MARGINAL NOTES

PRECAMBRIAN

The Knee Lake area (NTS 53M) is underlain by rocks of the Precambrian Shield. The Archean Superior Province in the south is flanked by the Churchill - Superior Boundary Zone to the north and the Proterozoic Churchill Province to the northeast. Glacial deposits, up to 50 m thick in the northeast, conceal over 50% of the bedrock.

SUPERIOR PROVINCE

Superior Province Archean rocks in the Knee Lake area are sudivided into the Pikwitonei granulite and the Gods Lake granite-greenstone domains. The contact between the two domains is defined as the orthopyroxene isograd (Weber and Scoates, 1978) of 2.7-2.65 Ga prograde metamorphism (Mezger *et al.*, 1990).

The Pikwitonei domain comprises granulite-facies metaplutonic and minor supracrustal rocks. Metaplutonic rocks are enderbitic gneisses (**En**) that represent granulite grade equivalents of tonalitic rocks in the Gods Lake domain (see below), and commonly contain mafic inclusions. The supracrustal rocks are orthopyroxene-bearing amphibolites (**A**x) with local preservation of pillow structures (*e.g.* northeast of High Hill Lake). Porphyritic granodiorite (**Gp**) at Diana Lake appears to be a lower grade enclave not overprinted by regional granulite facies metamorphism.

The Gods Lake domain in NTS 53M comprises granitoid rocks and older small greenstone belts. An abundance of greenstone lenses in granitoid rocks suggests that the extent of the supracrustal rocks was considerably larger prior to the emplacement of these intrusions.The greenstones make up the following belts:

1) Oxford Lake - Knee Lake
2) Atik Lake
3) High Hill Lake

Tonalite (B**T**) and granodiorite (B**G**) of the Bayly Lake complex are the predominant rock types of the Gods Lake domain in NTS 53M. These rocks intrude all of the greenstone belts along their margins. Granodioritic gneiss south of Atik Lake contains inclusions of migmatitic biotite gneiss (H**N**) that represents granitized mafic volcanic rocks. This unit also occurs along the southern margin of the Atik Lake belt, where it forms a transition from the greenstone belt to the Bayly Lake granitoid rocks. At Bigstone Lake leucogranite (B**Gl**) is also found at this contact.

The northern margin of the Oxford Lake - Knee Lake belt is exposed on the north arm of Knee Lake in the southeast portion of NTS 53M, and at Semple Lake in the southwest of the map area. The supracrustal rocks are part of the Hayes River Group. They consist dominantly of mafic metavolcanic rocks (H**V**, H**Vp**) with subordinate felsic metavolcanic rocks (H**V**f) and metasedimentary rocks (conglomerate, H**C**; greywacke/argillite, H**W**; and banded iron formation, H**IF**). Subvolcanic intrusions include gabbro (H**B**) and quartz feldspar porphyry (H**R**).

The Atik Lake and the High Hill Lake greenstone belts are lithologically similar to the Knee Lake belt, except they contain more extensive banded iron formation (H**IF**) and less felsic volcanic rocks (H**Vf**) than the Knee Lake belt supracrustal rocks. The same lithostratigraphic terminology has been applied to all three belts; however, none of the units of the Superior Province in NTS 53M has been dated to confirm this relationship. Based on the available flow top indicators the supracrustal rocks in the Atik Lake and High Hill Lake belts are south facing.

Plagioclase phyric mafic flows (H**Vp**) at Atik Lake represent tholeiitic basalt with plagioclase megacrysts that originally crystallized from a fractionated komatiitic melt in a shallow magma chamber. These magmas subsequently mixed with magma evolving along a tholeiitic Fe-enrichment trend before they were extruded (Phinney *et al.*, 1988).

Banded iron formation (H**IF**), generally oxide facies, produces strong magnetic anomalies in the supracrustal belts, most notably between Silsby Lake and the Bigstone River, and in the eastern extension of the Atik Lake greenstone belt. Magnetic anomalies west of northern Knee Lake have also been interpreted as banded oxide facies iron formation. Sulphide facies banded iron formation is exposed in the northwest part of Atik Lake, and was intersected in diamond drill core west of the Bigstone River and elsewhere. Volcanogenic hydrothermal alteration and related deposition of auriferous sulphide-bearing chert is associated with silicate-oxide facies iron formation at Atik Lake (Bernier and MacLean, 1989). The western extension of this iron formation (into NTS 63P) hosts a sub- economic gold deposit (The Northern Miner, July 13, 1987).

