GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES

PAPER 72-29

PRECAMBRIAN GEOLOGY OF THE NORWAY HOUSE AND GRAND RAPIDS MAP-AREA

I.F. Ermanovics

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(Report, 11 figures and Map 5-1972)

I.F. Ermanovics

DEPARTMENT OF ENERGY, MINES AND RESOURCES

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'Progress'

"Above the Forks [of the Gunisao River] the south branch is the larger. On this many rapids obstruct the stream up some of which the canoe was hauled with a line, while past twenty-two of the most serious it was necessary to carry the canoe".

...from the Summary Report of
J.B. Tyrrell to the Director
for the years 1890, 1891 and 1895.

"All these streams are well travelled and portage trails are cut around the numerous rapids and falls. Stevenson lake is reached from Norway House on Lake Winnipeg by ascending the Gunisao and McLaughlin rivers to Ponask lake, crossing the height of land by a series of portages to Lone Nest Lake to the southeast, and thence east by river through Pelican Lake to Stevenson Lake".

...from GSC map 423A by
A.W. Johnston 1936.

"Portage trails have vanished thus descending the [south branch of the Gunisao] River is facilitated by rubber boat. These can be navigated through and over most of the numerous rapids or be allowed to drop, unloaded and tethered to shore, over many of the small water falls".

...from 1971 field notes of
I.F. Ermanovics.

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ABSTRACT

Six thousand square miles of the Superior Province in southeastern Manitoba have been interpreted in terms of orogenic zones and depth. It is suggested that volcanic belt rocks, layered gneisses and mafic diorite, representing 24 per cent of the exposed rocks in the area, are the relicts of the meso- and supracrustal zones developed during the Kenoran orogeny; such rocks are confined to areas north of latitude 53°30'. Pre-Kenoran, remobilized leucocratic, foliated granodiorite and quartz dioritic rocks constitute 62 per cent of the map-area and occupy 85 per cent of the terrain south of latitude 53°30'. This latitude, marked by mylonite is the northern boundary of the Berens batholithic block. The mineral potential of a number of small ultramafic bodies and extensive 'metadiorite-gabbro' rocks should be evaluated.

RÉSUMÉ

Une aire de 6,000 milles carrés faisant partie de la province du lac Supérieur, dans le sud-est du Manitoba, a été interprétée par l'auteur du point de vue des zones orogéniques et de la profondeur. L'auteur propose que la zone de roches volcaniques, et les couches de gneiss et de diorite mafique qui représentent 24 p.100 des affleurements de la région sont les reliquats de zones mésocorticales et supracorticales formées au cours de la phase tectonique du Kenora; ces roches ne se présentent qu'au nord de la latitude 53°30'. Les leucocrates redisposés, les granodiorites foliés et le quartz dioritique tous du pré-Kénora recouvrent 62 p.100 de la surface couverte par la carte et 85 p.100 des terrains au sud de la latitude 53°30'. Cette latitude, caractérisée par les mylonites, constitue la frontière nord du bloc batholitique Berens. Il y a lieu d'évaluer le potentiel en minéraux d'un certain nombre de petits amas ultramafiques et d'un nombre considérable de roches gabbroïques associées aux métadiorites.

PRECAMBRIAN GEOLOGY OF THE NORWAY HOUSE AND GRAND RAPIDS MAP-AREA

INTRODUCTION

The study area includes the Norway House map-sheet (63H) and the Precambrian terrain of Grand Rapids map-sheet (63G).

Purpose of Study

The present work is a continuation of a remapping program between latitudes 51 and 53 degrees carried out in 1968 and 1969 in southeastern Manitoba (Ermanovics, 1970a, b) for the purpose of providing a broad framework for the Manitoba Mines Branch, large-scale, 'Greenstones Project'. Remapping provides the detail necessary for reinterpretations of Archean terrain in the light of new thoughts on tectonism and also provide an opportunity for reassessing the economic potential and pointing out favourable areas for prospecting.

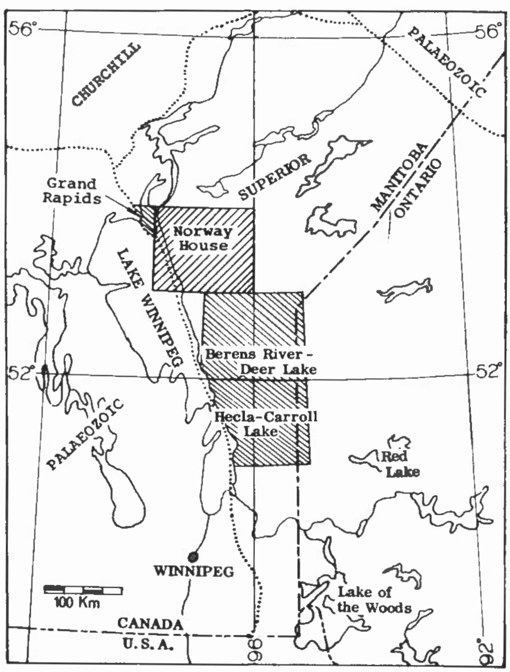

Figure 1. Index map for Norway House map-area and locations of Berens River–Deer Lake and Hecla–Carroll Lake map-areas (Ermanovics, 1970a and b).

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Final version approved for publication: May 5, 1972

Logistics and Physical Features

The area is covered with muskeg; however, outcrop is not lacking, even in string-bogs. Varved clays are abundant at Norway House, along the shore of Lake Winnipeg to latitude 53°30', and reach 20 miles inland along the Gunisao, Bélanger and Mukutawa Rivers. Additionally, all lakes in the area contain small deposits of sandy clay which become sorted locally to sandy beach deposits. Beaches along the eastern shore of Lake Winnipeg comprise clay-sand; the purer variety of sand forms dunes locally, as for example opposite Spider Island. The prominent ridge shown on topographic maps at latitude 53°30', 15 miles east of the shore of Lake Winnipeg, consists of sandy clay at the only three localities that were checked. The ridge marks an old lake bed which locally contains peat. A layer 2 feet thick, of brown, woody peat forms a continuous deposit from Montreal Point, northward for 6 miles along shore.

The area is poorly drained. The elevation ranges from 713 ± feet at Lake Winnipeg to an approximate elevation of 850 ± feet in the centre of the map-area, which serves as a drainage divide between streams flowing westerly into Lake Winnipeg and those flowing northeasterly to James Bay.

Previous Work

A.W. Johnston (1936a, b) recognized equal proportions of sediments and andesitic flows in the Ponask-Stevenson Lake belt; slate and conglomerate reported by Johnston were not found. The igneous plutonic rocks were divided by him into an early quartz diorite phase and a later granite phase.

Tyrrell (1900), exploring the region along Lake Winnipeg and its main rivers in 1890, 1891 and 1895 outlined areas of 'granitite' (biotite granodiorite and quartz diorite), schists and gneisses (metavolcanic and metasedimentary rocks), and granites. He recognized large areas of 'epidotic granitite' in which discrete grains were thought to be primary and those altering plagioclase secondary.

Present Work and Acknowledgments

The field party consisted of three traversing teams. Traverses were made from Gunisao, Stevenson, Ponask, Lebrix and Costes Lakes as well as the lake immediately southwest of Ponask Lake. The Bélanger, Nanawan and Mukutawa Rivers were traversed downstream along their length using rubber boats. Additionally, all lakes were investigated and those with connecting streams were traversed by canoe. The entire area was traversed systematically with helicopter along every 5-minute meridian of longitude in '12 flying days'. Six hundred thin sections were studied and 100 were point-counted.

The camps were supplied from Pine Falls on the Winnipeg River every 12 days coinciding with camp moves.

The successful completion of mapping in 1971 within the map-area in one field season is due, in no small part, to my assistants: L.S. Jen (Ottawa University), J.A.R. Stirling (University of New Brunswick), J. Delaney

(Carleton University), T. Dibus (University of Calgary), L.G. Annand (University of British Columbia) and P.-Y. Larose (University of Montreal). Mr. L.S. Jen made an interpretation of the volcanic rocks. Drs. T.N. Irvine and E. Froese (Geological Survey of Canada) helped in the textural interpretation of the metamorphic hornblendites, and metamorphic grade, respectively. Dr. R.H. Ridler, Geological Survey, reported on 10 polished sections of rocks containing sulphides. I am indebted to W. Lloyd Davison for his critical reading of the manuscript of this paper.

GENERAL GEOLOGY

Introduction

Excluding metavolcanic-sedimentary rocks (3)[1], the map-area comprises 99 per cent plutonic and gneissose rocks (1, 2). All rocks are metamorphosed with the exception of a two-pyroxene gabbro body (4a) north of Stevenson Lake and small diabase dykes (10) in the northwestern part of the area. The massive to weakly foliated plutonic rocks[2] are divided into quartz monzonite (9), mafic diorite and quartz diorite (5), and a group of leucocratic oligoclase quartz diorites to granodiorites (7) confined to the southern half of the map-area. Layered gneisses (1), thought to 'rest on' foliated augen-granodiorite to oligoclase quartz diorite (2), are classed, according to feldspar composition and colour index, into four groups. Mafic diorite and quartz dioritic (5) rocks are confined to the area north of latitude 53°30' where, in association with dioritic gneiss (1d), they are postulated to represent the intrusive chemical equivalents of the extrusive lavas. Rocks of unit 7 range from leucocratic oligoclase quartz diorite to quartz monzonitic granodiorite and are grouped according to dominantly hornblende (7b), biotite (7a) or microcline content (7c). The reason for the compositional spread of unit 7 lies not in the lack of mapping resolution alone but is based largely on the fact that contacts of these compositional variants are gradational over many miles so that any number of mixed rock-compositions is possible.

