of 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 Nejanilini Lake 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),

The Nejanilini Lake map sheet (NTS 64P) lies on the south flank of the Hearne Province of the Rae-Hearne Archean craton that extends into Nunavut and Saskatchewan (Fig. 1). Hearne Province rocks in the map area consist largely

Wollaston, Seal River, Great Island and Neianilini domains, The domains are defined by their cover rocks, the proportion or absence of basement rocks, and their dominant structural trends. Three of these domains, the Nejanilini, Seal River and Great Island, occur in the Nejanilini Lake 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.

# The Nejanilini Domain occupies most of the map sheet. It comprises mainly foliated Archean granitic and granitoid

Regional setting

rocks. The remainder of the map area, south of the Nejanilini Domain, is underlain by the metasedimentary and metavolcanic rocks of the Seal River and Great Island domains. All three domains are intruded by Paleoproterozoic plutons. The basement and cover rocks both 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,

iscontinuous inclusions of hypersthene-bearing, intermediate to mafic gneiss (units En and Tx). Clark and

Schledewitz (1988) referred to this complex of Archean rocks (units Zh, En and Tx) as the Nejanilini granulite

massif. A sample of the monzocharnockite yielded a Rb-Sr age of 2577±42 Ma, with an initial 8 Sr/8 Sr ratio of 0.7057 (Clark and Schledewitz, 1988). West of Nejanilini Lake, the Nejanilini Domain 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. 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. Segments and remnants of an east-trending belt of metasedimentary gneiss of uncertain age occur within the liated tonalite and granodiorite (unit **Tn**) on the west side of Nejanilini Lake, and within monzocharnockite (unit **Z**h) on the east side of the lake. This undated sequence of semipelitic biotite gneiss (unit N), calc-silicate and marble (unit **K**), and quartzite (unit **Q**) is lithologically similar to lower parts of the Wollaston Group, suggesting it may be Paleoproterozoic in age and lie unconformably on the grey tonalite (unit  ${f Tn}$ ) and monzocharnockite (unit  ${f Z}$ h). However, the metasedimentary rocks locally contain granulite-facies mineral assemblages (cordierite+sillimanite. hypersthene+cordierite+sillimanite+garnet+biotite and hypersthene+garnet+biotite), which are more compatible with their granulite facies Archean host. It is also possible, however, that these granulite-facies mineral assemblages were produced during Hudsonian thermotectonism at temperatures and pressures slighly above the typical Paleoproterozoic middle to upper amphibolite facies grade. In the absence of dates, the age of these

enclaves of metasedimentary rocks will remain uncertain (Eade, 1973; Weber et al., 1975b; Cummings and

The western boundary of the Nejanilini granulite massif (unit **Z**h) coincides with the Wolverine River fault system. This boundary, extending from Little Duck Lake southeast to Barr Lake, corresponds with a pronounced, striped, linear magnetic pattern approximately 12 km wide and 42 km long. A paucity of bedrock exposures in the latter area leaves the cause of this pronounced magnetic pattern indeterminate. Regional foliations in this region parallel the agnetic pattern, as do a series of elongate amphibolite exposures near Neianilini Lake. The southern contact of the massif with younger rocks of the Seal River and Great Island domains is occupied by a zone of Paleoproterozoic granitic rocks. These younger granitic plutons are also present throughout the Nejanilini massif, forming discrete intrusions with broad potassium feldspar alteration haloes (Clark and Schledewitz, 1988). The zones of alteration are mappable as a colour change from the characteristic greenish brown of the unaltered monzocharnockite to pink on the margins of Paleoproterozoic granitic intrusions.