Metamorphism in the supracrustal belts of the Superior Province in NTS 53M and 63P increases in grade toward the north. Rocks in the Knee Lake belt have undergone greenschist- to lower amphibolite-facies metamorphism; those in the Atik Lake and High Hill Lake belts have been metamorphosed under conditions of amphibolite (575° C/3kb, Mezger *et al.*, 1990) to upper amphibolite/granulite-facies, respectively. The higher grade rocks (H**V**) at High Hill Lake contain sillimanite and orthopyroxene in amphibolite (**A**x) in the Pikwitonei domain.

CHURCHILL - SUPERIOR BOUNDARY ZONE

The Churchill - Superior Boundary Zone in the northern part of NTS 53M contains gneisses (**N**n) and Early Proterozoic Fox River belt rocks.

Layered migmatitic hornblende–biotite gneiss (**N**n) is interpreted to have been derived from Pikwitonei type granulite through structural and metamorphic overprinting during the Hudsonian orogeny, similar to reworked gneiss in the transition zone between the Pikwitonei granulites and the Thompson belt.

Early Proterozoic Fox River belt rocks occur in the northeast corner of NTS 53M. They are part of the Circum-Superior belt that extends from the Thompson belt in the west to the Cape Smith belt and Labrador Trough in the north and east (Baragar and Scoates, 1981). The basal contact between the Fox River belt and migmatitic gneiss (**N**n) is not exposed. The belt may be para-autochthonous, possibly thrust southward onto migmatitic Superior craton gneiss (**N**n) (Weber, 1990).

The lithostratigraphic succession and interpreted, concealed unit contacts of the Fox River belt in NTS 53M are known chiefly from detailed studies of INCO drill core and magnetic maps, in addition to sparse outcrops in river beds (Scoates, 1981, 1990; Scoates *et al.*, 1981). The belt comprises a north-facing homoclinal succession that contains: Lower sedimentary and Lower volcanic formations (L**S**, L**V**); a Middle sedimentary formation (M**S**) into which the Fox River Sill was intruded; and Upper volcanic and Upper sedimentary formations (U**V**, U**S**). The metamorphic grade ranges from prehnite–pumpellyite facies at the top to lower greenschist facies at the base of the succession (Weber and Scoates, 1978).

The lower and upper formations are lithologically and compositionally similar. The Upper sedimentary formation (U**S**) comprises siltstone and shale that are typically carbonaceous. The Lower sedimentary formation (L**S**) contains iron formation (specular hematite/magnetite) (L**S**i), dolomite and limestone, sandstone and minor conglomerate. It is intruded by several differentiated mafic/ultramafic sills (L**U**) (Scoates *et al.*, 1981). The Lower and Upper volcanic formations (L**V**, U**V**) contain basalt and komatiitic basalt that are considered consanguineous. Massive flows at the base of the sequence are commonly differentiated with an olivine-rich base and a plagioclasephyric top (Scoates, 1981).
The Fox River Sill is an over 250 km long stratabound intrusion. Its western end occurs in the northeast part of NTS 53M. Structural data suggest that the sill has a lopolithic shape, that at depth is thicker than the 2 km section exposed at the present erosion surface. The sill rocks are predominantly ultramafic in composition; over 75% consist of olivine-rich cumulates. There are more than 70 compositional layers (≥ 1m in thickness) that represent at least 35 cyclic units (Scoates, 1990).

Based on lithologies and cyclic arrangements of units, the sill has been subdivided into a Marginal Zone (FR**B**m), a Lower Central Layered Zone (FR**U**l), an Upper Central Layered Zone (FR**U**u) and a Hybrid Roof Zone (FR**B**h) (Scoates, 1990).

