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DEPARTMENT OF ENERGY AND MINES
MINERAL RESOURCES DIVISION

THE SEAL RIVER AREA

(Major Parts of 54-L, M; 64-I, P)

by D.C.P. SCHLEDEWITZ

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TABLE OF CONTENTS

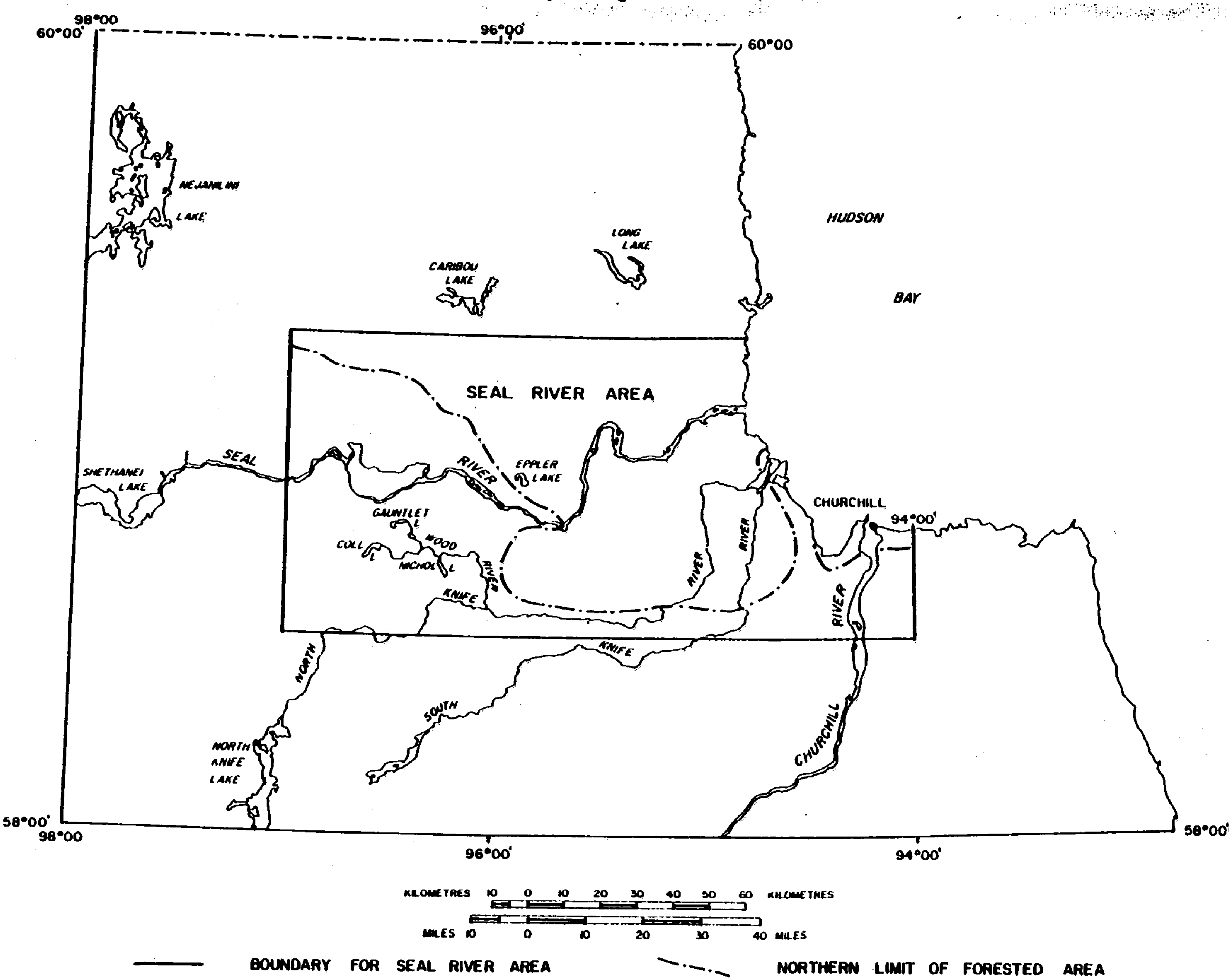

FIG 1, INDEX MAP FOR SEAL RIVER AREA

Introduction

This report outlines briefly the geological data collected from the Precambrian rocks exposed in the Seal River Project area and presents a preliminary interpretation of the geology, compiled from this data and previous work. In addition, the geology of the map-area is put into regional perspective from the Manitoba-Saskatchewan border to Hudson's Bay. A final section presents an evaluation of the mineral potential.

The Seal River Project area lies between Hudson's Bay and longitude 97°, and between latitudes 58°31' and 59°15'. The area includes the town of Churchill. The most noticeable geographic feature of the region is the transition from a forested area into one of dwarfed tree growth, thence northward into areas essentially barren of tree growth (Fig. 1). The general topographic relief is low to moderate, the lowest relief being in the coastal plain of Hudson's Bay from which the land surface gradually rises to the west. The coast is marked by a 2 km wide intertidal zone composed of clays, gravel and boulders. The extensive tidal flats make shoreline work very difficult and updated tide charts are a necessity. The deltas of the Seal River and North Knife River are greatly affected by the tidal variations and navigating these deltas at high tide is recommended. Inland from the coastal region a 40 km wide zone is generally treeless, flat and dotted by numerous black water ponds and shallow boulder-strewn lakes. Low outcrops make up less than 1% of the area. The first 10 km of this region is marked by a series of raised beaches marking the retreat of Hudson's Bay. The remainder is tundra, unsorted till and large sand plains. The large sand plains appear to be in part fluvial fan-like deposits and/or glacial deposits reworked by wave action. South of the Seal River the land surface continues to rise gradually with the greatest change being the sharp increase in the size and number of trees, boulder fields and frost shattered material near Duddles Lake. Here the topography is more irregular. Outcrops increase to about 2% and are of greatest relief and size. High, continuous eskers are common.

North of the Seal River the area changes from a flat, featureless coastal plain to one of boulders, frost shattered material and outcrop (2%). The outcrop is of low relief, 2-3 m, and occur in clusters of several hundred square miles. These outcrops are surrounded by broad plains of sand and gravel. The remnants of eskers are of very low relief and discontinuous. This broad plateau of sand, gravel, boulders and outcrop continues to the west and gives way to large rolling hills of moderate relief. These hills are crowned by outcrops and flanked by glacial deposits. Exposure is from 2-3%. The eskers in this region are up to 50 m in height and are of considerable length.

The Seal River and the North Knife River flow east across the map-area. With the exception of the Great Island region, outcrop exposures are sparse away from the margins of the river corridor. The Seal River is navigable by powered boat; however, upstream travel is hampered commonly by shallow water. An exception to this navigability is an impassable chute on the northwest side of Great Island in the north channel of the Seal River. The North Knife River is navigable downstream by power boat but a portage is required at a series of three falls at $96^{\circ}18'$. The nature of the river banks and the step-like outcrop requires roping of heavy equipment down the portage. The river is shallow in many areas making upstream navigation by powered boat very difficult.

General Geology

Hypersthene biotite gneiss ± hornblende, magnetite (1)
Foliated hypersthene quartz monzonite to quartz diorite (2)

Hypersthene gneisses (1) were observed on the north shore of McCann Lake and 5 km north of Washook Lake. The contact of the gneisses (1) with the surrounding hypersthene quartz monzonite to quartz diorite (2) is not exposed.

The hypersthene gneisses (1) are intermediate to basic in composition. The layering is defined by alternating buff plagioclase-rich layers and dark green to black mafic-rich layers. The plagioclase ranges in composition from An_{37-61}. Hypersthene and biotite are characteristic constituents and hornblende and magnetite are variable. Magnetite is conspicuous because of the associated 2 mm to 4 mm coronas of quartz and feldspar which form a pronounced bird's eye structure.

Foliated hypersthene quartz monzonite to quartz diorite (2) occurs in the northwest corner of the map-area. It forms part of a large area underlain by hypersthene-bearing granitic rocks extending north into the Northwest Territories and northwest of Nejanilini Lake. The rock comprises plagioclase (An_{23-33}), hypersthene and biotite. Hornblende and/or diopside may be present. Microcline and less common mesoperthite and perthite are present in the quartz monzonite. Orthoclase has been reported by W.L. Davison (Davison, 1962) in rocks of similar composition to the northwest.