The **Seal River Domain** in the Nejanilini Lake map area is dominated by muscovite-garnet-biotite gneiss (unit w**N**) that contains an easterly-trending foliation. Also present are minor amounts of impure quartzite (unit wQ), biotitefeldspar gneiss (unit wNb), quartz porphyry (R), biotite psammite gneiss (wSb) and marble (unit wK). The muscovite-garnet-biotite gneiss (unit wN) has tentatively been placed in the Wollaston Group because of its similarity to the basal Wollaston Group garnet-biotite gneiss (unit w**N**, present west of the map area). However, the exact relationship of this unit to rocks of the Wollaston Group to the west remains uncertain, as contacts are either not exposed or obscured by abundant Paleoproterozoic intrusive rocks (units **G**, **G**h and **T**).

Metamorphism in the muscovite-bearing quartzofeldspathic biotite gneiss (unit wN) ranges from middle to upper amphibolite facies and is characterized by assemblages containing muscovite±cordierite±sillimanite+biotite, plus plagioclase and potassium feldspar. In the Seal River Domain, the Archean granitic basement has been altered during this Paleoproterozoic thermotectonic event to a hybrid lithology that comprises foliated, medium- to coarsegrained monzogranite, foliated biotite monzogranite and altered hypersthene-bearing monzocharnockite within areas of a pink aplitic rock (unit Gh). The pink aplite is localized along the tectonized, altered and recrystallized boundary zone between the reworked Archean basement of the Seal River Domain and the better preserved

Archean rocks of the Nejanilini Domain.

Lake metavolcanic belt.

Metavolcanic rocks (V) and amphibolite (A) occur at the eastern end of the Seal River Domain and at the western end of the contiguous Great Island Domain. In the Seal River Domain, the volcanic rocks are an areally minor component and bear an uncertain relationship to the Seal River metasedimentary rocks (units wN and wQ). In the adjacent Great Island Domain, similar metavolcanic rocks lie unconformably beneath metasedimentary rocks. The Great Island Domain comprises a lower succession of mainly volcanic and intrusive rocks, the Seal River volcanic rocks, and an unconformably overlying succession of metasedimentary rocks, the Great Island Group (Schledewitz, 1986). The unconformable contact is inferred because intrusive contacts in the Seal River volcanic rocks are truncated at their contact with the overlying Great Island sedimentary sequence. 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 <sup>87</sup>Sr/<sup>86</sup>Sr ratio of 0.7150 for a quartz-feldspar porphyry (unit **R**) that intrudes the Seal River metavolcanic rocks (NTS 64I) onstrains the age of these volcanic rocks to Paleoproterozoic or older. Although a model for the temporal evolution of <sup>87</sup>Sr in the quartz-feldspar porphyry has been interpreted to be more consistent with a late Archean age than an early Proterozoic age (Clark and Schledewitz, 1988), the high <sup>87</sup>Sr/<sup>86</sup>Sr ratio for this age could be due to contamination by Archean material. The Paleoproterozoic age of the Great Island Group is based on the Rb-Sr dating of samples of quartzite and metagreywacke of the Great Island Group. Modelling the Rb-Sr isotopic data

The thickest and most complete depositional record of the Great Island Group and the underlying Archean volcanic rocks occurs at Great Island on the Seal River (NTS 64I). The metavolcanic rocks at Great Island form the lower part of a structural basin that is 30 km wide (west to east) and 50 km long (north to south). The northern part of the basin lies along the southern margin of this map area and the remainder lies to the south in the Shethanei Lake map area (NTS 64I). In the Nejanilini Lake map area, the metavolcanic rocks are mainly massive and pillowed andesite, with interlayered lapilli tuff and minor occurrences of basalt (unit V). The metavolcanic rocks, which contain two lenses of conglomerate (unit **C**) composed of clasts derived from volcanic rocks, are intruded by gabbro (unit **B**) and, to the south in NTS 64I, by stocks of quartz-feldspar porphyry (unit **R**). Similar metavolcanic rocks occur along the lower Seal River, in the Caribou Lake (NTS 54M) and Churchill (NTS 54L) map areas.

onstrains the time of sedimentation to between 2100 and 2000 Ma (Clark and Schledewitz, 1988).