The Marginal Zone (FR**B**m) is dominantly melanogabbro; it comprises olivine melagabbronorite, lherzolite-wehrlite, olivine websterite-clinopyroxenite, olivine gabbronorite and minor gabbroic pegmatite.

The Lower Central Layered Zone (FR**U**l) is mainly dunite and comprises serpentinite, dunite, wehrlite and minor lherzolite, olivine clinopyroxenite and minor olivine gabbro-gabbronorite.

The Upper Central Layered Zone (FR**U**u) is dominantly peridotite and comprises serpentinite, lherzolite-wehrlite, melatroctolite, olivine melagabbronorite and olivine websterite-clinopyroxenite.

The Hybrid Roof zone (FR**B**h) consists mainly of granophyric quartz gabbro, minor websterite, lherzolite, gabbroic pegmatite and diverse quartz-rich rocks derived from the melting of middle sedimentary formation roof rocks.

Zircons from a gabbroic pegmatite in the Marginal Zone yielded a U-Pb age of 1883 ± 1.5 Ma (Hea- man *et al.*, 1986). This age implies that the Fox River sill is coeval with intrusion of Molson dykes, dated at 1883.7 ± 1.7 and 1882.9 ± 1.5 Ma (Heaman *et al.*, 1986). The chemical similarity of the sill and the dykes (Scoates and Macek, 1978; Scoates, 1990) suggest that their magmas are not only coeval but consanguineous.

Compositional data suggest that the Fox River Sill is the subvolcanic chamber from which the flows of the Upper volcanic formation (U**V**) were derived, and a similar relationship has been suggested for the lower differentiated intrusions and flows of the Lower volcanic formation (Scoates *et al.*, 1981).

The ultramafic rocks have potential for economic concentrations of chromium, nickel and platinum-group minerals. Only a small portion of the belt has been explored thus far by INCO and BP-Selco.

The Fox River belt is lithologically similar to the Ospwagan Group in the Thompson belt; however, since the Molson dyke swarm intrudes the metasedimentary rocks of the nickel-bearing lower Ospwagan Group (Bleeker and Macek, 1988), the Fox River sill must be younger than the nickel-bearing ultramafic rocks of the Thompson belt (Weber, 1990).