Rocks of unit 2 weather deeply with an outer rusty orange-brown friable zone and a brown inner zone extending 5 - 10 cm into the rock. The fresh rock is green, this being the colour of the fresh plagioclase feldspar.

Hybrid rocks comprising a mixture of granulites and pink foliated biotite quartz monzonite (± hornblende) form 2 km wide zones peripheral to the hypersthene quartz monzonite-quartz diorite (2). The granulites commonly contain microcline porphyroblasts and pink massive granitic-quartz monzonitic lits. These lits grade into the brown granulite and may have been derived from them through recrystallization and partial melting. The foliated quartz monzonite is also possibly derived from the granulites through partial recrystallization under low grade metamorphic conditions. Further work will be undertaken in this granulite terrain in 1977 by M. Cameron.

Units (1) and (2) are considered to be Archean in age based on mineralogical, compositional and textural similarities with Archean granulites in the Kasmere area to the west (Weber et al., 1975).

Migmatites (3)

Granodioritic migmatites (3) occur mainly in the northeast (Eppler Lake) and in the southeast of the map-area. The migmatites (3) comprise lits of quartz monzonite and granodiorite composition alternating with dark grey, biotite-microcline-quartz layers. The granitic lits range from 2 mm - 2 cm wide and make up 20 to 60% of the rock. Pink microcline porphyroblasts and pink monzonite lits and veins have a sporadic distribution but are common near the major bodies of quartz monzonite (15). The presence of quartz monzonite lits indicates that the migmatite (3) is older than the quartz monzonite of unit 15. Inclusions of the migmatite in the feldspar porphyry (6) suggest that it is older than unit 6 and the associated volcanic sequence. However, the area delineated as granodioritic migmatite may be more complex and may contain phases of granodiorite (7).

Paragneiss, migmatite and amphibolite (4)

These rocks occur as large inclusion blocks in an area dominated by pink quartz monzonite (15) in the northwest quarter of the map region. Specifically they occur near the North Seal River, upstream from Great Island, near Big Spruce River. The paragneisses and migmatites represent a sequence of metasedimentary rocks which were metamorphosed under conditions of upper amphibolite facies of Abukuma type metamorphism. This is indicated by the assemblage cordierite-sillimanite and the absence of muscovite in cordierite-garnet-sillimanite-biotite gneisses (4d). Rock unit 4a comprises grey biotite-cordierite-sillimanite-plagioclase layers and white quartz monzonite lits (20 to 60% of the rock). White quartz monzonite comprises microcline (30%), plagioclase (30%, An_{27-29}), quartz, cordierite, garnet and graphite. It also forms large stocks (unit 4f). Garnetiferous quartzite layers, 1 cm to 2 m thick are sporadically interlayered with unit 4a.

Other rock types comprise hornblende-bearing arkosic gneiss (4a) amphibole (4b), biotite gneiss (4c), or impure quartzite to arkose (4e).

Hornblende-bearing arkosic gneiss (4a) is pale grey with pink granitic lit and has a spotted appearance due to the presence of black hornblende with coronas of feldspar and quartz. Two small occurrences of this rock type were observed. Amphibolite (4b) varies from a hornblende-plagioclase-bearing rock with accessory pyrrhotite to a layered rock with dark hornblende biotite layers and pale olive green amphibole-rich layers. These amphibolites may be derived from volcanic rocks which lie further east and north of Great Island. Biotite gneiss (4c) occurs as inclusions in the Seal River quartz monzonite (15) and north of Big Spruce River in quartz porphyry (10). The biotite gneiss (4c) contains biotite (15%), microcline, plagioclase and quartz. Linear trains of biotite give the rock a lineated appearance. Buff, fine- to medium-grained quartz monzonite lits are common. North of the Big Spruce River the lits are attenuated, boudinaged and rolled, giving the rock the superficial appearance of a conglomerate.

Impure quartzite to arkose (4e) contains microcline (5-20%), plagioclase (0-10%), quartz (40-60%), biotite (8%) and accessory magnetite. The rock is foliated and contains buff granitic lits. The association of semi-pelitic cordierite gneisses (4a), white quartz monzonite (4f), impure quartzite and hornblende-bearing arkosic gneisses occurs also in the Kasmere area (Weber, et al., 1975) and in the Munroe-Tadoule Lake area (Schledewitz, 1976). In the Kasmere area these gneisses are interpreted as (probable) Aphebian in age on the basis of a Rb-Sr whole rock isochron.

VOLCANIC ROCKS AND RELATED INTRUSIVE ROCKS

Andesite, rhyolite and tuffaceous rocks (5)

Volcanic rocks occur at Great Island and on the Seal River 45 km downstream from Great Island.

The Seal River volcanic rocks form a belt (30 km x 10 km) along the river. They consist of partly pillowed andesitic flows. A grey rhyodacite lens occurs in the central part. The southern and western outer zone (3 to 5 km wide) comprises an interlayered sequence of massive andesite and intermediate to basic tuffaceous rocks consisting of pale buff to green plagioclase-rich layers and black amphibole-rich layers (1-20 mm thick). It is not certain whether the layering is of primary or metamorphic origin. A small stock of gabbro has intruded the central region of the Seal River volcanic belt.

The Great Island volcanic rocks comprise: (1) andesite, partly pillowed or massive, and locally brecciated; (2) conglomerate; (3) interlayered tuffaceous rocks, andesite and dacite, in part pillowed; (4) intermediate tuffaceous rocks and lapilli tuff; (5) rhyolite and rhyodacite. These rocks have been intruded by stocks of quartz-feldspar porphyry (6) and gabbro (8). The andesite flows occur mainly at the east and southeast edge of the belt. They weather dark green and contain plagioclase, chlorite, actinolite, hornblende and alteration products such as epidote, calcite and albite. A volcanic breccia or possible hyaloclastic flow is exposed within the basic volcanic rocks along the Seal River east of Great Island. The interlayered tuffaceous rocks and partly pillowed andesite and dacite occur along the northern edge of the belt. An agglomerate occurs 5 km north of Meades Lake with fragments (up to 30 cm) of rhyodacite and dacite.

Acid to intermediate flows and volcanoclastic rocks and tuffaceous sediments make up 50% of the Great Island Volcanic Rocks. Rhyolite and rhyodacite are interlayered on a regional scale. The basic volcanic rocks occur to the east and southeast of Great Island and the volcanoclastic to tuffaceous rocks in the southwest and west. The acidic volcanic rocks are grey to pale green and dense to very fine-grained. The degree of foliation may vary from well foliated (almost schistose) to massive in any one locality. South of the Seal River at the east end of Great Island quartz-albite lits (5 mm wide) spaced 1 metre apart occur within the rhyolite. The tuffaceous rocks are most abundant between the west end of Great Island and Wood River. They are dark grey to dark grey-green and display a delicate layering on a weathered surface. They comprise very fine-to fine-grained plagioclase, microcline, quartz, biotite and chlorite. Blue green to green actinolite and hornblende overgrow the primary layering. This layering is locally disrupted and rotated or dislocated by closely spaced shear zones, particularly between

Gauntlet Lake and Wood River, where northwest trending zones of mylonitization have also been observed. Lapilli tuffs are exposed along the Seal River, at the west end of, and east of Great Island. The rocks are grey to dark grey and dense, and contain acid to intermediate clasts ranging from 2 - 5 cm in length and ½ - 1 cm in width.

Pink to grey fine-grained quartz feldspar porphyry (6), granodiorite to quartz-granodiorite (7) and gabbro (8), intrude the volcanic sequence (1).

Quartz-feldspar porphyry (6)

Quartz-feldspar porphyry weathers with a smooth dense surface. Pale cream coloured plagioclase (An_{30-31}) and microcline phenocrysts (2 - 5 cm) are set in a fine-grained matrix of microcline, plagioclase, quartz, olive-green biotite and variable amounts of acicular hornblende. The hornblende commonly exhibits alteration to actinolite, epidote and chlorite. Unit 6 forms dykes and stocks within the volcanic rocks, particularly in units 5c and 5e. The feldspar porphyry dykes are intruded by basic dykes and have been subsequently folded about easterly axial planes. The basic dykes may be related to the gabbro stock (unit 8).

Granodiorite to porphyritic quartz diorite (7)

This rock unit forms the predominant rock-type along the Seal River to 70 km west of Hudson's Bay. The rock is strongly to moderately foliated with localized zones of incipient cataclasis.