In this map area, the basal units of the overlying Great Island Group are protoquartzite to quartzite and interlayered grey-green phyllite (unit GiQ), overlain by a discontinuous unit of garnet-amphibole-magnetite iron formation (unit GIF), which pinches out to the north. These rocks are overlain by a light grey lithic metagreywacke (unit GIW). The uppermost rock type is a dark grey metasiltstone and interlayered meta-argillite (unit GIS). This lithostratigraphy was described in detail by Schledewitz (1986). Metamorphic mineral assemblages in phyllite and quartz metasiltstone of the Great Island Group record an

increase in the grade of regional metamorphism from east to west. Upper greenschist facies mineral assemblages occur in Great Island Group metasedimentary rocks east of Great Island and at the town of Churchill. The mineral assemblage andalusite+chlorite+garnet+muscovite+biotite in phyllitic rocks of the basal Great Island Group at Great Island indicates upper greenschist to lower amphibolite facies metamorphic conditions. Andalusite-bearing assemblages within underlying Seal River volcanic-derived schist at the northwest corner of Great Island in the Shethanel Lake map area (NTS 64I) indicate a similar grade of metamorphism. Middle amphibolite facies mineral assemblages (muscovite+cordierite+sillimanite+biotite) are present 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 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

formation [unit GIF], dolomitic marble [unit GIK] or an interlayered quartzite phyllite sequence [unit GIQ]) to deposition of an immature metagreywacke (unit clW). The timing of this change is uncertain but may coincide with tectonic destabilization in the Hurwitz Group.

The Great Island Group rocks display an abrupt change from cratonic basin and platform sedimentation (silicate iron

# **MARGINAL NOTES**

Economic geology

The Nejanilini Lake area was flown on 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 lakecentre sediment sampling, with an approximate density of one sample per 13 km<sup>2</sup>. 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 containing higher-than-average uranium contents, lelineated such zones of uranium enrichment in the Kasmere Lake map area (NTS 64N) and, to a lesser extent, the Munroe Lake map area (NTS 640). In the Nejanilini Lake map area, airborne radiometric uranium and coincident potassium anomalies with uranium greater than 2.8 ppm uranium equivalents (eU) occur along the east side of the map area, north and south of Caribou Lake. Lake sediment values of 200 to 500 ppm U coincide with one of the airborne anomalies immediately south of Caribou Lake. The uranium and potassium anomalies coincide with areas of Paleoproterozoic monzogranite, according to subsequent geological investigations by Soonawala (1980) and Schledewitz (1986).

Indications of base- and precious-metal concentrations are confined to 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 lcanogenic massive sulphidetype mineralization. The metavolcanic belt (measuring 5 km by 20 km) was the focus of a 6-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. The metavolcanic rocks farther west at Great Island are very similar to those along the lower Seal River but have been underexplored due to the presence of the overlying metasedimentary rocks of the Great Island Group (Schledewitz, 1986).

Gold mineralization in the Nejanilini 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 s 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

# Regional tectonic synthesis

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 Andeantype Wathaman-Chipewyan continental magmatic arc. The latter has a minimum strike length of 900 km and a width

Rocks of the Nejanilini Lake map area are part of the Trans-Hudson Orogen and were involved in the

# 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:

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 cratonicbasin sedimentation (Aspler and Bursey, 1990).

et al., 1997), unconformably overlies garnet-biotite gneiss (age uncertain). Wollaston Group calc-silicate rocks (Manitoba) overlie garnet-biotite gneiss (age uncertain). Pre-Hudsonian mafic igneous and volcanic rocks with 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

The entire Paleoproterozoic cover sequence, the juvenile synorogenic volcanic and intrusive rocks, and the Archean 'basement' were incorporated into the Trans-Hudson Orogen as follows: Possible early arc-continent collision 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.,