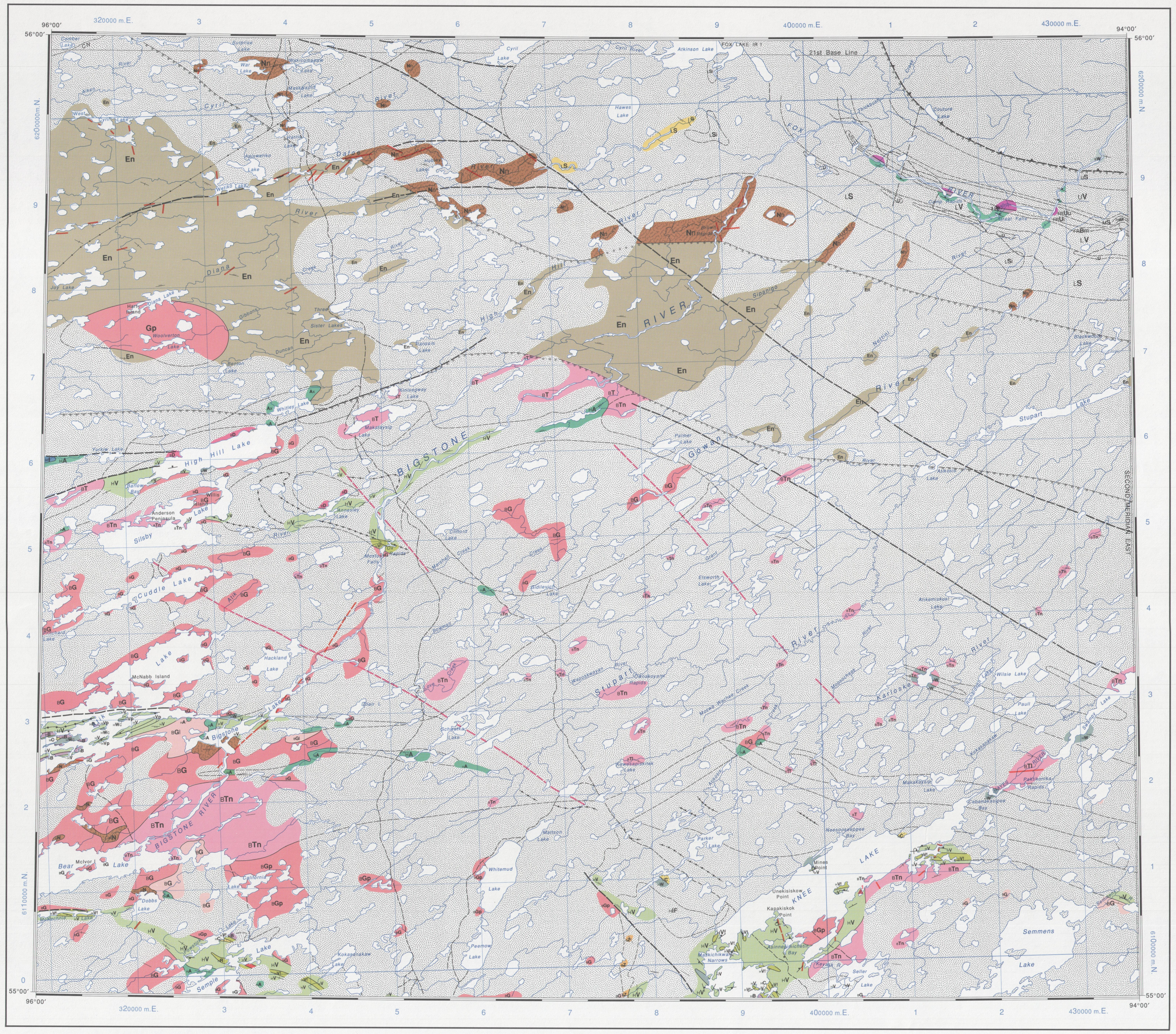
CHURCHILL PROVINCE

A single outcrop of Burntwood River metamorphic suite gneiss occurs north of the Fox River belt in NTS 53M. Structural and metamorphic data discussed by Scoates (1981) and isotopic and geophysical data (Weber, 1990) suggest that the contact between the Fox River belt and the Churchill Province is a major thrust.

Tectonic Synopsis

Following cratonization of the Superior Province during regional prograde metamorphism at 2.65 - 2.7 Ga, tectonic thinning occurred along the present margin of the craton. Due to the resulting gradual uplift of deeper crustal levels and erosion, an oblique cross section of approximately 20 km of middle to lower Archean continental crust is exposed in NTS 53M and 63P (Weber and Mezger, 1990).
Crustal thinning eventually led to rifting and the formation of Early Proterozoic oceanic crust and volcanic arcs in the Reindeer Zone that forms the internal zone of the Trans-Hudson orogen (the eastern part of the Churchill Province) in Manitoba. The Ospwagan Group and Fox River supracrustal rocks are interpreted to have been deposited in younger rift-like marginal basins along the thinned Superior craton margin (Halden, 1991).

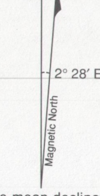
During the final compressional phase of the Trans-Hudson orogeny the Fox River succession was probably thrust onto more internal parts of the Superior craton. Similarly the Reindeer Zone was thrust southwards over the Fox River belt, for a distance of 100 km or more (Weber, 1990).



