THE UNIVERSITY OF MANITOBA

RUBIDIUM-STRONTIUM AGE DETERMINATIONS FROM THE CHURCHILL PROVINCE OF NORTHERN MANITOBA

by

RICHARD KIME ANDERSON

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ABSTRACT

The ages of three rock units from the Churchill Structural Province of Manitoba were determined by the rubidium-strontium, whole-rock method. A minimum age of 2636 ± 163 million years, with an initial ratio of 0.7025 ± 0.0034 was obtained for a foliated quartz monzonite from the Kasmere Lake area in Northern Manitoba (^{87}Rb decay constant of $1.39 \times 10^{-11} yr^{-1}$). This unit probably represents an Archean basement for the metasedimentary rocks of the Wollaston Lake Belt in Manitoba. Also from the Kasmere Lake area, a grey quartz dioritic to granodioritic gneiss gave a minimum age of 1941 ± 25 million years and an initial $^{87}Sr/^{86}Sr$ ratio of 0.7038 ± 0.0003. The isotopic data implies that this unit was formed from primary igneous material which was emplaced early in the Hudsonian Orogeny and underwent alkali metasomatism during a subsequent event.

A minimum age of 1818 ± 199 million years was obtained for a ferrohypersthene metatonalite, metadiorite and anorthositic gabbro from the Burntwood Lake area in central Manitoba. This age and the initial $^{87}Sr/^{86}Sr$ ratio of 0.7032 ± 0.0013 suggest that these ferrohypersthene rocks were derived from primary magma intruded during the Hudsonian Orogeny.

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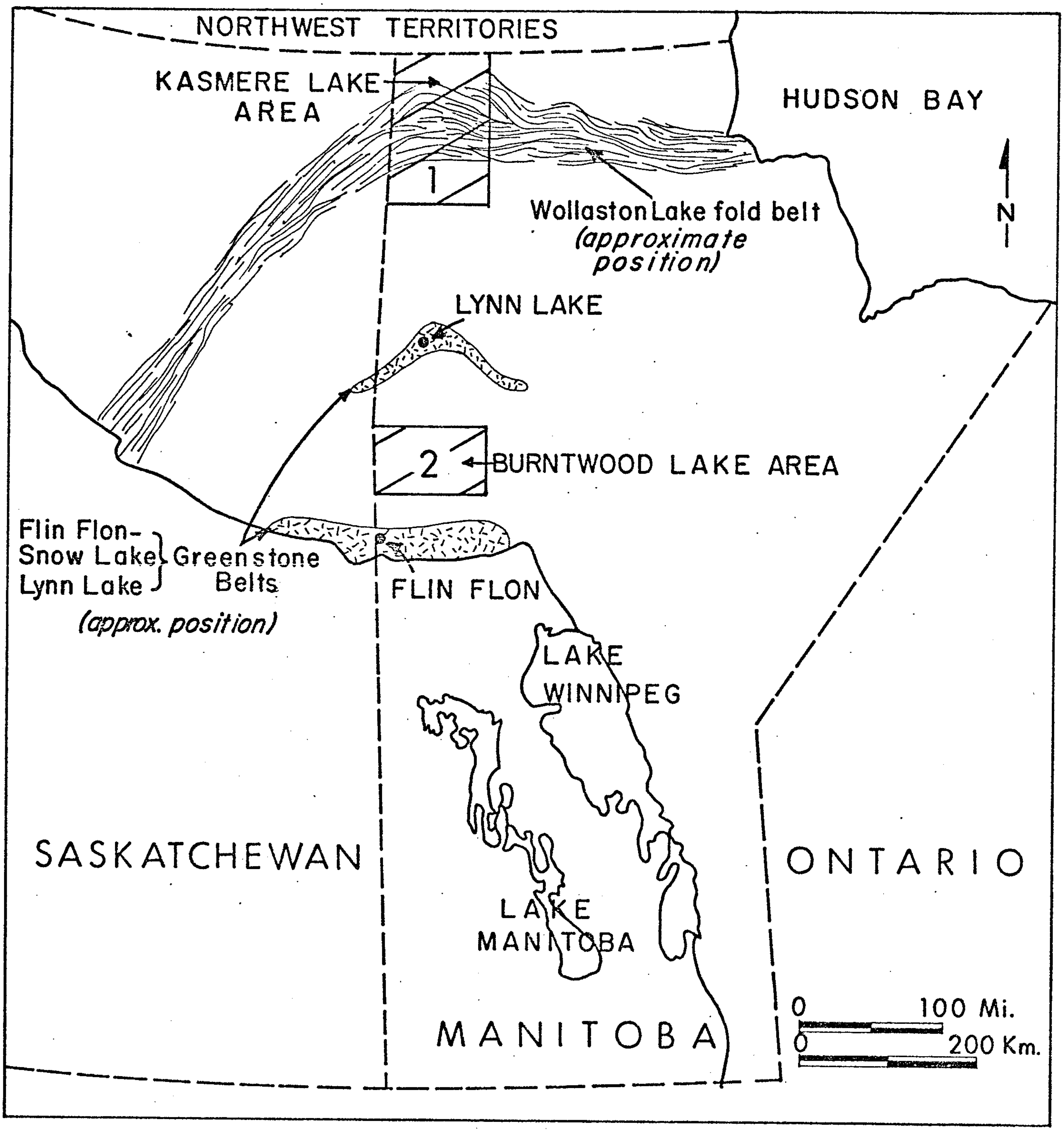
I. INTRODUCTION

