Geological Report GR83-2

Geology of the Saw Lake Area

By Alan H. Bailes

Manitoba
Energy and Mines
Geological Services

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MAP

Map 83-2-1:	Geology of the Saw Lake area.	(in pocket)

INTRODUCTION

The Saw Lake area is in the Churchill structural province and consists of coarsely recrystallized metavolcanic and metasedimentary rocks of the Early Proterozoic Flin Flon and Kisseynew Belts (Fig. 1). The southeast corner of the map is within 6 km of the faulted contact between the Churchill province and the older Archean rocks of the Superior Province. Flat-lying Ordovician dolomitic limestones overlie the Precambrian rocks in the south central quarter of the map-area. Pleistocene glaciolacustrine deposits, including lacustrine silt and clay and beach ridge sand and gravel, cover the Precambrian and Ordovician rocks in the central third of the map area.

This geological investigation of the Saw Lake area was designed to provide 1:50 000 scale mapping of the east end of the economically important Flin Flon volcanic belt (Fig. 1), to furnish further information on the relationship between the Flin Flon and Kisseynew Belts at their eastern extremities, and to supply data on the style and nature of deformation in these Proterozoic rocks adjacent to their boundary with the Archean Superior Province (Fig. l). Mapping was done in the summer of l976 using standard pace and compass traverses spaced 300 to 600 m apart; the traverses were augmented by spot helicopter-accessed examination of difficult-to-reach outcrops.

Bedrock exposure is abundant in the western third of the area, sporadic in the eastern quarter, and absent in the central and southern parts. Large exposures and shoreline outcrops are clean in the northwest part of the area; elsewhere they are moss- and lichen-covered.

The Saw Lake area (Figs. 1 and 2) covers approximately 1300 km^2 within longitudes 99°00' and 99°30' and latitudes 54°41' and 55°00'. The centre of the area is 50 km east of the town of Snow Lake.

Churchill-Superior Boundary Zone

The Saw Lake area is geologically interesting because of its close proximity to the boundary between the Churchill and Superior structural provinces (Fig. 1). Many geologists (Gibb and Walcott, 1971; Gibb, 1975; Dewey and Burke, 1973; Hubregtse, 1980; Baragar and Scoates, 1980) consider this boundary to be an Early to Middle Proterozoic collision suture between the younger Churchill province and the older Superior province, with the Thompson Mobile Belt interpreted to be the product of Proterozoic tectonic reactivation of the margin of the Archean Superior province during the collision. The distribution of Flin Flon and Kisseynew belt rocks, the timing of kinematic events, and the nature of the intrusive activity in the Saw Lake area are pertinent pieces of information for deciphering the geologic history within this potential collision zone.

At the present time there are two views on the timing of the hypothesized collision event relative to the peak metamorphic and deformational activity (Hudsonian orogeny?) in the Kisseynew belt. Bell (1971) and Peredery (1982) hold the traditional view that the two provinces were adjoined, possibly colliding, during the peak metamorphic and deformational activity in the Kisseynew belt. They interpret the northeast-trending structures and almandine-amphibolite facies mineral assemblages in the Thompson Mobile Belt to be the product of an Hudsonian overprint onto Archean-aged granulite facies Pikwitonei gneisses. The other view, tentatively put forward by Bailes (1975), Scoates (pers. comm., 1979) and Hubregtse (1980), is that the two provinces may not have collided until after the peak Hudsonian activity, with the tectonic overprint in the Thompson Mobile Belt

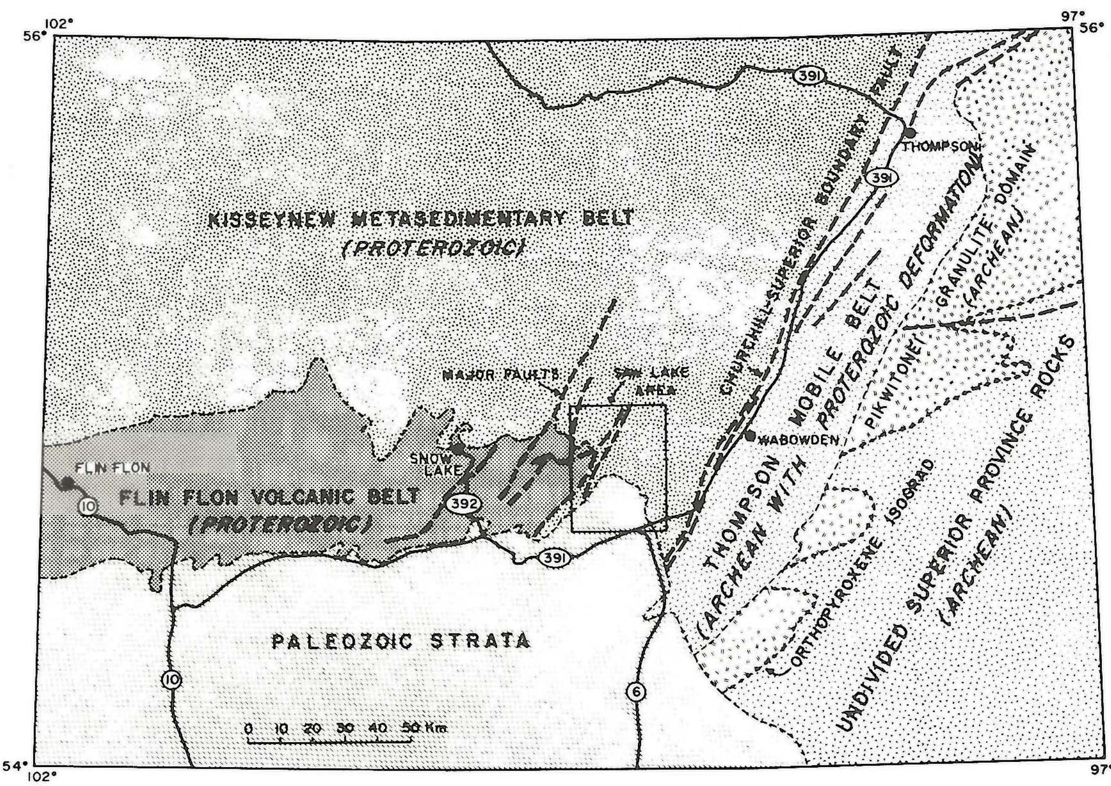


FIGURE 1: Generalized geological map of the northern Churchill province and adjacent Superior province, central Manitoba, showing the location of Saw Lake area.

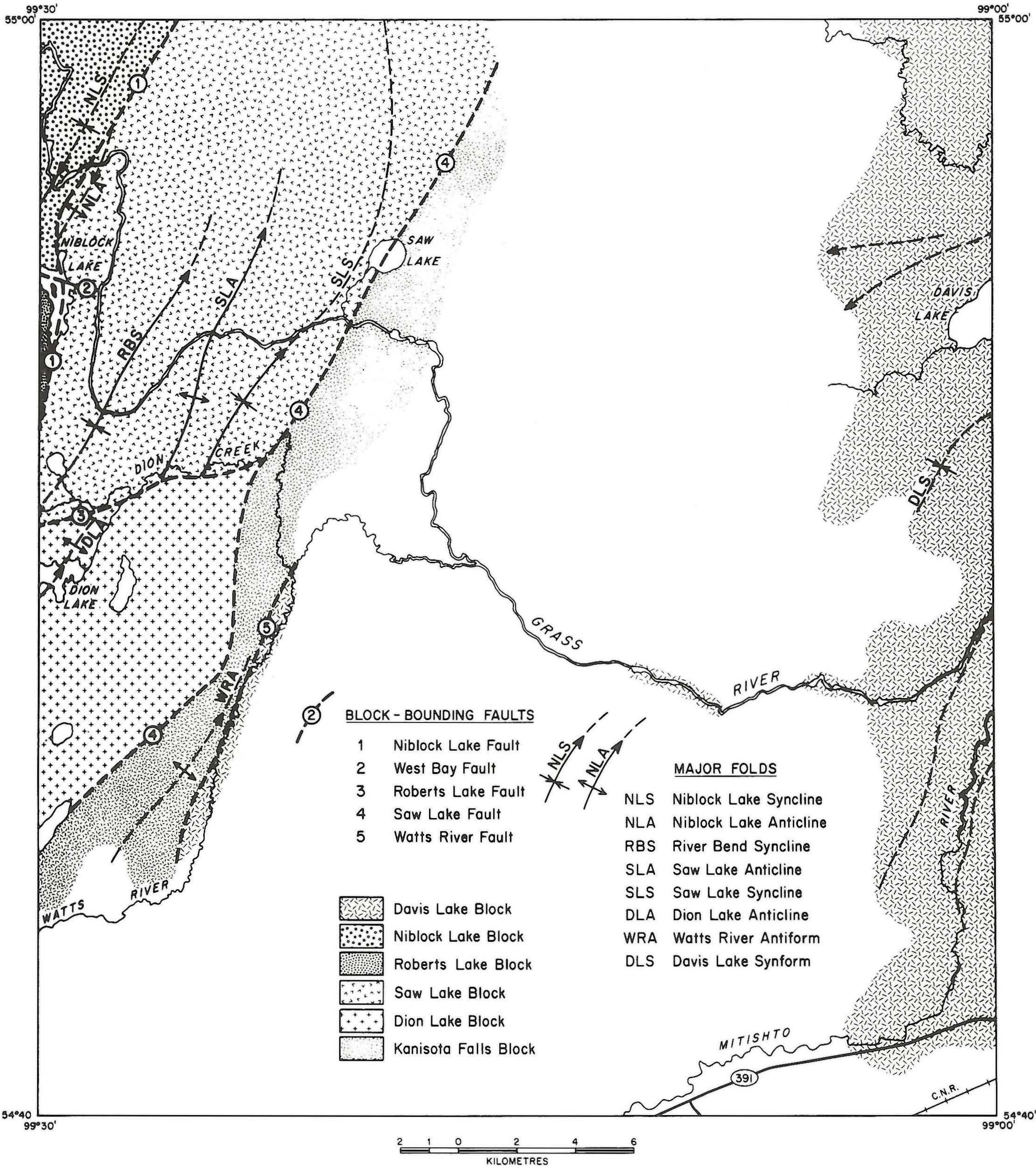
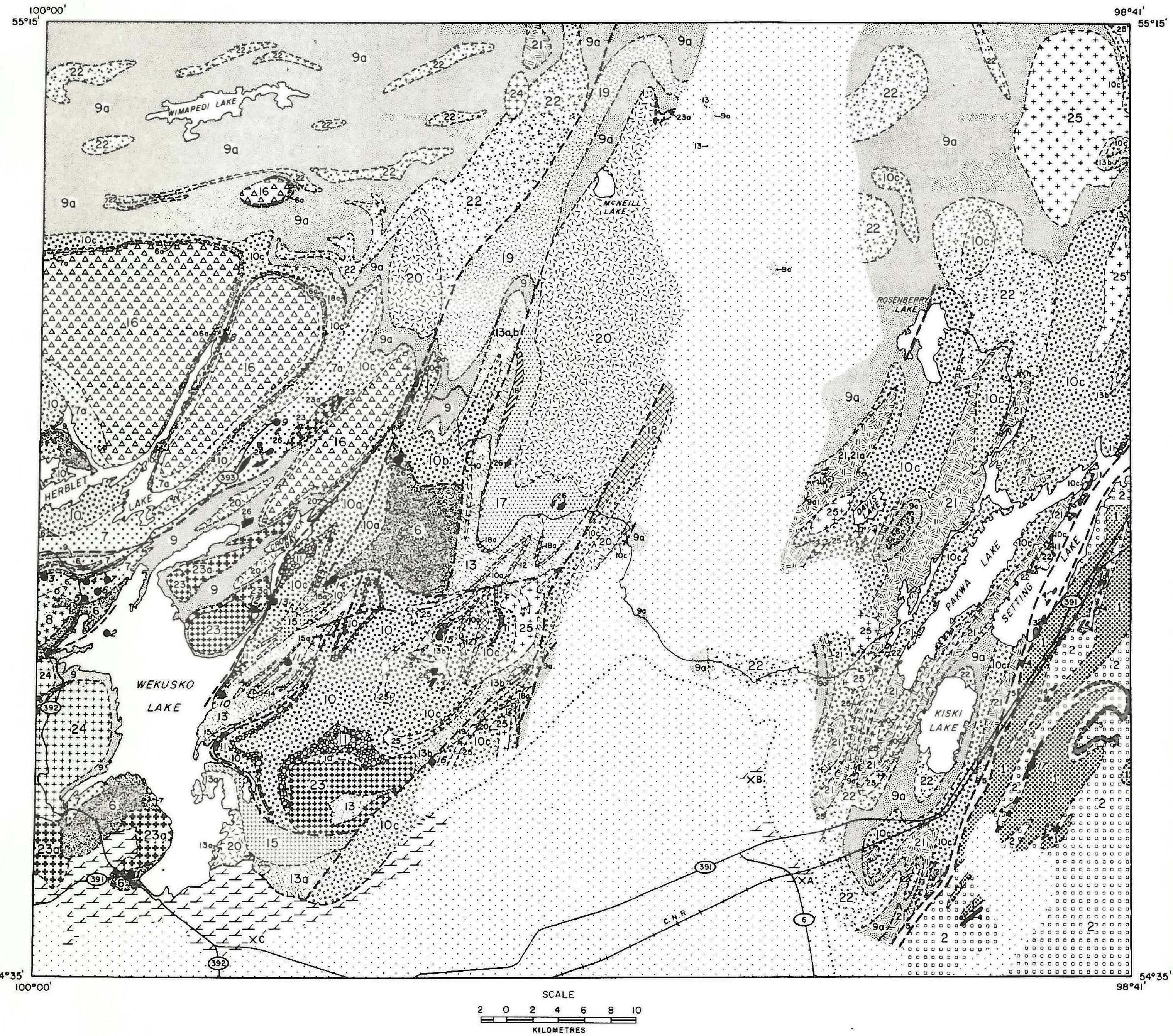


FIGURE 2: Major fault blocks, Saw Lake area.



LEGEND

QUATERNARY

Varved lacustrine clay and minor beach sand and gravel of Glacial Lake Agassiz

ORDOVICIAN

Red River Formation: mottled dolomitic limestone

CHURCHILL PROVINCE

EARLY PROTEROZOIC

Intrusive Rocks

Late- to Post-Kinematic Intrusive Rocks

26 Pegmatitic granite, felsic pegmatite

25 Magnetiferous leucogranite

24 Biotite-hornblende granite

23 Composite, differentiated intrusion of granite, granodiorite, diorite and gabbro; (23a) diorite-gabbro

Syn-Kinematic Intrusive Rocks

22 Gneissic leucogranite, anatectic derivative of unit 9a

21 Gneissic magnetiferous microcline-augen granite; (21a) gneissic magnetiferous microcline-augen hornblende monzodiorite, monzonite, quartz monzodiorite and quartz monzonite

20 Gneissic granodiorite, granite, tonalite

19 Gneissic hornblende tonalite

Early Kinematic Intrusive Rocks

18 Metagabbro; (18a) metapyroxenite

Missi Group

17 Protoquartzite, minor para-amphibolite

16 Felsic granoblastic orthogneiss, derived in part from units 14 and 15

15 Aphyric dacite flows, breccia and intrusions; (15a) quartz porphyry, quartz-feldspar porphyry

14 Felsic tuff, in part subaerial ash flow deposits

13 Mafic metavolcanic rocks, dominantly subaerial deposits; (13a) pillowed mafic metavolcanic rocks of uncertain affinity; (13b) ortho-amphibolite

12 Metacarbonate and para-amphibolite

11 Polymictic conglomerate

10 Subgreywacke, arkose and derived gneiss, local conglomerate layers; (10a) siliceous para-gneiss; (10b) staurolite metasiltstone and pebble conglomerate; (10c) quartzfeldspathic gneiss, locally migmatitic

Amisk Group

9 Greywacke, siltstone, mudstone and derived gneiss; (9a) garnet-biotite migmatite gneiss (Burntwood Metamorphic Suite)

8 Quartz-megacrystic tonalite

7 Felsic metavolcanic rocks; (7a) felsic ortho-gneiss

6 Mafic to intermediate metavolcanic rocks, dominantly subaqueous deposits; (6a) ortho-amphibolite

SUPERIOR PROVINCE

EARLY PROTEROZOIC

5 'Ospwagan Group'[2]: Quartz-rich siltstone, ferruginous shale and phyllite, iron formation, minor greywacke, and local mafic to ultramafic flows and intrusions

EARLY PROTEROZOIC AND ARCHEAN

4 Ultramafic intrusive and extrusive rocks

3 Mafic metavolcanic rocks and amphibolite

ARCHEAN

2 'Moak Lake gneiss'[2,3]: Layered, amphibolite facies migmatite gneiss, in part retrograde product of Pikwitonei Granulite Domain

1 Hornblende-biotite quartz diorite gneiss, part of retrograded Pikwitonei Granulite Domain

SYMBOLS

Geological contact

Fault

● Mineral deposit

1 Copper-Man (Cu-Zn sulphide)
2 Rice Island (Cu-Ni sulphide)
3 Anderson (Cu-Zn sulphide)
4 Stall Lake (Cu-Zn sulphide)
5 Ram (Cu-Zn sulphide)
6 Linda (Cu-Zn sulphide)
7 Rod (Cu-Zn sulphide)
8 Bee (Cu-Zn sulphide)
9 Osborne (Cu-Zn sulphide)
10 Laguna-Rex (Au)
11 Ferro (Au)
12 Sherritt Gordon (Li pegmatite)
13 Violet-Thompson (Li pegmatite)
14 Green Bay (Li pegmatite)
15 Dot-Bet-Gam group (U pegmatite)
16 Uran group (U pegmatite)
17 Manibridge (Ni-Cu sulphide)

X Quarry

A Ponton (crushed stone, dimension stone)
B Ponton North (crushed stone, dimension stone)
C Wekusko (crushed stone, dimension stone)

NOTE:

[1] Geology compiled from: Bailes (this report, 1975); Bell, (1978), Froese and Moore (1980), Lenton (1981), Cranstone (1969), Rance (1966), Frarey (1948), Armstrong (1941), and Stockwell (1937).

[2] 'Ospwagan Group' and 'Moak Lake gneiss' are informal names proposed by Scoates <u>et al</u>.(1977).

[3] Granulite facies rocks of Pikwitonei Domain were formed during late Archean to very earliest Early Proterozoic. The 'Moak Lake gneiss' is considered to be in large part Pikwitonei granulite gneisses that were retrograded to amphibolite facies during the late stages of Hudsonian orogeny (Hubretgse, 1980).

FIGURE 3: Simplified geological map of the Saw Lake and adjacent map areas.

TABLE 1
Table of Formations, Saw Lake area.