Layered Gneisses (1)

Lenticular concentrations of quartz + feldspar and biotite + hornblende produce pronounced layering in these rocks; they are subdivided texturally and compositionally as follows:

1a: fine- to coarse-grained, leucocratic quartz-feldspar gneiss; less than 20 per cent mafic layers; abundant quartz and microcline-perthite; highly granitized.

1b: fine- to coarse-grained, mesocratic, quartz-oligoclase gneiss; 20 per cent mafic layers; locally granitized.

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[1] Numbers in parentheses refer to map-units of geological map accompanying this report.

[2] The classification used is that of I.C. Brown, 1967 and is similar to that of Bateman *et al.*, 1963; see Fig. 4 of this report.

1c: medium-grained, melanocratic quartz-oligoclase gneiss; greater than 20 per cent mafic layers; antiperthitic when free microcline is absent.

1d: medium- to coarse-grained andesine quartz diorite and diorite gneiss interlayered with fine-grained metagabbro, aplite, oligoclase quartz diorite and amphibolite; includes diorite-amphibolite agmatite.

These subdivisions are made relative to each other and except for 1d, are not correlative across the map-area. Indeed (1a) to (1c) appear to be a series of granitized, originally quartzofeldspathic greywacke. Similarly, (1c) seems to be a granodioritized and dislocated form of subunit 1d which in turn, by virtue of its association with dioritic rock (5), appears to have constituted in part, a basaltic (metagabbro and amphibolite) host rock for the dioritic rock (5). Metagabbro and fine- and coarse-grained amphibolite of subunit 1d may, in fact, be the "floor" for the volcanic belt rocks (3) rather than 'derived' from the volcanic-belt rocks (3). This suggestion stems from the observations that no-where is it possible to trace volcanic rock into granitized hybrid volcanic rock (Fig. 2).

Where granitization effects in subunits 1c, b, and d are weak or absent, the gneisses are granoblastic and fresh. This is well illustrated at Playgreen Lake where many gneisses have the appearance of textural granulites not unlike those that the author is familiar with in areas of hypersthene granulite elsewhere in the Canadian Shield. Porphyroclasts of serrated, dislocated and zoned andesine, and antiperthite grains 'swimming' in a fine-grained, amoeboid matrix of quartz + oligoclase + biotite and hornblende are a common feature. Such porphyroclasts suggest that the original rock had a bimodal grain distribution and in the case of antiperthite porphyroclasts that the rock formerly may have been a metamorphic granulite. Although amphibolite layers, bespeaking altered sills, dykes, gabbros and volcanic rock enclaves are common, pelitic layers (bearing in any combination biotite, cordierite, sillimanite, muscovite) are rare. The sporadic occurrence of pelitic material however, does suggest a sedimentary origin for at least some portions of these gneisses.

Bell (1971) described identical amphibolite-facies gneisses in the Cross Lake area (immediately north of the present map-area) which he included in the Pikwitonei Province granulite complex and which he considers early Precambrain basement complex (i.e. pre-Kenoran basement). These gneisses are similarly granitized, veined and disrupted by quartz monzonite, granodiorite and leucocratic quartz diorite as are the gneisses of unit 1 in the present map-area.

Foliated Augen-Gneiss (2)

White to buff-coloured granodioritic and quartz dioritic oligoclase augen-gneiss is medium to coarse grained, occasionally porphyritic, and generally contains 10 per cent biotite. Although they are probably dominantly orthogneiss, mafic schlieren and ghost inclusions, in addition to accentuating the planar fabric locally, bespeak a component of paragneiss. These gneisses appear to underlie the layered gneisses (1) where they are distributed around closures of folds. Biotite commonly occurs as segregated clots; quartz is recrystallized to lenses and at Playgreen Lake these gneisses are granitized (Fig. 3).

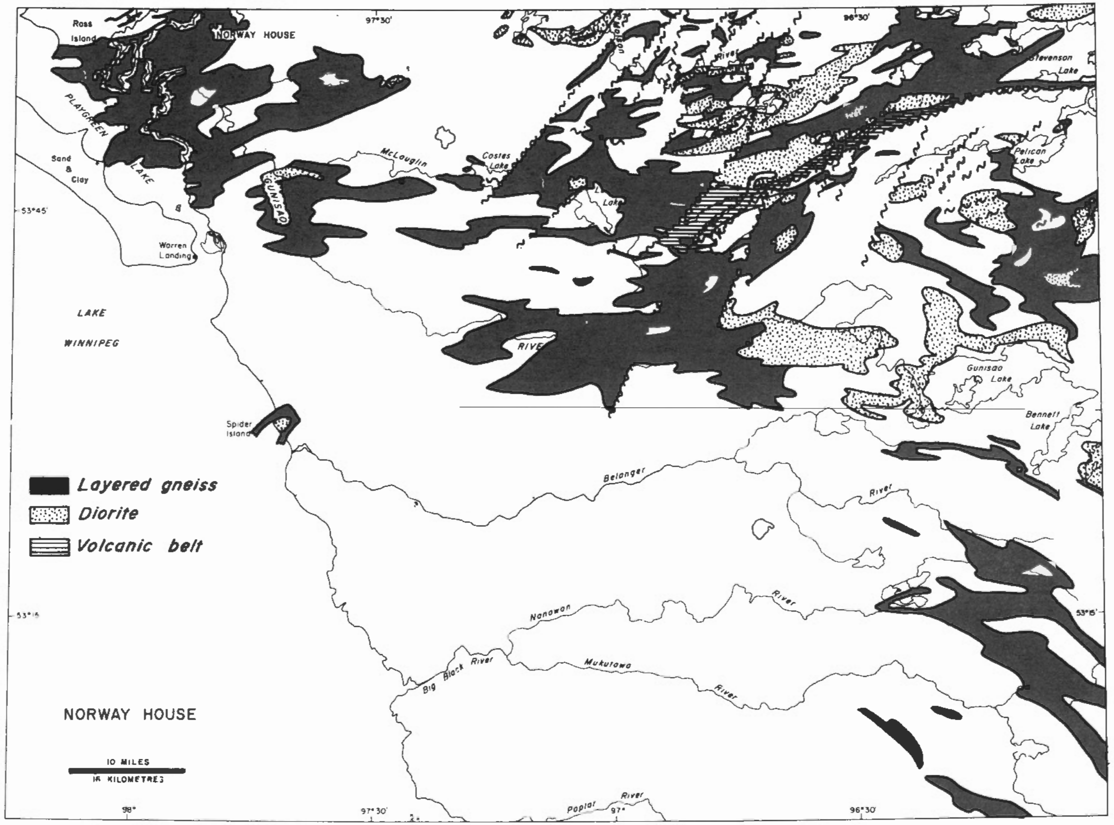

Figure 2. Distribution of layered gneiss (1), mafic metadiorite and quartz diorite (5), Ponask Lake metavolcanic-sedimentary belt (3) and assumed faults. This synoptic figure of the map-area shows the close association of all three rock units which represent the relict and most easily recognized elements of the tectogene. The configurations of gneisses north-northeast of Gunisao Lake leads eastward to volcanic rocks of Bigstone Lake; the configuration of gneisses south of Gunisao Lake leads eastward to volcanic rocks of Cobham River. Unshaded areas are massive to foliated quartz monzonite, granodiorite and quartz monzonite.

Metavolcanic and Metasedimentary Rocks (3)

These rocks occupy a linear belt 44 miles long, extending from Stevenson Lake to 12 miles southwest of Ponask Lake, with an outcrop width ranging from 0.5 to 4 miles, but a true thickness of probably no more than 2,000 feet. Primary textures and minerals in these rocks are rare, and are masked by metamorphic minerals such as hornblende, biotite, muscovite, oligoclase/andesine, garnet, and sillimanite. The north side of the belt is dominantly metasedimentary and appears to be intruded by diorite; the southern portion comprises mafic tuffs, greywackes and basic flows and lies in fault-contact with leucocratic (oligoclase) quartz diorite (7a). The western extremity of the belt is terminated abruptly by a normal fault displacement which has exposed layered gneiss (1d) postulated to underlie the volcanic rocks. A late cataclastic fabric characterizes most rocks in the belt; diaphthoresitic schists represent sheared amphibolite and basic flow rocks, and 'cherts' and mylonite in dominantly quartzofeldspathic rocks.

Metavolcanic rocks: (3a)

Epidote-chlorite-hornblende schists, and mafic schists bearing epidotized andesine and small pods of recrystallized quartz are by inference relegated to basic to intermediate volcanic rocks. The inference stems from rare relict volcanic textures (plagioclase microlites) found in these rocks and assumed isochemical metamorphic mineral transformations. Thus using the composition of plagioclase and amount of quartz, volcanic rocks ranging from basalt to dacite have been identified with those of andesitic to dacitic aspect being most abundant.

Nowhere was it possible to demonstrate convincingly the presence of flows more acid than dacite because leucocratic rocks in the belt are sheared. Additionally, seriate-textured quartzofeldspathic metasediments grade downwards into porphyroclastic rocks (recrystallized, porphyritic acid volcanics?) and upwards into aluminous paragneiss. Consequently rocks that have been metamorphosed to upper amphibolite facies, and subsequently sheared and recrystallized again will have to be classed chemically when such analyses become available.

