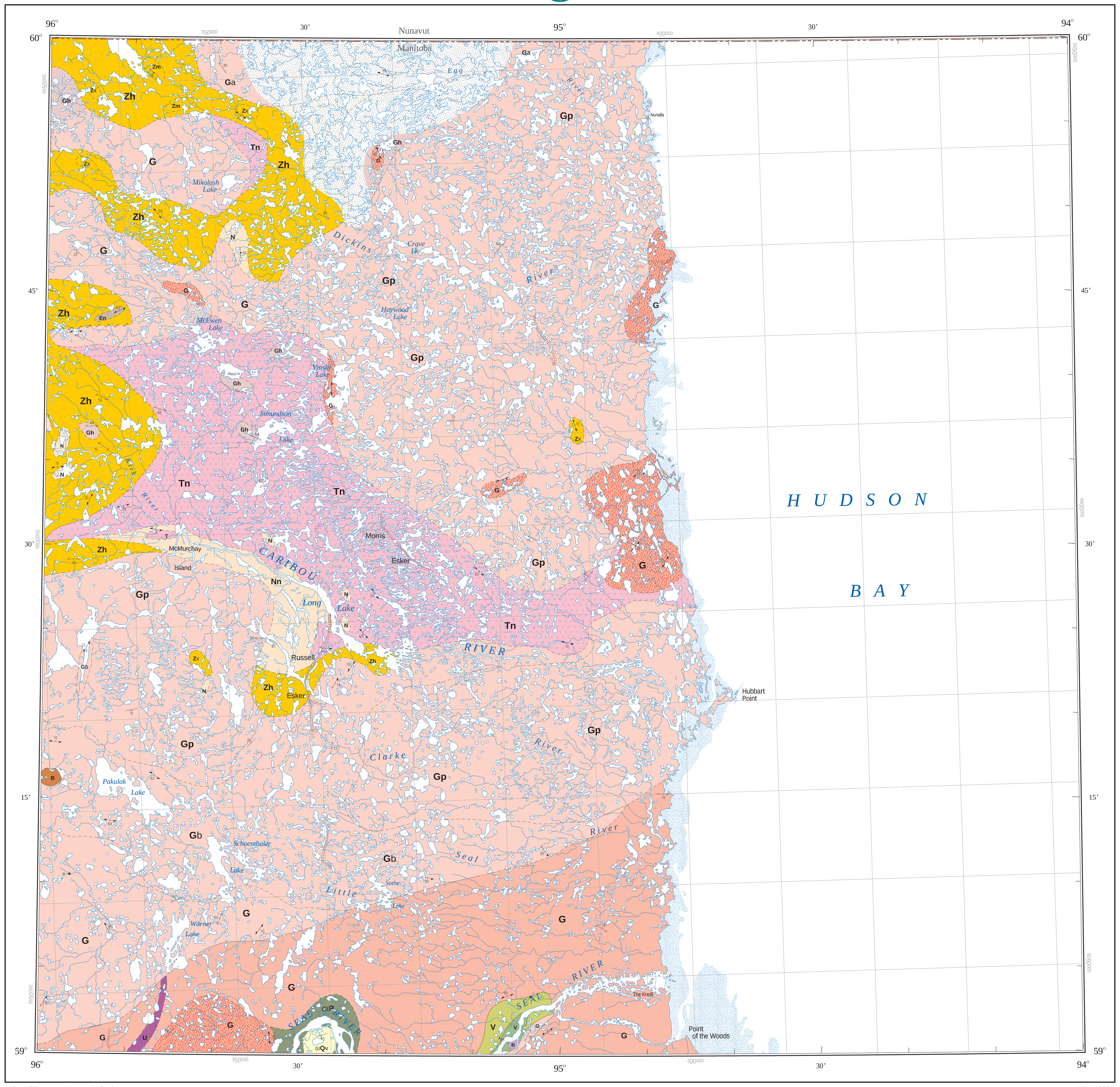


Universal Transverse Mercator Projection
Zone 15 North American Datum 1983

Printed 2005

Scale 1:250 000
Kilometres 5 0 5 10 15 20 25 Kilometres

LEGEND

NEJANILINI DOMAIN

Proterozoic

Hudsonian

Unit	Description
G	Granite; **Gp** - pink porphyritic granite; **G**a - pink porphyritic granite with amphibolite; **G**b - granite gneiss, + biotite + magnetite
Gh	Hybrid granite
T	Tonalite, cordierite bearing, ± tourmaline
B	Metagabbro, in part noritic; metabasic rocks
N	Semipelitic paragneiss to metatexite, + garnet; **Nn** - with tonalite, cordierite bearing