QUATERNARY			Surficial deposits of clay, and gravel
UNCONFORMITY			
ORDOVICIAN		22	Red River Formation: Mottled dolomitic limestone
UNCONFORMITY			
EARLY PROTEROZOIC — INTRUSIVE ROCKS	Late-to post-kinematic	21	Garnet hornblendite
			— Relationship unknown —
		20	Felsic pegmatite, pegmatitic granite
		19	Magnetiferous leucogranite
	INTRUSIVE CONTACT		
	syn-kinematic	18	Leucogranite
		17	Magnetiferous microline-augen granite
		16	Magnetiferous microcline augen monzodiorite, monzonite, quartz monzodiorite and quartz monzonite
		15	Enderbite
			— Relationship unknown —
		14	Kanisota Falls granodiorite/granite and tonalite
		13	Garnetiferous hornblende melatonalite and melagranodiorite
		12	Saw Lake granite, granodiorite and tonalite
	INTRUSIVE CONTACT		
	Early kinematic	11	Metagabbro
		10	Metapyroxenite
INTRUSIVE CONTACT			
EARLY PROTEROZOIC	MISSI GROUP	9	Protoquartzite, siliceous paragneiss
		8	Metabasalt, mainly massive flows; minor felsic metavolcanic rocks
		7	Carbonate-rich metasedimentary rocks, para-amphibolite
		6	Metasandstone, minor polymictic conglomerate
			— Relationship unknown —
		5	Staurolitic metasiltstone, polymictic pebble conglomerate
UNCONFORMITY			
EARLY PROTEROZOIC	AMISK GROUP	4	Metagreywacke, metasiltstone, metamudstone
			— Relationship unknown —
		3	Volcaniclastic breccia
		2	Metarhyolite, metadacite
		1	Metabasalt, mainly pillowed flows

reflecting the younger collision episode. According to this latter interpretation, a similar post-Hudsonian tectonic overprint would be expected on the Churchill side of the proposed suture, in the Saw Lake area. A post-Hudsonian tectonic overprint on Kisseynew belt rocks of the Saw Lake area has not been identified during this geological investigation.

Flin Flon and Kisseynew Belt Stratigraphy

The supracrustal rocks of the Saw Lake area comprise portions of the Flin Flon and Kisseynew belts (Fig. 1). These belts are generally considered to have developed contemporaneously, with volcanism localized in the Flin Flon belt and sedimentation localized in the Kisseynew belt (Bailes, 1980a, 1980b). Rocks of both belts have been dated by a variety of radiometric techniques (Sangster, 1978) and are between 1800 and 1900 Ma old. Both belts were deformed and metamorphosed at about 1760 Ma, during the Hudsonian orogeny.

The Flin Flon belt comprises at least 5000 m of subalkaline basalt and minor rhyolite with up to 1000 m of volcaniclastic greywacke turbidite (Byers and Dahlstrom, 1954; Bailes, 1980a; Syme *et al.*, 1982), plus 1300 to 3000 m of unconformably overlying sandstones and conglomerates. The volcanic rocks and associated volcaniclastic turbidites were largely deposited in a subaqueous environment and have been interpreted as an Early Proterozoic island arc association (Stauffer, Mukherjee and Koo, 1975; Fox, 1976). They are the oldest lithologies in the belt and were assigned to the Amisk Group by Bruce (1918). The younger sandstones and conglomerates, named the Missi Group by Bruce (1918), were deposited in a fluvial-alluvial environment. The presence of granitic clasts in the Missi Group and a basal angular unconformity indicates that it post-dates a major period of plutonism, deformation and uplift which affected the older Amisk Group (Syme *et al.*, 1982).

The rocks of the Amisk and Missi Groups can be traced across a steep metamorphic gradient into coarsely recrystallized equivalents in the adjacent Kisseynew belt (Byers and Dahlstrom, 1954; Bailes, 1971, 1980a). The transition from the volcanic-sedimentary Flin Flon belt into the Kisseynew belt is not only marked by an abrupt increase in coarse recrystallization and metamorphic grade but also by a facies change in the Amisk Group from volcanic to predominantly sedimentary rocks (Bailes, 1980a, 1980b; Froese and Moore, 1980). At the western end of the belts the facies change from volcanism to sedimentation is abrupt, and easily serves to identify their boundary; however, at the eastern end of the Flin Flon belt there is a preponderance of sedimentary rocks and the boundary between the two belts is more difficult to delineate. Froese and Moore (1980) used the biotite-sillimanite-almandine garnet isograd to separate the two belts in the Snow Lake area and this isograd has been used to delineate the boundary between them in the Saw Lake area, as shown in Figure 1.

The Kisseynew metasedimentary belt consists of two main supracrustal successions: a lower sequence of migmatitic greywacke-, siltstone- and mudstone-derived gneisses; and an overlying succession of migmatitic subgreywacke- and arkose- derived gneisses. At present no unified system of stratigraphic nomenclature exists for these rocks, but similarity of these strata throughout the belt suggests that broad regional correlations may be possible (Harrison, 1951; Sangster, 1978; McRitchie, pers. comm., 1979). On the south flank of the Kisseynew belt, these strata are generally referred to, respectively, as the Nokomis and Sherridon Groups (Robertson, 1953). In the Snow Lake area Froese and Moore (1980) and Bailes (1980a, 1980b) have correlated Nokomis and Sherridon Group paragneisses to sedimentary rocks of the Amisk and Missi Group, respectively, of the Flin Flon belt.

In the Saw Lake area over ninety per cent of the rocks lie above the biotite-sillimanite-almandine garnet isograd and, as such, belong to the Kisseynew belt (Fig. 1). Despite this the Amisk and Missi terminology of the Flin Flon belt has been used throughout the area rather than using the Nokomis and Sherridon names for the coarsely recrystallized Kisseynew belt equivalents. This retention of the Amisk and Missi nomenclature system for Kisseynew belt strata at the east end of the Flin Flon belt has been a common practice for many recent mapping projects (Bailes, 1975, 1980a; Froese and Moore, 1980; Gordon and Gall, 1982).

Stratigraphic Framework of the Map Area

The disposition of the main rock units in the Saw Lake area and their relationship to those in adjacent map areas is shown in Figure 3 The Saw Lake area rocks are divided by a series of east and northeast-trending major faults into six distinct blocks (Fig. 2). Each block has a slightly different supracrustal sequence, grade of metamorphism and suite of intrusive rocks. However, there are enough similarities in the supracrustal and intrusive rocks to permit some correlation between the blocks and to permit construction of a unified Table of Formations (Table 1). The faults are not exposed; their existence is inferred from the truncation and offset of major units and from the termination of major north- northeast-trending fold structures.

The stratigraphic order of volcanic and sedimentary rocks (Table 1) is largely established from the least metamorphosed supracrustal sections in the Roberts Lake, Niblock Lake and Saw Lake Blocks, where facing direction of strata are known. Coarsely recrystallized and migmatized paragneisses of the Dion Lake, Kanisota Falls and Davis Lake Blocks are interpreted to be the more highly metamorphosed equivalents of the supracrustal rocks in the Niblock and Saw Lake Blocks. This correlation is particularly tentative for the quartzo-feldspathic paragneisses on the west side of the Davis Lake Block.

The relative ages of intrusive rocks are only approximate as they rarely show mutually cross-cutting relationships and are generally not exposed in the same structural block. Age relationships are based on their estimated time of intrusion relative to a major kinematic episode (D_2/M_2, Table 7, p. 26).

Paleozoic Rocks and Pleistocene Deposits

Flat-lying upper Ordovician mottled dolomitic limestone (unit 22) overlaps the Precambrian basement in the south central quarter of the map-area. The dolomitic limestone and the Precambrian basement are in turn overlain by Pleistocene glaciolacustrine deposits that cover the central third of the map-area.

The dolomitic limestone (unit 22) is only exposed as a small outcrop on the Mitishto River and a small outcrop ridge 6.5 km north of Ponton (Map GR83-2-1). The dolomite belongs to the lower part of the Red River Formation. It is fossiliferous, purplish to brownish red in colour, and contains irregular patches, streaks and bands of brownish to greyish yellow hue. Several small quarries, where the dolomite has been crushed for use in road construction, are located just south of the map-area.

The Pleistocene glaciolacustrine deposits, which largely cover the Paleozoic rocks, were formed in Glacial Lake Agassiz. They include thick sections of varved clay and silt, locally exceeding 23 m thick on the banks of the Grass River (Antevs, 1931), and a curvilinear ridge of sand and gravel which is part of the Minago beach (Ringrose, 1975). The Minago beach represents the highest water level of Glacial Lake Agassiz. A C-14 age from a shell dates the beach ridge at 8310 ± 180 years before present. Detailed descriptions of several of the varved clay sections along the banks of the Grass River in the Saw Lake area are given by Antevs (1931).

AMISK GROUP METAVOLCANIC AND METASEDIMENTARY ROCKS (UNITS 1 to 4)

Subalkaline mafic and felsic volcanic and volcaniclastic rocks (units 1 to 3) of the Roberts Lake Block (Map GR83-2-1, Fig. 2) have been tentatively identified as the oldest rocks in the map-area and placed in the Amisk Group. Also belonging to the Amisk Group are metagreywacke, metasiltstone and metamudstone (unit 4a), of the Niblock Block, and coarsely recrystallized and partly melted migmatitic equivalents (unit 4b) that outcrop in the Davis Lake Block.

The Roberts Lake Block metavolcanic units comprise subaqueously deposited basalt flows (unit 1) intercalated with small amounts of felsic tuff and flows (unit 2), and a narrow unit of heterolithic volcaniclastic breccia (unit 3). These volcanic rocks could belong to either the Amisk or Missi Group, as similar volcanic rocks are known in both groups in the Snow Lake-Wekusko area. They are tentatively placed in the Amisk Group on the basis of the following inconclusive criteria:

1) the Missi time interval was generally characterized by terrestrial conditions of deposition, therefore it is more likely that this several kilometer thick subaqueously deposited sequence was deposited during the Amisk time interval where marine depositional conditions are known to have prevailed; and
2) analyses of known Missi Group basalts in the Saw Lake area have high Ni and Cr values (cols. 10 to 13, Appendix A; Fig. 12) whereas the unit 1 basalts have low Ni and Cr values (cols. 1 and 2, Appendix A) comparable to those of typical Amisk Group basalts (Fig. 12, p. 16).[1]

The metabasalts (unit 1) are aphyric, pillowed to massive, and include weakly to strongly vesicular varieties. They are weakly foliated and completely recrystallized to upper greenschist facies mineral assemblages. They are low K-tholeiites in composition. Narrow layers and locally mappable units of plagioclase-phyric meta-rhyolite tuff and lapilli tuff (unit 2) are intercalated with the basalt flows. Two analyses of the tuffs are given in Appendix A (cols. 3 and 4). Units 1 and 2 are overlain by heterolithic stratified volcaniclastic breccias (unit 3) interpreted as debris flows; they outcrop in several large clean exposures along the west shore of Niblock Lake. Beds in unit 3 vary from 20 cm to 8 m thick and from massive to weakly graded. Fragments, which are unsorted and matrix-supported, include a wide variety of rock types. The two dominant clast lithologies in unit 3 are: 1) angular non-vesicular 5 to 20 cm rhyolite blocks, some with re-entrants, which form up to 50 per cent of most beds; and 2) complete and broken pillow fragments of moderately vesicular aphyric basalt (Fig.4). Strongly vesicular metadacite flows (unit 2a) top the exposed Amisk sequence on Niblock Lake. Vesicularity in these flows commonly exceeds 20 per cent and is locally greater than 50 per cent. Vesicles are typically carbonate-filled. A chemical analysis of a massive, weakly quartz amygdaloidal metadacite is given in Appendix A (col. 5).

The stratigraphic position of unit 4 paragneisses relative to the Roberts Lake Block metavolcanic rocks (units 1 to 3) is not known as the metavolcanic rocks are fault-bounded. However, if units 1 to 3 are Amisk in age, the unit 4 paragneisses can be inferred to be slightly younger on the basis of stratigraphic relationships between comparable units elsewhere in the Snow Lake area (Froese and Moore, 1980; Bailes, 1979, 1980a).

In the Niblock Lake Block unit 4a paragneisses occur in tiny exposures along the Grass River. They contain the following characteristic middle almandine-amphibolite facies mineral assemblages:

Garnet + sillimanite + biotite + quartz + plagioclase ± staurolite + muscovite;

Garnet + biotite + quartz + plagioclase; and

Garnet + biotite + muscovite + quartz + plagioclase.

The paragneisses are bedded and readily recognizable as derived from

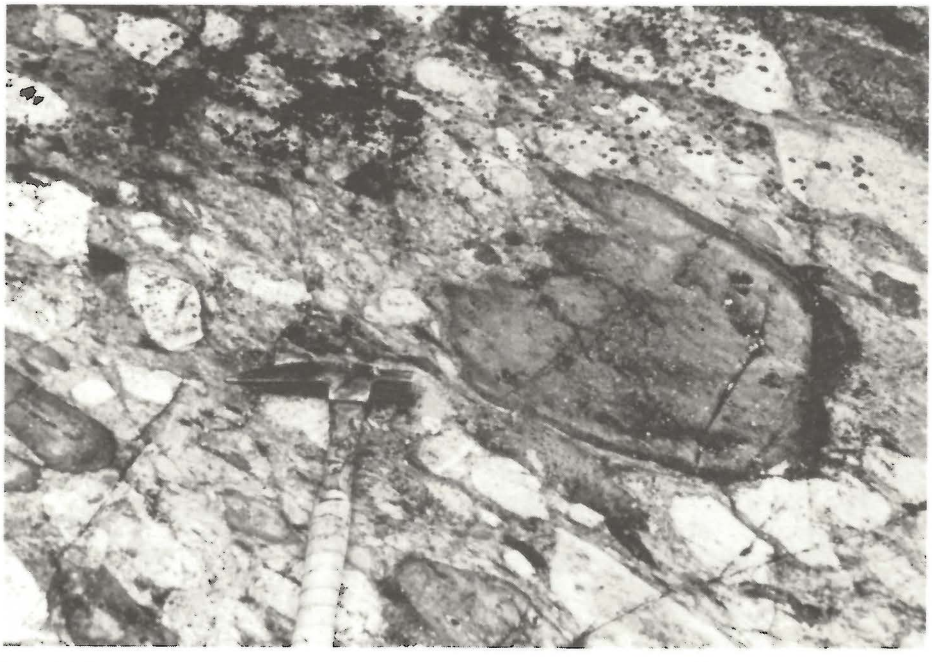


FIGURE 4: Heterolithic volcaniclastic debris flow breccia (unit 3), west shore of Niblock Lake, containing angular rhyolite clasts (white) and basalt pillow fragments (dark). Note dark selvage on large basalt pillow fragment to right of hammer.

an interbedded unit of greywacke, siltstone and mudstone. They can be traced to the north into Amisk/Nokomis Group migmatitic paragneisses mapped by Bailes (1975). Elsewhere, Bailes (1980a, 1980b) has demonstrated that these rocks are composed of immature felsic to intermediate volcanic detritus and were deposited by subaqueous mass-sediment gravity flows, mainly turbidity currents. Bailes has suggested that this detritus was probably derived from contemporaneous Amisk volcanoes and was transported by a subaqueous fan sediment dispersal system into the Kisseynew sedimentary basin.

Unit 4b migmatitic paragneisses outcrop in the Davis Lake Block as isolated exposures in the clay-covered central and eastern part of the map-area. They contain the following upper almandine-amphibolite to lower granulite facies mineral assemblages:

Garnet + biotite + quartz + plagioclase;

rare { Garnet + biotite + sillimanite + quartz + plagioclase;
Garnet + biotite + orthopyroxene + quartz + plagioclase.

The gneisses are coarsely granoblastic with 0.5 to 2 mm grain size. They are migmatitic with 10 to 30 per cent granitic mobilizate. Garnet and cordierite xenoblasts are common in the mobilizate which occurs in narrow veins, irregular bodies and as rare discrete mappable intrusions (unit 18). The unit 4b paragneisses can be traced to the north into the Burntwood River Metamorphic Suite (Lenton, 1981). The Burntwood River Metamorphic Suite encompasses high grade gneisses and migmatites that are at least in part equivalent to the lower grade paragneisses of the Amisk/Nokomis Group.

MISSI GROUP METASEDIMENTARY AND METAVOLCANIC ROCKS

Rocks of the Missi Group (units 5 to 9) dominate the supracrustal succession of the Saw Lake area. They correlate with a several kilometre thick section of Missi Group rocks exposed to the west in the adjacent Wekusko Lake area (Fig. 3). They also correlate with a wide belt of quartzofeldspathic paragneisses that can be traced to the west-northwest in the Kisseynew belt past the type locality for the Sherridon Group at Sherridon, Manitoba, and on into Saskatchewan.

Many of the Missi Group rocks in the Saw Lake area and adjacent Wekusko Lake area lie above the biotite-sillimanite-almandine garnet isograd and by definition belong to the Sherridon Group of the Kisseynew belt. For simplicity, the name Missi Group has been retained for these rocks for both the Flin Flon and Kisseynew belts in the Saw Lake area.

In its type localities, at Flin Flon and Amisk Lake, the Missi Group consists of relatively unrecrystallized metasubgreywacke and meta-arkose that were deposited in a piedmont alluvial fan environment (Mukherjee, 1971; Stauffer, 1974). In the Saw Lake-Wekusko Lake area the Missi Group is more coarsely recrystallized, and lithologically more heterolithic. The more heterolithic character of the Missi Group in the Saw Lake-Wekusko Lake area is interpreted to reflect: 1) a more variable environment of deposition that included marine as well as terrestrial conditions; and 2) a modification of the typical Missi sedimentation pattern by local volcanic activity which provided periodic influxes of volcanic flows and immature volcaniclastic detritus. The contemporaneous volcanic activity and the local marine conditions of deposition are two features that the Saw Lake Missi Group rocks share in common with the type Sherridon Group rocks at Sherridon, Manitoba (Froese and Goetz, 1981). In addition, the Missi/Sherridon rocks in both areas are coarsely recrystallized and contain mappable units of metacarbonate.

The Missi Group in the Saw Lake area is thought to lie unconformably on top of the Amisk Group, as it does at Flin Flon. However, as the lower contact of the Missi Group is not exposed in the Saw Lake area, this relationship must be inferred from the large amount of volcanic detritus in conglomerate units in the adjacent Wekusko Lake area (Shanks and Bailes, 1977) and from rare fragments of "onion skin textured" weathered basalt. The latter is a common fragment type in basal Missi Group conglomerates, at Flin Flon, where it can be demonstrated to be derived from a regolith on the underlying Amisk Group volcanic strata (Price, 1977; Syme *et al.*, 1982).