Aphanitic to fine-grained black layers are intercalated with the volcanic rocks and form the base of the exposed volcanic rocks in places. Microscopically, these black rocks are schists consisting of thin laminae of quartz, oligoclase and idioblastic tremolite. These appear to be metasedimentary amphibolites whose fine grain-size is comparable to that of the aluminous metasediments. On the scale of the present mapping it was not possible to separate such fine-grained amphibolites of possible metasedimentary origin from the amphibolitized mafic lavas.

A sill of andesite composition occurs near the southwestern extremity of Ponask Lake (Fig. 10). The rock is hornfelsed and rings when struck with a hammer.

Metasedimentary rocks (3b, c).

The series of rock-types within the belt grades upwards from recognizable volcanic rock (3a) as follows: fine- to medium-grained quartz-hornblende-oligoclase gneiss (3b) → laminated, varicoloured epidote-hornblende-quartz-oligoclase gneiss (3b) → fine-grained quartzofeldspathic gneiss (in part cataclastic 'cherts') (3a), →pelitic gneiss (3c).

The origin of mafic hornblende gneiss (3b) associated with both lavas (3a) and laminated gneiss (3b) is problematical. Laminated epidote-rich gneisses (3b) may have been tuffaceous greywackes. Acid tuffs and quartzofeldspathic sediments may be represented by fine-grained quartzofeldspathic gneisses (3a). Well laminated and sheared, these acid rocks bespeak a previous bimodal grain distribution as might be expected in tuffs and certain sediments. Porphyroclasts in acid rocks consist of plagioclase and quartz, and rarely microcline; the matrix is granoblastic.

Pelitic rocks (3c) contain mainly quartz and andesine (An_{36}), and are fine-grained, granoblastic and intercalated with medium-grained quartzofeldspathic gneiss (3c). Fine-grained titaniferous biotite, not visible in the hand specimen, generally imparts a red-brown hue to the fresh surface of such rocks.

Ponask Lake Pegmatite (4b)

Pegmatites are numerous in some areas but only at Ponask Lake was one of these lenses mapped in detail. The pegmatite is metamorphosed and intrudes both diorite (5) and volcanic rocks (3). The body is a quartz-rich, albite-perthitic microcline-muscovite-biotite rock. Large crystals of muscovite and tourmaline are common.

Ultramafic Bodies (x) and Gabbro (4)

Amphibolites, marked as "x" within metavolcanic rocks on the map accompanying this report, are inferred to have been pyroxenites on the basis of relict pyroxene and layers of serpentinite. All gabbro (4) is metamorphosed with the exception of a two-pyroxene-bearing mass (4a) north of Stevenson Lake.

Ultramafic bodies (x)

These rocks are generally recognized as medium- to coarse-grained (commonly pegmatite crystal sizes), foliated amphibolites. They occur as round plugs (50 to 200 feet in diameter) and as lenses in volcanic rock (3a). Most rocks show an amphibolitized orthopyroxene cumulate with interstitial altered clinopyroxene, plagioclase and traces of quartz. Most crystals are hornblende pseudomorphs after pyroxene. A second metamorphism related to shearing has produced layers of albite-epidote-biotite. Serpentinite, with calcite-antigorite lenses, was found in association with pyroxenite.

Gabbro (4 and 4a)

Coarse-grained metagabbro (4) occurs as dykes and small plugs associated with quartz monzonite and granite, chiefly in the faulted region between Ridge and Pakatawacun Lakes. However, fresh, medium-grained, two-pyroxene gabbro (4a) was discovered north of Stevenson Lake where it occurs as a conformable east-west striking lens 0.5 mile wide and 2.5 miles long. Occasional portions exhibit, in thin section, primary, aligned, plagioclase (oscillatory zoned An_{50} to An_{18}) cumulate parallel to the long axis of the body. Progressively increasing hornblende pseudomorphism after pyroxene develops as the gabbro is traced into metadiorite (5a). Gabbroic lenses with relict clinopyroxene are abundant in the area surrounding the main gabbro mass. The gabbro is interpreted as being the basic cumulate of the diorite and that both were emplaced during folding. Why portions of this gabbro escaped metamorphism remains unexplained.

Mafic Metadiorite and Quartz Diorite (5)

Mafic dioritic rocks, as defined in this report, are confined to the northeastern portions of the map-area, where they are associated with the volcanic belt rocks (3), and layered gneiss (1) (Fig. 2). Three varieties are recognized:

(5a): medium- to coarse-grained, mesocratic diorite; biotite-hornblende (20 to 45%), andesine; contains fine-grained gabbro and amphibolite, and inclusions of rocks of unit 3;

(5b): medium- to coarse-grained, mesocratic diorite and quartz diorite; biotite-hornblende (15 to 35%), andesine; grades to granodiorite bearing 10 per cent perthitic microcline;

(5c): medium- to coarse-grained, white to light grey oligoclase/andesine quartz diorite; 20 per cent biotite + hornblende.

These rocks are metamorphosed, although not always foliated. The extreme effect of the metamorphism was to produce biotite at the expense of hornblende, although hornblende commonly recrystallized to poikiloblastic grains as well. Recrystallized quartz and various degrees of epidotization of plagioclase are the most common expressions of metamorphism in massive portions. In areas where shearing was intense, epidote and quartz were mobile as expressed by veins dominantly of this composition parallel to foliation.

A common feature in subunit 5a near the contact with metasediments (3c) is regular layering (4 to 5 inches thick) of mafic-poor quartz diorite and mafic diorite. This feature may be due to primary crystal differentiation during syntectonic (syn-folding) emplacement of the plutonic rock or to metamorphic differentiation.

Although these plutons may be cogenetic (by virtue of similar kind and proportions of minerals) they may not be coeval. They are exposed now at different levels and associated with different rocks. The pluton (5c) exposed at Gunisao Lake ranges from mafic diorite to a more felsic quartz diorite which in turn has a composition similar to the most mafic portions of the ubiquitous, leucocratic quartz diorite of unit 7b to be discussed later. Diorite 5a, ('dirty diorite'), on the other hand, associated with gneiss and lavas, is more consistently mafic and basic than either 5b or 5c.

Leucocratic Metamorphosed Quartz Diorite (6)

Coarse-grained quartz diorite, strongly foliated, and locally sheared, with highly variable colour index (5 to 25%) is confined to the southwestern portion of the map-area along the shore of Lake Winnipeg. The rock is distinguished by its high epidote content, both as epidotized plagioclase (oligoclase/andesine) and up to 20 per cent free epidote. The rock has a green hue and is unusual enough to have caused Tyrrell (1900) to postulate a crystallization sequence of epidote → biotite → hornblende. In fact, however, the quartz diorite is metamorphosed to produce biotite → hornblende and then sheared to produce epidote + calcite, + magnetite + chlorite after biotite. The rock's well developed planar fabric, its heterogeneous composition and epidote content warrant its separation (unit 6) from other rock types. Its planar fabric is similar to that of granodiorite augen-gneiss (unit 2), and it may be of the same age as the gneiss.

Granodiorite and Undivided Quartz Diorite (7)

This unit comprises a huge volume of ubiquitous rock which seems to intrude diorite (5) and layered gneiss (1) north of latitude 53°30', and forms 'seas of granite' south of that latitude. The rocks are subdivided as follows:

(7a): biotite, perthitic microcline (5 to 15%), quartz, oligoclase; medium-grained, white to light grey, less than 15 per cent biotite; local oligoclase quartz diorite; massive to weakly foliated.

(7b): biotite, hornblende, perthitic microcline (ca. 10%), quartz, oligoclase; less than 15 per cent biotite + hornblende; locally, oligoclase quartz diorite; massive to weakly foliated.

(7c): granitized 7b; highly variable composition, and may include 25 per cent perthitic microcline; generally well foliated.

Recrystallization cannot be always demonstrated in these rocks especially in massive portions. Consequently, 7a and 7b may constitute areas in which granodiorite intrudes older leucocratic quartz diorite and the epidotized quartz diorite (6) may be the host to magmas of unit 7. Unit 7c, with relatively high microcline content, appears to contain a granitizing phase which culminates with the emplacement of quartz monzonite.

Metadiabase (8)

Black, fine- to medium-grained, foliated amphibolite dykes (sills?) 20 to 300 feet long and ranging in thickness from 2 to 6 feet, are found in all rocks, except quartz monzonite (9), and most appear to be confined to the northeast quadrant of the map-area. Certainly, with the exception of 2 or 3, all dykes are confined north of latitude 53°30'. The dykes are occasionally folded, and with rare exceptions strike parallel to the adjacent foliation of the country rock. Generally, they have a granoblastic texture comprising 65 per cent poikilitic, green hornblende, 25 per cent poikiloblastic (recrystallized) epidote and plagioclase, and 1 to 10 per cent recrystallized quartz. At least some of this quartz appears to be introduced secondarily.