In order to solve common geological problems encountered in the study of the Churchill Structural Province of the Canadian Shield, it is often necessary to determine whether the rocks were: 1) crustal rocks formed during the Archean, 2) primary or anatectic intrusive rocks associated with the Kenoran Orogeny, 3) crustal rocks formed during the Aphebian or 4) primary or anatectic intrusive rocks emplaced during the Hudsonian Orogeny. Occasionally geologic evidence alone is not sufficient to confirm a rock unit's origin and history, particularly in those areas where outcrop is poor. In such cases, isotopic age determinations can be employed to obtain the rocks absolute age and, hopefully, the evidence necessary to confirm its genesis.

To assist in solving the mentioned problems, rubidium-strontium whole-rock age determinations were performed on three rock units from the Churchill Province in Manitoba. Two of these units are closely associated with the Wollaston Lake Belt, a linear zone of folded Aphebian metasediments and minor metavolcanics (Fig.1). The samples were collected from an area referred to as the Kasmere Lake area, which is situated in the northwest corner of Manitoba, and is bound by latitudes 58° 30' and 60° 00' north and by longtitudes 100° 00' and 102° 00' west (Fig.1).

FIGURE 1. Location of Study areas
(positions of geologic features are approximate, after Davidson, 1972)



NORTHWEST TERRITORIES
KASMERE LAKE AREA
HUDSON BAY
1
Wollaston Lake fold belt (approximate position)
N
LYNN LAKE
2
BURNTWOOD LAKE AREA
Flin Flon-
Snow Lake
Lynn Lake
Greenstone Belts
(approx. position)
FLIN FLON
LAKE WINNIPEG
SASKATCHEWAN
ONTARIO
LAKE MANITOBA
MANITOBA
0 100 Mi.
0 200 Km.

The first geologic unit dated from this area is a foliated quartz monzonite. Similar rocks in Saskatchewan form the basement for the Wollaston Lake fold belt and gave an Archean age when dated by the rubidium-strontium whole-rock method (Money et al., 1970; Davidson, 1972). Age determinations were performed on the foliated quartz monzonite to confirm that it is also part of the basement rocks for the Wollaston Lake fold belt in Manitoba.

The second unit dated from the Kasmere Lake area is a grey quartz dioritic to granodioritic gneiss. This unit lies along the northwestern boundary of the Wollaston Lake Belt.

The third geologic unit investigated is a ferro-hypersthene bearing metatonalite, metadiorite and anorthositic gabbro. Samples of this unit were collected from an area surrounding Burntwood Lake. (Fig.1) The area is bound by latitudes 55° 15' and 56° 00' north and longtitudes 102° 00' and 100° 00' west.