Recrystallization, complex folding and faulting have combined to obscure many stratigraphic relationships in the Missi Group rocks in the Saw Lake area. Nevertheless an approximate stratigraphic sequence can still be recognized (Tables 1 and 2; Map GR83-2-1). Five main units are recognized:

- Protoquartzite, siliceous paragneiss (unit 9)
- Metabasalt, minor felsic metavolcanic rocks (unit 8)
- Carbonate-rich metasedimentary rocks, para-amphibolite (unit 7)
- Metasandstone, minor polymictic conglomerate (unit 6)
- Staurolitic metasiltstone, polymictic pebble conglomerate (unit 5)

The metasedimentary rocks, particularly those of unit 6, dominate the Missi Group. They vary considerably in appearance depending on the degree of recrystallization (Table 2). The least recrystallized rocks are in the Niblock Lake and Saw Lake Blocks in the northwest part of the map area. They contain upper greenschist to middle almandine-amphibolite facies mineral assemblages and locally retain many of their primary textures and structures. Those to the south and east, in the Dion Lake, Kanisota Falls and Davis Lake Blocks, contain upper almandine-amphibolite to lower granulite facies mineral assemblages, are coarsely recrystallized and commonly have a granitoid appearance.

Both marine and terrestrially deposited metasandstones are recognized in the Missi Group in the Saw Lake map-area. The terrestrial successions (units 6b to 6f) dominate. On Niblock Lake they are characterized by trough cross-bedded fluviatile sands (Fig. 5), gravels and pebble conglomerates (unit 6b), and elsewhere, in more highly metamorphosed strata, they are characterized by a high aeromagnetic response, probably due to recrystallization to magnetite of hematiferous cement and rock fragments. The marine successions (units 6a, 7 and 9) are characterized by a low flat aeromagnetic response, which

TABLE 2
Tentative correlation of Missi Group rocks between fault blocks

NIBLOCK LAKE BLOCK	SAW LAKE BLOCK	DION LAKE BLOCK	KANISOTA FALLS BLOCK	DAVIS LAKE BLOCK
	Protoquartzite siliceous paragneiss (9)			
	Metabasalt (8a, 8b, 8c)	Mafic metavolcanic gneiss (8c) and amphibolite (8d)		
	Fluviatile metasandstone (6b)	Quartzofeldspathic magnetite-bearing paragneiss (6c) and derived migmatitic gneiss (6e) polymictic conglomerate (6d)	Quartzofeldspathic magnetite-bearing biotite gneiss (6e)	Coarsely granoblastic quartz-feldspar-magnetite-biotite gneiss (6f)
	Layered garnetiferous para-amphibolite (7d)	Metacarbonate, para-amphibolite (7a, 7b)	Layered metacarbonate and siliceous paragneiss (7c)	
	Siliceous paragneiss with local layers of metacarbonate protoquartzite and formational sulphides (6a)	Siliceous paragneiss with local layers of metacarbonate protoquartzite and formational sulphides (6a)	Quartzofeldspathic migmatic biotite gneiss (6e), local protoquartzite and siliceous paragneiss (6a)	
Staurolitic metasiltstone polymictic pebble conglomerate (5)				
Metabasalt (8b)				

Increasing grade of metamorphism and degree of recrystallization →

Lower Almandine-Amphibolite Facies — Middle to Upper Almandine-Amphibolite Facies — Upper Almandine-Amphibolite to Lower Granulite Facies

Decreasing reliability of stratigraphic reconstructions →

probably reflects absence of the hematiferous cement and oxidized rock fragments. Local beds of metacarbonate, some of mappable dimensions (unit 7), and beds of protoquartzite are characteristic of these deposits. In addition the marine metasandstones are generally more siliceous than those deposited in the terrestrial environment. Disseminated sulphides occur locally in the marine units and in those near the marine to subaerial transition. Disseminated chalcopyrite is present in metasediments of unit 6a and 6b near metacarbonate units and near this transition.

Volcanic rocks, atypical of the Missi Group elsewhere, are abundant in the Saw Lake area and in the adjacent Wekusko Lake area. They are largely mafic in composition and could be confused with mafic volcanic strata of the earlier Amisk Group. However, they can locally be demonstrated to overlie Missi Group fluviatile sediments and are typically massive flows and fragmental subaerial deposits in contrast to the Amisk Group volcanic rocks which are almost exclusively pillowed flows and subaqueous volcaniclastic deposits. In addition, Missi Group volcanic rocks are characterized by a high variable aeromagnetic response which contrasts with the low aeromagnetic response of Amisk Group volcanic rocks. Metarhyolite units in the Missi volcanic succession east of Wekusko Lake contain flattened shards and fragments which suggest that they are probably subaerially deposited welded ash flows (Shanks and Bailes, 1977; Gordon and Gall, 1982).

Staurolitic metasiltstone, polymictic pebble conglomerate (unit 5)

Unit 5, which outcrops only in the Niblock Lake Block, is atypical for the Missi Group. It consists of staurolitic metasiltstone and metamudstone with 1 to 3 m thick beds of unsorted polymictic pebble conglomerate. Massive metasandstone, with rare cross-laminations and trough cross-bedding, is locally associated with the conglomerate beds.

The staurolitic metasiltstone and metamudstone, which are typically monotonous compositionally uniform rocks, are bedded and delicately laminated with numerous randomly oriented euhedral porphyroblasts of biotite (1 - 3 mm) and staurolite (1 - 30 mm). The laminations are defined by biotite-rich partings and the bedding, which is typically nebulous, is defined by slight variations in grain size and biotite content. Other primary structures are rare. A small outcrop 1 km downstream from the first set of falls on the Grass River contains 1 to 5 cm thick beds with finer grained ripple laminated tops. These beds are associated with fluviatile trough cross-bedded sandstone and pebble conglomerate. An outcrop 1 km on strike to the north is similarly bedded and locally contains intraformational mudstone fragments.

The staurolitic metasiltstone and metamudstone contain lower to middle almandine-amphibolite facies mineral assemblages formed during the peak Hudsonian metamorphic event, M_2. Characteristic assemblages are:

Lower almandine-amphibolite facies

- Staurolite + muscovite + chlorite + biotite ± garnet + quartz + plagioclase
- Staurolite + chlorite + biotite ± garnet + quartz + plagioclase
- Muscovite + chlorite + biotite + quartz + plagioclase
- Chlorite + actinolite + biotite + quartz + plagioclase

Middle almandine-amphibolite facies

- Anthophyllite + staurolite + chlorite + biotite ± garnet ± muscovite + quartz + plagioclase
- Staurolite + anthophyllite + chlorite + biotite + garnet + quartz + plagioclase
- Anthophyllite + cummingtonite + chlorite + biotite + quartz + plagioclase

The composition of, and mineral assemblages in, these rocks are similar to those reported for Amisk Group greywacke, siltstone and mudstone turbidites (Froese and Moore, 1980; Bailes, 1980a). However, their depositional environment differs in that they are associated with fluviatile sandstones, albeit in small amounts, and with chaotic, unsorted pebble conglomerate with rounded clasts.

The pebble conglomerates are composed of a polymictic mixture of moderate to well-rounded clasts. The pebbles are strongly flattened and elongated in foliation surfaces. They average 1 to 3 cm in diameter, and are rarely up to l5 cm in diameter. The pebbles are highly variable in composition and include the following rock types, in approximate order of abundance:

- Leucocratic fine grained fragments (felsic volcanic clasts?)
- Fine- to medium-grained mafic fragments (volcanic?)
- Porphyritic felsic volcanic clasts
- Quartz-phyric tonalite

The conglomerates are framework-supported with only minor detrital matrix. They are recrystallized but do not contain the staurolite porphyroblasts typical of the interbedded mudstones and siltstones. Their typical metamorphic mineral assemblage is:

Green amphibole + quartz + plagioclase ± biotite ± chlorite.

Monotonous non-staurolitic sandstones and rare fluviatile sandstones, with large trough cross-beds, are locally associated with the pebble beds.

Although it is not possible to positively identify the environment of deposition, the occurrence throughout this unit of fluviatile-deposited sandstones strongly suggests a river environment. Accordingly, the siltstone and mudstone beds, which dominate the unit, may represent overbank deposits and the pebble conglomerate beds could be debris flow deposits or flash flood deposits.

Siliceous paragneiss, quartzofeldspathic biotite paragneiss and protoquartzite (unit 6a)

Unit 6a outcrops in the Dion Lake Block in the core of the Dion Lake antiform, and in the Saw Lake Block in the core of the Saw Lake antiform. It consists of siliceous paragneiss and quartzofeldspathic paragneiss containing local layers of protoquartzite, metacarbonate and rare pebbly metasandstone. Thin layers of formational graphite, graphite-pyrite and recrystallized pyrrhotiferous chert have been encountered in drill holes. Two, several hundred meter thick metacarbonate sequences (units 7a and 7b) are associated with unit 6a strata in the Dion Lake Block, and a layered garnetiferous para-amphibolite (unit 7d) overlies unit 6a in the Saw Lake Block.

Unit 6a siliceous paragneisses and quartzofeldspathic biotite paragneisses are locally well bedded, but are typically massive, light grey or pale buff weathering rocks without recognizable layering. They are granoblastically recrystallized with upper almandine-amphibolite facies mineral assemblages:

- biotite + quartz + plagioclase;
- biotite + microcline + quartz + plagioclase;
- biotite + sillimanite + muscovite + microcline + quartz + plagioclase; and
- biotite + garnet + hornblende + quartz + plagioclase.

Protoquartzite and metacarbonate beds occur together in unit 6a. The protoquartzites are white weathering with a low biotite content. The metacarbonate layers are identical to those of unit 7.

The quartzofeldspathic paragneisses and siliceous paragneisses of unit 6a differ from similar Missi Group paragneisses of units 6b, 6c and 6e in the following characteristics: a) presence of interbedded metacarbonate and protoquartzite; b) general absence of well-developed layering; c) a low flat aeromagnetic signature; d) the common occurrence of disseminated pyrite and other sulphides; and e) the local occurrence of formational layers of graphite and graphite-pyrite. These differences are tentatively interpreted to be a consequence of a marine environment of deposition of unit 6a strata compared to an interpreted terrestrial environment of deposition for most rocks of units 6b, 6c and 6e. This upward (possibly fluctuating) transition from marine to terrestrial conditions of deposition for units 6a, 6c and 6e on Dion Lake may be economically significant for copper mineralization (see p. 35).

Fluviatile metasandstone (unit 6b), quartzofeldspathic magnetite-bearing biotite paragneiss (unit 6c) and polymictic metaconglomerate (unit 6d)

Units 6b, 6c, 6e and 6f are a succession of progressively more coarsely recrystallized metasandstones which are at least in part stratigraphically equivalent (Table 2). They vary from well preserved fluviatile metasandstones (unit 6b), with lower almandine-amphibolite facies assemblages, on the east shore of Niblock Lake to granitoid coarsely recrystallized quartzofeldspathic migmatitic gneisses (unit 6f), with granulite facies mineral assemblages, in the centre of the Davis Lake Block.

Unit 6b comprises fluviatile metasandstone which outcrops in a wedge-shaped east-facing 0 to 1 km thick succession located east and northeast of Niblock Lake in the Saw Lake Block. It is truncated to the north-northwest, together with underlying and overlying pillowed metabasalt (unit 8b), by the Niblock Lake Fault. Primary structures and textures are moderately well preserved.

Unit 6b metasandstones weather light grey, buff grey and white and are light grey on fresh surfaces. They include minor siltstone, grit sandstone and pebble sandstone. They are medium to very thick bedded, typically in 30 cm to 1 m wide beds. Their bedding is lensy and discontinuous. Characteristic features include large-scale trough cross-bedding (Fig. 5), in sets up to a metre wide; large scour channels with rare pebble lags; heavy mineral concentrations on foreset laminae of cross beds; well-developed laminations, both foreset cross laminations and parallel laminations; and zoned calc-silicate nodules developed by metamorphic recrystallization of carbonate concretions. Transport directions indicated by trough cross beds are highly variable, and difficult to measure due to absence of exposed bedding plane surfaces; a northerly component of transport is most common.

Recrystallization and deformation has generally obscured boundaries of fine grained clasts and detrital matrix, and has partly recrystallized and obscured intragranular textures of even coarse grained clasts. Nevertheless, a number of typical clast-types have been recognized microscopically (Table 3) in coarse grained sandstones, and macroscopically, in pebble-bearing beds. The fragments indicate derivation from a mixed volcanic and felsic plutonic source terrane. No felsic plutonic clasts were observed but the abundant fragments of polycrystalline quartz and crystals of plagioclase are most logically interpreted to have a plutonic source. Quartzite grains and pebbles are common and may have a different source-area than the other dominantly volcanic-plutonic clasts. Alternatively, the quartzite may represent metamorphically recrystallized chert fragments of volcanic affinity.

Mudstone and siltstone fragments are locally abundant. They are extremely angular and obviously intraformational, and some may be dessicated mud chips. Clasts with weathering rinds and rare cobbles of weathered "onion skin textured" volcanic rocks are locally present in unit 6b metasandstones.

Metamorphic mineral assemblages in metamudstones and metasiltstones are lower to middle almandine-amphibolite facies; they include:

biotite + chlorite + muscovite + staurolite + quartz + plagioclase ± garnet;
biotite + chlorite + muscovite + cordierite + quartz + plagioclase; and
biotite + muscovite + andalusite + staurolite + quartz + plagioclase.

The cordierite forms large elliptical strongly sieved blasts up to 3 cm in size (Fig. 6). On weathered outcrop surfaces some of the cordierite blasts resemble lithic pebbles, except that they overprint and contain remnants of laminations.

Similar but much more strongly recrystallized metasandstones (unit 6c) outcrop east of Dion Lake in the Dion Lake Block. Primary textures and structures are rarely preserved in these rocks which consist of granoblastic upper almandine-amphibolite facies mineral assemblages, including:

biotite + microcline + quartz + plagioclase;
biotite + hornblende + quartz + plagioclase; and
biotite + sillimanite + muscovite + quartz + plagioclase.

Unit 6c paragneisses are characterized by accessory magnetite, high variable aeromagneetic response, numerous narrow interbeds of polymictic conglomerate and absence of metacarbonate beds. They weather light buff-grey and are light to medium grey on fresh surface. To the south, with increase in metamorphic grade, they change into migmatitic paragneisses of unit 6e.

Northeast of Dion Lake, disseminated sulphides, including chalcopyrite, are locally present at the base of unit 6c. In one locality, 2 km northwest of Dion Lake and 300 m east of Dion Creek, the paragneisses contain up to 4 per cent disseminated chalcopyrite. No iron oxide stain or geophysical EM anomaly is associated with this sulphide occurrence, and the fine grains of chalcopyrite were only observed during a routine check of samples after completion of the field season. Thus, the extent and significance of this sulphide occurrence is uncertain.

A 200 to 300 m wide unit of polymictic pebble conglomerate (unit 6d) occurs within unit 6c paragneisses. This unit consists of numerous beds of pebble conglomerate and rare cobble conglomerate, interlayered with metasandstone and pebbly metasandstone. Pebbles, which are generally well rounded, are moderately to strongly flattened in the foliation surface (Fig. 7). Granoblastic recrystallization has caused many of the clast-types to be virtually indistinguishable from the detrital matrix. The most prominent clasts are leucocratic granoblastic mixtures of quartz and feldspar, which have an uncertain and probably varied parent lithology. Metaquartzite pebbles are also common.

Granoblastic magnetite-bearing quartz-plagioclase-microcline-biotite gneiss and migmatitic gneiss (units 6e and 6f).

Unit 6e outcrops in the Dion Lake Block and in the Kanisota Falls Block. In the Dion Lake Block, it is the more coarsely recrystallized equivalent of unit 6c. In the Kanisota Block unit 6e has a low flat aeromagnetic response, local metacarbonate, and associated protoquartzite that suggest it probably is at least in part the recrystallized equivalent of unit 6a.

Light grey to buff weathering leucocratic quartzofeldspathic biotite gneisses, which are generally light grey on fresh surface, are the dominant lithology in unit 6e. White weathering siliceous gneisses and pink weathering varieties are locally present. Grain size of the gneisses varies from 0.5 to 3 mm and is typically 0.5 to I mm. The rocks are usually homogeneous but rare bedding, defined by slight variations in grain size and biotite content, and rare laminations, defined by biotite or magnetite concentrations, are present. Strongly flattened, almost unrecognizable pebbles occur locally, most prominently south of unit 6d, in the Dion Lake Block, and more rarely north of the stock of magnetite-rich granodiorite (unit 19c), in the Kanisota Falls Block. Small sills, veinlets and irregular plugs of granitic rocks are common. Many are recognizable offshoots from the large bodies of granodiorite (units 14 and 19), but others are probably products of partial anatexis of the potassium feldspar-rich host unit 6e paragneisses. A considerable drop in the abundance of these granitic sills in more siliceous potassium feldspar-poor paragneisses is consistent with *in situ* derivation by partial melting.

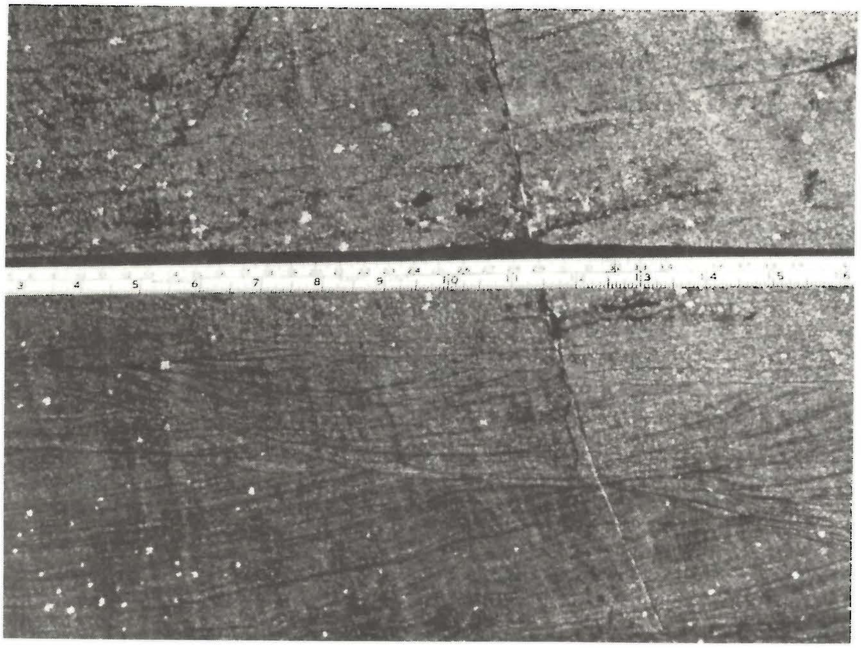


FIGURE 5:
Trough cross-bedded metasandstone (unit 6b), east shore of Niblock Lake.