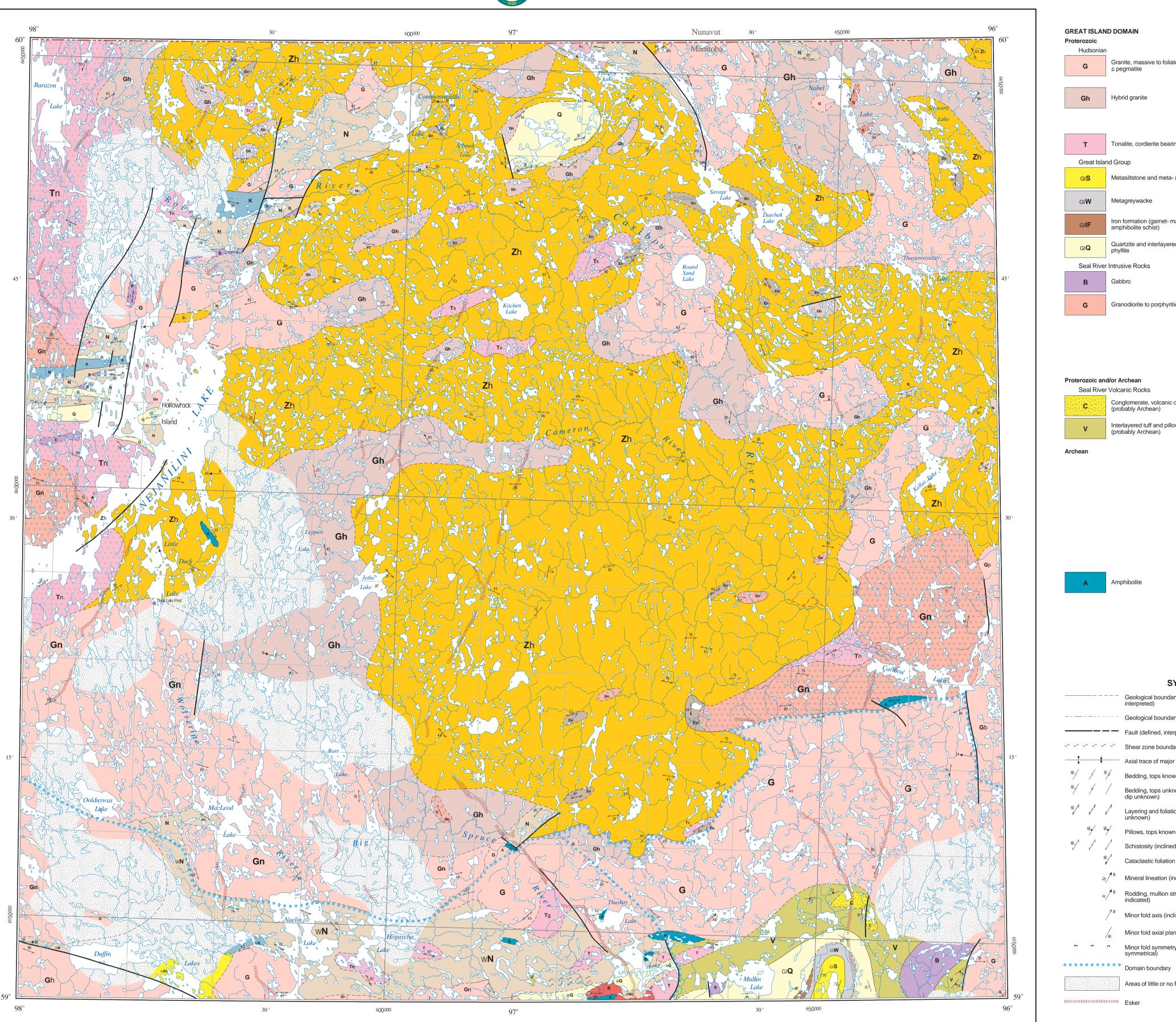
Emplacement of the Wathaman-Chipewyan plutonic complex between 1865 and 1855 Ma (Van Schmus and Schledewitz, 1986; Meyer et al., 1992), possibly as a continental-margin magmatic arc related to a northerly subduction flip. This magmatic arc lies between the Archean Rae-Hearne craton and an accreted terrane 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.