The ferrohypersthene bearing rocks are intruded into the Kissenew gneiss complex that separates the Flin Flon greenstone belt from the Lynn Lake greenstone belt (Fig.1). Geologic evidence indicates that this unit is the oldest primary igneous intrusive unit in the Burntwood Lake area (McRitchie, personal communication). The age obtained for the ferrohypersthene bearing rocks may give the minimum age of deposition in the sedimentary basin between the two greenstone belts.

A. Acknowledgements

I would like to acknowledge the Faculty of Graduate Studies and the National Research Council for their financial assistance. I am also grateful to many individuals for their assistance in this study: Dr. G.S. Clark supervised the study. Dr. W.D. McRitchie supplied geologic information and maps for the Burntwood Lake area, and the ferrohypersthene bearing metatonalite, metadiorite and anorthositic gabbro. Dr. W. Weber, D. Schledewitz and C.F. Lamb supplied the geologic information and maps pertaining to the Kasmere Lake area. D. Schledewitz supplied the information for the description of the foliated quartz monzonite. C.F. Lamb supplied the necessary information for the geologic description of the grey quartz dioritic to granodioritic gneiss. Paul Beaudoin assisted in the chemistry of many of the samples. Drs. G.S. Clark, W. Weber and A.C. Turnock read the manuscript and offered many helpful suggestions.

II. GEOLOGIC DESCRIPTIONS

A. Geologic Settings of the Kasmere Lake and Burntwood Lake Areas

Both areas from which samples were collected for age determinations are in the Churchill Province of the Canadian Shield. The Churchill Province contains curved and linear belts of variably metamorphosed rocks, predominantly of Aphebian age, which are underlain by gneissic and granitoid rocks of great structural and petrologic complexity. Plutonic and crustal remnants of Archean age are rarely recognizable. The Hudsonian Orogeny caused slight to intense folding and metamorphism associated with granite intrusion; during this orogeny many of the Aphebian rocks were converted to granitic gneisses (Stockwell, et al., 1970; Davidson, 1972).

One of the major tectonic belts in the Churchill Province in Manitoba is the Wollaston Lake Belt. This fold belt extends from the southern edge of the Canadian Shield in central Saskatchewan into Manitoba at Kasmere Lake (Fig.1). The Kasmere Lake area part of the fold belt trends east-northeast towards the Hudson Bay whereas the other part appears to plunge to the north (Weber, personal communication; Money, 1968; Money et al., 1970; Davidson, 1972)

The Wollaston Lake fold belt consists mainly of Aphebian supracrustal rocks which have been divided into four groups (Money et al., 1970). The oldest recognized group comprises the metagreywacke, meta-arkose and metavolcanic rocks of the Sandfly Lake Group. It is unconformably overlain by quartzite, oligomictic conglomerate, and pelitic metasedimentary rocks of the Meyers Lake Group. The Meyers Lake Group is unconformably overlain by metamorphosed arkose, greywacke and pelitic rocks of the Daly Lake Group. A fourth assemblage, assigned to the Meyers Lake Group consists of quartz pebble conglomerate, quartzite and pelitic schist (Money et al., 1970). The structure of the Wollaston Lake fold belt is characterized by closely spaced, northeast trending, isoclinal folds, commonly with steep limbs. The granitoid basement is exposed in anticlinal cores (Davidson, 1972).