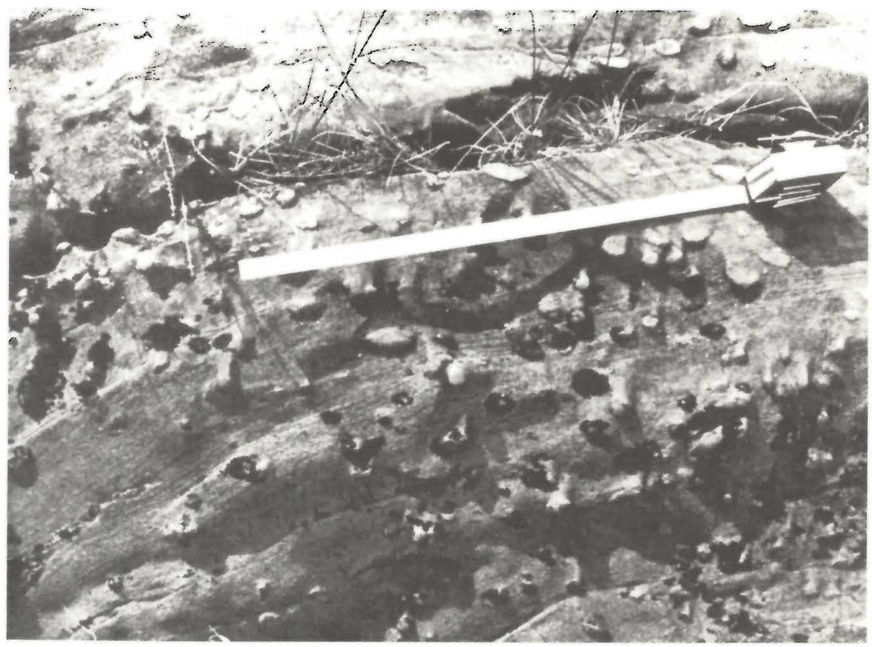


FIGURE 6:
Large elliptical cordierite porphyroblasts in metasandstone (unit 6b), east shore of Niblock Lake.

Unit 6e paragneisses are granoblastic aggregates of quartz, plagioclase, microcline and biotite. Microcline content varies from 0 to 25 per cent and biotite from 3 to 5, and rarely up to 15 per cent. Magnetite is common in unit 6e in the Dion Lake Block and occurs locally in the Kanisota Falls Block. Porphyroblasts of muscovite, sillimanite (interwoven fibrolite and quartz), hornblende and garnet occur locally. Muscovite porphyroblasts are not abundant because the muscovite stability limit, in association with albite plus quartz, has been exceeded for most of unit 6e.

Unit 6f outcrops in the east half of the Davis Lake Block and is compositionally and texturally the more coarsely recrystallized equivalent of unit 6e. To the northeast it correlates with locally cross-bedded conglomeratic and weakly conglomeratic quartzofeldspathic paragneisses exposed on the west shore of Setting Lake (Bailes, 1977). The conglomerates on Setting Lake contain abundant quartzite pebbles and, in this respect, are unlike Missi Group conglomerates observed by the author in the Flin Flon belt.

The unit 6f gneisses are coarsely granoblastic, locally granitized, migmatitic, and composed of quartz + plagioclase + microcline + biotite + magnetite + garnet. They are typically light creamy pink to pink and rarely white, light grey or buff weathering. On fresh surface, they are light pink to white. Their grain size varies from 0.5 to 3 mm and averages 1 to 2 mm. They contain no remnant layering and commonly show signs of remobilization. They are riddled by dykes and irregular bodies of granitic rocks (units 16 to 20) and by *in situ* generated partial melts. Potassium metasomatism and local microcline blastesis is common, particularly in close proximity to plugs of microcline augen-monzodiorite and granite (units 16 and 17).

TABLE 3
Description of detrital components in metasandstone (unit 6b), Missi Group

Polycrystalline quartz:	Subangular to rounded 0.3 to 1 mm clear multiple grain units; internal grain size varies from 0.1 to 0.4 mm; internal grain boundaries vary from lobate-sutured to polygonal granoblastic; locally include nebulous partly recrystallized twinned 0.2 to 0.4 mm plagioclase crystals; probably includes recrystallized chert and vein quartz, but common occurrence with plagioclase crystals strongly suggests derivation from fine grained felsic plutonic rocks.
Plagioclase:	Partly recrystallized 0.2 to 0.4 mm twinned and untwinned crystal fragments, identical to those within and adhering to polycrystalline quartz fragments; abundance of plagioclase crystals correlates directly with abundance of clasts of polycrystalline quartz; many plagioclase crystals are partly or wholly recrystallized to fine grained aggregates that are virtually indistinguishable from detrital matrix.
Felsic microcrystalline rock fragments:	Very fine grained ($<$ 0.03 mm) clasts which vary in size from fine sand to pebbles; typically well rounded; granoblastic mixture of quartz, plagioclase and minor biotite; identical, except for absence of phenocrysts, to porphyritic felsic volcanic rock fragments.
Quartzite:	Rounded coarse sand to pebble-size fragments composed of granoblastic polygonal quartz (internal grain size 0.2 to 0.4 mm); pale sandy-brown weathering colour; similar to polycrystalline quartz clasts but characterized by absence of plagioclase; origin uncertain, some may be recrystallized chert.
Quartz-phyric felsic volcanic fragments:	Identical to felsic monocrystalline fragments but contain up to 10% 0.2 to 1.0 mm quartz phenocrysts.
Mafic rock fragments:	Amphibole-rich fine grained fragments; typically strongly flattened in foliation; locally feldspar-phyric; likely volcanic.
Iron formation fragments:	Black magnetite-rich opaque fragments up to cobble size; some interlayered with quartzite (probably recrystallized chert); vary from subangular to rounded.
Intraformational mudstone and siltstone fragments:	Angular dark grey to black weathering fragments from 2 mm to several centimetres in size; composed of muscovite- and biotite-rich mixture of fine grained quartz and plagioclase.
Detrital matrix:	Fine grained interstitial material composed dominantly of quartz and plagioclase; includes small porphyroblasts of biotite, muscovite, chlorite and amphibole.

FIGURE 7: Tectonically flattened cobbles in polymictic metaconglomerate (unit 6d), 2.4 km east of Dion Lake.

Carbonate-rich metasediments and para-amphibolite (unit 7)

Five mappable units of calcareous metasediments and para-amphibolites (units 7a to 7e) are recognized. They outcrop in the Dion Lake, Saw Lake, and Kanisota Falls Blocks. They are hosted by non-magnetite-bearing siliceous quartzofeldspathic paragneisses of unit 6a and 6e. They include both massive and layered varieties; diopside-, calcite and amphibole-rich varieties; and garnet-rich and garnet-poor types. All varieties are coarsely and granoblastically recrystallized with upper almandine-amphibolite facies mineral assemblages (Table 4, Fig. 8).

Two units of metacarbonate (units 7a and 7b) outcrop in the Dion Lake Block. Both are up to 500 m wide, thin to the south, and are terminated to the north by the Roberts Lake Fault. Unit 7a is massive, carbonate-rich and garnet-poor. Unit 7b is fragmental (tectonic), amphibole-rich and garnet-porphyroblastic.

Unit 7a outcrops south of Dion Lake and is hosted by east-facing(?) quartzofeldspathic paragneisses of unit 6a. Massive non-garnetiferous dark green to black weathering amphibolite forms the lower half of unit 7a. The upper half consists of massive mottled white and green coloured calcite-diopside-andesine-scapolite gneiss. The contact between the two varieties is gradational. Layering is rare and, where present, has been tectonically disrupted. A carbonate- pyrrhotite-bearing siliceous gneiss, up to 50 m thick, overlies unit 7a. It is probably a recrystallized sulphide- carbonate-bearing chert. A weak, formational electromagnetic anomaly coinciding with this unit was tested in 1965 by two diamond drill holes. Traces of disseminated chalcopyrite were reported to occur in these holes by Noranda Exploration Limited. Two whole rock chemical analyses of unit 7 metacarbonates are given in Appendix A (cols. 8 and 9).

Unit 7b is an amphibolite characterized by 5 to 15 per cent 0.5 to 1 cm anhedral garnet porphyroblasts and by tectonically fragmented

TABLE 4
Metamorphic mineral assemblages of calcareous metasedimentary rocks (unit 7)

UNIT NO.	SAMPLE NO.	pl[2]	cpx	c	alm	kf	qz	sc	sp	bi, ph	hb	tr	cum	OTHER
7a	07-76-359-1	38	cpx	*c/c*		kf	qz	sc	sp	*bi*	*hb*			
	07-76-360-3	39	cpx	*c/c*		kf			sp	*ph*	*hb*			
	07-76-094-1	37	cpx	*c/c*				sc	sp		*hb*	*tr*		*zo*
	07-76-360-2*[3]	42		*c/c*			qz	sc	sp	ph	*hb*			mu
	07-76-098-1	37	cpx	*c*		kf	qz		sp			*tr*		*zo*
	07-76-2007-3	38	cpx			kf			sp	*ph*		*tr*		
	07-76-094-2	52	cpx	*c/c*			qz		sp		hb/*hb*			
	07-76-094-2	pl		*c*	alm				sp	bi	hb			
	07-76-094-3	pl		*c*	alm		qz			bi	hb			
	07-76-097-1	pl		*c*			qz		sp		hb			
	07-76-084-1	pl		*c*						bi	hb		cum	
	07-76-2041-1	pl		*c*					sp		hb			
	07-76-2046-1	pl		*c*					sp		hb			
7b	07-76-2009-2	70	cpx	*c/c*		kf	qz	sc	sp		*hb*			
	07-76-2009-2	pl	cpx	*c*			qz		sp	bi	hb/*hb*			
	07-76-089-1*	71	cpx	*c*	alm		qz		sp		hb/*hb*			
	07-76-2013-1	36		*c*	alm		qz			bi	hb			
	07-76-2014-2	31		*c*			qz			bi	hb		cum	*ch*
	07-76-2018-1	44	cpx	*c*			qz		sp		hb/*hb*			
	07-76-2018-1	pl					qz				hb			
7c	07-76-614-2	33	cpx	c		kf		sc	sp	*bi*				*zo*
	07-76-614-3	42	cpx	*c/c*				sc	sp		*hb*			
	07-76-614-1	27	cpx	*c/c*				sc	sp		hb			
	07-76-614-1 & 3	pl	cpx						sp		hb			
	07-76-582-1*	74	cpx	*c/c*	alm		qz		sp		hb/*hb*			
	07-76-580-2	49	cpx	c					sp		hb/*hb*	*tr*		
	07-76-584-1	26					qz			bi	hb		cum	
7d	07-76-246-1*	pl	cpx	c	alm		qz			bi	hb			*ch*
	07-76-2219-1	40		c	alm		qz			bi	hb			*ch*
7e	07-76-338-2*	60		c	alm		qz		sp	bi	hb		cum	
	07-76-622-2*	42	cpx	c	alm		qz				hb			*ch*

Mineral Abbreviations:

alm	= almandine	*cum*	= cummingtonite	ph	= phlogopite
bi	= bi:tite	*hb*	= hornblende	qz	= quartz
c	= calcite	*kf*	= potassium feldspar (microcline)	sc	= scapolite
ch	= chlorite			sp	== sphene
cpx	= clinopyroxene	*mu*	= muscovite	tr	= tremolite
				zo	= zoizite

NOTE: [1]Metamorphic minerals were generated during M_2, except minerals in italics which are retrograde and post-M_2.
[2]Numerals indicated An content of plagioclase.
[3]Mineral assemblages in samples with asterisks cannot be represented on ACF diagram (Figure 8).

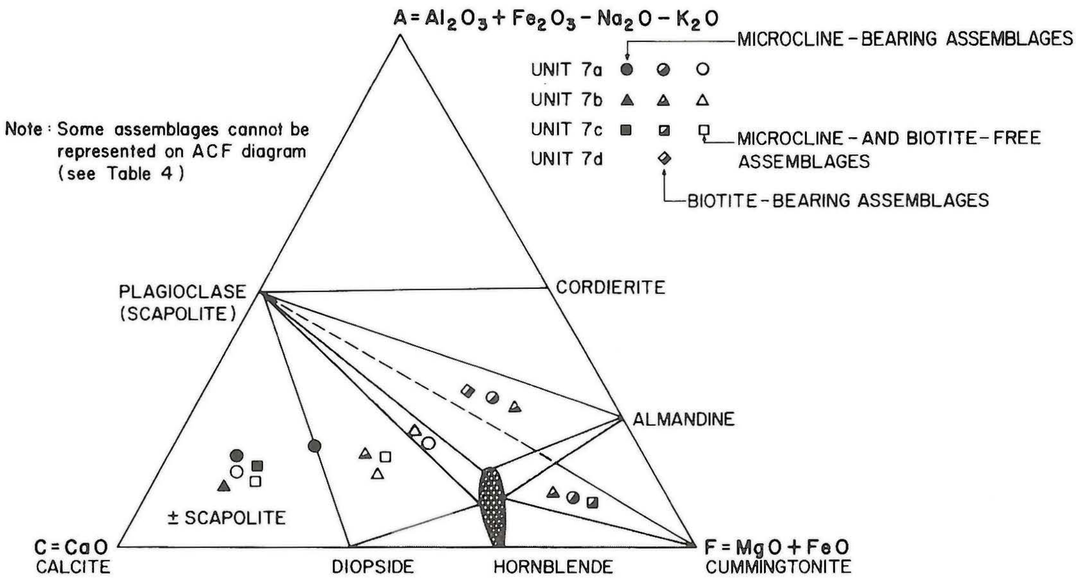


FIGURE 8: ACF diagram showing metamorphic mineral assemblages of calcareous metasedimentary rocks (unit 7).

(boudinaged) diopside-rich or quartzofeldspathic layers. It outcrops southeast and east of Dion Lake and occurs 500 m stratigraphically above(?) unit 7a. It is underlain by poorly exposed locally pyrite-bearing siliceous metasedimentary rocks of unit 6a and is overlain by similar but magnetite-rich paragneisses of unit 6c. The unit is up to 500 m wide, but thins to the south and north. The amphibolite is dark grey to black weathering and grey-green, dark grey or black on fresh surface. Diopside-rich layers are white, grey-green or orange-brown weathering. Traces of pyrite and chalcopyrite are locally present.

Unit 7c consists of well layered diopside-calcite-scapolite gneiss, garnetiferous para-amphibolite, and rare siliceous paragneiss and quartzofeldspathic biotite paragneisses. It outcrops in the Kanisota Falls Block and, with the exception of a cluster of small outcrops south of the Grass River (1 km west of Kanisota Falls), is poorly exposed and largely swamp-covered. A lateral strike-length of over 10 km is indicated by four small widely separated outcrops north of the Grass River. The exposed width of the unit is 1 km, but its true width is unknown as it is truncated to the west by the Watts River fault. To the north it is cross-cut by granodiorite of unit 12. The calc-silicate layers are white, pale green or orange-brown weathering. Mineralogically they are identical to the carbonate-rich gneiss of unit 7a (see Table 4). The para-amphibolite layers, which dominate most outcrops, are dark grey to black and consist of granoblastic 0.25 to 0.5 mm grains of hornblende, andesine, biotite, sphene and rare quartz. Almandine or clinopyroxene or both are commonly present in the para-amphibolite. Siliceous paragneisses and quartzofeldspathic biotite paragneisses in unit 7c are similar to those in adjacent exposures of unit 6e, but are typically more siliceous and locally rusty weathering.

Unit 7d consists of interlayered siliceous paragneiss and garnetiferous amphibolite. It outcrops in the Saw Lake Block at the contact between siliceous paragneisses of unit 6a and mafic metavolcanic rocks of unit 8. The amphibolite is a black weathering, layered rock of probable metasedimentary derivation. It is folded by the northeast-trending Saw Lake antiform. Although not exposed on the northwest limb of this fold it has been intersected by drill holes testing a strong formational EM conductor. The formational conductor is a 1 m wide pyrite-pyrrhotite sulphide zone that has been traced and tested for over 3 km along strike. Several other EM conductors have been tested in this area in the adjacent siliceous paragneisses of unit 6a (Fig. 27).

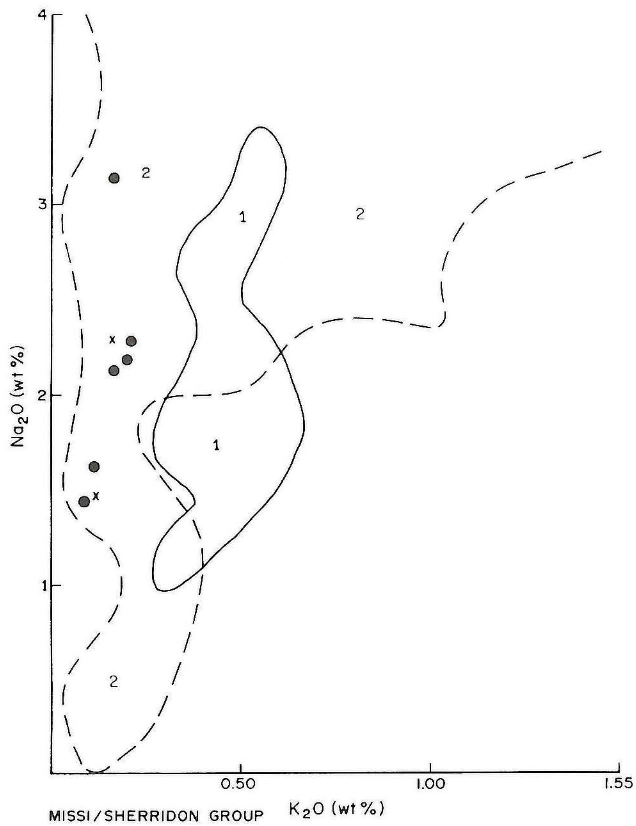
Unit 7e, which outcrops in the Kanisota Falls Block, consists of several metre-wide layers of strongly garnetiferous diopside-bearing amphibolite contained in rusty weathering protoquartzite. These rocks are exposed in several small outcrops in a swampy area occupying the hinge zone of the northeast moderate-plunging Watts River antiform, and are cut off by a fault to the east and by a granodiorite intrusion (unit 14a) to the west. Protoquartzites without the amphibolite layers occur in outcrops due north and northeast of unit 7e. Anhedral masses of almandine garnet locally compose up to 50 per cent of the amphibolite layers. The amphibolite layers are probably derived from carbonate-rich mudstone. The protoquartzite layers are possibly recrystallized chert.

Metabasalt, minor felsic metavolcanic rocks (unit 8)

Missi Group metavolcanic rocks outcrop in three localities: in the Niblock Lake Block; in the Saw Lake Block, and in the Dion Lake Block. With the exception of one narrow unit of felsic meta-volcanic rocks (unit 8e) in the Saw Lake Block, metabasalt is the dominant rock type. The metabasalt includes both subaerially and subaqueously deposited flows and includes both relatively unrecrystallized rocks, with upper greenschist facies mineral assemblages and preserved primary textures and structures, and coarsely recrystallized orthogneisses.