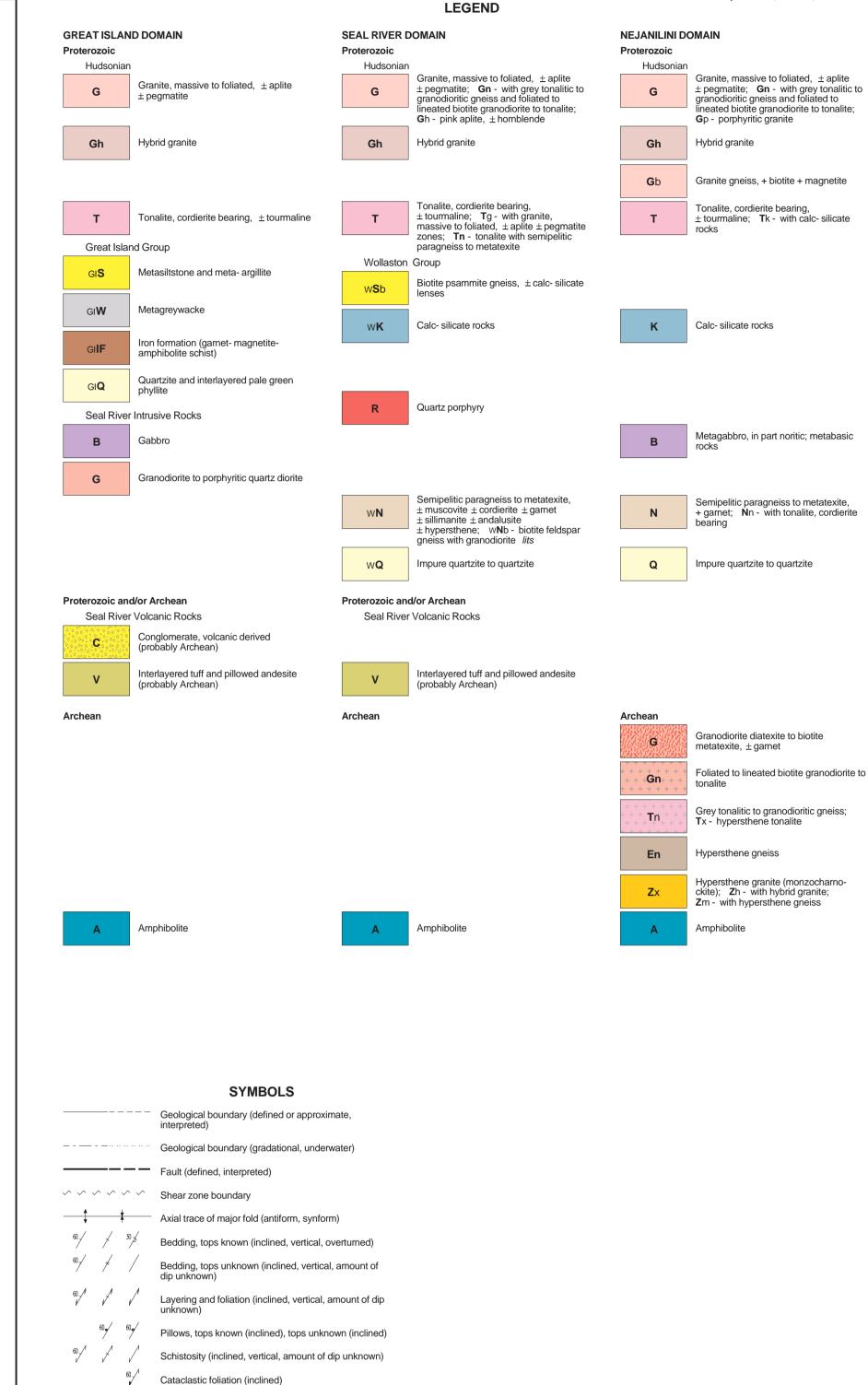
Continent-continent collision, deformation and emplacement of nappe sheets (1830-1800 Ma; Bickford et al., At 1855 to 1800 Ma (Stauffer and Lewry, 1993), the northwestern margin of the Wathaman-Chipewyan magmatic arc was deformed along the Needle Falls Shear Zone (an oblique collision structure), along its boundary with the