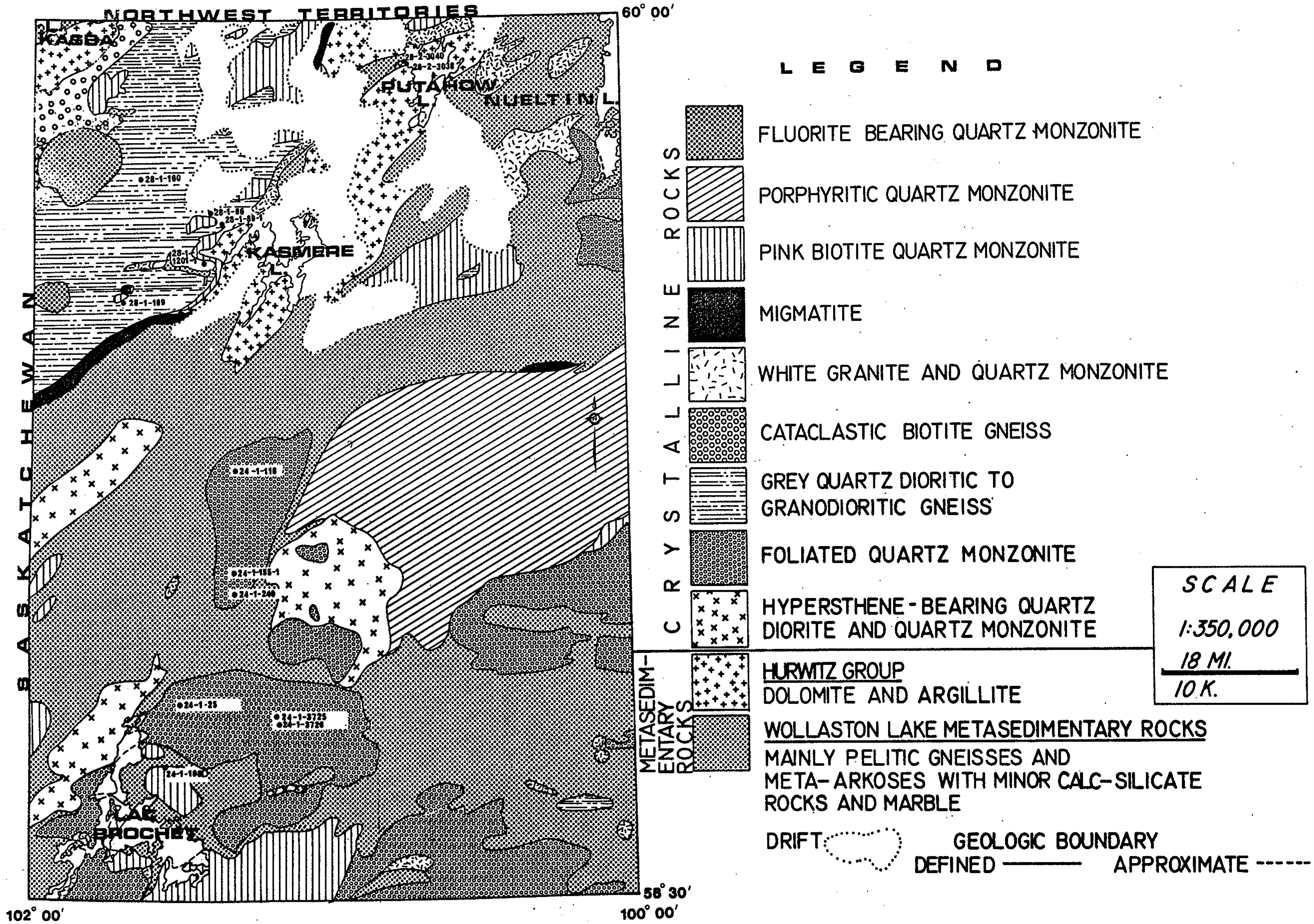
In the southern part of the Churchill Province in Manitoba, the Lynn Lake greenstone belt and the Flin Flon-Snow Lake greenstone belt are separated by the gneissic and granitoid rocks of the Kisseynew complex (Harrison, 1951; Davidson, 1972). These gneisses are believed to be the remnants of the sedimentary basin that existed between the two volcanic belts before deformation, metamorphism and intrusion by granitic rocks (Harrison, 1951; McRitchie, personal communication). The structure of the southern portion of this belt is dominated by tight, nearly isoclinal, easterly trending folds which are overturned to the south (Bailes, 1971).

B. Geology of the Kasmere Lake Area

Geologic mapping of the Kasmere Lake area has recently been completed at a scale of 1:50,000 by geologists with the Manitoba Mines Branch. The following summary of the geology of the area and the brief descriptions of the foliated quartz monzonite and the grey quartz dioritic to granodioritic gneiss are from the Summary of Geologic Field Work (Weber et al., 1972) and from W. Weber, C.F. Lamb and D. Schledewitz (personal communication).