The composition varies from a grey granodiorite comprising plagioclase (An_{24-26}), quartz (10-15%), biotite and hornblende. The plagioclase in general is saussuritized. Granodiorite and quartz diorite (7) have intruded the volcanic rocks of the Seal River belt. This is indicated by the increasing intensity of alteration, the formation of amphibole in gneisses derived from the volcanic rocks, and inclusions of volcanic rocks in the granodiorite near the contact of these rocks.

Inclusions of the granodiorite to quartz diorite (7) within the quartz monzonite (15) suggest unit 7 is older than unit 15. Potassium feldspar blastesis and pink quartz monzonite lits occur in granodiorite near the contact with quartz monzonite (15), e.g. north of Eppler Lake. Consequently, the areas mapped as granodioritic migmatite (3) may in part be derived from unit 7.

Gabbro (8), Ultramafic (9)

Stocks of gabbro are common in the Great Island volcanic rocks. The composition varies from coarse grained gabbro with buff plagioclase laths to a hornblendite with accessory pyrrhotite and minor chalcopyrite. The gabbro contains hornblende, diopside, plagioclase (An_{27-40}) and biotite. The degree of alteration is highly variable, some zones being intensely altered to actinolite, chlorite, carbonate and epidote.

Two other intrusive rock types that have been tentatively grouped with the volcanic rocks are ultramafic (9), and quartz porphyry (10). The ultramafic body occurs as an arcuate-shaped dyke north of Eppler Lake. No surface exposures of the dyke were observed, but a distinct linear zone was mapped of frost shattered serpentine fragments in areas of dark orange-brown sand. This zone of fragments coincides with a magnetic high which has been drilled at several localities revealing ultramafic bedrock. The contacts as indicated on the maps are based on the surface distribution of the fragments together with the continuity indicated by the magnetic anomaly. The northeast end of the aeromagnetic anomaly is truncated sharply. The relationship of the gabbro to the ultramafic is unknown.

Quartz porphyry (10)

Quartz porphyry occurs near the Big Spruce River. Its contact with the volcanic rocks is not exposed.

The rock is dense, and weathers buff to pink on the fresh surface. Lenticular quartz eyes are 2 - 5 mm long. Foliation is defined by aligned biotite and parallel lenticular quartz eyes. The rock type is grouped with the igneous sequence (units 6 to 9) because of its similarity to the quartz-feldspar porphyry (6).

ROCKS OF UNCERTAIN AFFINITY

Rocks of uncertain affinity comprise a sequence of metaconglomerates, quartzites with interlayered metasiltstone, and phyllites, south of Great Island. These metasedimentary rocks bear a strong resemblance to rocks of the Great Island Group in their metamorphic grade and composition. However, the metasiltstones and phyllites are intruded by a large body of white fluorite-tourmaline quartz monzonite. Since diabase dykes are the only intrusions recorded within the Great Island Group, it is possible that the metasedimentary rocks south of Great Island are older than the Great Island Group.

Volcanic conglomerate (11)

This conglomerate outcrops 1 km east of Gauntlet Lake and 6 km southeast of Gauntlet Lake. It forms lenses which are interlayered with greywacke, metasiltstone and meta-argillite to phyllite.

The clast supported conglomerate contains clasts of feldspar porphyry (6) and tuffaceous rocks, and voids filled with sub-greywacke.

This conglomerate may represent part of the basal sequence of the Great Island Group, rather than an inter-formational conglomerate as inferred in this report.

Quartzitic conglomerate (12), quartzite (13), metasiltstone andalusite phyllite (14), and derived schists (13a and 14a)

Quartzitic conglomerate occurs at the northeast end of Coll Lake, between Great Island and Gauntlet Lake, and east of Gauntlet Lake. The clasts are mainly quartzite, subordinate quartz sericite and rare quartz with tourmaline. The matrix varies from quartzite to quartz sericite schist, magnetite (1-3%) and pyrite (0-3%). A sequence of quartzites (13) and interlayered metasiltstones and andalusite-bearing phyllites (14) overlie the conglomerate at Coll Lake. The quartzite varies from a grey highly indurated quartzite to ferruginous quartzite. Eleven km east of Coll Lake, at Nichol Lake, the quartzite ranges from a highly indurated white quartzite to an andalusite-sericite quartz schist (13a) derived from the quartzite (13). It contains folded quartz veins.

Unit 14 varies from buff metasiltstone to quartzite with thin minor, widely spaced laminae of phyllite, to a finely laminated sequence of metasiltstone and interlayered pale green to grey phyllite $\pm$ garnet $\pm$ andalusite). The phyllite comprises chlorite, sericite, biotite, quartz and feldspar.

Unit 14 is coarser grained southeast of Coll Lake, corresponding to an increase in the biotite content and a decrease in the chlorite content. Twelve km southeast of Coll Lake, 100 m large inclusion blocks of garnet-andalusite-muscovite biotite schist (14a) occur in white quartz monzonite (17). These schists are considered to be derived from unit 14.

POST-VOLCANIC INTRUSIVE ROCKS

The following intrusive rocks are considered to post-date the volcanic rocks (5):

1) Quartz monzonite and aplite (15)
2) Porphyritic quartz monzonite ± fluorite (16)
3) Red quartz monzonite ± fluorite (16a)
4) White quartz monzonite ± fluorite (17)

The quartz monzonite to aplite (15) forms the main part of a major batholithic body which extends from Hudson's Bay west and southwest to the Saskatchewan border. It is considered to be of Hudsonian age. The rock is pale pink, medium- to coarse-grained and comprises microcline (30-40%), plagioclase (An_{21-27}, 30-40%) quartz (25-40%), biotite (3-8%) and magnetite (0-2%). Aplitic phases with gradational contacts to the quartz monzonite form small bodies of 10,000 m^2 to areas greater than 20 km^2. The rocks exhibit a foliation which is variable and is defined by aligned elongated interstitial quartz and incipient feldspar augen. In the western border of the map-area along the North Seal River, upstream from Great Island, these rocks are fine- to medium-grained, show a cataclastic foliation and pronounced augen structure and are associated with linear gneissic hornblende-biotite quartz monzonite (15a).

Inclusions of volcanic rocks (5), feldspar porphyry (6) and granodiorite to quartz diorite (7) occur in the quartz monzonite near these units, indicating that the quartz monzonite is younger than the volcanic related igneous rocks.

Porphyritic quartz monzonite (16) occurs at and east of Nichol Lake. It intrudes basic volcanic rocks (5a) and gabbro (8) north of Nichol Lake. The contact with the metasedimentary rocks is not exposed.

Rocks of unit 16 are coarse-grained to porphyritic, and generally massive to weakly foliated, comprising microcline (40%), plagioclase (15-25%), quartz 40-45%), biotite (30-35%) and sporadic purple fluorite. The microcline phenocrysts (½ - 1 cm long) are sporadically layered.

Another fluorite-bearing quartz monzonite (16a) occurs immediately east of Nichol Lake where it is exposed in several small outcrops between the Seal River and the North Knife River. The rock is deep orange-red on the fresh surface and weathers pale pink to white. The white weathered surface is related to the high humic acid conditions of weathering. In addition to a characteristic deep orange-red, caused by coarse-grained to porphyritic microcline, the milky blue colour of the coarse-grained quartz is typical.

White quartz monzonite (17) occurs near the North Knife River 9 km south and southwest of Nichol Lake. The rock comprises microcline, plagioclase, biotite, muscovite and sporadic garnet and fluorite. It is massive, medium- to coarse-grained and forms large high outcrops which contain inclusions of muscovite-biotite-quartz schist ($\pm$ garnet $\pm$ andalusite) and blocks of amphibolite as remnants of basic dykes. The pegmatite phases are common in the inclusion areas. Books of muscovite and biotite 6 inches thick and up to 10 inches in length and accessory garnet are present in the pegmatitic phases.

The white quartz monzonite (17) is intruded by wide pink microcline pegmatites. These are numerous along the North Knife River where remnants of basic dykes occur as discontinuous blocks of amphibolite.

THE METASEDIMENTARY ROCKS OF THE GREAT ISLAND REGION, NORTH KNIFE RIVER REGION AND THE CHURCHILL REGION

The rocks of the Great Island region outcrop in the area along the Seal River at Great Island and at Meades Lake further north. These rocks were previously named Great Island Group (Taylor, 1958). In this report metasedimentary rocks further east along the Seal River and east of Eppler Lake are also correlated with the Great Island Group.