Wollaston Domain and along shear zones at the boundary with the Peter Lake Complex (Reindeer Lake, 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.

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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### 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

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).

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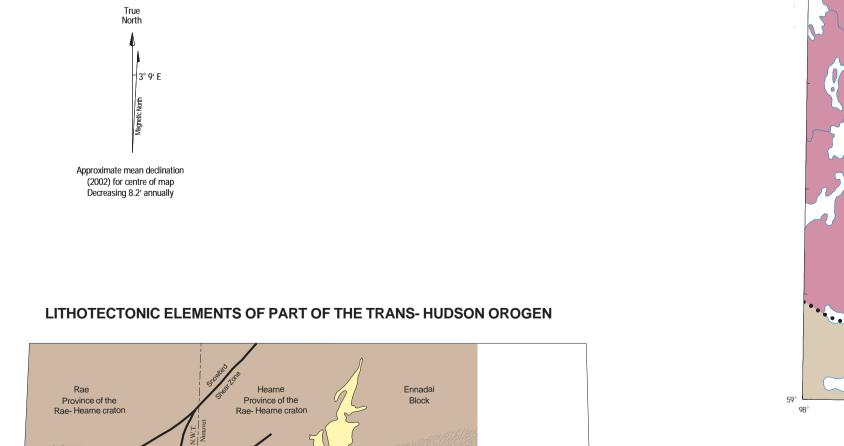
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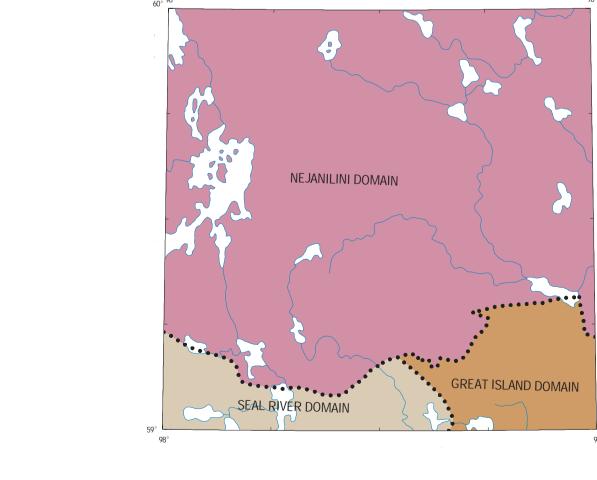
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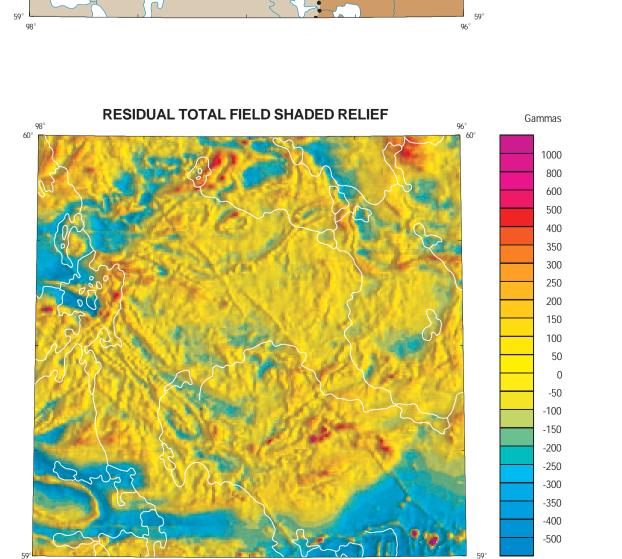
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# BEDROCK GEOLOGY COMPILATION MAP SERIES **NEJANILINI LAKE**

NTS 64P

Synoptic geology by D.C.P. Schledewitz

GIS Cartography by L. Chackowsky

Manitoba Industry, Trade and Mines

scale 1:250 000.