Archean

Unit	Description
G	Granodiorite diatexite to biotite metatexite, ± garnet
Tn	Grey tonalitic to granodioritic gneiss and foliated to lineated biotite granodiorite to tonalite
En	Hypersthene gneiss
Zx	Hypersthene granite (monzocharnockite); **Zh** - with hybrid granite; **Zm** - hypersthene granite and hypersthene gneiss

GREAT ISLAND DOMAIN

Proterozoic

Hudsonian

Unit	Description
G	Granite, massive to foliated, ± aplite ± pegmatite

Great Island Group

Unit	Description
GIQv	Quartzite and interlayered pale green phyllite to biotite-muscovite schist, ± garnet
GIP	Grey to grey-green phyllite, ± andalusite ± biotite poikiloblasts and black pyritic meta-argillite and black acicular amphibole-garnet

Seal River Intrusive Rocks

Unit	Description
U	Ultramafic and serpentinite
B	Gabbro
G	Granodiorite to porphyritic quartz diorite

Proterozoic and/or Archean

Seal River Volcanic Rocks

Unit	Description
V	Interlayered tuff and pillowed andesite (probably Archean)
V	Andesite and minor basalt

Archean

Unit	Description
G	Granodiorite diatexite to biotite metatexite, ± garnet

SYMBOLS

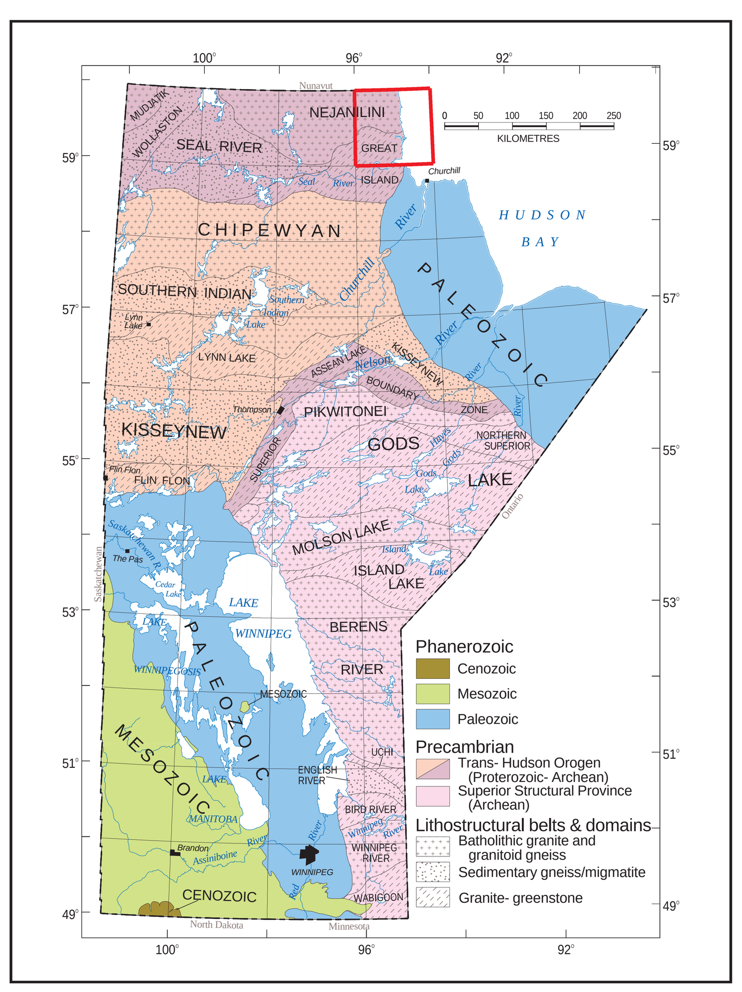
- Geological boundary (approximate, interpreted)
- Fault (defined, interpreted)
- Shear zone boundary
- Bedding, tops known (inclined, vertical, overturned)
- Metamorphic layering (inclined, vertical, amount of dip unknown)
- Igneous layering, tops unknown (inclined, amount of dip unknown)
- Gneissosity (inclined, vertical, amount of dip unknown)
- Schistosity (inclined, vertical, amount of dip unknown)
- Cataclastic foliation (inclined)
- Mineral lineation (inclined, plunge indicated)
- Minor fold axis (inclined, plunge indicated)
- Minor fold axial plane (inclined, dip indicated)
- Minor fold symmetry (Z-shaped, S-shaped, symmetrical)
- Domain boundary
- Area of little or no Precambrian outcrop
- Esker