The metasedimentary rocks of the North Knife River region outcrop east of longitude 96°18', marked by a series of falls, along the North Knife River and the South Knife River 1 km southwest of the confluence of these rivers.

Rocks of the Churchill region are confined to the large ridge-like outcrops that occur on both sides of the mouth of the Churchill River at Hudson's Bay. On the west side of the Churchill River the rocky, bare ridges occur over a 9 km width and extend 24 km west to the southwest of Button Bay. Bare ridges 1 to 4 km wide, extend 27 km east of the river mouth.

The rocks of the North Knife River region west of 96°, and the rocks of the Churchill region were described in detail by H.H. Bostock (1969). He indicates that rocks along the North Knife River are similar to the rocks of the Great Island region. He also points out the difficulties encountered in attempting to correlate them with the rocks west of 96°18' longitude along the North Knife River, upstream of the falls at longitude 96°18'. The rocks west of the falls are grouped as rocks of uncertain affinity in this report, whereas the metasedimentary rocks of the North Knife River regions (i.e. east of 96°18' along the North Knife River) are included in the Great Island Group.

Great Island Region

The thickest section of the Great Island Group metasedimentary rocks occurs in the Great Island region. The Group lies unconformably on the rocks of the Great Island volcanic belt. However, at the southern contact, northwest of Gauntlet Lake, the lowermost protoquartzite (19) of the Group lies directly above a conglomerate and interlayered protoquartzite (11) of uncertain affinity.

The exact nature of the basal unit of the Great Island Group and the relationship with the underlying beds can only be inferred approximately as the contact is not exposed. In general the basal unit comprises an interlayered sequence of grey quartzite, protoquartzite, metasiltstone and 10-15% widely spaced discontinuous layers of grey-green to grey phyllite (19). North of Meades Lake the basal unit is 1200 m thick. Current cross-bedding and wave ripple marks, though recorded, are too rare for reliable top and current direction inferences. The primary clastic texture of the protoquartzite is preserved as rounded coarse to medium-grained quartz crystals with secondary silica overgrowths and a silica cement. Sericite, chlorite, biotite and hematite are present as accessory minerals. In areas of tight folding subsequent recrystallization has resulted in a massive or foliated quartzite.

The variability of the basal unit near the predicted contact is indicated in a number of diamond drill holes, geophysical surveys, and from rock exposures at three key localities:

1) Northwest end of Great Island
2) 10 km northeast of Meades Lake
3) 10 km north of Meades Lake

At the northwest end of Great Island a garnet-andalusite-sericite-quartz schist (18) with red pin-head garnet displays primary interlayering of micaceous and quartzite laminae intersected by a prominent schistosity. The alignment of the sericite defines a schistosity that gives the rock the structure and appearance of a phyllite. The underlying volcanic rocks are highly foliated and schistose and in places garnetiferous. Younger graphitic and pyritic slickensided shear zones are also present along the contact indicating repeated episodes of faulting and recrystallization. The relatively high metamorphic grade of the garnet-andalusite-sericite schist may indicate that it is a similar age to those rocks of uncertain affinity. However, andalusite is also present near the base of the Great Island Group northwest of Meades Lake. At this locality the rock is a protoquartzite with 15% very fine-grained biotite and sericite. Ghost-like pebbles and cobbles defined by an increase in the percentage of biotite (25%) are also present. Andalusite occurs as irregular knot-like composite intergrowths of several highly poikiloblastic andalusite grains up to 1.5 cm across.

Interlayered quartzites, protoquartzites and a biotite-sericite-bearing metasiltstone, exposed in a series of outcrops near the base of a large esker, represent the third locality 10 km north of Meades Lake. The metasiltstone contains 15-20% very fine-grained biotite, chlorite and sericite. The rocks of the most southerly outcrop are a grey, massive to poorly laminated protoquartzite. To the north the laminae became progressively thinner across strike ultimately comprising an interlayered sequence of protoquartzite (1 cm to 2 cm) and biotite-chlorite-sericite-rich metasiltstone (1 cm to 2 cm).

Airborne geophysical surveys, E.M. Surveys (Open File Assessment Reports) indicate elongate discontinuous conductors close to the inferred position of the base of the Great Island Group. The nature of these conductors is uncertain; however, they may represent graphitic or pyritic fault planes parallel to the unconformity or graphitic pyrite beds at the base of the Great Island Group.

In summary the main variations observed toward the base of the protoquartzite (19) of the Great Island Group are:

(a) the suggested increase in the content of aluminum indicated by the presence of andalusite and sericite;

(b) the increase in the potassium content indicated by the presence of sericite and biotite; and

(c) an increase of the ferromagnesian content indicated by the presence of biotite and chlorite in the laminated rocks.

The rocks which overlie the protoquartzite are metadolomite (20), pyritic meta-argillite and slate (21), iron formation (22), grey to grey-green phyllite ± garnet ± biotite porphyroblasts (23), meta-arkose (25) and metasiltstone to meta-argillite (26). This sequence is 1200 - 1400 m thick between Meades Lake and the north end of Great Island. These rock types are laterally discontinuous and the pyritic meta-argillite and slate, iron formation and grey-green phyllite may represent time equivalent units. However, outcrops along the Seal River on the north side of Great Island directly south of Meades Lake suggest the carbonates (20) underlie the iron formation.

The metadolomites (20) weather pink to red due to iron staining. Abundant lath to rod-shaped clinochlore porphyroblasts are present. Quartz occurs as discontinuous quartz veins, lenses and disseminated grains, indicating deposition of silica sand contemporaneously with the carbonate minerals.

The iron formation (22) is made up of:

(1) Garnet-amphibole meta-argillite and slate with discontinuous lenses of massive pyrite and pyrrhotite-bearing argillite.

(2) Layered garnet-magnetite-amphibole layers, magnetite-amphibole layers and massive magnetite layers.

The garnet-amphibole meta-argillite and slate occur interlayered with the grey-green phyllite along the Seal River, on the south side of Great Island. The rock weathers grey and/or brown with a smooth dense surface and a pronounced layering. The layering is defined by garnet-amphibole layers interlayered with dense hard argillite which sporadically contains pyrite and pyrrhotite. The garnets are deep red, small and pinhead-sized whereas the amphibole is black and acicular in shape. A second occurrence of the garnet amphibole and pyrite pyrrhotite-bearing iron formation outcrops east of Great Island 1 km north of Seal River.

The brilliant red weathering layered magnetite-amphibole iron formation occurs along the Seal River on the north side of Great Island. The outcrop comprises a red shale with acicular grains of an unidentified white mineral pseudomorphing the amphibole. A green shaly zone possibly derived from a pyritic member of the iron formation occurs structurally below the red weathering zone. The fresh magnetite-amphibole iron formation was observed only in drill core. The diamond drilling was done in the early 1950's by the Great Island Prospecting and Development Syndicate in an area that lies between Meades Lake and the Seal River. Other drill locations were along the Seal River at the eastern limits of the Great Island Group east of Great Island. Some of the drill core is stored in a cabin on the north side of Great Island along the Seal River whereas additional incomplete drill core is stored at the drill site location along the Seal River east of Great Island. The iron formation in the drill core comprises layers 2 cm to 2 m thick of disseminated magnetite (10 to 15%) within acicular olive-green amphibole crystals oriented in a random and radiating pattern, alternating with layers of massive magnetite and minor olive-green amphibole. The magnetite layers are 2 mm to 1 cm thick.

The black pyritic meta-argillite to slate (21) occurs along the Seal River on the south side and also east of Great Island. It forms a thin layer up to 100 m thick. The weathered surface is brown to reddish brown and the fresh surface is black. The pyrite (5-8%) is disseminated and also occurs along bedding planes and fracture cleavage. The pyrite has been mobilized into the fracture cleavage which is axial planar to minor folds. This rock type may represent a sulphide phase of the iron formation.