Printed 1992

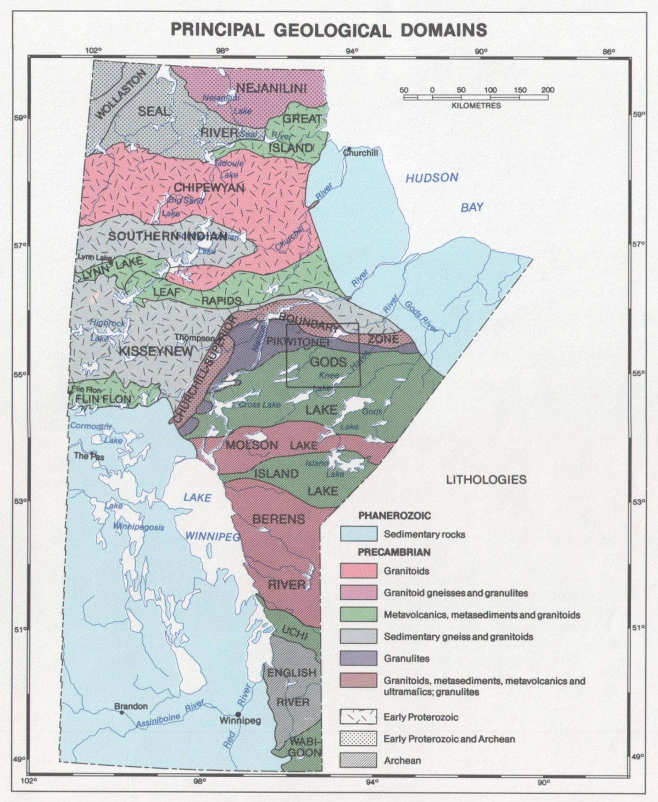
Scale 1:250 000

KILOMETRES 5 0 5 10 15 20 25 KILOMETRES



Approximate mean declination (1992) for centre of map
Decreasing 8.1′ annually

PRINCIPAL GEOLOGICAL DOMAINS



Every possible effort has been made to ensure that the information presented on this map is accurate. However, the Province of Manitoba and Manitoba Energy and Mines do not assume liability for any errors that may occur. References are included for users wishing to verify critical information.

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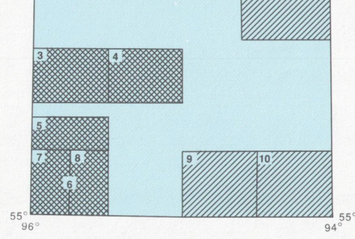

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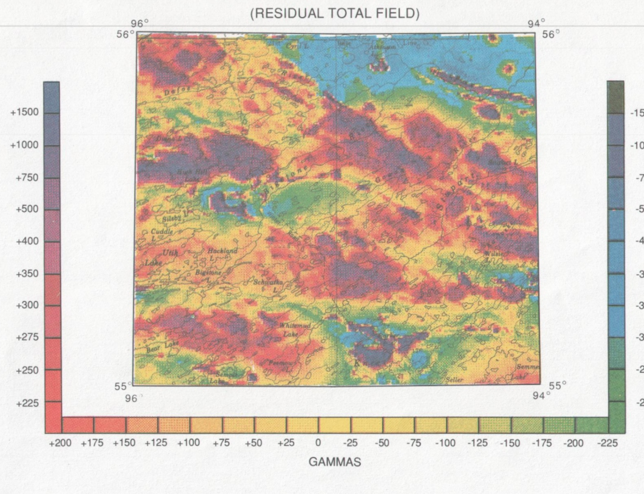
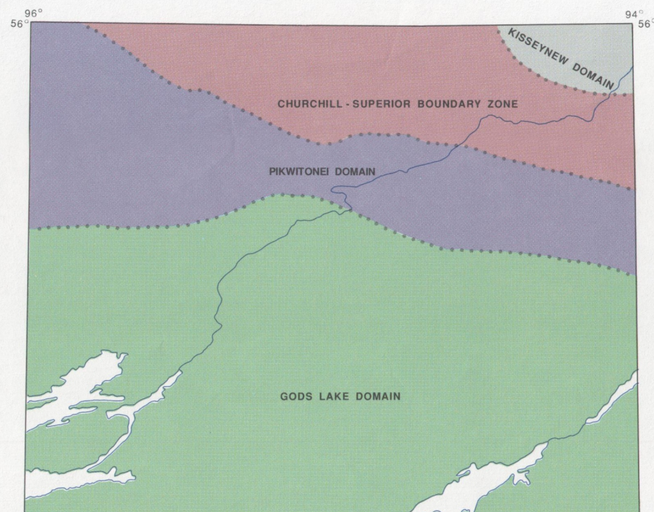
MAGNETIC ANOMALY MAP

(RESIDUAL TOTAL FIELD)