BEDROCK GEOLOGY COMPILATION MAP SERIES

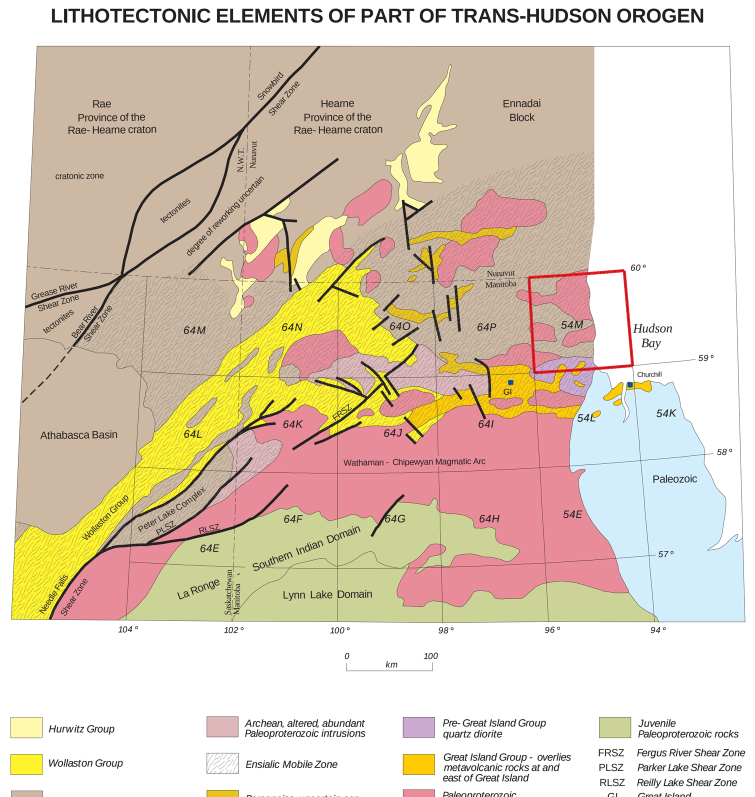
CARIBOU RIVER

NTS 54M

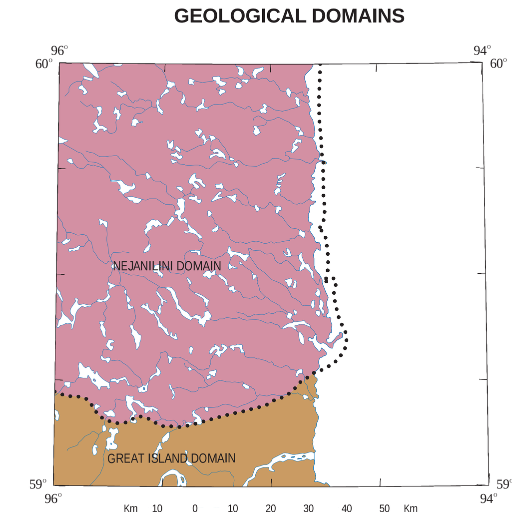
PRINCIPAL GEOLOGICAL DOMAINS



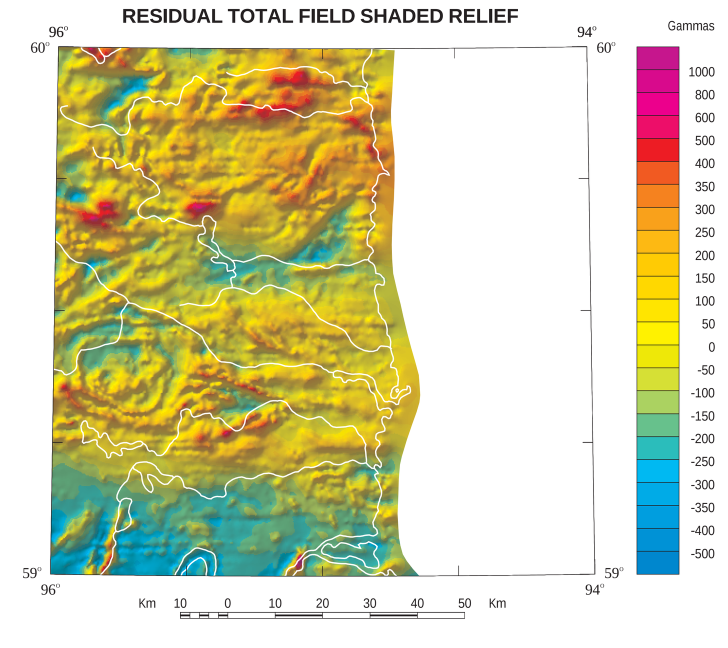