In the Niblock Lake Block, a 700 m thick section of pillowed metabasalt (unit 8b) directly overlies turbidity current-deposited(?) Amisk/Nokomis Group metasediments. These flows, which were probably deposited in a submarine environment, are exposed in a north-northeast-plunging anticline, the east limb of which is terminated by the Niblock Lake fault. Like other subaqueously deposited flows in the Saw Lake and adjacent Wekusko Lake area, they have a low, flat aeromagnetic response.

In the Saw Lake Block, massive, featureless, fine grained metabasalt flows (unit 8a), minor pillowed flows (unit 8b), and a 150 m thick unit of felsic to intermediate heterolithic lapilli tuff and breccia (unit 8e)



MISSI/SHERRIDON GROUP

● Missi Group metabasalt (unit 8), Saw Lake area

1 Sherridon Group metabasalt/ortho-amphibolite (n=15), Sherridon area (Goetz, 1980)

AMISK GROUP

x Amisk Group metabasalt (unit 1), Saw Lake area

2 Amisk Group metabasalt (n=66), Snow Lake, File Lake, Flin Flon and Coronation areas (Williams, 1966; Froese, 1969a; Stauffer *et al*, 1975; Bailes, 1980a; Bailes and Syme, unpublished analyses)

FIGURE 9:
K_2O-poor character of Missi Group basalts, Saw Lake area: K_2O-vs-MgO diagram.

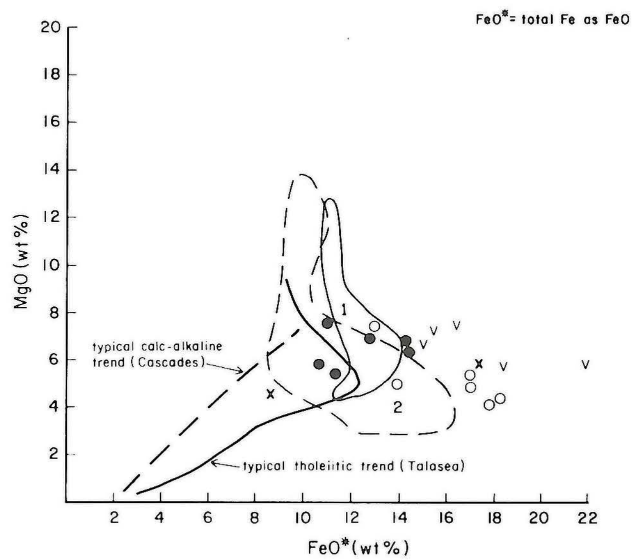
comprise a 2 km thick sequence that can be traced 20 km along strike to the southeast, from Niblock Lake to the Saw Lake Fault, across a series of north-northeast moderately shallow-plunging anticlines. On Niblock Lake the basalt flows are only slightly recrystallized with many primary features well preserved. To the southeast they become coarse grained granoblastically recrystallized orthogneisses (unit 8c) in which most primary structures are destroyed.

The massive metabasalt flows (unit 8a) east of Niblock Lake overlie fluviatile metasandstones (unit 6b) and are interpreted to have been deposited subaerially. They are fine grained, granoblastic, featureless rocks that rarely contain small, albite-filled vesicles. They are characterized by a high variable aeromagnetic signature (up to 3700 gammas). They include narrow units of pillowed metabasalts (unit 8b) that are well exposed along the east shore of Niblock Lake. The pillowed metabasalts directly underlie and overlie fluviatile metasandstones (unit 6b). Since these pillowed flows are unlikely to have formed in a submarine environment they are interpreted to have developed in a shallow lake, which could have formed in response to damming of a river system by the flows themselves. The upper metre of the flow that directly underlies unit 6b is strongly oxidized and altered (garnet-rich), possibly due to subaerial weathering preceding deposition of the overlying fluviatile sediments.

In the Dion Lake Block a 1 km thick unit of coarse grained granoblastically recrystallized amphibolites and hornblende-plagioclase gneisses (units 8c and 8d) outcrops 4 km east of Dion Lake. These rocks overlie Missi Group metasandstones of unit 6a and 6c and, allowing for possible lateral facies variations in the metasandstone sequence, are at a similar stratigraphic position to the previously described massive metabasalts of the Saw Lake Block. Like the Saw Lake Block metabasalts, they have a high variable aeromagnetic response.

The unit 8 metabasalts and orthogneisses in the Saw Lake area probably correlate with the Missi Group metabasalts recognized by Stockwell (1937), Frarey (1948), and Gordon and Gall (1982) in the adjacent Crowduck Bay-Wekusko Lake area. They represent the only significant occurrence of Missi Group volcanic rocks in the Flin Flon belt and are of interest in terms of their tectonic setting. Other volcanic rocks of approximately comparable age and stratigraphic setting are the coarsely recrystallized mafic gneisses in the Sherridon Group at Sherridon, Manitoba. Goetz (1980) and Froese and Goetz (1981) have interpreted the latter to have been deposited in a marine environment.

In Figures 9 to 12 the Missi Group metabasalts, both massive (cols. 10 to 13, Appendix A) and pillowed (cols. 14 & 15, Appendix A) varieties, are compared to Amisk Group metabasalts. In a very general way they are compositionally similar. For example, they are both potassium-poor (Fig. 9) and tholeiitic (Fig. 10). However, with respect to certain elements there are recognizable differences between the Missi Group metabasalts and typical Amisk Group metabasalts. For



MISSI / SHERRIDON GROUP

● Missi Group metabasalt (unit 8), Saw Lake area

V Sherridon Group high - Ti metabasalt / ortho - amphibolite, Sherridon area (Goetz, 1980)

1 Sherridon Group low - Ti metabasalt / ortho - amphibolite (n = 11), Sherridon area (Goetz, 1980)

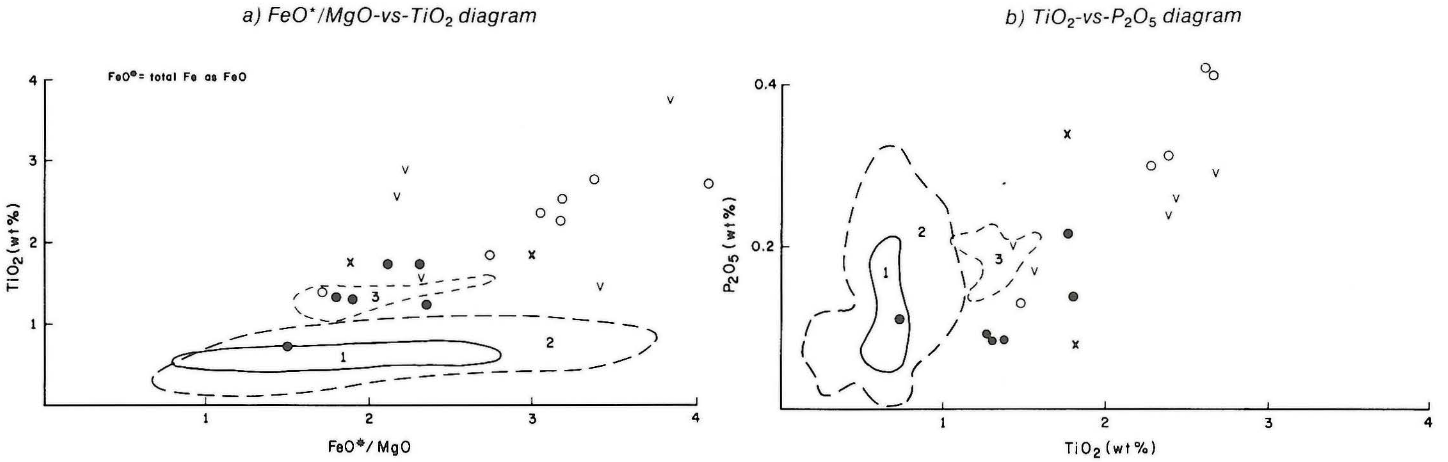
AMISK GROUP

X Amisk Group metabasalt (unit 1), Saw Lake area

O Amisk Group high - Ti metabasalt, White Lake area (Bailes and Syme, unpublished analyses)

2 Amisk Group metabasalt (n=63), Snow Lake, File Lake, Flin Flon and Coronation areas (Williams, 1966; Froese, 1969a; Stauffer *et al* 1975; Mwanang'onze, 1978; Bailes; 1980a, Bailes and Syme, unpublished analyses)

FIGURE 10:
Tholeiitic character of Missi Group basalts, Saw Lake area: FeO-vs-MgO diagram.*



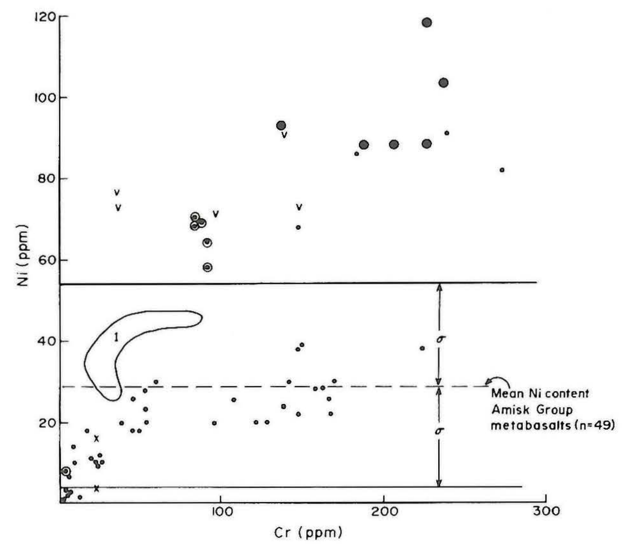
MISSI / SHERRIDON GROUP

● Missi Group metabasalt (unit 8), Saw Lake area
V Sherridon Group high-Ti metabasalt / ortho-amphibolite, Sherridon area (Goetz, 1980)
1 Sherridon Group low-Ti metabasalt / ortho-amphibolite (n = 11), Sherridon area (Goetz, 1980)

AMISK GROUP

X Amisk Group metabasalt (unit 1), Saw Lake area
O Amisk Group high-Ti metabasalt, White Lake area (Bailes and Syme, unpublished analyses)
2 Amisk Group metabasalt (n = 57), Snow Lake, File Lake, Flin Flon and Coronation areas (Froese, 1969; Williams, 1966, Stouffer *et al*, 1975; Mwanang'onze, 1978; Bailes, 1980; Bailes and Syme, unpublished analyses)
3 Amisk Group metabasalt (n = 6), Scottle Lake (Bailes and Syme, unpublished analyses)

FIGURE 11:
TiO_2-rich character of Missi Group basalts, Saw Lake area, relative to typical Amisk Group basalts



MISSI / SHERRIDON GROUP

● Missi Group metabasalt (unit 8), Saw Lake area
V Sherridon Group high-Ti metabasalt/ortho-amphibolite, Sherridon area (Goetz, 1980)
1 Sherridon Group low-Ti metabasalt/ortho-amphibolite (n=11), Sherridon area (Goetz, 1980)

AMISK GROUP

x Amisk Group metabasalt (unit 1), Saw Lake area
◉ Amisk Group high-Ti basalt, White Lake area (Bailes and Syme, unpublished analyses)
• Amisk Group metabasalt, White Lake area (Bailes and Syme, unpublished analyses)

FIGURE 12:
Ni-rich character of Missi Group basalts, Saw Lake area, relative to typical Amisk Group basalts: Ni(ppm)-vs-Cr (ppm).

example, the Missi Group metabasalts are distinctly richer in TiO_2 (Fig. 11), with the exception of the Amisk Group metabasalts from the Saw Lake area and the volumetrically minor unit of high-Ti basalts at White Lake, near Flin Flon. The Missi metabasalts are also richer in Ni (Fig.12) than typical Amisk Group basalts, and much richer in both Ni and Cr than the unit 1 Amisk Group basalts of the Saw Lake area. It is probably significant that TiO_2- and Ni-rich metabasalts also occur in the Sherridon Group, at Sherridon, Manitoba (Figs. 11 and 12).

Amisk Group metabasalts are remarkably similar in composition to low-K tholeiites of modern island arcs (Stauffer *et al.*, 1975; Bailes, 1980a). The much higher TiO_2 and Ni contents of the Missi Group metabasalts indicate that they probably formed in a different tectonic setting. The chemical and geological data available at this time do not permit identification of this environment.

Protoquartzite, siliceous paragneiss (unit 9)

East of Niblock Lake, in the Saw Lake Block, a thick sequence ($>$ 1500 m) of protoquartzite and siliceous paragneiss (unit 9) overlies the Missi Group subaerial metabasalts (unit 8a). This unit, which can be traced for 25 km along strike, is not known to occur outside the Saw Lake area in either the Flin Flon or Kisseynew Belts. It may be the youngest and stratigraphically highest supracrustal unit recognized so far in either belt. It is stratigraphically conformable with the underlying Missi metabasalts; however, the lower contact is not exposed and is locally intruded by pyroxenite (unit 10) and gabbro (unit 11). The siliceous paragneisses and protoquartzites have been included with the Missi Group, with some reservations as this unit is markedly different from normal Missi metasediments. For example, it is a much more mature sediment, one that is not likely to have formed in the fluvial-alluvial environment characteristic of the Missi Group.

The lower 500 m of unit 9, which is poorly exposed, consists largely of light grey to pale rusty-brown weathering siliceous paragneisses. This is followed by 500 m of white to light grey weathering protoquartzite, with minor interbeds of siliceous paragneiss and local narrow ($<$ 5 m) layers of fine grained granoblastic orthoamphibolite (unit 9a). A 300 m wide no-outcrop interval is followed by 100 m of rusty weathering sillimanite- and biotite-rich quartzofeldspathic gneiss (unit 9c) and a 100 m wide layer of fine grained massive orthoamphibolite (unit 9b). The upper contact of unit 9 is an intrusive contact with granodiorite and tonalite (unit 12). The paragneisses and the granodiorite-tonalite body are structurally conformable and are deformed into a series of large, north-northeast-trending moderately shallow plunging folds.

The protoquartzites and siliceous paragneisses are typically massive, featureless rocks, but locally contain rare bedding and biotite-rich laminations. The protoquartzites have silica contents that exceed 85 per cent (cols. 16 & 17, Appendix A). The siliceous paragneisses rarely contain over a few per cent biotite, from which it can be inferred that they contained very little mud or clay. The siliceous paragneisses are mineralogically simple and are typically composed of quartz, plagioclase, biotite and muscovite, with rare tiny garnet porphyroblasts.

The environment of deposition of unit 9 paragneisses is not known. The high quartz content of these sediments suggests extensive reworking of detritus, possibly in a beach or shallow water environment, prior to deposition.

POST-MISSI INTRUSIVE ROCKS

Three main groups of post-Missi intrusive rocks occur in the Saw Lake area (Map GR83-2-1; Table 1):

Late- to post-kinematic intrusions

Syn-kinematic intrusions

Pre- to early kinematic intrusions

Their ages relative to major metamorphic and tectonic events are summarized in Table 7 (p. 26). They are named according to the system proposed by the IUGS Sub-commission on Nomenclature of Igneous Rocks (Streckeisen, 1976).

The early kinematic intrusions are concordant bodies of metapyroxenite (unit 10) and tholeiitic metagabbro (unit 11). The syn-kinematic intrusions are folded, gneissic, stratiform bodies of felsic to intermediate granitic rocks (units 12 to 18). They accompanied a lengthy period of tectonism that involved several pulses of deformation and culminated in a high temperature regional metamorphic event. The late- to post-kinematic intrusions are unfoliated to weakly foliated and include plugs and irregular bodies of leucogranite (unit 19) and associated pegmatite (unit 20), and a small outcrop-size intrusion of garnet hornblendite (unit 21).

Regional Setting

The intrusive rocks of the Saw Lake area are part of a 60 km wide north-northeast-trending fold belt characterized by above average abundance of felsic plutonic rocks. The author (Bailes, 1975 & 1976) previously suggested that development of this fold and plutonic belt postdated the Kisseynew belt peak metamorphic-deformational event ($\sim$ 1760 Ma), and this has raised speculation that they are manifestations of a younger orogenic event ($\sim$ 1700 Ma), localized along the contact between the Churchill and Superior Provinces (Weber and Scoates, 1978; Scoates, pers. comm., 1979; Hubregtse, 1980). However, the north-northeast-trending fold structures and most of the plutonic rocks in the Saw Lake area are now known to either predate or to be synchronous with the Kisseynew belt M_2 thermal climax (Table 7). A Rb-Sr whole rock isochron of 1767 $\pm$ 190 Ma on a syn-kinematic felsic pluton (equivalent to unit 17) in the Setting Lake area (Cranstone and Turek, 1976) is consistent with this interpretation as it gives an age close to that of the peak of Kisseynew belt metamorphism. A post-kinematic intrusion (equivalent to unit 19), also dated by Cranstone and Turek (1976), gives an age of 1693 $\pm$ 90 Ma.

Age Relationships

The sequence of intrusive events is rarely defined by cross-cutting relationships, and is largely determined relative to major folding and faulting episodes, as well as inferred timing relative to the main regional M_2 thermal metamorphic climax (Table 7, p. 26). The only cross-cutting relationships are: 1) felsic pegmatite dykes (unit 20) intruding the Saw Lake pluton (unit 12) and enderbite (unit 15); 2) dykes of magnetiferous microcline-augen granite (unit 17) cutting microcline augen quartz monzodiorite (unit 16); and 3) dykes of massive magnetiferous leucogranite (unit 19a) intruding foliated, folded magnetiferous microcline-augen monzodiorite to granite (units 16 and 17).

The early- and syn-kinematic intrusions are deformed by major north-northeast-trending F_2 folds and truncated by east and northeast striking D_4 faults; the late- to post-kinematic intrusions are not affected by these events. The syn-kinematic intrusions are typically sheet-like stratiform bodies that vary from pre- to syn-F_2. Syn-F_2 intrusions may have acted as a plastic-fluid cushion and lubricant which facilitated the release of stress and the formation of the F_2 folds; they form both fold sheets (units 16 and 17) and planar sheets (units 14 and 15), the latter possibly parallel to F_2 axial planar thrust shears.

The early kinematic metapyroxenite (unit 10) and metagabbro (unit 11) are only exposed in relatively unmetamorphosed strata and their age relative to the syn-kinematic intrusions cannot be determined, but they are most logically interpreted as equivalents to early kinematic metagabbro intrusions recognized in areas to the west (Bailes, 1980a; Froese and Moore, 1980). Bailes (1980a) showed these intrusions to be associated with an early episode of F_1 recumbent folding.