Quartz Monzonite (9)

Medium- to coarse-grained, leucocratic, quartz monzonite, containing 90 to 97 per cent perthitic microcline, quartz and calcic oligoclase outcrops as three batholiths on Gunisao and Stevenson Lakes and north of Costes Lake (Fig. 3). Biotite is the common mafic mineral. Modes of the bodies, mapped as quartz monzonite, tend toward the granodiorite field (Fig. 4). The bodies at Gunisao and Stevenson Lake are bounded and transected by shear zones and in those quartz is recrystallized and biotite appears frayed. The edges of these masses grade into an altered, (epidote) granodiorite, usually foliated, and bearing up to 18 per cent biotite and minor hornblende; some phases are muscovite-rich and porphyritic. The quartz monzonite mass north of Costes Lake is commonly porphyritic and appears to have a granitized aureole (subunit 7c) at least twice the diameter of the quartz monzonite body.

Diabase and Gabbro Dykes (10)

Twelve massive, aphanitic diabase and two coarse-grained gabbro dykes (10a) whose primary texture and mineralogy are still preserved were found. Their azimuth ranges from 350 to 015 with the exception of one differentiated gabbroic dyke that strikes at 030. They are confined to the area north of the mylonite zone extending from Stevenson Lake to Spider Island on Lake Winnipeg.

The aphanitic diabases vary in thickness ranging from 6 inches to 3 feet, and exhibit a variable mineralogy and state of alteration. Phenocrysts, as large as 2 mm, comprise quartz, olivine, ortho- and clinopyroxene or plagioclase. Plagioclase (An_{70}) shows oscillatory zoning. Olivine and orthopyroxene are generally serpentinized. Green biotite and actinolitic amphibole pseudomorph small portions of some pyroxenes, and epidote + sericite (alter ?) some plagioclases.

Coarse-grained gabbro dykes (10a) contain layered, labradorite cumulate, and range from 6 to 65 feet in thickness. Fresh labradorite and clinopyroxene, and serpentinized orthopyroxene enclose interstitial granophyre. Ilmenite and magnetite has been replaced by leucoxene and sphene. These dykes were noted only in passing in the field and their detailed petrography and origin must await further study.

METAMORPHISM

With the possible exceptions of small portions of quartz monzonite bodies (9) and some portions of massive granodiorite (7a, b) all rocks in the area are metamorphosed. To a first approximation three periods of metamorphism can be distinguished over the map-area.

M_1: sillimanite, garnet, andesine (An_{36}), cordierite, biotite, muscovite assemblages in pelitic and quartzofeldspathic gneisses, compatible with biotite and amphibole in quartz diorite and mafic lavas.

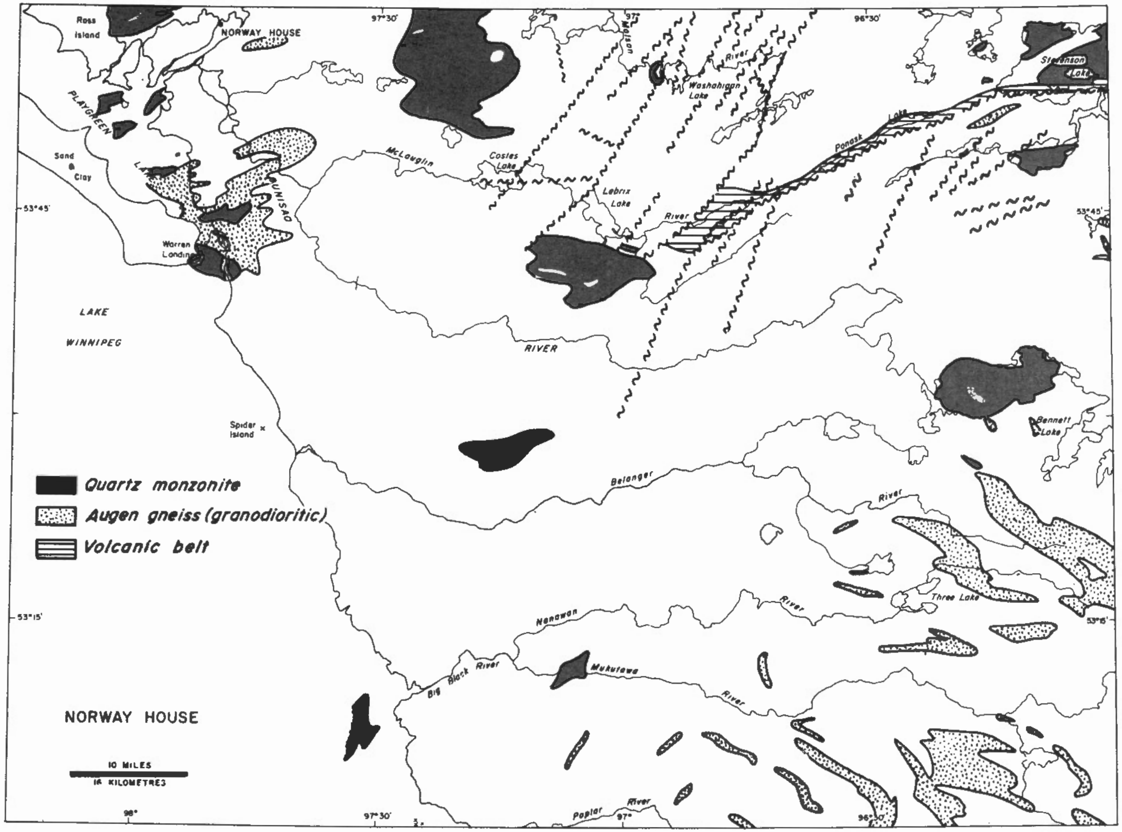

Figure 3. Distribution of quartz monzonite (9), leucocratic granodioritic and quartz dioritic augen-gneiss with clotted mafics and schlieren (2), Ponask Lake metavolcanic-sedimentary belt (3), and assumed faults. This synoptic figure of the map-area shows the most easily recognized oldest (augen-gneiss) and youngest (quartz monzonite) rocks of the pre- and post-main orogenic event. Nevertheless, quartz monzonite bodies show preferred east-west orientations. The absence or non-recognition of this type of augen-gneiss, or indeed the absence of any unconformity adjacent to the volcanic belt rocks, suggests large scales of active plutonism in the area of the volcanic belt.

M_2: diaphthoresitic metamorphism, related to shearing, producing chlorite, albite and epidote in quartzofeldspathic compositions, and albite, epidote, tremolite and actinolitic amphibole, and chlorite, in mafic compositions.

M_3: a post-Kenoran thermal event, based on K/Ar age dating of granitoid rocks, which in the map-area must represent the southernmost limit of the Cross Lake subprovince, similarly affected. Presently, little is known of this event texturally in the map-area and it is based purely on one age determination on biotite on Kettle Island in Playgreen Lake, yielding 2,190 m.y.

Ordinarily M_2 is confined to small shear zones. However, in a number of localities where shear zones extend over the map-area several miles wide, retrograde metamorphism becomes important. This is especially true of the Stevenson Lake-Ponask Lake volcanic belt, where shearing resulted in mylonitizing rocks of quartzofeldspathic compositions and 'greenschisting' formerly upper amphibolite facies, volcanic rocks. Areas of plutonic rocks so affected lie in the wedge of land between the mylonite zone immediately south of Gunisao Lake, and the zone extending from Stevenson Lake to Spider Island on Lake Winnipeg.

The following are M_1 and some M_2 mineral assemblages (grains touching) from Ponask-Stevenson Lake rocks ranging from pelitic to quartzofeldspathic to mafic (basaltic) compositions: (quartz is also present).

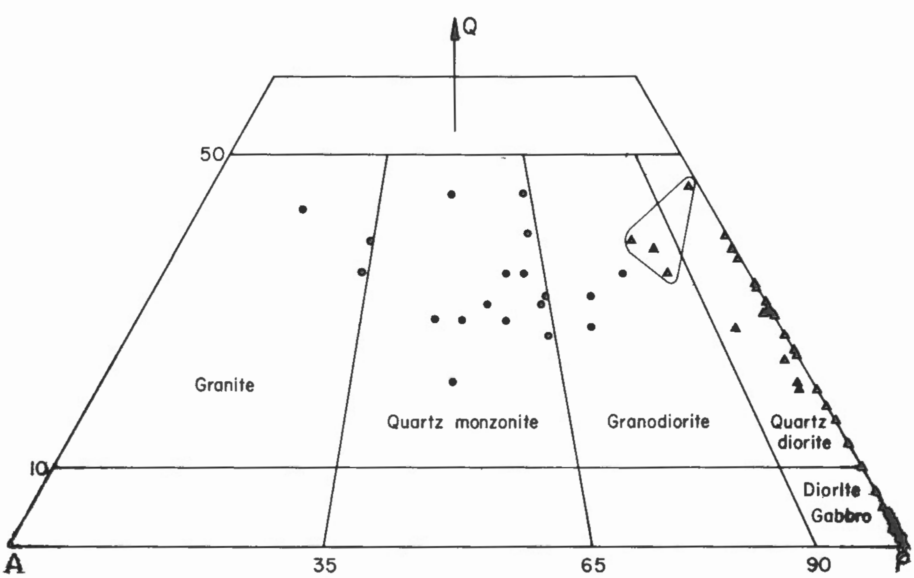

Figure 4. Quartz-microcline-plagioclase diagram showing distribution of modal compositions of rocks mapped as quartz monzonite (9) (closed circles) and mafic metadiorite and quartz diorite (5) (triangles). In 95 per cent of the quartz monzonite specimens Σ (Q+A+P)$\geq$ 90%. All dioritic rocks plotted (triangles) show Σ (Q+A+P)$\leq$80%; the singular variation of Q-P in these rocks is in large part the effect of metamorphic differentation; the field of four triangles represents the modes of granitized quartz diorite.

a. biotite + muscovite + sillimanite + An_{36} + (M_2 chlorite + muscovite).

b. biotite + muscovite + garnet + An_{40}.

c. sillimanite + muscovite; garnet + biotite + muscovite; biotite + sillimanite.

d. biotite + muscovite + chloritoid (M_2?) + chlorite (poikiloblastic plagioclase).

e. biotite + muscovite + (synfolding poikilitic plagioclase).

f. biotite + muscovite + (synfolding poikilitic plagioclase).

g. biotite + garnet; hornblende + plagioclase (laminated rock).

h. biotite + hornblende + poikiloblastic plagioclase + epidote (M_2).

i. biotite + hornblende + plagioclase.

j. diopside + feldspar; hornblende (green) + epidote.

k. hornblende (M_1) + hornblende (M_2) + biotite.

l. hornblende (green) + epidote + plagioclase.

m. hornblende (green) + epidote + relict An_{45} microlites.

n. biotite + muscovite + sillimanite + cordierite + plagioclase (an inclusion in migmatite near Diamond Falls on Gunisao River).