The grey-green phyllite (23) (± garnet ± biotite porphyroblasts) occurs along the Seal River on the south side of Great Island. This rock type comprises 2 - 5 mm laminations of very fine-grained to felty chlorite, biotite, sericite and alternating layers of buff metasiltstone. The euhedral biotite porphyroblasts are 1 mm in diameter and 2 mm to 5 mm in length. The rock is intruded by quartz veins which are abundant in areas where the rock is tightly folded and a fracture cleavage well developed. It is in these areas of mobilized quartz and tight folding that red pin-head garnets are developed and transposition of the primary layering is observed. The outcrops of the phyllite occur along the south channel of Great Island as a narrow zone no wider than the river. Contacts with the surrounding protoquartzite are not exposed. All layering measurements are made on the fine laminae and reflect deformation within the layer. The minor folds are complex structures with two distinguishable ages of fracture cleavage. One set of fracture cleavages trends easterly and dips steeply north or south. These are intersected by a later fracture cleavage which trends north to northeast.

Other occurrences of the phyllite were recorded at the northwest end of Great Island and in the centre of Great Island. Both of these occurrences lie within the protoquartzite unit (19). It is uncertain whether the phyllite (23) reflects a cyclic phase of sedimentation alternating with thick beds of protoquartzite or whether the beds are repeated by the system of folds and faults.

The meta-arkose (25) occurs in a series of outcrops, centered on Meades Lake. These outcrops define a north-south elongate basin-like structure. The meta-arkose overlies the iron formation (22) along the Seal River north of Great Island. At this locality the meta-arkose forms a series of cliffs along the north bank of the Seal River. The meta-arkose is thickly bedded, and sporadic graded bedding indicates the beds in the cliffs along the Seal River are steeply overturned to the north. Elsewhere around Meades

Lake the dips are towards the centre of the basin-like structure.

The meta-arkose is light grey on the weathered surface with prominent milky white to bluish-white quartz clasts. The rock is dark grey on the fresh surface, medium- to coarse-grained, and massive to weakly foliated. Foliation is a fracture cleavage. The mineralogy of the meta-arkose comprises plagioclase (35%), microcline (20%), quartz (35-40%), and lithic fragments (5%). The lithic fragments comprise plagioclase and quartz. The clasts are angular to sub-rounded. The matrix occurs as inter-clast void fillings and is fine-grained feldspar, quartz and sericite. The rock has a weakly metamorphosed appearance.

An interlayered sequence of meta-argillites, slates, biotite schists and metasiltstones (26) overlies the meta-arkose. These rock types represent the youngest member of the Great Island Group.

Outliers of metasedimentary rocks of the Great Island Group equivalent to the protoquartzite (19) and the interlayered phyllite (23) occur along the north-trending section of the Seal River 11 km east of Eppler Lake. The continuity of the metasedimentary outcrop is broken by an extensive area of drift cover along the river. However, frost shattered material along the Seal River indicates the outlier of the Great Island Group is 24 km long and 2-6 km wide. At the north end of the outlier a frost shattered outcrop of phyllite occurs on the west side of the river whereas outcrops of interlayered protoquartzite (19) and grey-green phyllite (23) define open to tight folds with steeply dipping easterly axial planes and shallow easterly plunges. An anomalous variety of quartzite was observed at the south end of the outlier at a point 8 km southeast of the Seal River. The rock is a white quartzite with well defined medium- to coarse-grained quartz clasts in a quartz matrix. The anomalous feature is the presence of traces of very fine-grained galena, pyrite and disseminated very fine-grained brilliant green muscovite (1%).

North Knife River region

The sequence of rocks in the North Knife River region is:

Protoquartzite and discontinuous conglomerate lenses (Churchill quartzite), unit 27.

Protoquartzite and interlayered grey-green phyllite (19).

Quartz pebble-bearing slate to meta-argillite (21a) and minor black pyritic slate (21).

Grey-green phyllite and inter-laminated metasiltstones (23).

Interlayered red to green meta-arkose and grey to grey-green phyllite (24).

These rocks form a narrow zone of outcrops along the course of the North Knife River and a series of outcrops 6 km southwest of the confluence of the South and North Knife Rivers. The grey protoquartzite (27) occurs 1-2 km south of the North Knife River 12 km west of Teepee Falls. The rock is medium- to coarse-grained with the outline of the clastic quartz grains preserved. A faint layering is present and is defined by variations in the concentration of sericite (5-15%), chlorite and hematite. Quartz pebbles and quartz cobbles are present. These cobbles are widely spaced in a grey hematite-bearing quartzite. This rock type is very similar to the Churchill quartzite (27) at the townsite of Churchill.

The interlayered quartzite, protoquartzite and grey-green phyllite (19) in the North Knife River region are very similar to the quartzites and interlayered phyllites at Great Island. This rock type may represent the lateral facies change of the Churchill quartzite to the southwest. At a point 3.5 km downstream from Teepee Falls along the North Knife River the protoquartzite (19) is folded into a series of Z-folds with steep dipping easterly trending axial planes and shallow plunge. The folds are of moderate closure with north facing limbs dipping 60-70 degrees and south facing limbs 20-30 degrees. The shallow plunges of the folds reverse their orientation from west to east every 100 feet. H.H. Bostock referred to these folds as "whale back folds" (Bostock, 1969). Right way up current cross-bedding is preserved in the protoquartzite beds half a kilometre from the Z-folded rocks. The current directions, indicated by the current bedding, reverse rapidly over short vertical stratigraphic intervals. This could indicate a river delta and tidal environment.

The protoquartzite also occurs in a basin-like structure 6 km southwest of the confluence of the North Knife and South Knife Rivers. At this locality the volume of phyllite and metasiltstone in the protoquartzite is 30-40%. The protoquartzite to quartzite beds vary from 1 metre to 100 metres thick.

This unit of protoquartzite and interlayered phyllite and metasiltstone is the most laterally persistent and widespread member of the metasedimentary rocks in the map-area. It occurs as erosional remnants from Hudson's Bay west to the Great Island area. The grey-green phyllite (23) and the interlayered red to green meta-arkose and phyllite (23) are exposed along the upper reaches of the North Knife River east of longitude 96°18'. The phyllite (23) is very similar to the grey-green phyllite at Great Island. However, along the North Knife River pyrite porphyroblasts are more common in the phyllites than biotite porphyroblasts or garnet. These rocks (23, 24) are folded into a series of very tight folds with steep dipping axial planes overturned to the north. The axial planes trend easterly and the plunges of the folds show sharp reversals in orientation from east to west. The river runs parallel to sub-parallel to the easterly structural trend and as a consequence little diagnostic stratigraphic information is available. The arkose (34) varies from red to grey-green depending on the hematite and chlorite content. Quartz grains (40%) are generally clear to grey or white but at one locality the quartz grains are a distinctive milky blue-white colour. This type of quartz is a characteristic feature of the red quartz monzonite (16a) which outcrops north and south of the North Knife River. The microcline which occurs in the arkose with these quartz grains is a deep orange-red colour which is also characteristic of the microcline feldspar in the quartz monzonite (16a). At one locality an inverted bedding is indicated by well preserved rip-up structures at the contact of an arkose and meta-argillite.

The presence of this coarse, more immature clastic metasediment may correspond to the deposition of the meta-arkose (25) at Great Island. These rocks may indicate a period of more rapid erosion and uplift during a period of faulting late in the depositional cycle.

The Churchill Region

Outcrops in this region are confined to a series of ridges west and east of the mouth of the Churchill River. The rock types in the Churchill region comprise an interlayered series of orthoquartzites and protoquartzites and minor conglomerate. H.H. Bostock, in his mapping of the Churchill region, made a detailed description of the Churchill quartzite (Bostock, 1969). He described the rocks as a sequence of dominantly grey to light grey sub-greywacke and minor interlayered quartzite beds. Chemically the rocks approximate a sub-greywacke. However, the mineralogy does not correspond to that of a sub-greywacke. The clastic material is dominantly fine- to medium-grained rounded quartz grains and where lithic components are present (0-30%) they are clasts of quartzite. The only other prominent components are authigenic sericite (3-25%), minor very fine-grained chlorite (0-3%), hematite (1-5%). The sericite and chlorite are considered to be derived from void filling clay minerals because of their disseminated distribution in the rock. The hematite occurs on bedding planes and as disseminated very fine grains, indicating an oxidizing environment of deposition. The strict definition of sub-greywacke requires that the lithic fragments be of greater percentage than the feldspar. Thus the term sub-greywacke implies a degree of immaturity. This degree of immaturity is not displayed by the rocks of the Churchill region. Therefore, the rocks of the Churchill region are interpreted as a series of interlayered protoquartzites and orthoquartzites.