The geology of the Kasmere Lake area is shown in Figure 2. With the exception of minor bodies of paragneiss, the oldest rocks in the area are granitic rocks which were probably intruded during the Archean. These granitic bodies are overlain by Aphebian metasedimentary rocks which are similar to those of the Wollaston Lake fold belt. Also overlying the Archean granitic rocks, but not otherwise associated with the Wollaston Lake Belt, are two units of metamorphic rocks of uncertain age and genesis. These two units, the grey quartz dioritic to granodioritic gneiss and the cataclastic biotite gneiss, separate the Wollaston Lake metasedimentary rocks from the younger sedimentary rocks of the Hurwitz Group in the northwest corner of the map area. Aphebian intrusive rocks and migmatites which were probably formed during the Hudsonian Orogeny are widespread in the Kasmere Lake area.

FIGURE 2. Generalized geologic map of the Kasmere Lake area.
(after Weber et al., 1972; and Weber, personal communication)


NORTHWEST TERRITORIES
60° 00'
KASBA L.
PUTAHOW L.
NUELTIN L.
KASMERE L.
SASKATCHEWAN
LAC BROCHET
58° 30'
102° 00'
100° 00'
LEGEND
CRYSTALLINE ROCKS
FLUORITE BEARING QUARTZ MONZONITE
PORPHYRITIC QUARTZ MONZONITE
PINK BIOTITE QUARTZ MONZONITE
MIGMATITE
WHITE GRANITE AND QUARTZ MONZONITE
CATACLASTIC BIOTITE GNEISS
GREY QUARTZ DIORITIC TO GRANODIORITIC GNEISS
FOLIATED QUARTZ MONZONITE
HYPERSTHENE-BEARING QUARTZ DIORITE AND QUARTZ MONZONITE
METASEDIMENTARY ROCKS
HURWITZ GROUP
DOLOMITE AND ARGILLITE
WOLLASTON LAKE METASEDIMENTARY ROCKS
MAINLY PELITIC GNEISSES AND META-ARKOSES WITH MINOR CALC-SILICATE ROCKS AND MARBLE
DRIFT
GEOLOGIC BOUNDARY
DEFINED
APPROXIMATE
SCALE
1:350,000
18 MI.
10 K.