Mafic rocks (lavas) appear to have had little crystal growth during M_1 because primary relict microlites (assemblage m) have survived even through M_2. Even M_1 pelites have a remarkably fine grain-size. That both pelitic sediments and mafic lavas have been affected by upper amphibolite M_1 cannot be disputed since they are intercalated. However, M_2 - 'greenschisting' of the mafic volcanic rocks makes it appear as though these rocks never attained grades higher than upper greenschist facies. Carbonate, epidote and chlorite in the mafic rocks are suggestive of water pressures capable of depressing metamorphic grade and at the same time permitting biotite and hornblende to exist over a wide range of temperature.

Figure 5 is a preliminary attempt to synthesize M_1 mineral assemblages on an AFM projection. The present level of exposure within the map-area seems to indicate uniform sillimanite-almandine-muscovite zone metamorphism in the metavolcanic-sedimentary belt, and in layered gneisses (1) in the region of granitization southeast of Norway House.

STRUCTURAL GEOLOGY

Foliation

Tectonic fabric (preferred orientation of minerals L_2 and layering L_1) is on the whole, faithfully represented by the aeromagnetic pattern of GSC Map 7739 G. Layering (L_1) was probably produced during M_1 - metamorphism and this fabric is commonly transected by a second planar fabric (L_2) related to M_2 metamorphism. On the geological map accompanying this report, layering is distinguished from preferred mineral alignment and their

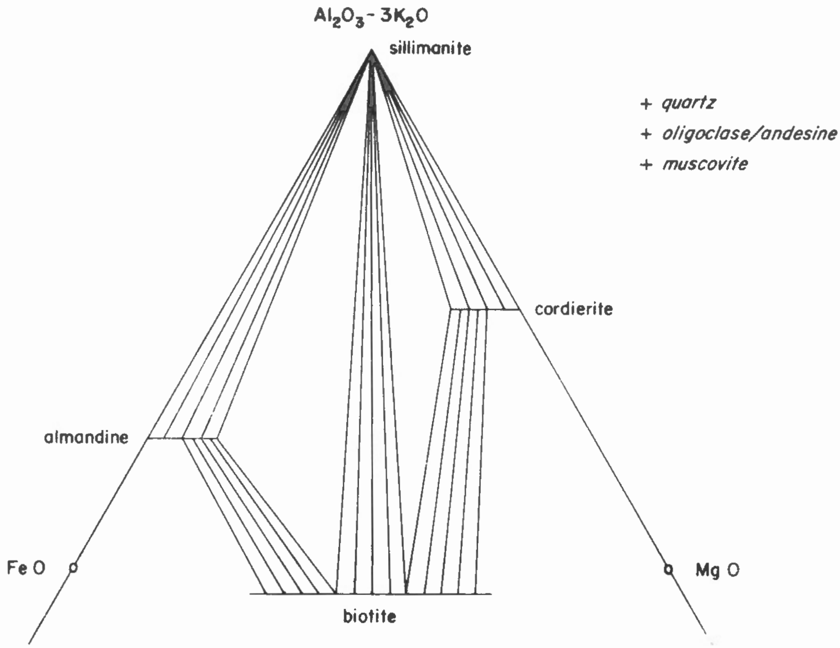

Figure 5. Schematic presentation of mineral assemblages (coexisting with quartz, plagioclase and muscovite) in the Norway House map-area in the system SiO_2-Al_2O_3-MgO-FeO-K_2O-H_2O.

intersections commonly give rise to mullion structures and mineral lineations. Whereas layering generally follows the strike of the rock unit which thus can be shown to be folded, a regional appraisal of L_2 is not easy. In many localities L_2-foliations appears to be related to shearing, which, as along the southern contact of the volcanic belt, is in turn related to a fault. Elsewhere, L_2 may be of the same generation as tectonite L_1.

Regional foliation north of latitude 53°30' strikes east-west with variable but steep dips (greater than 70°). However, the metavolcanic-sedimentary belt and the L_2-foliation of the southern, adjacent quartz diorite (7a) strikes 065. L_1-foliation within the belt however, strikes east-west similar to the regional foliation of the northern part of the map-area. At Stevenson Lake the belt swings east-west parallel to regional foliation. The present areal disposition of the volcanic belt therefore appears to be the product of faulting.

Faults and Mylonite

A swarm of faults or lineaments[1] striking 040, dominates the geological map-pattern in the northeastern part of the map-area. Extended northward, they match lineaments of similar strike at Molson Lake (Bell, 1962).

[1] A lineament is inferred to be a fault when it truncates or offsets lithologic units.

Although some lineaments are bounded by highly hydrothermalized rock (sericite, muscovite, epidote, carbonate) no evidence for shearing or cataclasis could be found i.e. the regional east-west foliation does not seem to have been deflected. Movement on these faults appears to have been normal, dip-slip.

Two major cataclastic-rock lineaments in the area may also be faults. Within such lineaments an entire cataclastic reaction series may be found, from epidotized augen-gneiss to mylonite (Ermanovics et al., 1972); mafic rocks are converted to schists, and lenses of epidote and carbonate are common. The cataclastic-rock lineament associated with the volcanic-rock belt strikes at 065 degree and extends for 56 miles from Stevenson Lake to the Gunisao River beyond which, for lack of outcrop it can only be inferred from the aeromagnetic maps to extend for an additional 24 miles to Spider Island. Kakirite, ultramylonite and sheared tourmaline veins in quartz dioritic rock (7a) characterize the fault zone parallel to the metavolcanic rock (3). The cataclastic-rock lineament south of Gunisao Lake strikes at 105 degrees and extends for 44 miles from the eastern edge of the map-area to intersect the 065-degree lineament at the Gunisao River. The 105-degree lineament marks a line south of which metadiabase (8) and diorite (5) are absent; from the Gunisao River to Spider Island on Lake Winnipeg, the southerly dipping 065-degree lineament serves the same purpose and additionally represents the southern limit of the occurrence of post-Kenoran diabase dykes (10).

Structural Elements within the Metavolcanic-Sedimentary Belt

The belt strikes east-west at Stevenson Lake and at 065 from the foot of Stevenson Lake to beyond Ponask Lake. The rocks are faulted along the southern contact against quartz diorite (7a), and at the western extremity against layered gneiss (1d), but appear to be in intrusive but abrupt contact with diorite (5a) on the northern contact. Several northeast-striking normal faults transect the belt and may be responsible for some of the pinch-and-swell configuration of the belt. Mineral lineations and axes of small folds (F_1) show systematic variation and two reversals of plunge (see Map 5-1972). In the westernmost portions of the belt folds are commonly refolded about an east-west axis. Drag-folds related to shearing also show east-west movement planes, and together with refolded folds probably represent F_2 - generation folds. Assuming that the basic lavas occupy the base of the section, then a section can be constructed to show the volcanic rocks occupying an antiform and the sediments a synform; the axial planes of these folds dip southeast at 80 degrees.

GRANITIZATION

Layered gneisses of Playgreen Lake become progressively granitized along their strike towards the east where they give way to a hybrid granodiorite (7c). This granodiorite, with increasing microcline content, eventually culminates in quartz monzonite north of Costes Lake. The area involved is 600 square miles.