Manitoba Industry, Trade and Mines

Manitoba Geological Survey

Suggested reference:

Mineral lineation (inclined - plunge indicated)

<sup>30</sup> Rodding, mullion structure (inclined - plunge

Minor fold axis (inclined - plunge indicated)

Areas of little or no Precambrian outcrop

Minor fold symmetry (Z- shaped, S- shaped,

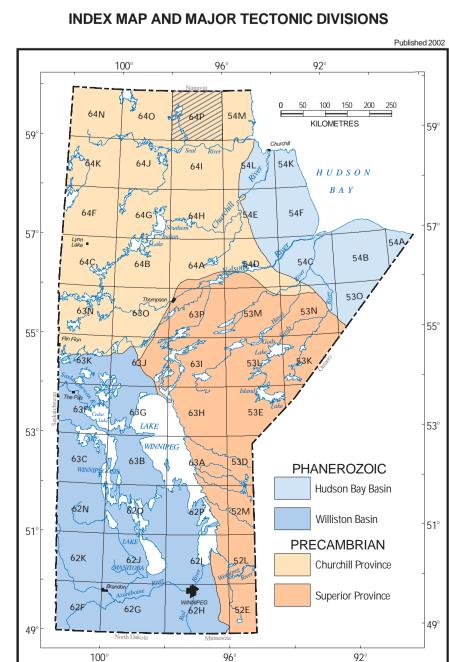
Minor fold axial plane (inclined - dip indicated)

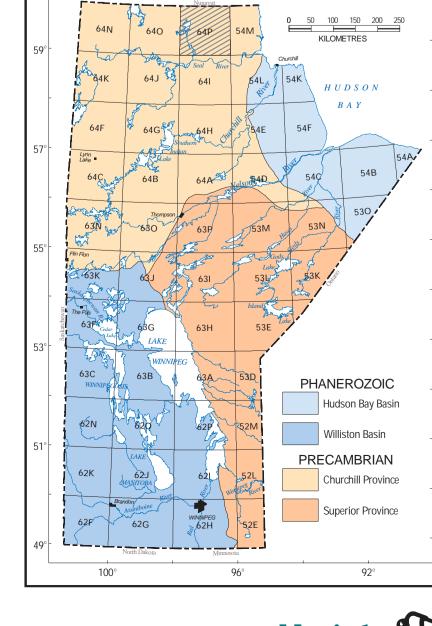
Compilation by D.C.P. Schledewitz and D. Lindal

Digital CAD drafting B. Lenton and M. McFarlane

2002: Nejanilini Lake; Manitoba Industry, Trade and Mines, Manitoba

Geological Survey, Bedrock Geology Compilation Map, NTS 64P,





# HUDSON

Every possible effort has been made to ensure that the information presented on this map is accurate.

for any errors that may occur. References are included for users wishing to verify information.

However, the Province of Manitoba and Manitoba Industry, Trade and Mines do not assume liability

ithostructural belts & domains

Sedimentary gneiss/migmatite

Batholithic granite and

granitoid gneiss

Granite-greenstone

PRINCIPAL GEOLOGICAL DOMAINS

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Juvenile Paleoproterozoic rocks FRSZ Fergus River Shear Zone

Paragneiss, uncertain age

PLSZ Parker Lake Shear Zone RLSZ Reilly Lake Shear Zone