A preliminary appraisal of the lithofacies distribution has been based on the occurrence of conglomerate lenses, primary structures and trends in mineralogy. The conglomerate lenses are most abundant in the ridges east of the Churchill River around and east of 94^{o} longitude. At these localities the conglomerate makes up 15-20% of the outcrop. The conglomerate lenses are generally 2-10 cm thick and arcuate in shape when viewed in three dimensional exposure. They occur in trough cross-bedding and at the base of scour channels. Clasts range from 1 cm to 10 cm in diameter and are rounded to well rounded. The clasts comprise vein quartz, quartzite, dark grey impure meta-siltstone and very rare medium-grained buff granodiorite. The matrix is sericite, chlorite and quartz. Four kilometres to the west, north of the Churchill airport, the conglomerate makes up less than 5% of the outcrop and an occurrence of isolated cobbles in the protoquartzite is more common. In the area of Fort Prince of Wales on the west bank of the Churchill River the conglomerate lenses are rare, and isolated pebbles and cobbles are more common. The conglomerate characteristically forms thin discontinuous lenses.

Current cross-bedding of the trough (festoon) type and asymmetric cross-bedding are common primary structures on the east side of the Churchill River. This type of cross-bedded protoquartzite is interlayered with tabular bedded protoquartzite with asymetric cross-bedding. On the west side of the Churchill River the trough cross-bedding is still common, but becomes less apparent in the rock 4 km southwest of Fort Prince of Wales. Beyond this point tabular bedding with minor asymmetric cross-bedding is more common. It is in these regions of tabular bedding that the most distinct interlayered sequences of protoquartzite and orthoquartzite beds are observed. The layers of orthoquartzite are from ½ m to 2 m thick, interlayered with quartzite layers 2 cm to 4 m thick. Isolated cobbles up to 3 cm in diameter occur sporadically. In general the primary layering in the most southwest ridges on the west side of the river is more or less obscured by the schistosity. The protoquartzite beds consistently contain 20% sericite whereas this mineral is less abundant in the orthoquartzite.

In summary the coarse clastics and the trough cross-bedding, both indicators of high velocity currents, decrease from the west to the east. Tabular bedding is more common in the rocks that form the southwest ridges on the west side of the Churchill River. An increase in the sericite content of the protoquartzite is coincident with the increase in tabular bedding.

However, this apparent lithofacies pattern does not imply that the current direction was from the east to the west. Based on limited current bedding direction measurements the main current direction was to the north or northwest. The present volume of data on current directions is inadequate to properly establish a sedimentary model. Further evaluation of the cross-bedding, mineralogical trends and the structural geology of the Churchill quartzite is still required.

The rocks of the Churchill region have been metamorphosed and deformed. The protoquartzite is well foliated to weakly foliated. The foliation varies from a fracture cleavage to a schistosity. The foliation in general is at a very high oblique angle to the bedding on the east side of the Churchill River but is parallel or oblique to the bedding in the rocks of the southwest ridges on the west side of the river. The schistosity is defined by the alignment of sericite and locally by the elongation of quartz clasts. In the conglomerate the clasts are often aligned parallel to the foliation. The realignment is most appreciable in impure metasiltstone clasts. The schistosity is very intense in northeast and north trending shear zones. These zones, up to 10 m wide, comprise alternating weakly foliated and/or intensely foliated planar zones. The intensely foliated zones contain abundant sericite, are buff in colour and the rock is fissile and friable. In the area of 94° longitude some shear zones contain pyrite, weathered to a rusty surface, and sporadically developed gossan zones. The less sheared protoquartzite in these areas may locally exhibit a pale green colour possibly due to secondary sericite.

Mobilized quartz occurs as veins and as tensional fracture fillings. More than one age of quartz veining is indicated by the presence of folded quartz veins cut by later non-folded veins. Veins vary in size from 1 mm to 2 m and specular hematite is a common constituent. Pegmatitic lazulite and chlorite are rare accessories in the quartz veins. Lazulite is a robin's egg blue coloured mineral. It is massive and forms irregular shaped bodies up to 4 cm across in the quartz veins. The most abundant occurrences of lazulite are in the area of Cape Merry on the east bank of the Churchill River.

Diabase dykes (28)

The diabase dykes of the Seal River map-area outcrop at two locations on the south and north sides of Great Island. Several diabase dykes have been inferred from aeromagnetic anomaly patterns by H.H. Bostock (Bostock, 1969); "these dykes trend northwestwards and are therefore parallel to the Mackenzie swarm of about 1200 m.y. with which they have been correlated (Fahrig *et al*., 1965)".

The dyke on the north side of Great Island on the Seal River is exposed over a strike length of 1 km. The dyke trends in a northwest direction. The second exposure on the south channel trends more northerly but its strike length is only 300 m.

The rock weathers reddish-brown and has a medium- to coarse-grained trachytic texture. The plagioclase on the weathered surface has a yellowish-green colour. In thin section the rock comprises plagioclase (An_{36-40}) which can be heavily to moderately saussuritized, hornblende, clinopyroxene and minor biotite. Magnetite and very minor pyrrhotite are present as accessory minerals.

Metamorphism

The metamorphic grade in the map-area ranges from granulite to middle greenschist facies. In the northwest corner of the map-area a regional granulite grade of metamorphism is indicated by the presence of enderbitic gneisses (1) and charnockite (2). These granulites display variable degrees of retrograde metamorphism with hypersthene altering to biotite in the charnockites and to hornblende and/or diopside in the basic enderbitic gneisses. Overlying the granulites are semi-pelitic to pelitic paragneisses and migmatites containing cordierite-garnet-sillimanite-biotite-plagioclase. Palingenetic granitic bodies of white quartz monzonite ± cordierite ± garnet are associated with the migmatites. These rocks are characteristic of upper amphibolite facies, low pressure, high temperature Abukuma type of metamorphism.

These rocks are tentatively correlated with the Archean granulites and younger Aphebian migmatites in the Kasmere region and the Munroe-Tadoule Lakes region to the west. The retrograde metamorphism observed in the hybrid zone of the Archean granulites in the Seal River area is thought to reflect a superimposed Hudsonian metamorphic event.

The eastward and southeastward extension of the semi-pelitic paragneisses and migmatites in the Seal River map-area is broken by the presence of a younger quartz monzonite. This quartz monzonite appears to be part of a major batholithic complex which extends southwest from Hudson's Bay to the Saskatchewan border. The quartz monzonite (15) in the northwest corner of the map-area forms a septum of the regional batholith. This quartz monzonite septum separates the region of high grade granulite and upper amphibolite metamorphic terrain, from a region of middle greenschist to lower amphibolite grade comprising rocks of the volcanic suite (5) and the metasediments of the Great Island Group. It is not known how the metamorphic events on either side of the intrusive quartz monzonite septum are related. The quartz monzonite (15) intrudes the paragneisses and migmatites of unit 4 and the volcanic rocks of unit 5 but has not been observed within the rocks of the Great Island Group.

The mineral assemblages chlorite-epidote-albite and blue-green amphibole ± hornblende were observed within the volcanic rocks indicating conditions of the upper greenschist to lower amphibolite facies of regional metamorphism. Near the contact with the quartz monzonite the hornblende in the volcanic rock is coarser grained and the volcanic rocks locally are amphibolitic. The rocks of the Great Island Group at Great Island display the following mineral assemblages:

1) Andalusite-garnet-muscovite-biotite-quartz (18).
2) Andalusite ± chlorite-biotite-quartz (19).
3) Garnet-amphibole (iron formation) (22).
4) Chlorite-muscovite-feldspar-quartz ± biotite porphyroblasts ± garnets (23).

These assemblages indicate a low pressure and high temperature regime of Abukuma type metamorphism; of lower greenschist to locally lower amphibolite grade. Therefore both the volcanic rocks (5) and the rocks of the Great Island Group in the area of Great Island display similar regional metamorphic gradients.

The mineral assemblage chlorite-muscovite-biotite-quartz in the outliers of the Great Island Group rocks (1) east of Great Island; (2) along the North Knife River; and (3) at Churchill is not diagnostic of specific conditions of metamorphism but in general indicates the greenschist facies of regional metamorphism. The general trend indicated by the metasedimentary rocks appears to be a lowering in grade of metamorphism eastward from Great Island. However, the rocks of uncertain affinity south of Great Island and the rocks of the Seal River volcanic belt east of Great Island indicate slightly higher grades of metamorphism in those areas.