LITHOTECTONIC ELEMENTS OF PART OF TRANS-HUDSON OROGEN



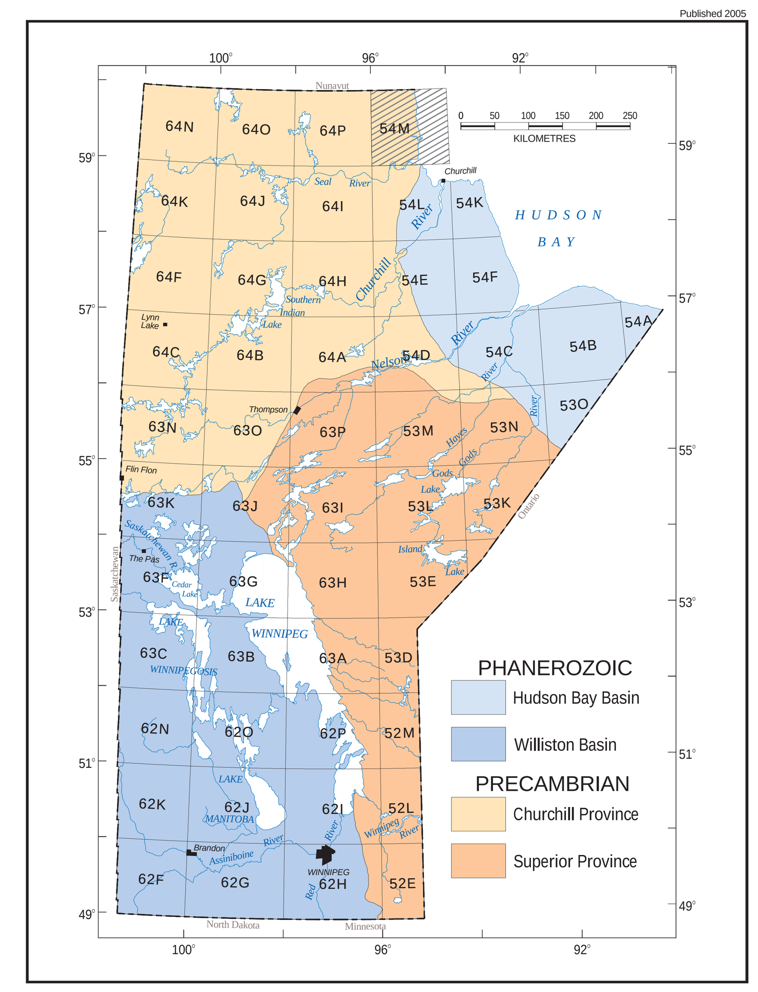
GEOLOGICAL DOMAINS



RESIDUAL TOTAL FIELD SHADED RELIEF



INDEX MAP AND MAJOR TECTONIC DIVISIONS



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