MAJOR DOMAINS



LEGEND

PRECAMBRIAN

CHURCHILL PROVINCE

Proterozoic

KISSEYNEW DOMAIN

Burntwood River Metamorphic Suite

- B**W** — Garnet–biotite ± hornblende gneiss

Reference for U-Pb zircon age:
1 ⊛ *Heaman et al.*

CHURCHILL - SUPERIOR BOUNDARY ZONE

- Diabase, gabbro (Molson swarm)

Fox River belt

- Upper sedimentary formation: siltstone, shale — U**S**
- U**V** — Upper volcanic formation: basalt and komatiitic basalt flows

Fox River Sill

- *Hybrid Roof Zone; dominantly granophyric quartz gabbro* — FR**B**h
- FR**U**u — *Upper Central Layered Zone; dominantly peridotite*
- FR**U**l — *Lower Central Layered Zone; dominantly dunite*
- 1⊛ FR**B**m — *Marginal Zone; dominantly melanogabbro (1: 1883 ± 1.5 Ma)*
- Middle sedimentary formation: siltstone, argillite, sandstone, minor calcareous rocks — M**S**
- L**V** — Lower volcanic formation: basalt and komatiitic basalt flows
- Lower differentiated mafic-ultramafic intrusions — L**U**
- L**S** — Lower sedimentary formation: siltstone, argillite, limestone, sandstone, minor conglomerate
- Hematite/magnetite iron formation — L**S**i

Archean and/or Proterozoic

- **N**n — Layered migmatitic hornblende–biotite gneiss derived from **En**

SUPERIOR PROVINCE

- Diabase, gabbro (MacKenzie swarm)
- Diabase, gabbro (Molson swarm)

Archean

GODS LAKE DOMAIN

Bayly Lake Complex

- B**G** — Granite; B**Gl** - leucogranite
- B**Z** — Syenite
- B**G** — Granodiorite; B**Gp** - porphyritic granodiorite
- B**T** — Tonalite, granodiorite; B**Tn** - gneissic tonalite; B**Tl** - layered tonalitic to granodioritic gneiss with concordant amphibolite layers

Hayes River Group

- H**R** — Feldspar porphyry
- H**D** — Diorite, quartz diorite
- H**B** — Gabbro, anorthositic gabbro
- H**I** — Anorthosite
- H**W** — Greywacke, argillite; H**W**c - cordierite–garnet ± anthophyllite-bearing semipelite
- H**C** — Polymictic conglomerate
- Banded iron formation, dominantly oxide facies — H**IF**
- H**V**f — Felsic to intermediate pyroclastic rocks
- H**N** — Biotite gneiss ± hornblende with granitoid *lit par lit* injections; migmatitic metabasalt
- H**A** — Amphibolite, metabasalt
- H**V** — Mafic, massive and pillowed flows; H**Vp** - plagioclasephyric flows

PIKWITONEI DOMAIN

- **Gp** — Porphyritic granodiorite
- **En** — Enderbitic gneiss with mafic inclusions
- **A**x — Orthopyroxene amphibolite

STRATIGRAPHIC NOTE:
The map units within each domain are in approximate chronological order.

SYMBOLS

- Geological boundary (approximate, interpreted)
- Bedding, (top known)
- Pillowed flow (inclined, overturned)
- Foliation ± metamorphic layering (dip unknown, 0°-29°, 30°-59°, 60°-79°, 80°-90°)
- Fault (inferred)
- Thrust fault (inferred)
- Iron formation (known from outcrops and interpreted from aeromagnetic anomalies)
- Domain boundary
- Area of little or no outcrop
- 1⊛ Sample locality for U-Pb age determination

IMPORTANT MINERAL OCCURRENCES

	Name	UTM Northing/Easting	Commodity	References
1 ▲	Johnston Knee Lake, Knee Lake Gold	6108000/404000	Au	MI 53M/2 AU1, AU2[1]

PROPERTY STATUS
Important mineral property..........▲

COMMODITY
Au...........gold

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Compilation by W. Weber and D. Lindal
Cartography by T. Franceschet

Suggested reference to this publication:
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INDEX MAP AND MAJOR TECTONIC DIVISIONS