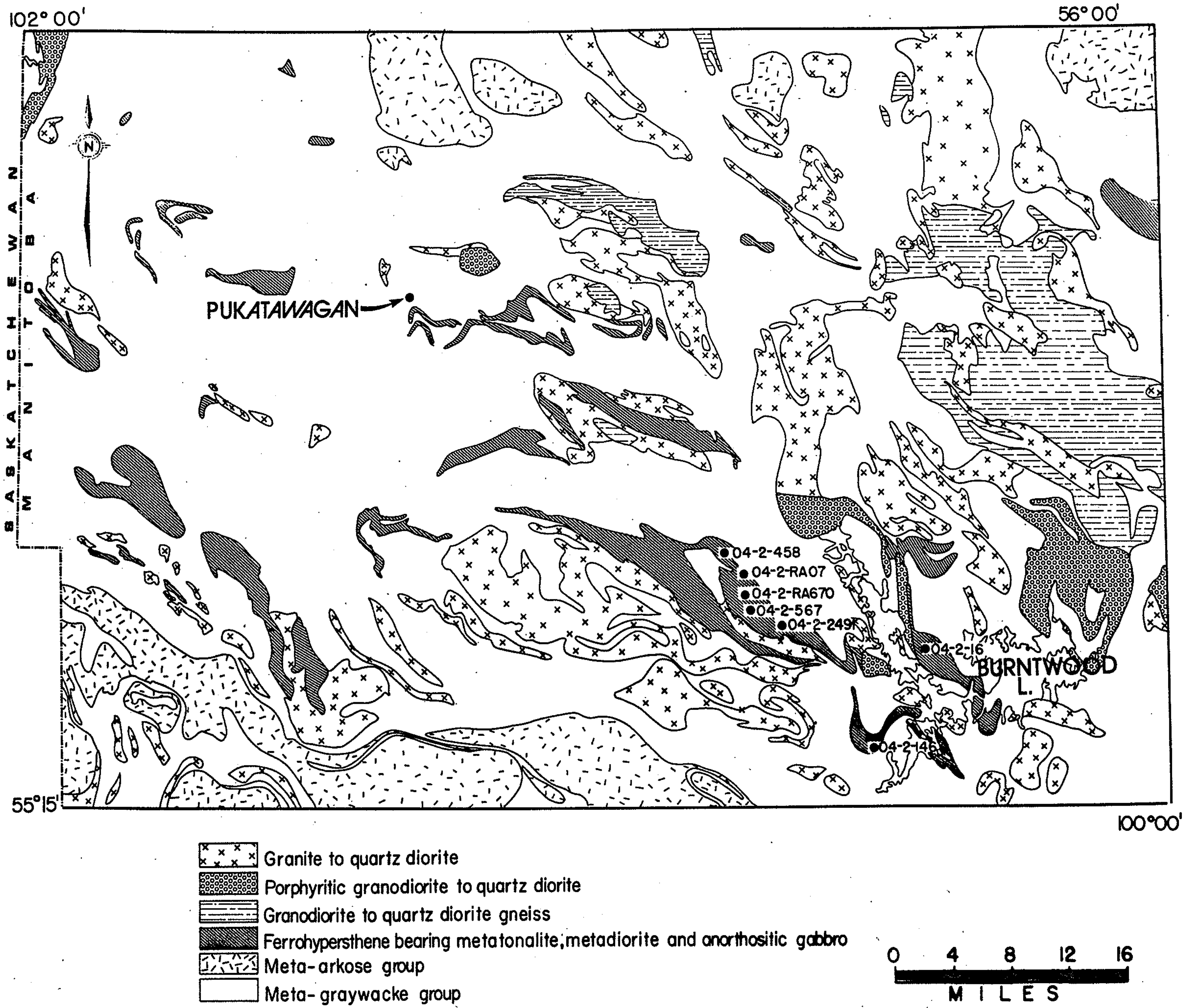
C. Geology of the Burntwood Lake Area

The geology of the Burntwood Lake area (Fig.3) has most recently been studied by the Manitoba Mines Branch. The majority of information necessary for this brief geologic description of the area, and of the ferrohypersthene bearing metatonalite, metadiorite and anorthositic gabbro was supplied by the Manitoba Mines Branch in their preliminary report (McRitchie et al., 1972) and by W.D. McRitchie (personal communication).

Much of the Burntwood Lake area is underlain by layered psammitic to pelitic paragneisses that have been metamorphosed to the middle or uppermost amphibolite assemblage. The majority of the paragneisses are greywacke gneisses, but isolated bodies of arkosic gneiss occur at the northern and southern limits of the area. As a result of metamorphism, the sedimentary rocks have been converted to a variety of lit par lit gneisses, diatexites, and wholly or partially anatectic and nebulitic granitic rocks.

Intrusive rocks of various ages are abundant throughout the Burntwood Lake area. The oldest intrusive rocks are probably large sills of ferrohypersthene bearing metatonalite, metadiorite and anorthositic gabbro. Where subjected to metamorphism, the ferrohypersthene bearing intrusive rocks grade into a tonalitic to granodioritic gneiss. Later alkali enrichment converted tracts of the tonalitic to granodioritic gneiss to a porphyritic quartz

FIGURE 3. Generalized geologic map of the Burntwood Lake area (after McRitchie, et al., 1972; McRitchie, personal communication)


102° 00'
56° 00'
55°15'
100°00'
SASKATCHEWAN
MANITOBA
N
PUKATAWAGAN
04-2-458
04-2-RA07
04-2-RA670
04-2-567
04-2-249
04-2-16
04-2-146
BURNTWOOD L.
Granite to quartz diorite
Porphyritic granodiorite to quartz diorite
Granodiorite to quartz diorite gneiss
Ferrohypersthene bearing metatonalite, metadiorite and anorthositic gabbro
Meta-arkose group
Meta-graywacke group
0 4 8 12 16
MILES

monzonite. A complex of granites, quartz monzonites, pegmatites and aplites form the youngest intrusive complex in this area.