The late- to post-kinematic intrusions form irregular plugs and sheets that cross-cut F_2 folds and locally invade post-F_2 faults. The magnetiferous leucogranites (unit 19) appear to have invaded relatively cool host rocks, possibly being emplaced at quite a high structural level as indicated by relatively fine grain sizes and by contacts marked by swarms of narrow dykes.

EARLY KINEMATIC INTRUSIVE ROCKS

The early kinematic intrusive rocks comprise metapyroxenite (unit 10) and metagabbro (unit 11), that may be equivalent to the early kinematic Josland Lake Gabbro of the File Lake area (Bailes, 1980a). Unlike the Josland Lake Gabbro these intrusions are not strongly differentiated. Also, metapyroxenites are not associated with the Josland Lake Gabbro as they are with gabbros in the Saw Lake area.

The metapyroxenite and metagabbro form stratiform bodies along the contact between Missi Group mafic flows (unit 8) and overlying orthoquartzites and siliceous paragneisses (unit 9).

Metapyroxenite (unit 10)

A 300 m wide, several kilometer long, recrystallized orthopyroxenite sill (unit 10) outcrops in the core of a syncline 3 km southeast of Niblock Lake and in an isolated outcrop in the core of the next syncline to the east. Several drill holes (Fig. 27, Appendix B) have intersected unexposed portions of the metapyroxenite sill at the same stratigraphic position and it is possible that the sill is laterally continuous for over 10 km. An olivine metapyroxenite (unit 10a), exposed 100 m west of the Watts River, and a melagabbro (unit 10b), exposed 400 m north of Niblock Lake, have been included in unit 10 but are not necessarily genetically related to the sill.

The metapyroxenite (unit 10) is medium to coarse grained, reddish brown (oxidized) on weathered surfaces, and grey to green-grey on fresh surfaces. It is composed almost entirely of fibrous anthophyllite that has pseudomorphically replaced large plates of colourless orthopyroxene. The orthopyroxene contained 5 per cent exsolved magnetite, which is now largely converted to hematite. The metapyroxenite may contain up to 2 per cent olivine. Two chemical analyses are given in Appendix A (cols. 18 and 19).

The olivine metapyroxenite (unit 10a) is similar to the metapyroxenite (unit 10) but is significantly more olivine-rich. It is composed of 30% 0.5 to 5 mm grains of olivine, 25% large (up to 10 mm) plates of orthopyroxene, 42% 0.5 to 2 mm grains of pale green-brown hornblende, 2% 0.2 mm grains of magnetite and 1% calcite. The olivine and orthopyroxene are primary. The hornblende, magnetite and calcite are secondary minerals. The hornblende has partly replaced olivine and orthopyroxene. Magnetite forms both discrete 0.2 mm grains, enclosed in hornblende, and reaction rims on olivine grains that are partly replaced by hornblende.

The melagabbro (unit 10b) is composed of 40 per cent dark green amphibole (0.5 - l mm) set in a fine grained groundmass mixture of colourless chlorite, dark green amphibole and minor quartz. A chemical analysis (col. 20, Appendix A) indicates it was probably an orthopyroxene-rich melagabbro.

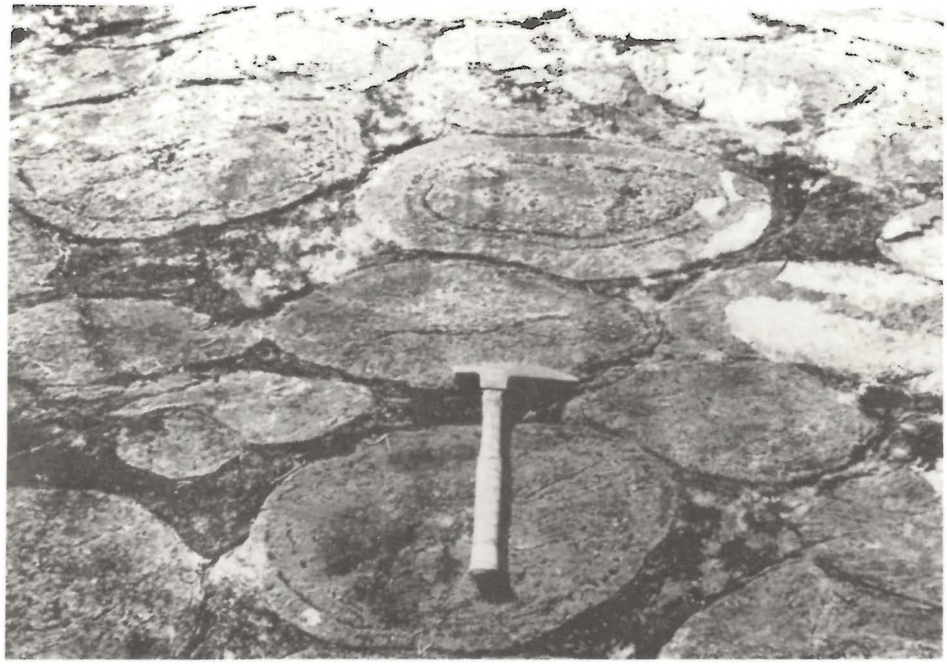


FIGURE 13:
Large feldspar orbicules in orbicular gabbro (unit11a) exposed 4.5 km east of northwest corner of the map area. Several of the feldspar orbicules contain internal amphibole-rich rings.

Metagabbro (unit 11)

The metagabbro (unit 11) forms a concordant intrusion, up to 400 m thick and over 5 km long, that follows the contact between metabasalt (unit 8) and protoquartzite and siliceous paragneiss (unit 9). It is best exposed in several large clean outcrops located 5 km east-southeast of the northwest corner of the map area. The intrusion consists mainly of medium grained metagabbro (unit 11a), but includes layers of orbicular gabbro (unit 11a) characterized by exceptionally large and well developed feldspar orbicles (Fig. 13).

Metagabbro (unit 11) forms the margins of the intrusion and is interlayered with the orbicular gabbro (unit 11a) in the centre of the intrusion. A 1 to 2 mm grain size, ranging up to 5 mm, is typical. Weathered surfaces are a mottled white and green. The metagabbro is composed of 40-50% secondary green amphibole (after clinopyroxene), 50-60% granoblastically recrystallized plagioclase, and 1-3% sphene (after titaniferous magnetite exsolutions in the clinopyroxene). Chemical analyses of the metagabbro (cols 21 and 22, Appendix A) indicate it to be tholeiitic.

The orbicular gabbro (unit 11a) forms layers, approximately 90 m across. The orbicules are 15 to 70 cm in diameter, in mutual contact, slightly flattened, and composed of 1 - 2 cm crystals of andesine. The larger orbicules commonly contain one or two 1 cm wide rings of amphibole or amphibole and plagioclase (Fig. 13). The material between the orbicules consists of 2 - 4 cm amphibole grains (after clinopyroxene). The feldspar in the orbicules is granoblastically recrystallized and partly replaced by calcite, zoisite and minor amounts of green amphibole.

SYN-KINEMATIC INTRUSIVE ROCKS

The syn-kinematic intrusive rocks comprise stratiform foliated granitic bodies that vary widely in composition (Table 5, Fig. 14). Seven distinct intrusive units have been recognized:

East half of map area
- Leucogranite (unit 18)
- Magnetiferous microcline-augen granite (unit 17)
- Magnetiferous microcline-augen monzodiorite, monzonite, quartz monzodiorite and quartz monzonite (unit 16)
- Enderbite (unit 15)

West half of map area
- Kanisota Falls granodiorite and tonalite (unit 14)
- Garnetiferous hornblende melatonalite and melagranodiorite (unit 13)
- Saw Lake granite, granodiorite and tonalite (unit 12).

These intrusions were emplaced after F_1 folding (Table 6), probably over a considerable span of time. Ages of intrusions in the east half of the area relative to those in the west half could not be determined.

The intrusions are sheet-like 0.5 to4 km thick bodies that are roughly stratiform with large lateral continuity (up to 30 km). Their stratiform shape reflects lateral intrusion that probably resulted from a combination of the following factors during their emplacement: 1) low density contrast with the host metasedimentary rocks; 2) low ductility contrast with host rocks; and 3) intrusion at a deep crustal level. These factors all favour sill-like intrusions rather than plug-shaped diapirs (Pitcher, 1979).

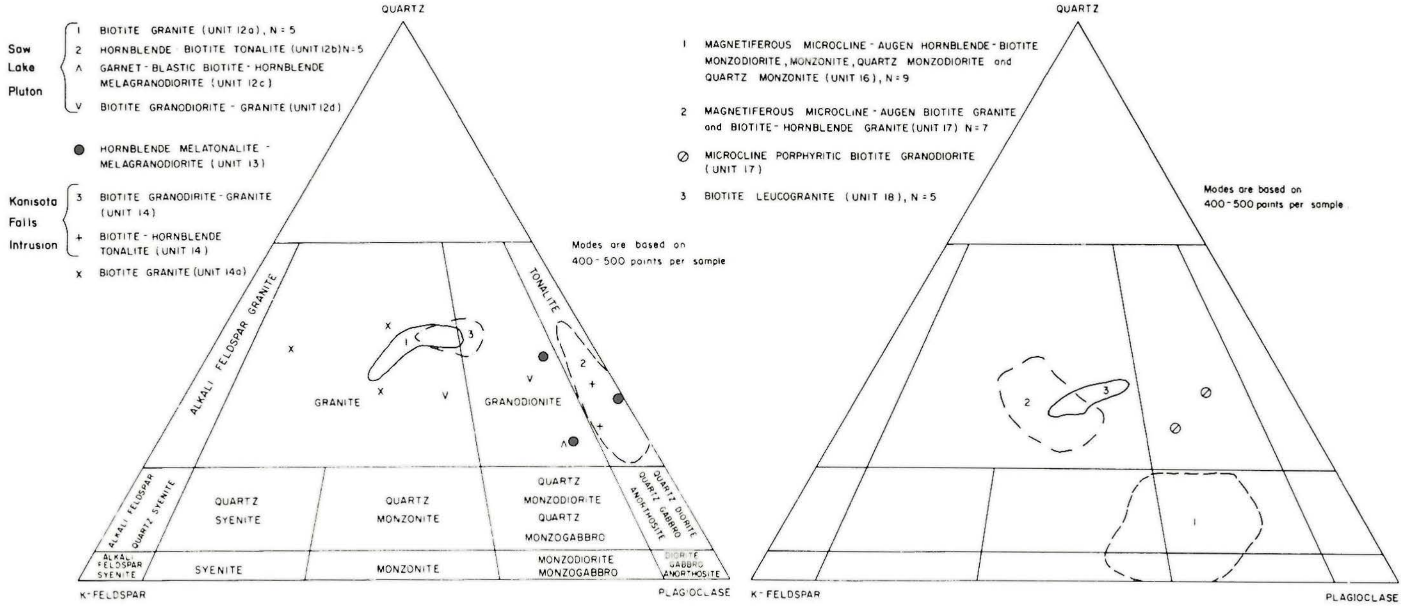
The syn-kinematic intrusions are present both as F_2 folded sheets (units 16 and 17) and as sheets axial planar to F_2 folds (units 14 and 15). This is interpreted to be a function of structural control on intrusion style rather than an indication of different ages for these intrusions. For example, it is possible that the unfolded intrusions were emplaced along F_2 axial planar zones of weakness at the same time as other intrusions were intruded into and folded by actively deforming F_2 folds. This is feasible as most of the syn-kinematic intrusions appear to have been emplaced into a hot, tectonically mobile environment as they have migmatitic-metasomatic envelopes as well as completely gradational contacts with host rocks. A notable exception is the Saw Lake pluton which was intruded early and has well defined unmigmatized margins.

TABLE 5

Modal composition of syn-kinematic intrusive rocks, Saw lake area.

Unit No.	12				13	14			16	17	
Column No.	1	2	3	4	5	6	7	8	9	10	11
Plagioclase	29.1	53.7	42.6	43.5	40.3	35.0	54.5	21.4	48.9	26.8	44.6
Quartz	39.7	26.5	17.4	31.8	22.0	41.1	27.2	39.6	4.2	30.0	26.8
K-feldspar	26.5	2.1	9.4	19.1	6.3	19.3	4.3	36.4	26.3	36.4	14.6
Biotite	4.0		18.0	5.4				2.4			14.0
Hornblende					29.3		12.2				
Hornblende/ Biotite		15.7				4.3			19.4	6.6	
Magnetite	tr	tr					0.5	0.1	1.2	0.2	
Garnet	0.7	2.0	6.8	0.2	3.9	0.3	0.2	0.2			

1. Biotite granite (unit 12a), Saw Lake pluton, n = 5
2. Hornblende-biotite tonalite (unit 12b), Saw Lake pluton, n = 5
3. Garnet porphyroblastic biotite-hornblende melagranodiorite (unit 12c), Saw Lake pluton, n = 1
4. Biotite granodiorite and granite (unit 12d), Saw Lake pluton, n = 2
5. Garnetiferous hornblende melatonalite and melagranodiorite (unit 13), n = 3
6. Biotite granodiorite and granite (unit 14), Kanisota Falls intrusion, n = 5
7. Hornblende-biotite tonalite (unit 14), Kanisota Falls intrusion, n = 5
8. Biotite leucogranite (unit 14a), n = 3
9. Magnetiferous microcline-augen monzodiorite, monzonite, quartz monzonite and quartz monzodiorite, n = 9
10. Magnetiferous microcline augen biotite granite and biotite-hornblende granite (unit 17), n = 7
11. Microcline porphyritic biotite granodiorite (unit 17a), n = 2



a) western Saw Lake area

b) eastern Saw Lake area

FIGURE 14: Modal composition of syn-kinematic intrusive rocks

Saw Lake pluton (unit 12)

The Saw Lake pluton is a zoned felsic intrusion exposed northwest of Saw Lake (Map GR83-2-1, Fig. 15). The southern contact dips north at 45° to 65° and is structurally conformable with the underlying protoquartzites and siliceous paragneisses of unit 9. Internal contacts, particularly between units 12a, 12c and 12d (Fig. 15), outline a steeply plunging dome or cylinder. The northern half of the 30 by 12 km intrusion is exposed in the McNeill Lake area (Lenton, 1981). In the McNeill Lake area the intrusion cross-cuts host Missi Group paragneiss and, according to Lenton, is a steeply plunging cylinder-shaped body. Lenton suggests that the intrusion may have pierced the Missi Group strata in the McNeill Lake area and then been emplaced laterally as a tongue-shaped body into rocks of the Saw Lake area. The Saw Lake pluton is deformed by F_2 folds.

Five discrete zones (Fig. 15) and four distinct rock lithologies (Map GR83-2-1) are recognized in the pluton. The zones, which vary from 0.2 to 2 km in width, probably represent discrete magma pulses, but may in part represent remnants of highly recrystallized host paragneiss incorporated into the intrusion. The grain size of zone 1 (unit 12a) decreases over 50 m to a very fine grained chilled contact with unit 9 siliceous paragneisses.

The F_2 folded Saw Lake pluton is the oldest of the synkinematic intrusions and predates the M_2 thermal climax (Table 7). The timing relative to the M_2 event is indicated by: 1) imprint of M_2 isograds and porphyroblasts onto already F_2 folded rocks in the Niblock Lake area; and 2) the strongly foliated and recrystallized nature of the intrusion. Small garnet porphyroblasts and thin veinlets of syenitic melt were locally produced during the M_2 recrystallization; the syenitic veins are particularly prominent in the northern half of the pluton (Lenton, 1981). A strong F_2-folded pervasive foliation, defined by flattened annealed quartz grains and aligned crystals of biotite, hornblende, or both, is ubiquitous and parallels the outer margin as well as the internal zones of the intrusion.

The pluton differs from the younger syn-kinematic intrusions as: 1) it only rarely contains inclusions (an exception is the northern half of the pluton which has abundant inclusions (Lenton, 1981); 2) it has an abrupt lower contact with no associated metasomatism or migmatization of host rocks; and 3) it has an internal zonation in part conformable to the host paragneisses. The other syn-kinematic intrusions are full of inclusions, have large metasomatic and migmatitic envelopes, and were probably emplaced during deformation and may have lubricated the release of stress.

Zones 1 and 3 of the Saw Lake pluton are composed of gneissic biotite granite and minor gneissic hornblende tonalite (unit 12a). Zone 1 is characterized by ubiquitous, well defined air photo linears which parallel the gneissic fabric of the pluton. No satisfactory explanation for these linears was found, but they most likely represent a subtle primary internal layering. Such layering was locally observed, and can be inferred from a subtle but recognizable heterogeneity in sample suites taken from the intrusion.

The gneissic biotite granite (unit 12a) is generally uniform in colour and texture. It typically weathers white to pale pink and has an average grain size of 1 to 3 mm, and ranges up to 5 mm. It is composed of oligoclase, quartz, microcline, red-brown biotite, garnet porphyroblasts and traces of magnetite (col. 1, Table 5; Fig. 14a). Grain boundaries are lobate sutured. The fine grained lower 50 m of the intrusion is bright pink to red weathering. A 2 to 3 km wide zone, immediately west

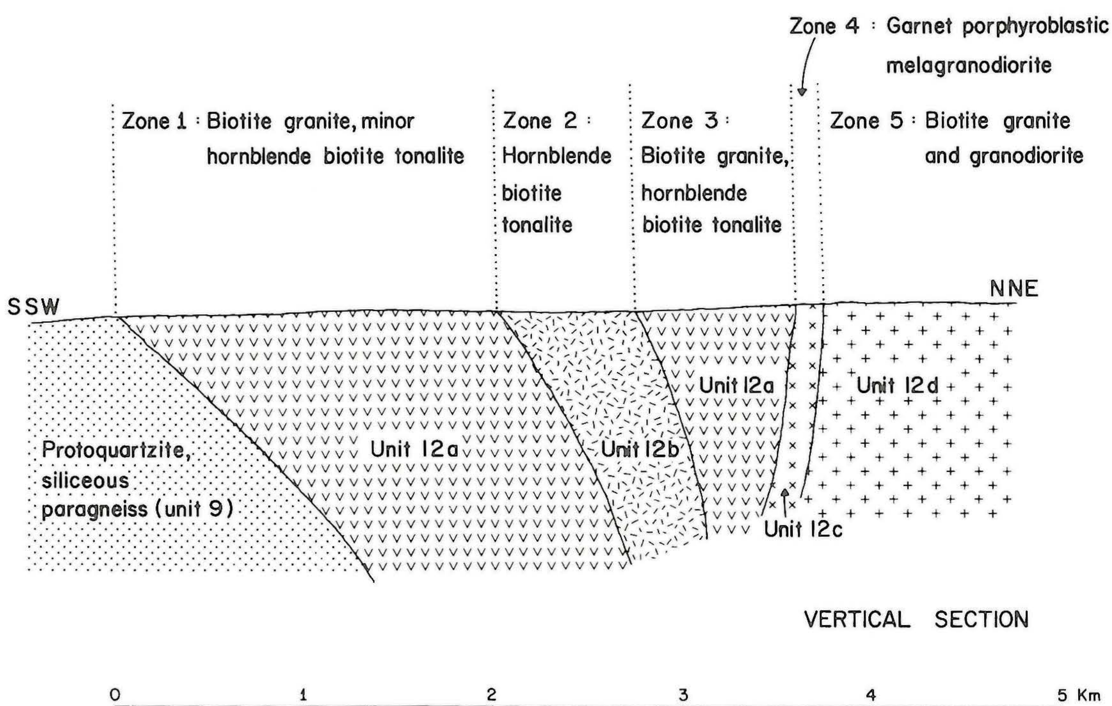


FIGURE 15: Internal zones in the Saw Lake pluton (unit 12).

of Saw Lake is also bright pink to red weathering. The colour of the latter zone is due to hematization of feldspars and is likely related to numerous, small, late intrusions of felsic pegmatite (unit 20). Layers(?) of hornblende-biotite tonalite, equivalent to those in unit 12b of zone 2, are locally present.