The layered gneisses (1) can be divided into paragneiss and orthogneiss. Paragneiss is generally recognizable by its granoblastic texture and

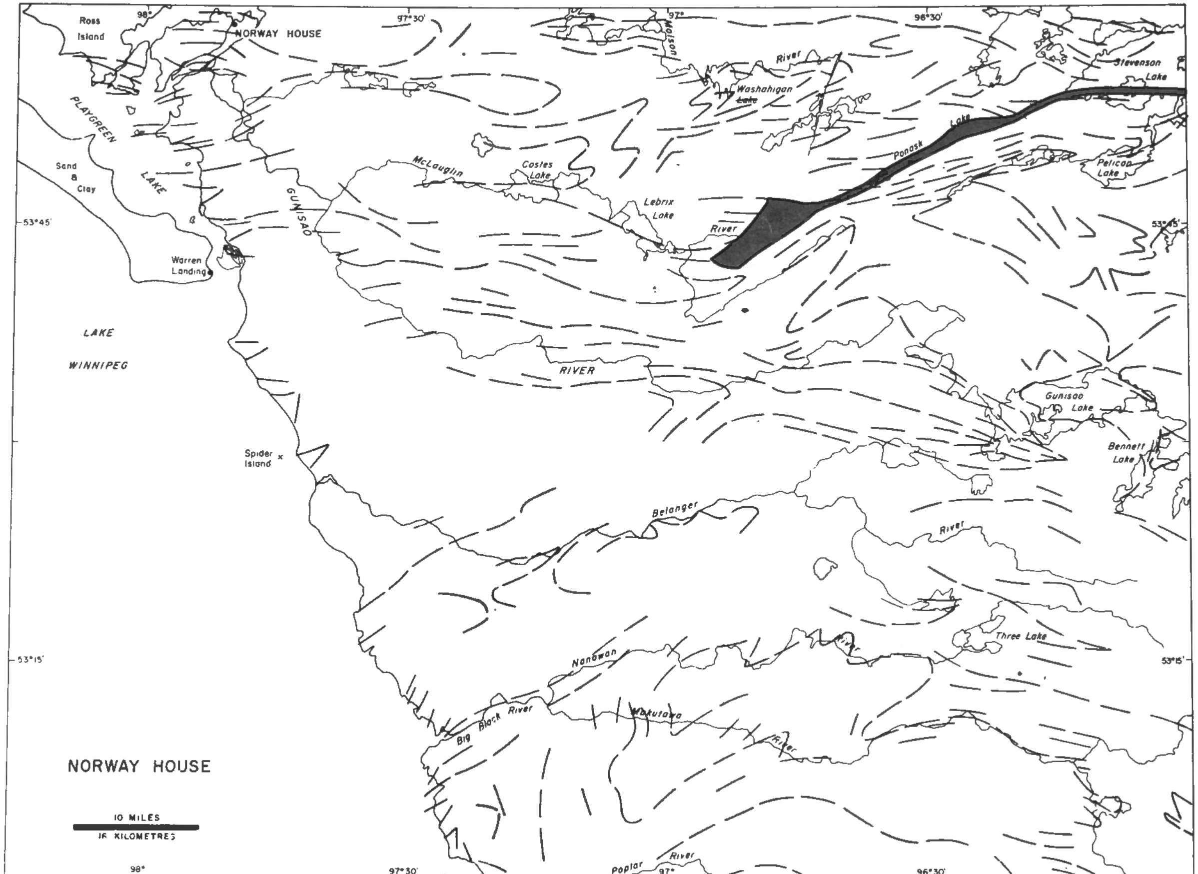

Figure 6. Interpretative foliation trends (L and L -foliations) compiled from approximately 800 ground - measurements. The southern part of the area appears to show a broad, regional change in trend about a north-south axis; this area is the Berens batholithic block. The northern portion of the map-area appears to show interference patterns produced from change in trends about east-west and north-south axes.

its composition which ranges from pelitic through quartzofeldspathic to amphibolitic. It is likely that these compositions served as 'templates' for the formation of seriate composite gneiss (1). Added granitic material probably constitutes more than one half the volume of the layered gneisses.

An unexplained feature of the greenstone belts in the area is that they exhibit remarkably little evidence of granitization. Although the sediments along the northern contact do show intercalations of dioritic rock, the contact is abrupt. Nowhere was layered gneiss of the type-unit (1) found to be in contact with metasediments (3c), nor are mafic volcanic rocks traceable to hybrid-amphibolites. The nearest gneisses are invariably separated from volcanic belts by various thicknesses (1,000 feet to 6 miles) of metadiorite. That dioritic rock does underlie portions of the volcanic belt is shown along the fault within the volcanic rocks at the western extremity of the belt as well as on the upthrown side of the fault terminating the belt. It would seem that the dioritic rock, being solid but plastic, removed much of the volcanic material during intrusion to higher levels than presently exposed. Consequently, no hybrid gneiss remains now in contact with the belt rocks.

MINERAL OCCURRENCES

A number of rusty zones can be traced along strike for 1 to 1 1/2 miles in the southwestern portion of Ponask Lake. These zones, 1 to 3 feet in thickness, consist of mafic greywacke that carries disseminated pyrite, pyrrhotite, chalcopyrite and sphalerite. Results of assessment work in 1958, on file with the Manitoba Mines Branch, indicated a zone of pyrite and pyrrhotite along a transitional contact between andesite and biotite greywacke. The holes were located at 53°49'13"N and 96°33'00"W, inclined north -50°, and intersected 12 to 50 feet of scattered bands, blebs and disseminations of pyrite and pyrrhotite at 200 feet. Ten polished sections of rocks (collected by the present author) from rusty zones and sheared rocks were examined by Dr. R. Ridler of the Geological Survey. The following is a condensation of this report. A number of specimens showed 1 to 10 per cent sulphides and minor quantities of oxides with relative quantities as follows: po > py (or py > po) > cpy > sph > mag. The assemblage is suggestive of polymetallic sulphide exhalite assemblage often associated with felsic volcanics; the presence of Zn suggests proximity to an exhalite source (Ridler, 1971). Chalcopyrite is associated with sphalerite as irregular masses or as 'exsolution' inclusions in sphalerite. One specimen from core (depth unknown) collected at an old drill-site shows lamellar pyrrhotite blebs in layers parallel to F-1 foliation. Although F-2 foliation is present in the specimen no significant migration into the F-2 fabric was observed. In one specimen, in which F-1 and F-2 are coincident, irregular lath-like aggregates of py > po > py were found disseminated in this pronounced foliation. In the sheared leucogranodiorite (7a) adjacent to the volcanic belt contact pyrite euhedra are seamed and replaced by magnetite. Pyrite in the belt rocks shows an early interstitial habit, a later porphyroblastic euhedral habit (silicate and pyrrhotite inclusions), and a late texture consisting of brecciated grains showing anisotropic strain.

Both airborne and ground magnetic and electromagnetic surveys in 1959 (Canadian Longyear Limited) established a number of magnetic anomalies within the Stevenson Lake-Ponask Lake belt. Those anomalies that also proved to be conductors were found, by the present author, to correspond to coarse-grained amphibolitized pyroxenites and serpentinites mixed with lenses of calcite + antigorite. Bodies (50 by 100 feet and larger) of pyroxenite are marked "x" on the geological map.

Most of the anomalies, including those shown to be conductive, lie at or near the contact of the belt rocks. The south side of the belt is faulted, and mylonite and sheared rock continues variously from a few hundred feet to 1 mile into the leucocratic granodiorite-quartz diorite rock (7a). Thus meteoric waters as the cause of electromagnetic anomalies cannot be dismissed except where these are also magnetic anomalies. Tourmaline and quartz veins, carbonate smears and disseminated pyrite occur near the contact in the granitic (7a) and volcanic rocks. The northern side of the belt is mainly metasediments (3b, c) against layered and folded diorite (5a, 'dirty diorite') and although rocks are sheared, no fault could be found to parallel the contact. However, a pink granitic tourmaline-muscovite-bearing pegmatite dyke (4b) was found to cut both diorite and the belt rocks close to the contact.

A number of small anomalies in diorite north of the belt, like those within the volcanic rocks which were shown to be amphibolitized pyroxenites, could not be evaluated because the underlying rocks are covered by swamp.

The critical intersections, on Gunisao River, of the 105-degree shear-lineament with the 065-degree shear-lineament were not examined in detail.

There are therefore three metallogenetic environments to be considered in the map-area. These are, (1) Ni-Cu in ultramafic rocks, (2) Cu-Zn in intermediate to acid volcanigenic rocks and (3) possibly Cu in the cataclastic rock zones.

TECTONIC OVERVIEW

A number of proposals have been recently published, based on aeromagnetic and gravity data and some lithologic data, to subdivide the Superior Province in Manitoba according to tectonic domains (Bell, 1971, Ermanovics 1971, Kornik, 1971, McRitchie, 1971, Walker, 1971, Wilson, 1971). In general these authors agree that the Berens batholithic block (Fig. 7) represents remobilization of old 'basement'. Systematic 4-mile mapping (Ermanovics, 1971) has demostrated that at one time the Berens block once did include volcanic rocks and sediments. Consequently it could be argued that mineral deposits also must have been present. However, the various abundant orthogneisses and minor paragneisses now exposed in terrains like that of the Berens block, probably never did contain mineral deposits - not by virtue of their higher metamorphic grade, but rather because of their probable already deep-seated position at the time of the formation of ore in supracrustal rocks near centres of volcanic activity. The future development of this hypothesis must be regarded as of singular importance and may provide a criterion for delimiting favourable prospecting areas in the granitoid terrain of the Superior Province. Within the map-area, lithologies of the Berens block versus Cross Lake block (Sachigo River block, R.J.W. Douglas, 1972, Gods Lake block H.D.B. Wilson, 1971) are as follows:

Map-unit	Berens block	Cross Lake block
Layered gneiss (1)	X	XX[1]
Granodioritic augen gneiss (2)	X	X
Metavolcanic-sedimentary rocks (3)		X
Gabbro (4) and ultramafic rocks		X
Mafic metadiorite and quartz diorite (5)		X
Epidotized meta quartz diorite (6)	X	
Granodiorite (7)	XX	X
Metadiabase dykes (8)		X
Quartz monzonite (9)	X	XX
Diabase (10)		X

From this comparison it is evident that the Berens block, within the map-area, by virtue of the dearth of mesozone and supracrustal rock assemblages, constitutes the catazone. That this catazone was active during the last orogeny is demonstrated by its granitization and metamorphism.