The gneissic belt in the Burntwood Lake area has a dominant west-northwest structural trend. This is overprinted in some areas by a younger northeast trend which results in northeast trending ellipsoidal bodies.

D. Rock Descriptions

1) Foliated Quartz Monzonite

The foliated quartz monzonite is present as three large bodies in the southern half of the Kasmere Lake area and as two smaller bodies in the northeastern portion (Fig.2). The quartz monzonite is pink on both the weathered and fresh surfaces. The rock has a schistosity which may be accompanied by a cataclastic foliation. The texture varies from a porphyroclastic texture, with aligned microcline or plagioclase porphyroblasts, to a well developed cataclastic texture with feldspar augen. A gneissosity may also be present in the form of granitic injections which strike parallel to the schistosity (Schledewitz, personal communication).

The mineralogy is generally constant throughout the foliated quartz monzonite bodies. Quartz constitutes twenty to thirty percent of the rock with feldspar making up sixty to eighty-six percent of the rock. Potassium feldspar is often more abundant than plagioclase and may make up to fifty-five percent of the rock. Biotite, which may be partially altered to chlorite, is present in abundances varying from four to ten percent and is the only primary mafic mineral present in the rock (Schledewitz, personal communication).

The fabric and mineralogy of the foliated quartz monzonite suggest that the rock was affected by two metamorphic events. The first event was deformational, leading to cataclasis, and the second event caused recrystallization associated with minor mobilization of the alkalies and calcium (Schledewitz, personal communication).

2) Grey Quartz Dioritic to Granodioritic Gneiss

The grey gneiss is present in a northeast trending layer in the northwest corner of the Kasmere Lake area (Fig.2). It is generally medium grained but may be locally coarse grained and massive. The rock is commonly schistose with a foliation formed by the alignment of biotite. Elongate quartz and feldspar grains are also parallel to the foliation. Associated with the coarse grained variety of the grey gneiss are irregular veins and dikes of biotite granite which appear to have caused local areas of alkali enrichment (Lamb, personal communication).

The grey gneiss consists of quartz distributed in irregular patches, and generally subordinate microcline which may locally constitute up to twenty percent of the rock. Biotite, hornblende, and chlorite are also present in minor amounts (Lamb, personal communication).

The genesis of the grey gneiss is uncertain. Eade (1970) suggested that the predominant banding and composition of some of the xenoliths, ten to thirty miles to the north, in the Northwest Territories, indicate a sedimentary origin for the grey gneiss. In Manitoba however, Lamb suggested that the composition of analyzed samples of the grey gneiss is that of a leucogranite rather than a metasediment; the SiO_2 contents are higher and the Al_2O_3 contents are lower than arkose, greywacke and subgreywacke.

3) Ferrohypersthene Bearing Metatonalite, Metadiorite and Anorthositic Gabbro

Sill-like intrusive bodies of ferrohypersthene bearing intrusive rocks occur intermittantly over a large portion of the Burntwood Lake area (Fig.3). The sill complexes vary in size from three meters across to large sills three kilometers across and forty kilometers in length. The rock is typically medium grained, equigranular, homogeneous and weakly automorphic. The ferrohypersthene bearing metatonalite, metadiorite and anorthositic gabbro is a mesocratic rock comprising plagioclase, biotite and potassium feldspar. The most common accessory minerals are magnetite, apatite and zircon (McRitchie, personal communication).

The larger occurrences of the ferrohypersthene bearing intrusive rocks are cut by dykes of pink pegmatite, aplite and porphyritic quartz monzonite. Generally the dykes contain a one to ten centimeter thick silicified zone along their contact with the ferrohypersthene bearing rocks. The ferrohypersthene bearing metatonalite, where in contact with the dykes, is recrystallized to a bleached, medium grained, equigranular, homogeneous, garnet-biotite-plagioclase-quartz gneiss (McRitchie, personal communication).