The rocks of uncertain affinity which lie to the south of Great Island are intruded by the fluorite-bearing white monzonite (17). The mineral assemblage andalusite-garnet-muscovite + chlorite-quartz is characteristic of lower amphibolite facies regional metamorphism. However, the presence of a high percentage of the paragonite molecule in the muscovite, which occurs as inclusions in the andalusite poikiloblasts, is indicative of temperatures of at least 500°C during metamorphism.

The rocks of the Seal River volcanic belt, which underlie the outliers of the Great Island Group metasedimentary rocks, east of Eppler Lake, contain the mineral assemblage epidote-andesine plagioclase blue-green amphibole (actinolite and hornblende) indicative of lower to middle amphibolite facies metamorphism. The volcanic rocks are intruded by the granodiorite to quartz diorite (7) and are altered to epidote-hornblende-biotite plagioclase gneisses near the contact with granodiorite. The granodiorite to quartz diorite has been metamorphosed and intruded by the quartz monzonite (15).

Therefore, in addition to the apparent decrease of metamorphism to the east as indicated by the metasedimentary rocks of the Great Island Group, there also appears to be an increase in the metamorphic grade (a) to the south of Great Island and (b) east of Eppler Lake.

Structure

The regional structural trend in the map-area is easterly. This trend has been modified by later deformation about northeast and north trending axes. The easterly trend is indicated by a synclinal fold structure in the hypersthene-bearing rocks of units 1 and 2 in the northwest of the area. This structure is defined by measurement of foliation and schistosity and comprises an open fold which plunges at a shallow angle to the west-southwest.

The metasedimentary rocks in the central part of Great Island define an earlier west plunging syncline that has been refolded about northeast axial planes. At Meades Lake, to the northeast, a series of syncline and anticline pairs have been cross-folded into a north elongated basinal structure. The bedding at the south end of the structure is steeply dipping and locally overturned to the north. At the north end of the basinal structure an open fold plunges moderately to the south. The volcanic rocks at the north end of the structure exhibit a strike which is parallel to that of the overlying metasedimentary rocks of the Great Island Group. However, the volcanics dip much more steeply.

South of Great Island the rocks of uncertain affinity dip steeply to the northwest and southeast. Fracture cleavage and bedding intersections, and minor folds indicate the rocks are shallow plunging to horizontal. The dominant trend of the strike of the steeply dipping axial planes is to the east and northeast.

Along the North Knife River, immediately east of the rocks of uncertain affinity, the rocks of the Great Island Group are tightly folded. The folds are overturned to the north and have steep dipping axial planes. The plunge of the fold axes is moderate to steep and the minor fold axes exhibit abrupt reversals in plunge azimuth. Northeast, in the area of Teepee Falls on the North Knife River, the minor folds are asymmetric Z-shaped. These shallow plunging folds indicate the existence of a major anticlinal axis to the south. In the Churchill region the structure as interpreted by Bostock (1969) defines a tightly folded syncline overturned steeply to the northwest. This structure has been deformed about a northwesterly surface. The interpretation is compatible with the fold structures observed by the present author along the North Knife River. East of Eppler Lake the structures are ill-defined and not clearly understood. The outlier of metasedimentary rocks of the Great Island Group (19 &23) on the Seal River comprises a body which is elongate in a northeasterly direction. The folds at the north end of the outlier are upright open folds with shallow plunges to the west. The minor folds at the south end of this outlier plunge moderately to the east. A northeast trending fault may occupy the river corridor at this location, in which case the anomalous plunges could be explained as being in part due to reorientation of the original structural elements by displacement along the fault. Further east the minor structures in the volcanic rocks dip steeply with a northeast strike which is parallel to that of the previously inferred fault in the metasediments immediately to the west.

These isolated belts of metasediment and metavolcanics, separated by granitoid domains, may be interpreted as supracrustal keels sandwiched between the diapiric granites and migmatitic rocks. However, the role of block faulting and low angle thrust faults within the younger and more brittle metasediments has not been fully explored and is not likely to be in view of the poor exposure available.

Regional synthesis

At this time it should be noted that the coverage of the entire region north of 58° varies greatly in scale of mapping, much of which is at 1:100 000 or 1:250 000. The synthesis presented, therefore represents an initial attempt to describe the main lithologic elements common to all areas in addition to the inferred stratigraphic relationships of the major groups. A major part of the region has not yet been investigated by the writer and must of necessity be described on the basis of previous work by Bostock (1969), L. Davison (1965), and F. Taylor (1958). Elsewhere continuity of coverage is limited by sparse outcrop and large areas of frost heaved boulder fields. The difficulties of regional correlation are further compounded by a lack of diagnostic marker zones and the possibility of original facies changes between the isolated and deformed areas of supracrustals now remaining.

Archean hypersthene-bearing granulitic rocks form the crystalline basement for the region. They occur as a series of discontinuous bodies which trend from Misty Lake to the northeast into the area of Nejanilini Lake. These rocks are unconformably overlain by a sequence of metasedimentary derived gneisses of Aphebian age. The metasedimentary rocks comprise a later sequence of pelitic and semi-pelitic gneisses overlain by carbonates and/or quartzites which are in turn capped by meta-arkose to arkosic gneisses. At Great Island and downstream on the Seal River, metavolcanic rocks otherwise unique to the area occur as two irregularly shaped belts. Low grade metasedimentary rocks cap the older sequence at three distinct localities. These have been identified by previous workers as the "Hurwitz" in the northwest of Kasmere Lake, the Great Island Group at Great Island and the North Knife River, and the Churchill quartzite at the mouth of the Churchill River. The contact between these sedimentary groups and the underlying units is generally not exposed but in the case of the Great Island Group it can be defined on a regional scale as an unconformity. The extent of the hiatus between the older sedimentary and volcanic rocks and the younger "Hurwitz", Great Island Group and Churchill quartzites is of uncertain duration. Consequently, two equally feasible models can be presented at this time.

If the generally low grade and metamorphosed character of the younger metasedimentary groups is taken to be a consequence of a large or extended hiatus between their deposition and the evolution of the older higher grade early Aphebian gneisses then the "Hurwitz", Great Island Group, and Churchill quartzites may all be of late Aphebian age.

If, however, the low grade character of the younger metasedimentary rocks is explained on the basis of an originally different crustal setting then the Great Island Group in particular, lying as it does above the low grade volcanic rocks in the Great Island region, may be of equivalent age to the arkose and meta-arkose gneisses of the Munroe-Tadoule and Kasmere regions, the differing lithologies being a result of original facies variations. In this context the possibly analogous situation of the low grade Missi overlying the Amisk volcanics and the high grade Missi overlying greywacke gneisses of the Kisseynew mobile belt should be noted as a well documented example.

However, such inferences based on analogies with the Flin Flon belt may not be valid in view of the widespread occurrence of granulitic basement in the Seal River region and the possibly contrasting nature of the volcanic rocks.

As an extension of the first model the volcanic rocks may be considered to be indicative of a stage of major uplift during the Hudsonian orogeny. The volcanic rocks may have been intruded in an east trending graben or half graben structure in the central part of the Seal River area. The emplacement of a major west to southwest trending batholith complex of Hudsonian granitic rocks took place at this time. Following a hiatus, deposition of the younger metasedimentary rocks took place. Renewed deformation, metamorphism and intrusion of the porphyritic rocks, in part fluorite-bearing, represented the final phase in the Hudsonian orogeny.

Age relationships in the Seal River area

The youngest rocks are the diabase dykes 1200 m.y. (Fahrig, 1965). The igneous rocks of intermediate composition (15, 16, 16a & 17) are part of a major batholith that extends west and southwest across the map-area from Hudson's Bay. This batholith is part of a much larger welt-like batholithic complex which extends west to the Saskatchewan-Manitoba border south of Lac Brochet (Fig. 2), where it joins the Wathaman batholithic complex of Lewry et al., (1976). The granitic rocks south of the North Knife River have yielded potassium argon K-Ar ages from 1610 - 1840 m.y. (Wanless, 1967). Different phases of intrusion and episodes of intrusion are indicated by the deformation and recrystallization in some areas of these igneous rocks. This is especially evident in the quartz monzonite (15) in the area west and northwest of Great Island. The quartz monzonite (15) intrudes the paragneisses and migmatites of unit 4, and the volcanic rocks (5) and their related intrusions (6-9).