SUMMARY

The following are area-percentages of rock-types within the map-area:

Map-unit	Per cent
Layered gneisses (1)	17.6
Granodioritic augen-gneiss (2)	3.9
Metavolcanin-sedimentary (3)	0.7
Mafic metadiorite, gabbro and meta quartz diorite (5 and 4a)	5.1
Epidote quartz diorite (6)	3.0
Leucocratic granodiorite and quartz diorite (7)	58.2
Meta quartz monzonite (9)	4.3
Cover (east of Montreal Point and Spider Island)	7.2
	100.0

The proportion of volcanic rock (3a) to sediments (3b, c) is 1:1. The ratio of hornblende-bearing (7b) to biotite-bearing (7a) to granitized (7c) granodiorite and quartz diorite is 1:1:1; combining all unit 7 subunits, 58 per cent of the area is underlain by leucocratic (less than 15 per cent mafic minerals) granodiorite-quartz diorite. Indeed, south of latitude 53°30' 85 to 90 per cent of the rocks exposed are those of unit 7. Thus the cataclastic-rock lineaments centred about 53°30'N, serve as a major lithologic boundary (tectonic boundary) and represent the northern boundary of the Berens batholithic block. The southern boundary near 51°30'N, following the Bloodvein River, serves as a similar discontinuity (Ermanovics, 1970b and 1971).

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[1]Denotes that rock unit is present in proportion of at least 3 multiples greater.

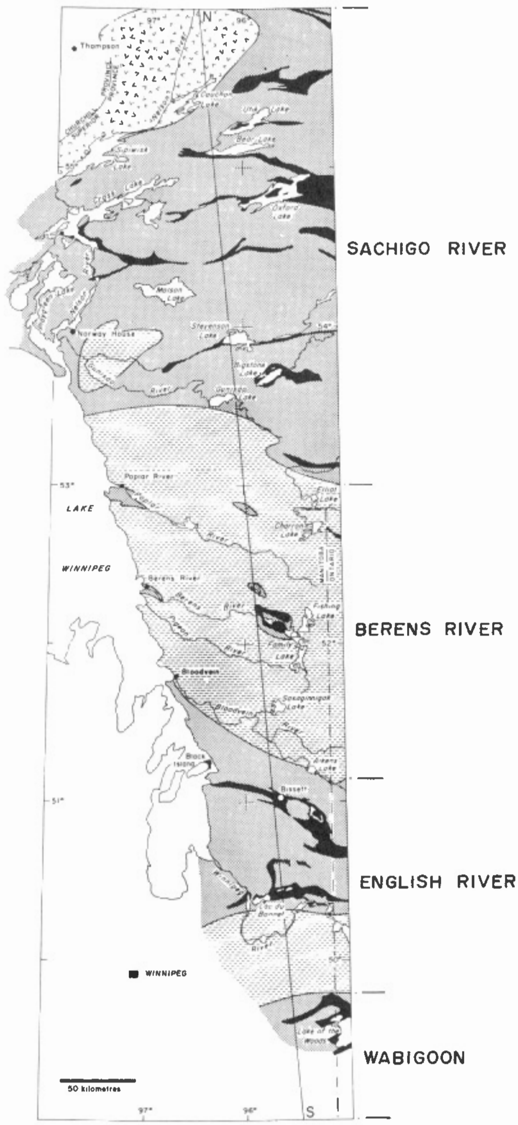

Figure 7. First-order lithologic division of the Superior Province in Manitoba; black shading = metavolcanic-sedimentary belts; dot-pattern = paragneiss, migmatite, and mafic dioritic and quartz dioritic rocks; dash-pattern = acid, leucocratic granitoid and migmatite-gneisses; v-pattern = granulite (Pikwitonei sub-province). By conceptual inference it is implied that with time (because acid plutonism is late) or depth (erosion) the Sachigo River, English River and Wabigoon belts would expose progressively more of the "granitic" rock-types of the variety found in the Berens block. Pre-Kenoran sediments and volcanic rocks could thus be distinguished from earlier Archean rocks by using models involving granitization and anatexis.

The various stages in the geological history of the map-area are believed to have been as follows:

1. 'Granitic country rock' represented now by augen-gneiss (2), epidotized quartz diorite (6) and in part by portions of unit 7.
2. Deposition of volcanic rocks, greywackes and pelitic rocks, in part of the varieties, now constituting the metavolcanic-sedimentary belt (3).
3. Layered quartzofeldspathic gneisses (feldspathic greywackes and minor quantities of pelitic rock) (1) belong either to a pre-volcanic depositional period or the volcanic period. Because these gneisses are not in contact with the volcanic belt rocks, their age relationship is doubtful. However, because their fabric reflects one order of magnitude larger grain-size than volcanic belt sediments and because they are granitized, the layered gneisses more likely represent earlier (pre-volcanic) supracrustal rocks. This implies a pre-M_1 deformation and a metamorphic event of considerable importance, but one which must await further information for its delineation.
4. Syntectonic (folding prior to metamorphism) emplacement of mafic diorites near, and adjacent to, volcanic sources. Emplacement of ultramafic bodies (4) in lavas (3a), and mafic greywacke (3b).
5. Emplacement of dykes (now metadiabase 8).
6. M_1-metamorphism to sillimanite-almandine-muscovite zone, which at the present level of exposure of the area, appears to be uniform and widespread. Intercalated pelitic assemblages indicate that the 'volcanic greenschists' and feldspathic, layered gneisses (1) and mafic diorites (5 and 6) reached similar grades of metamorphism in the same zone.
7. Emplacement of leucoquartz monzonite (9). Remobilization of assemblages representing early granitic crust (1, 2 and 6), and granitization of some rocks of unit 7, and following (7c).
8. M_2-metamorphism concomitant with and following shearing, compression (cataclasis) and faulting. The effects of this metamorphism are limited primarily to shear zones (as in quartz monzonite), but include the destruction of primary and M_1-textures in the lavas (3a) of the volcanic belt rocks.
9. Northeast-trending, normal faulting accompanied by hydrothermalization of silicates with only limited and local shearing (slickensides) and cataclasis. This faulting may or may not have been accompanied by a post-Kenoran thermal event in the northern portion of the map-area, whose effect and distribution are unknown.
10. Intrusion of small northerly-trending aphanitic diabase dykes (10) and two layered gabbroic dykes (10a). Their unmetamorphosed condition suggests that these rocks are post-Kenoran. Various degrees of serpentinization of olivine and orthopyroxene may be the result of deuteric alteration.

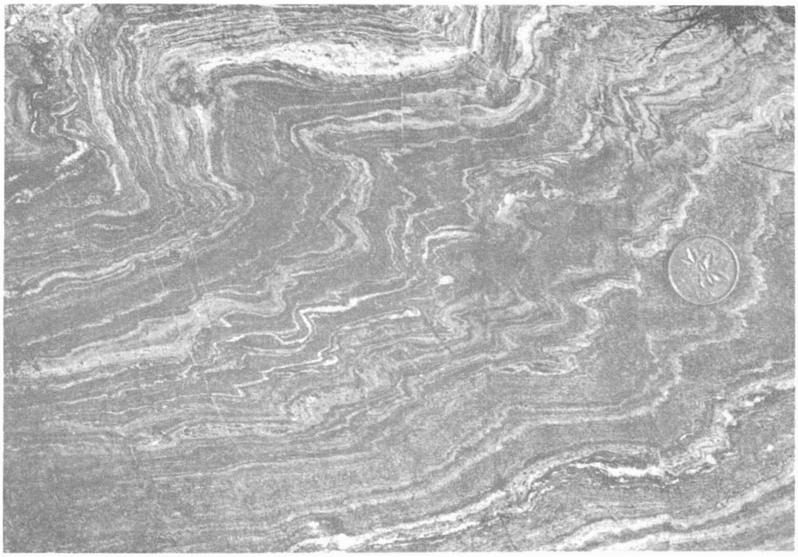

Figure 8-A. F-2 folds in mafic greywacke-gneiss, Ponask Lake. GSC photo 202076-A.