The hornblende-biotite tonalite (unit 12b) of zone 2 (Fig. 15) is white on weathered surfaces and light to medium grey on fresh surfaces. There are several large outcrops of this unit north-northeast of Saw Lake, but elsewhere it is largely swamp-covered. Contacts with adjacent zones are not exposed. The hornblende-biotite tonalite is locally layered, with layering defined by variable grain size, garnet content and hornblende/biotite ratio; it is extensively injected by narrow veinlets and *lit* of white granitic mobilizate. Petrographically the tonalite is composed of antiperthitic andesine, quartz, yellow-green to dark green hornblende, red-brown biotite, microcline, garnet and traces of magnetite and apatite (col. 2, Table 5; Fig. 14a). A 1 to 2 mm grain size, gneissic metamorphic textures and poikiloblastic hornblende and garnet characterize unit 12b. The garnets, which are distinctive and ubiquitous, are pale pink and small ($\leq$ 1 mm).

A 200 m wide strongly foliated garnet-porphyroblastic biotite-hornblende melagranodiorite (unit 12c) composes zone 4 in the pluton (col. 3, Table 5; Fig. 14a). It is a coarsely gneissic rock with a 3 to 5 mm grain size and 5 to 10 mm rotated flattened phenocrysts of plagioclase and microcline. It contains 5 - 15 mm euhedral, poikiloblastic M_2 generated garnet porphyroblasts that are neither flattened nor rotated.

The core of the pluton (zone 5) is composed of white weathering weakly foliated biotite granodiorite and granite (unit 12d). It is composed of an equigranular mixture of plagioclase, quartz, microcline and red-brown biotite (col. 4, Table 5; Fig. 14a), with an average grain size of 3 to 4 mm, which ranges from 2 to 5 mm. White weathering 1 to 2 cm phenocrysts of microcline are common. Garnet porphyroblasts, which range in size from 1 to 5 mm, are locally present.

Garnetiferous hornblende melatonalite and melagranodiorite (unit 13)

Unit 13 forms a stratiform NNE-trending 300 m wide and greater than 5 km long intrusion which outcrops 2.7 km south-southeast of Dion Lake. It is axial planar to the F_2 NNE-trending Watts River antiform and has a faulted western margin. The intrusion is M_2 recrystallized and is cross-cut by numerous small irregular bodies of pink granodiorite (unit 19b).

The melatonalite and melagranodiorite of unit 13 weather dark grey and are dark grey to black on fresh surface. They are gneissic, have a 1 to 3 mm grain size, are granoblastically recrystallized, and are composed of antiperthitic plagioclase, quartz, potassium feldspar, yellow-green to dark brown-green hornblende, red-brown biotite, pink garnet and traces of magnetite and zircon (col.5, Table 5; Fig. 14a). The hornblende and garnet are poikiloblastic. Well zoned zircon crystals and distinctive antiperthitic plagioclase are characteristic of unit 13. The melatonalite and melagranodiorite of unit 13 are compositionally, texturally and mineralogically similar to the hornblende tonalite (unit 12b) of the Saw Lake pluton and the hornblende-biotite tonalite (unit 14) of the Kanisota Falls intrusion.

Granodiorite/granite and tonalite (units 14 and 14a)

Unit I4 comprises gneissic biotite granodiorite/granite, with minor hornblende-biotite tonalite (cols. 6 and 7, Table 5; Fig. 14a). It outcrops in the stratiform 2 by $\geq$ 20 km Kanisota Falls intrusion. A small conformable intrusion of biotite granite (unit 14a), possibly genetically related to the Kanisota Falls intrusion, outcrops 1km west of the Watts River. Both intrusions contain numerous nebulous inclusions and layers of migmatized and metasomatized paragneiss, some with tight minor folds of F_2 age. This, plus the apparent discordancy of the Kanisota Falls intrusion with stratigraphy of the host paragneisses, suggests that the intrusions are axial planar to the F_2 Watts River antiform. The gneissic texture and metamorphic mineralogy of the intrusions suggest syntectonic emplacement, probably during F_2 folding and coincident with M_2 metamorphism.

Biotite granodiorite/granite (unit 14), the main component of the Kanisota Falls intrusion (col. 6, Table 5; Fig. 14a), is typically creamy pink to pink-grey weathering, but is locally white or bright pink in colour. Colour variations, on an outcrop scale, are common. The granodiorite/granite is granoblastic, 1 to 3 mm in grain size, and strongly gneissic. Pinhead-size garnets are common in white weathering varieties. The granodiorite/granite has a gradational contact with host granoblastic paragneisses of unit 6e. The contact is characterized by extensive migmatization and metasomatism of the paragneisses such that the distinction between the paragneisses and the intrusive granodiorite/granite is difficult.

The granodiorite/granite is composed of poorly twinned to untwinned oligoclase, quartz, microcline, green amphibole, brown biotite, garnet and traces of magnetite and zircon. Local sericitization and hematization of plagioclase is common, and in part accounts for the bright pink colour of portions of this unit. Patchy, irregular distribution of potassium feldspar is also responsible for the rapid colour fluctuations, and indicates considerable potassium mobility. The plagioclase is locally antiperthitic and the microcline is locally perthitic. The quartz grains have scalloped, highly irregular grain boundaries. The rocks are texturally, compositionally and mineralogically similar to the biotite granodiorite (unit 12a) of the Saw Lake pluton (Table 5; Fig. 14a). The major differences are: 1) rapid fluctuation in texture and grain size of unit 14 relative to more texturally homogeneous unit 12a; 2) the numerous nebulous paragneiss inclusions in unit 14 and their absence in unit 12a; and 3) the gradational outer contact of unit 14 relative to the well-defined outer contact of unit 12.

Hornblende-biotite tonalite (col. 7, Table 5; Fig. 14a) is a minor component of the Kanisota Falls intrusion. It is composed of antiperthitic plagioclase, quartz, microcline, brown-green to blue-green hornblende, brown biotite, garnet, and traces of magnetite, sphene and apatite. The hornblende and biotite, which overprint primary clinopyroxene in one sample, are metamorphic.

Biotite leucogranite (unit 14a) outcrops in a separate intrusion, but is compositionally and texturally similar to the biotite granodiorite/granite of the Kanisota Falls intrusion. It is slightly coarser grained (2 to 5 mm) and more potassic (Fig. 14a). It is white to creamy pink in colour and, like the biotite granodiorite/granite of the Kanisota Falls intrusion, is locally garnetiferous.

Enderbite (unit 15)

White to pale buff-weathering enderbite (unit 15) outcrops 3.5 km north-northwest of Davis Lake. The enderbite has a 1 mm grain size and is strongly foliated. It is locally cross-cut by small intrusions of pink pegmatitic granite (unit 20).

The enderbite is composed of 10 per cent hypersthene (EN53-62), 5 per cent red-brown biotite, 70 per cent antiperthitic andesine and 15 per cent quartz. The hypersthene and biotite are partly retrograded to brown-green amphibole. At contacts between grains of hypersthene and biotite, the amphibole locally forms symplectic intergrowths with quartz.

The Saw Lake enderbite is along strike of a prominent zone of enderbite and orthopyroxene-bearing tonalite and diorite intrusions located 75 km to the northwest at Burntwood Lake in the south-central part of the Kisseynew belt. Baldwin *et al* (1978) consider these intrusions to be amongst the oldest in the Kisseynew belt and to predate the peak M_2 metamorphic event. These intrusions have a Rb-Sr whole rock isochron age of 1786 $\pm$ 80 m.y. with an initial $^{87}Sr/^{86}Sr$ ratio of 0.7030 $\pm$ 0.007 (Clark et al., 1975). It is not known whether this age represents the primary crystallization or the metamorphic recrystallization of the intrusion. In the Burntwood River area, the enderbite and hypersthene-bearing tonalite and diorite intrusions are stratiform, 1 to 8 km wide, and over 50 km in strike length. They outcrop across a 20 km wide belt that has been traced for 150 km from Harriot Lake, Saskatchewan, to Burntwood Lake, Manitoba.

Magnetiferous microcline-augen monzodiorite, monzonite, quartz monzonite and quartz monzodiorite (unit 16)

Three sill-like to podiform intrusions of unit 16 outcrop in the Saw Lake area. One is located just north of Davis Lake, another is on the Grass River at the east boundary of the map-area, and the third is 1 km west of Mitishto River. They average 0.3 km in width and vary from 1 to over 8 km in length. The intrusions exhibit rare cross-cutting contacts and local, small xenoliths of quartz-feldspar-biotite gneiss and amphibolite. They are spatially associated with and are locally cross-cut by dykes of magnetiferous microcline-augen granite (unit 17). Both units (units 16 and 17) are strongly foliated, deformed by major northeast- and north-northeast-trending folds, and cross-cut by unfoliated, undeformed dykes of magnetiferous leucogranite (unit 19).

Unit 16 comprises monzodiorite, monzonite, quartz monzonite and quartz monzodiorite (Fig. 14b) characterized by a high hornblende content and by flesh-coloured, flattened, irregularly-shaped 0.5 to 2 cm phenocrysts of microcline. A 2 to 4 mm grain size and a strong gneissosity defined by aligned grains of hornblende, biotite and flattened microcline is typical. The rocks are white, light grey and creamy pink on weathered surfaces and are grey to light creamy pink on fresh surfaces. They are composed of twinned andesine, microcline (typically as phenocrysts), anhedral quartz with undulose extinction, light to dark green hornblende, straw yellow to dark brown biotite and small amounts of magnetite, apatite and zircon (col. 9, Table 5; Fig. 14b). Myrmekitic intergrowths of quartz and plagioclase are common along boundaries between plagioclase and microcline.

Magnetiferous microcline-augen granite (unit 17)

Four sill-like folded intrusions of magnetiferous microcline-augen granite (unit 17) and one of microcline-porphyritic granodiorite (unit 17a) outcrop in the east half of the Saw Lake area. They are all intruded along the contact between paragneisses of unit 4b and those of unit 6f. They vary in width from 0.5 to l.5 km and can be traced continuously along strike for over 10 km. Small dykes of units 17 and 17a cross-cut bodies of unit 16.

Unit 17 is a biotite and biotite-hornblende granite (Fig.14b) characterized by large (1 to 5 cm), flesh-coloured, flattened microcline augens. It is distinguished from unit 16 by the large microcline augens, the presence of abundant quartz, and a low content or absence of hornblende. Rocks of unit 17 are coarsely gneissic with a 2 to 5 mm grain size. They are pink on weathered surfaces and pale pink on fresh surfaces. They are composed of plagioclase, microcline (typically as phenocrysts), quartz, biotite, hornblende and minor magnetite (col. 10, Table 5; Fig. 14b). The microcline phenocrysts are typically mantled by rims of plagioclase (rapakivi texture). Adjacent to unit 17, rocks of unit 6f are commonly metasomatized and contain porphyroblasts of microcline.

The microcline-porphyritic granodiorite (unit 17a) is similar to and almost certainly genetically related to the microcline augen granite (unit 17). It is not as microcline-rich (col. 11, Table 5; Fig.14b) and typically is much less strongly foliated. The latter is due to a local decrease in intensity of the imposed foliation and does not reflect a post-kinematic age for the intrusion. The granodiorite is typically 1 to 3 mm in grain size with prominent plagioclase-mantled 0.5 to 2 cm subhedral microcline phenocrysts. Small, subhedral to anhedral, 0.3 to l.0 cm plagioclase phenocrysts are also common.

Leucogranite (unit 18)

Two bodies of leucogranite (unit 18) outcrop in the Saw Lake area. A large body, almost entirely swamp-covered, outcrops in the centre of the map-area, and is exposed for 8 km upstream (west) of Whitewood Falls in sporadic, small outcrops along the Grass River. The other is a narrow body exposed along the Mitishto River at the southeast corner of the map area. Small bodies, *lit* and veinlets of this unit are also present as the mobilizate phase in the migmatites of unit 4b.

The leucogranite (unit 18) is white to pale creamy pink. It is uniform in composition (Fig. 14b) and texture, except for local pegmatitic segregations. It varies in grain size from 2 to 5 mm, averaging 2 to 3 mm, and is composed of plagioclase, quartz, microcline, red-brown biotite, xenoblasts of garnet and rare cordierite, and traces of graphite. Xenoliths of foliated and sometimes migmatitic garnet-biotite gneiss (unit 4b) are locally present.

Similar intrusions of leucogranite are widespread throughout the highly metamorphosed paragneisses of the Kisseynew belt. They have been demonstrated to be a product of partial melting of mudstones and siltstones of the Burntwood River Metamorphic Suite (and Nokomis/Amisk equivalents) during high grade regional metamorphism (Bailes and McRitchie, 1978). They are characterized by their intimate and exclusive association with paragneisses of the parental Burntwood River Metamorphic Suite (unit 4b in the Saw Lake area) and by xenoblasts of garnet and cordierite which they inherit from their paragneiss progenitors during the M_2 melting reaction:

$$\text{biotite} + \text{sillimanite} + \text{plagioclase} + \text{quartz} + H_2O \rightleftharpoons \text{granitic melt} + \text{cordierite} + \text{garnet}.$$

The age of unit 18 relative to units 12 to 17 is uncertain as they rarely outcrop together. They are probably all similar in age and emplaced during the same metamorphic-tectonic event. However, rocks of units 12 to 17 typically show evidence of recrystallization during the main high grade metamorphic culmination and, for this reason, unit 18 is inferred to be slightly younger.

LATE- TO POST-KINEMATIC INTRUSIVE ROCKS

Late- to post-kinematic intrusive rocks are unfoliated to weakly foliated rocks that were intruded after F_2 folding and the main M_2 thermal climax (Table 7). Three units are recognized:

Garnet hornblendite (unit 21)
Felsic pegmatite (unit 20)
Magnetiferous leucogranite (unit 19).

The magnetiferous leucogranite (unit 19) outcrops throughout the map area in highly irregular intrusions characterized by margins marked by swarms of narrow dykes - a feature consistent with emplacement at relatively high structural levels into relatively cool competent host rocks. The felsic pegmatites (unit 20) outcrop in mappable bodies in the west half of the map area, and in a broad sense belong to the Wekusko Lake pegmatite field (Černý *et al.*, 1981). Li-and rare U-bearing pegmatites occur in this field in the Crowduck Bay and Dion Lake areas, respectively. The similar age of the magnetiferous leucogranite (unit 19) and felsic pegmatite (unit 20), and the occurrence of pegmatitic phases in the magnetiferous leucogranite (unit 19), indicate there may be a genetic link between these intrusions and the pegmatites. The garnet hornblendite (unit 21) is an unusual rock composed of cumulate garnet and hornblende. It outcrops in one locality, in a small exposure in a swampy area adjacent to the Watts River.

The late- to post-kinematic intrusive rocks are younger than the peak metamorphic-deformational events which occurred at approximately 1760 Ma. A Rb-Sr whole rock isochron age of 1693 $\pm$ 90 Ma (Cranstone and Turek, 1976) on a magnetiferous leucogranite (equivalent to unit 19) and K-Ar muscovite and biotite ages of 1735 $\pm$ 55 Ma, 1610 ± 50 Ma, and 1790 ± 50 Ma (Wanless *et al.*, 1965; Wanless *et al.*, 1967) on pegmatites from the Wekusko Lake field, suggest these intrusions were emplaced closely following the metamorphic-deformation cycle. The age of the garnet hornblendite (unit 21) is uncertain; it is likely to be considerably younger.

Magnetiferous leucogranite (unit 19)

Numerous irregularly-shaped bodies of magnetiferous leucogranite, up to 8 by 1.5 km in size, outcrop in the map area. It is likely that these intrusions are approximately equivalent in age and genetically related, but this is based only on some shared characteristics, similarity in composition and texture, and similar age relations to metamorphic-deformational events. Rocks of variable age and genetic affiliation may be included in this unit. According to McRitchie (pers. comm., 1981) these intrusions are part of a suite of late, magnetite-rich leucogranites, which are preferentially localized in the Churchill Province rocks adjacent to the Churchill-Superior boundary.

In the east half of the map area, rocks of unit 19 are demonstrably late as they are unfoliated to weakly foliated and cut across strongly foliated and folded intrusions of units 16 and 17 (Fig.16). In the west half of the map area, the age of unit 19 intrusions is not well defined. They cross-cut unit 13, and one body - a dyke of unit 19d cross-cuts the post-foliation, post-F_2, and post-M_2 Roberts Lake fault. The weakly foliated to massive character of rocks of unit 19 in the west half of the map area is consistent with a late- to post-kinematic age.

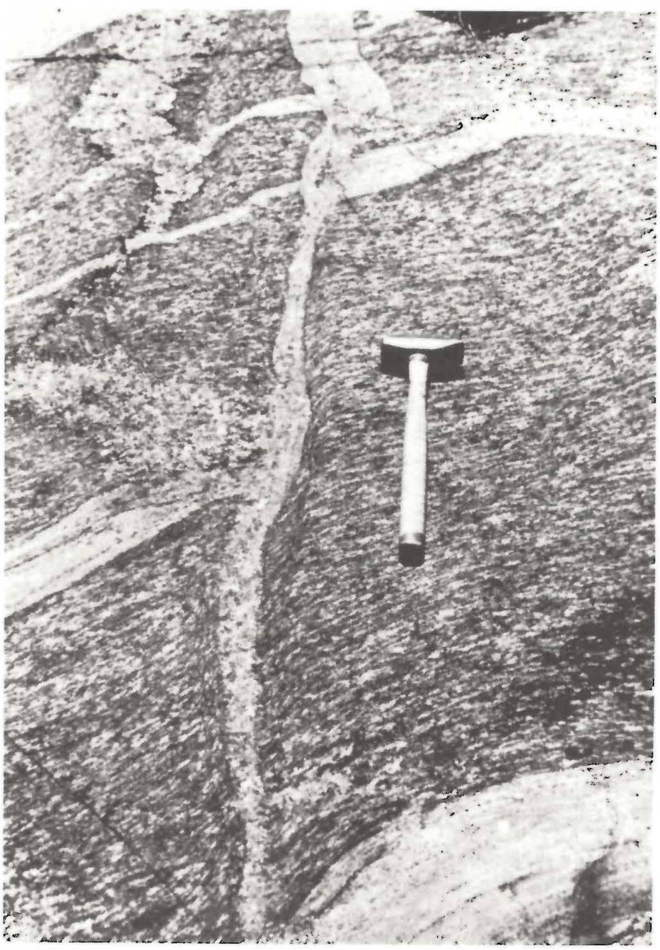


FIGURE 16:
Unfoliated leucogranite dykes (unit 19) cutting foliated quartz monzodiorite (unit 16) on Pakwa Lake, 5 km east of map area.