The porphyritic and in part fluorite-bearing quartz monzonite of units 16, 16a and 17 is considered to be younger than unit 15. These massive fluorite-bearing quartz monzonites (17) have intruded the metasedimentary rock of uncertain affinity in the area of the North Knife River south of Great Island. These granitic rocks apparently have not intruded the metasedimentary rocks of the Great Island Group at Great Island. However, the local presence of andalusite in the Great Island Group at Great Island and the degree of metamorphism of these rocks may be related to the final phases of orogenic activity and the emplacement of the late Hudsonian intrusive rocks.

Lithostratigraphic problems yet to be resolved are:

1) the age relationship of the volcanic rocks (5);
2) age relationship of the rocks of uncertain affinity (11-14);
3) age relationships of the rocks of the Churchill region (Churchill quartzites, (27)).

Amphibolites (4b) within the paragneisses (4) west of Great Island and the Spruce River are possibly derived from the volcanic rocks of unit 5. This would indicate that the volcanic rocks are of the same age as the paragneisses and are of early Aphebian age.

The rocks of uncertain affinity exhibit many lithologic similarities to the rocks of the Great Island Group. These rocks are intruded by the late Hudsonian granitic rocks (17) while the rocks of the Great Island Group at Great Island and along the North Knife River are not intruded by the fluorite-bearing quartz monzonites. However, the presence of the localized occurrences of andalusite in the Great Island Group rocks at Great Island, and the degree of metamorphism may be related to the final phases of orogenic activity and the emplacement of the later Hudsonian intrusive rocks. If this is so then the rocks of uncertain affinity and the rocks of the Great Island Group are of similar late Aphebian age.

In the North Knife River region, 6 km upstream from Teepee Falls, an occurrence of arkose (24) contains distinctive coarse detritus apparently derived from granitic rocks of units 16a. This occurrence raises the possibility that the meta-arkose at this locality is a small wedge of paleohelikian rocks and is younger than the surrounding rocks.

The rocks of the Churchill region (27) may, as H.H. Bostock (1969) suggested, represent a shallow water proximal facies whereas the rocks along the North Knife River and those of the Great Island Group represent the deeper water distal facies. However, no direct age relationships have been established between the rocks of the Churchill region and the rocks of the Great Island Group.

Evaluation of Mineralization in the Seal River map-area

Four distinct environments for potential base metal mineralization can be identified in the Seal River map-area. They are:

1) the interlayered acid and intermediate volcanic rocks and siliceous to tuffaceous rocks;
2) gabbroic rocks which intrude the volcanic rocks;
3) the layered metasedimentary sequence of metadolomite (20), iron formation (22) and pyritic meta-argillite to slate (21);
4) the amphibolite (4b) associated with the paragneisses west of Great Island.

In the volcanic rocks pyrite, and pyrite with minor chalcopyrite are persistent accessories. Mineralized localities are indicated on maps 1977S-1 and 1977S-2. The assemblage sphalerite chalcopyrite and pyrite is less common and was observed at only one locality in the volcanic rocks of the Seal River belt. The sulphides and carbonate occur mainly as small amounts of fracture and void fillings within the volcanic rocks of intermediate composition. These andesitic rocks may be massive to pillowed and brecciated flows. Pyrite and chalcopyrite occur as narrow veins within zones of silicification and chloritization in the more siliceous rocks. The rocks of the Seal River belt have been investigated by the Manitoba Mineral Resources Limited during the years 1974, 1975 and 1976. The mineralization in the volcanic rocks at Great Island is very similar to that in the Seal River belt. However, at Great Island agglomerates occur, acid volcanic rocks are more abundant and a high volume of tuffaceous rocks are also present.

A magnetite-bearing iron formation occurs in the metasedimentary rocks on the north side of Great Island. Pyrrhotite and pyrite are also present but are associated with alteration zones in areas of intense quartz veining. The main magnetite mineralization occurs in beds 1 mm to 1 cm thick interlayered with amphibole and disseminated magnetite (2-5%). The frequency of the magnetite laminae is variable and the magnetite beds are identified over an interval of 15 metres.

A grey-green clay with weathered fragments of pyritic slate underlies the iron formation. Some exploration pits have been dug along the strike of the contact with the iron formation and pyritic slates. Zinc has been reported from this locality (Taylor, 1958) but the nature of the mineralization is unknown. Pyritic slates are also present along the south side of Great Island in the channel of the Seal River.

A sedimentary iron oxide-iron sulphide facies model is applicable to the rocks of this sequence. The possibility of zinc in the pyritic slates of the north channel should be investigated in detail. The zonation of an iron-sulphide-zinc sulphide facies and possible copper sulphide facies as a sedimentary model for deposition of base metals is applicable here.

The gossan zones within the amphibolites (4b) west of the Big Spruce River are visible from an aircraft at low altitudes. The mineralization observed is disseminated pyrrhotite and pyrite. These sulphides occur as disseminated grains and as massive clots. The altered plagioclase in the mineralized amphibolite is a pale green colour.

The potential for uranium mineralization in this region must be considered in view of the similarity of the "Seal River" lithologies with those of the contiguous uranium-bearing Wollaston Fold Belt. These include the widespread occurrence of Archean basement overlain by graphite-bearing pelitic metasediments and the association of subsequently derived granitic segregations. The region differs, however, in the less pronounced northeast structural trend and the absence of the overlying Athabasca Formation, a feature which may simply be related to a deeper level of post-Precambrian erosion. During field mapping a limited radiometric survey of the rocks of the Seal River was carried out using a geiger counter. On-rock readings were taken, where possible, otherwise readings were made on hand samples. No anomalous areas were noted; however, certain rock types in the map-area appear to have potential for uranium mineralization despite the low geiger counter readings. More detailed examination of the following rock types should be considered:

1) the conglomerate of unit 12;
2) the pyritic shale (21) at Great Island and along the North Knife River;

3) the interlayered grey-green meta-arkosic rocks interlayered with phyllite (24) along the North Knife River;
4) late igneous porphyritic and fluorite-bearing porphyritic rocks of quartz monzonite to granite composition in the south half of the map-area.

The conglomerates (12) south of Great Island are of interest because of their pyrite-bearing phases. The presence of pyrite indicates a reducing environment during deposition that would have been favourable for uranium deposition in such coarse clastic rocks. However, the conglomerate is locally heavily weathered and deeply leached which could greatly reduce the surface radiometric response of the rock.

The pyritic slates of Great Island, North Knife River and the interlayered grey-green meta-arkose on the North Knife River can also be considered a potential zone of deposition for uranium because of the inferred reducing environment at the time of deposition.

The late granitic rocks (16, 16a & 17) may prove to have zones of uranium enrichment. This prediction is based on the radiometric response of very similar rock types in areas to the west in the Kasmere and Munroe-Tadoule Lake areas.

The paragneiss (4b), of pelitic and semi-pelitic composition and derived anatectic rocks (4f) immediately west of Great Island are of more limited potential. To the west, in the Kasmere area, numerous radiometric anomalies are present in these rock types; however, the anomalies decrease markedly in size and number to the east towards the Great Island region.

The Churchill quartzite (27) in the area of Churchill has been of interest for uranium exploration for some time. However, H.H. Bostock (1969) indicated several important differences between this rock and the uranium-bearing conglomeratic Matinenda formation of the Elliot Lake-Blind River area, Ontario. The nature of the source area was different as is indicated by the quartz and plutonic pebbles in the Matinenda formation as opposed to the mainly quartz and quartzite to protoquartzite pebbles in the Churchill quartzite. Feldspar is common in the Matinenda while it is essentially absent in the Churchill quartzite. Perhaps one of the most significant contrasts is the presence of abundant coarse-grained pyrite associated with the radioactive minerals in the Matinenda formation, as opposed to the presence of specular hematite along the bedding planes and as disseminated grains in the Churchill quartzite. The potential for deposition of uranium in the oxidizing depositional environment of the Churchill quartzite would be low making this rock type unfavourable for significant primary accumulations of uranium.

Secondary pyrite related to later shearing is present in the eastern part of the Churchill quartzite near and east of 94° longitude. The significance of this secondary pyrite relative to uranium and gold mineralization should be examined.

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