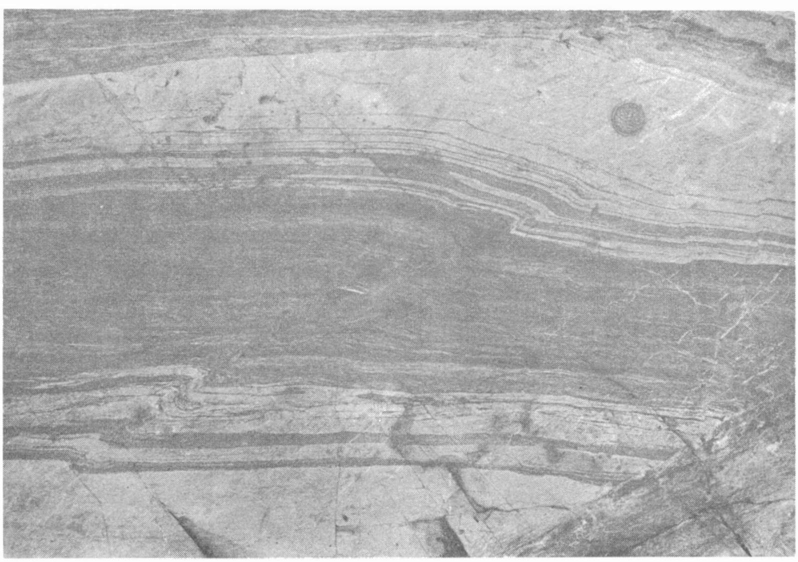

Figure 8-B. F-2 folds in mafic greywacke and pelitic (lighter) gneiss, Ponask Lake; greywacke consist of hornblende + epidote and quartz + feldspar + biotite layers; pelitic gneiss is composed of sillimanite + garnet + biotite + quartz + plagioclase [muscovite]. GSC photo 202076-B

Figure 9-A. F-1 and F-2 folds in mafic greywacke-gneiss, Stevenson Lake; F-1 axial plane is parallel to long axis of pocket knife and makes an angle of 60 degrees with F-2 axial planes. GSC photo 202076-G

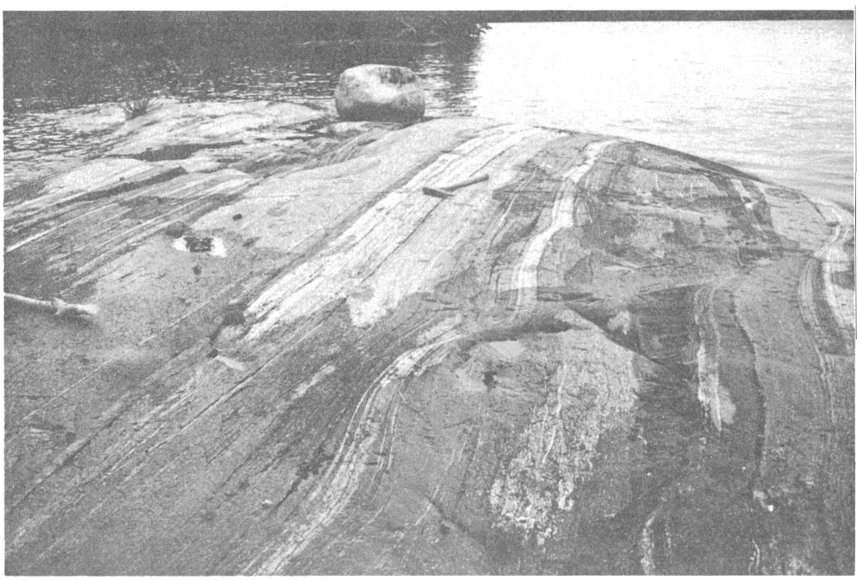

Figure 9-B. F-1 and F-2 folds; same locality as A. GSC photo 202076-F.

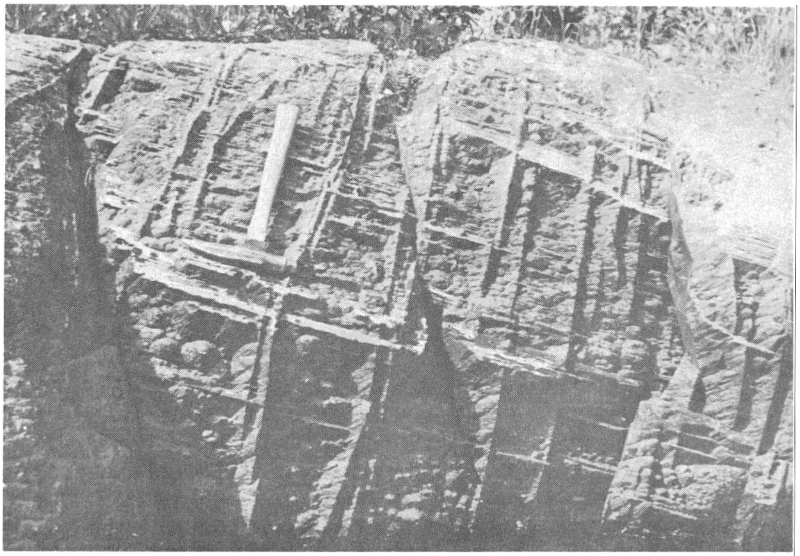

Figure 10-A. Fine-grained meta-andesite (amphibolite) penetrated by quartzofeldspathic mullion plunging 15 degrees northeast (to the right) and epidote-filled fractures dipping 80 degrees in the opposite sense. Ponask Lake. GSC photo 202076-D.

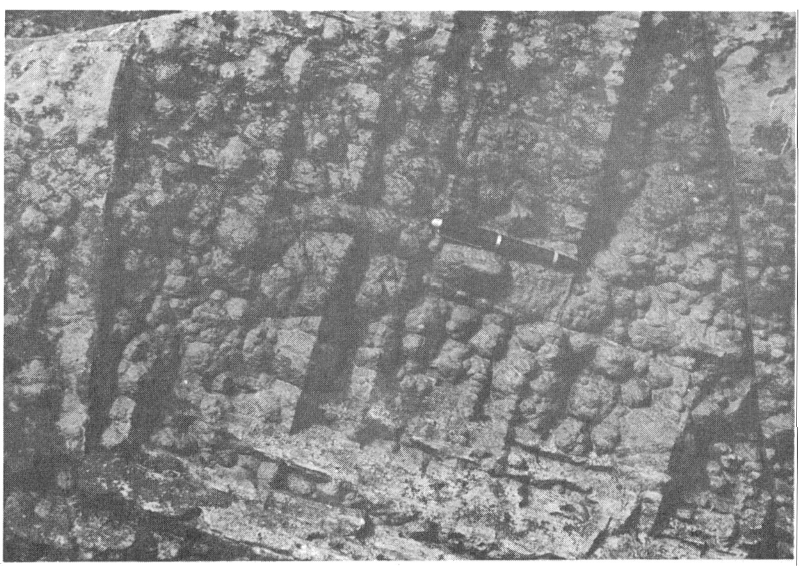

Figure 10-B. Detail of Figure 10-A; cone-structures are probably the result of the intersecting of mullions and fractures, accentuated by weathering. Ponask Lake. GSC photo 202076-C.

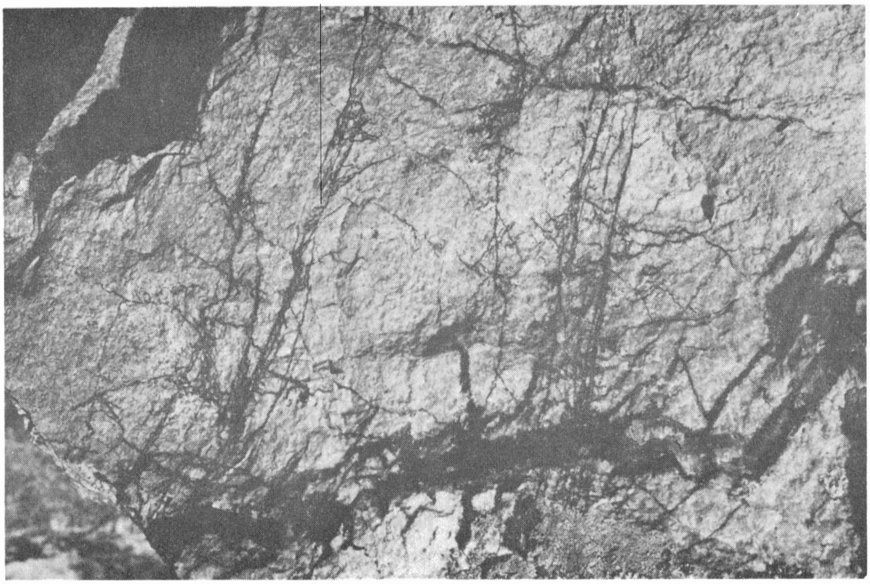

Figure 11-A. Black tourmaline, filling fractures in shattered leucogranodiorite at faulted southern contact with volcanic rocks, Stevenson Lake. GSC photo 202076.

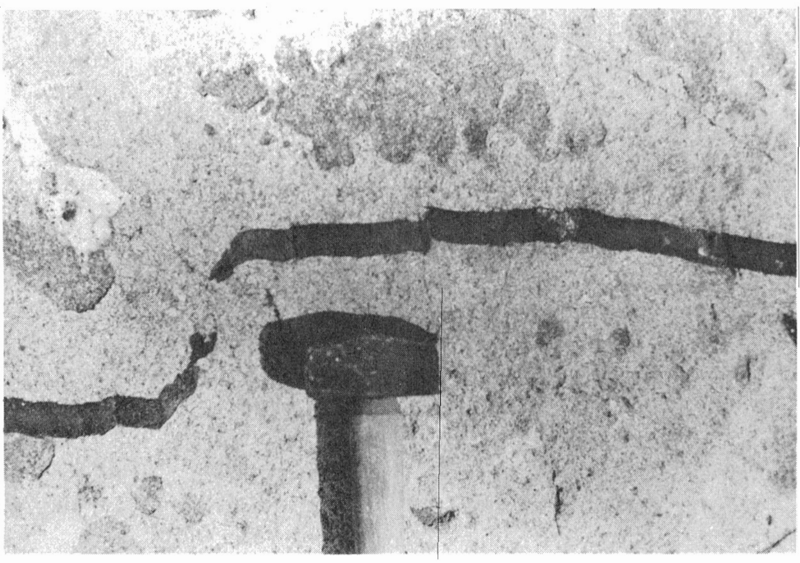

Figure 11-B. Diabase dyke (10) in granodioritic-augen-gneiss, Playgreen Lake; the dyke is massive and consists of microlites of labradorite, and orthopyroxene and clinopyroxene. GSC photo 202076-E.

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