TABLE 6
Modal composition of late-kinematic intrusive rocks of unit 19, Saw Lake area

Unit No.	19a	19b	19c		
Column No.	1	2	3	4	5
Plagioclase	29.2	24.7	29.6	23.2	32.6
Quartz	31.3	39.1	42.2	43.2	33.3
K-feldspar	37.1	35.3	24.6	30.6	28.1
Biotite	2.1	0.1			
Hornblende (Biotite)			1.9	1.4	3.8
Muscovite		0.6			
Magnetite	0.3	0.2	1.6	1.6	1.2

1. Magnetiferous biotite leucogranite, pluton east of Mitishto River, n = 3.
2. Leucogranite, pluton between Grass and Mitishto Rivers, n = 2.
3. Magnetiferous hornblende leucogranite, pluton 4 km east of Dion Lake, n = 6.
4. Magnetiferous hornblende leucogranite, pluton 1.6 km west of Watts River, n = 1.
5. Magnetiferous hornblende leucogranite, pluton 8 km south of Dion Lake, n = 2.

Intrusions of unit 19 share many features in common: they

i) are all leucogranites (Table 6, Fig. 17);
ii) are all bright salmon pink in colour;
iii) are all massive to weakly foliated and, in general, have a uniform 1-2 mm grain size and texture;
iv) have irregular shapes with margins characterized by swarms of small dykes;
v) are typically magnetite-bearing, with prominent high aeromagnetic signatures;
vi) are spatially associated with pegmatite dykes and locally contain pegmatitic phases; and
vii) commonly have distinctive sericitic alteration of feldspars and hematite coatings on grain boundaries (the latter is in part responsible for their bright pink colour).

One distinct difference is that intrusions in the east half of the map area form small plugs and stocks whereas those in the west half form semi-concordant irregular sill-like bodies.

In the east half of the map area, unit 19 is exposed in eight discrete small plugs or stocks, the largest having a diameter of 2km. The three southern plugs are massive and magnetite-rich (unit 19a). The northern five are weakly foliated and only locally magnetite-bearing (unit 19b). Dykes of these rocks are prominent throughout the east half of the map area. They cut foliated and folded intrusions of units 16 and 17, contain foliated inclusions of these rocks, and are themselves unfoliated (Fig. 16).

Units 19a and 19b are identical in general appearance and in composition in the east half of the map area (Fig. 17), with the exception of differing magnetite content and differing intensity of foliation. Both are bright salmon pink, homogeneous and equigranular (1 to 2 mm), and both locally contain rare small phenocrysts of albite and

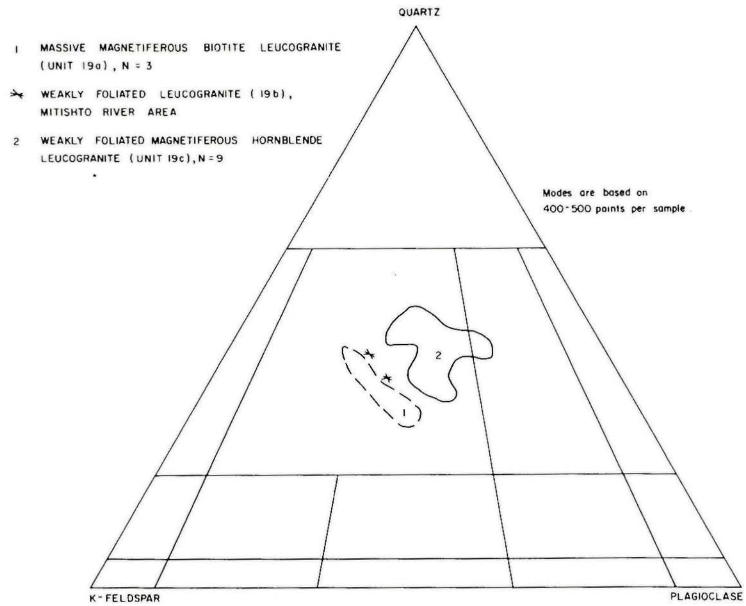


FIGURE 17: Modal composition of late-kinematic rocks of unit 19.

microcline. They are composed of antiperthitic untwinned albite (5% microcline), quartz characterized by scalloped embayed grain boundaries, microcline, green-brown biotite, subhedral to euhedral 0.5 to 1.0 mm magnetite grains, and minor amounts of a distinctive alteration assemblage that includes sericite (and muscovite), chlorite and hematite.

In the west half of the map area several intrusions of unit 19 are exposed in the Dion Lake and Kanisota Falls Blocks, including four semi-condordant intrusions of unit 19c (with numerous small satellite bodies) and one small body of unit 19d. Intrusions of unit 19c are similar to those of unit 19a, with the following differences; they:

i) are semi-conformable sill-like bodies rather than pods and plugs;
ii) contain more quartz and plagioclase (Fig. 17) and more magnetite (Table 6);
iii) are locally foliated and, in some areas, strongly foliated; and
iv) are hornblende - rather than biotite-bearing.

Unit 19c intrusions vary from massive at their centres, to swarms of narrow sills with intervening screens of country rocks, at their margins. They are typically bright pink, featureless, equigranular (2-3mm) rocks. They are composed of sericitized, twinned to untwinned albite; quartz with scalloped, embayed margins; perthitic microcline (15-20% albite); interstitial yellow-green to green-black hornblende; euhedral to subhedral crystals of magnetite; and traces of zircon. Like unit 19a, these rocks are characterized by seriticitization and hematization of feldspars. The quartz is locally megacrystic.

The intrusion of unit 19d north of Dion Lake is a quartz-phyric magnetiferous leucogranite. It is 4 km long by 0.3 km wide and cross-cuts the Roberts Lake fault. The leucogranite is fine grained, contains 2 to 4 mm phenocrysts of quartz, is buff to orange-pink weathering, and is foliated. It is composed of plagioclase (locally antiperthitic), quartz phenocrysts, microcline, euhedral crystals of magnetite, plus retrograde muscovite, bright green chlorite and traces of zoisite, epidote and calcite. Compositionally, it is similar to rocks of unit 19c; both have similarly sericitized and hematized feldspars.

Intrusions of unit 19 have a different intrusive style than those of the preceding syn-kinematic intrusions. They are far more irregular in shape and their margins, which are characterized by dyke swarms, show evidence of forceful injection into a competent host. This is in sharp contrast to the lenticular, commonly folded and strongly foliated bodies of syn-kinematic granitic rocks that appear to have been emplaced into mechanically incompetent rocks. This is presumably due to increased competency of the host rocks during the thermal drop-off following the M_2 metamorphic culmination.

Felsic pegmatite, pegmatitc granite (unit 20)

Numerous small bodies and local dykes of felsic pegmatite and pegmatitic granite (unit 20) outcrop throughout the map area. Mappable bodies of these intrusions, up to 0.7 by 1.2 km in size, are restricted to the northeast portion of the area. They comprise part of the Wekusko Lake pegmatite field (Černý *et al.*, 1981).

The pegmatites and pegmatitic granites form irregular-shaped stocks, plugs and lenticular dykes. The shapes of small bodies are consistent with injection into dilation fractures. The pegmatites cross-cut foliated rocks and contain numerous foliated inclusions. They occur most abundantly in relatively competent siliceous paragneisses (unit 6a) and protoquartzites (unit 9) and were probably selectively introduced into these rocks during late brittle deformation, perhaps during tightening of F_2 fold structures. Specific data on age relationships to other intrusive rocks are not available, with the exception that they intrude the Saw Lake pluton (unit 12) and enderbite (unit 15).

The pegmatites are white to pink weathering, unfoliated, biotite-bearing, and contain large blocky crystals of potassium-feldspar. They are granites in composition. One intrusion on Dion Lake contains tourmaline. None of the samples from the intrusions in the map-area are uraniferous.

Although no Li- or U-bearing pegmatites were identified in the map-area, there is a slight potential for this type of mineralization in pegmatites of the map area, for the simple reason that these pegmatites are part of the Wekusko Lake pegmatite field, where these types of mineralization are found (Černý *et al.*, 1981).

Černý *et al.* (1981) could not identify a parental granite intrusion for the Wekusko Lake pegmatite field, and concluded that if such an intrusion existed it occurred at depth. No such intrusion has been positively identified in the Saw Lake area, but intrusions of unit19 could be a potential candidate as: i) they are the right age; ii) they are locally pegmatitic; and iii) they are spatially associated with small unmappable pegmatite dykes throughout the east half of the map area.

Garnet hornblendite (unit 21)

A small dyke of garnet hornblendite (unit 21) is exposed in a tiny outcrop in a swampy area 300 m west of the Watts River. It is an unusual rock both in composition, mineralogy, and the complete absence of any imposed tectonic fabric. It is composed of 50 per cent 0.4 to 2.0 mm euhedral cumulate crystals of garnet, 4 per cent euhedral cumulate crystals of an opaque oxide, 35 per cent 0.4 to 1.2 mm subhedral to euhedral cumulus and intercumulus crystals of medium green-brown hornblende, 10 per cent 0.2 to 1.2 mm subhedral intercumulus crystals of plagioclase, and 5 per cent miarolitic cavities filled with clear quartz and minor chlorite. The cumulus crystals of garnet and magnetite are both enclosed and bounded by primary cumulus and intercumulus grains of green-brown hornblende. The hornblende varies from unaltered grains to others that are completely replaced by chlorite and minor calcite. Plagioclase is an intercumulus phase between crystals of hornblende. The miarolitic cavities filled by quartz and chlorite are significant as they indicate that this is a high level intrusion. Since unit 21 intrudes para-amphibolite and quartzite that contain upper almandine-amphibolite facies mineral assemblages, the emplacement of this intrusion must postdate a major episode of uplift and erosion. Thus, it is obviously much younger than other intrusions in the map-area.

METAMORPHISM AND DEFORMATION

Several episodes of metamorphic recrystallization and deformation have affected the Proterozoic rocks of the Saw Lake and adjacent areas (Table 7). Froese and Gasparrini (1975), Bailes (1975, 1980a), Bailes and McRitchie (1978) and Froese and Moore (1980) give descriptions of these events that will not be repeated in this section.

The Saw Lake area is part of a 60 km wide north-northeast-trending zone which borders the Churchill Province along its margin with the older Superior Province. In the Saw Lake area, this zone is characterized by: 1) an apparent absence of the ubiquitous recumbent F_1 folds (D_1) that are typical of areas to the west (Table 7); 2) an apparent absence of east-trending F_3 folds (D_3) so abundant to the northwest in the Guay-Wimapedi Lakes area; 3) the dominance of north-northeast-trending F_2 folds; 4) a change from east to north-northeast in trend of M_2 isograds at the west boundary of the Saw Lake area; and 5) an above average abundance of felsic plutonic rocks. All of these features, particularly the apparent absence of recumbent F_1 folds, indicate this zone to be an important and discrete kinematic entity in the Churchill Province. The location of the zone at and parallel to the margin of the Churchill Province with the Superior Province indicate that it was probably produced by tectonic interaction between the two provinces.

Emphasis will be given to this section to the three events that most strongly affect the Saw Lake area, namely: 1) north-northeast-trending F_2 folds belonging to D_2; 2) metamorphic mineral assemblages formed during M_2; and 3) faults formed during D_4.

North northeast-trending F_2 folds

Moderately open to tight folds with north-northeast-trending, steep-dipping axial surfaces occur throughout the Saw Lake area. These folds, which are prominent in the Churchill structural province, were originally considered by the author (Bailes, 1975 & 1976) to belong to a late tectonic event. However, in the northwest part of the Saw Lake area these folds are pre- to early M_2 and as such they belong to an early deformational event, probably part of the Hudsonian orogeny.

The F_2 folds plunge shallowly to the north-northeast in the northwest part of the map area where they fold: 1) an early S_1-generated schistosity; 2) the early kinematic intrusions of pyroxenite (unit 10) and gabbro (unit 11); and 3) the syn-kinematic Saw Lake pluton (unit 12). Randomly to slightly oriented M_2 porphyroblasts of staurolite, biotite and anthophyllite as well as undeformed M_2 isograd surfaces overprint the F_2 folded rocks and indicate that the peak metamorphic conditions were most likely reached during the late stages of F_2 folding. The F_2 folds and the M_2 isograds are offset by D_4 faults, such as the Niblock Lake fault (Fig. 2).

In the Kanisota Falls and Davis Lake Blocks, the timing of the F_2 folds relative to syn-kinematic intrusive events and the M_2 recrystallization event is less clear. Most evidence indicates that in these blocks the high grade regional metamorphic culmination (M_2), the syn-kinematic intrusive activity, and the F_2 folding event all occurred more

TABLE 7
Summary of major metamorphic, deformational and intrusive events, Saw Lake and adjacent areas

DEFORMATION[1]	METAMORPHISM	INTRUSIVE ROCKS
		Intrusion of garnet hornblendite (unit 21)
		Intrusion of felsic pegmatite and pegmatitic granite (unit 20)
		Intrusion of magnetiferous leucogranite (unit 19)
D_4: Late fractures and faults. Faults offset F_2 folds. Both east- and north-northwest trending faults. Minor to major offsets recorded on faults.		
D_3: East to east-northeast-trending flexural folds (F_3) of S_1 and S_0 surfaces. F_3 folds not observed in Saw Lake area but are present in Wekusko Lake area to the west and Guay-Wimapedi Lakes area to the northwest.		
	M_2: Strong regional metamorphic event which increases from lower almandine-amphibolite facies at Niblock Lake to upper almandine-amphibolite facies to the north and upper almandine-amphibolite to lower granulite to the southeast.	Intrusion of anatectic granodiorite and monzogranite (unit 18)
D_2: Major north-northeast-trending open to tight folds (F_2)		Intrusion of synkinematic granite, granodiorite, tonalite, quartz monzonite, quartz monzodiorite, monzonite, monzodiorite and enderbite (units 13 to 17)
		Intrusion of Saw Lake granite, granodiorite and tonalite (unit 12)
D_1: Isoclinal recumbent folds (F_1 of primary layering (S_0). F_1 folds have an axial planar schistosity (S_1). F_1 folds not observed in Saw Lake area, but S_1 schistosity is present.	M_1: Muscovite, chlorite and biotite define S_1. They were largely recrystallized during M_2.	
		Intrusion of sills of pyroxenite (unit 10) and gabbro (unit 11)

[1]Deformation events in italics were not recognized in the Saw Lake map area.

or less simultaneously. The intrusions, which have extensive migmatitic-metasomatic envelopes and completely gradational contacts, appear to have been emplaced into a hot, tectonically mobile environment. Some appear to have been intruded along F_2-related zones of weakness and others appear to have been intruded into and deformed by active F_2 folds. The pattern of plutonism, deformation and metamorphism in these blocks is similar to that described by Haller (1971) for the East Greenland Caledonides.

M_2 metamorphic zones and isograd reactions

Froese and Gasparrini (1975), Bailes (1975, 1980a) and Gordon have (1981) identified metamorphic isograd reactions in muscovite-bearing pelitic gneisses in areas west and northwest of the Saw Lake area. The traces of these isograd reaction surfaces in the Saw Lake and adjacent Wekusko Lake area are shown on Figure 18. The M_2 metamorphic event occurred approximately 1760 Ma ago.

In the northwest corner of the Saw Lake area, pelitic rocks belonging to units 4a and 5 are widespread and contain well developed M_2 metamorphic mineral assemblages. Here, specific metamorphic reactions have been used to delineate four metamorphic zones (Fig. 19) in the manner described by Thompson (1957) and Carmichael (1970). Three discontinuous reactions have been identified for muscovite-bearing rocks (Table 8, Fig. 20) and one for muscovite-free rocks (Table 8, Fig.21). Discontinuous reactions in muscovite-bearing rocks were used to delineate the four metamorphic zones in Figure 19. Each zone is named after its most characteristic assemblage:

1) staurolite-biotite zone;
2) andalusite-biotite zone;
3) sillimanite-biotite zone; and
4) sillimanite-garnet-biotite zone.

The discontinuous reactions (Table 8) which define the zone boundaries are isograd surfaces; they have been named as follows:

andalusite-biotite isograd (reaction 1);
sillimanite isograd (reaction 3); and
sillimanite-garnet-biotite isograd (reaction 4).

Assemblages in high grade rocks in the centre of the map area indicate they have exceeded reaction 5 (Table 8). This reaction is a combination of the following two reactions:

biotite + sillimanite + quartz $\rightleftharpoons$ K-feldspar + garnet + cordierite + H_2O; and
K-feldspar + plagioclase + quartz + H_2O $\rightleftharpoons$ melt.

It leads to partial melting and migmatization of pelitic and semi-pelitic rocks (see Winkler, 1976, p. 84 and p. 309). The absence of sillimanite in the upper high grade zone (Fig. 18) is a consequence of this reaction.

The M_2 metamorphic event is clearly late- to, perhaps, post-F_2 in the northwest part of the Saw Lake area as undeformed M_2 isograds overprint F_2 folds (Fig. 19) and because the M_2 porphyroblasts are typically untectonized, randomly to weakly oriented and overprint the F_2 deformed rocks (Figs. 22, 23 and 24).

Textures in the pelitic gneisses (Fig. 25) do not always agree with the topologically deduced reactions (Table 8), but this does not invalidate these reactions and simply indicates that their reaction mechanism is more complicated than a single direct transformation from reactant to product. Elsewhere, such textures have been demonstrated to be the result of diffusion-controlled cation exchange reactions (Carmichael, 1969; Foster, 1977, 198l; Bailes and McRitchie, 1978; Bailes, 1980a).

The isograd reaction surfaces vary in orientation on a regional scale. In the Snow Lake area the traces of the isograd reaction surfaces trend easterly (Fig. 18) and define a rapid northerly increase in M_2 metamorphic temperature from less than 450° C at Wekusko Lake to over 700° C at Wimapedi Lake, with pressures indicated to have been approximately 4.5 kilobars (Fig. 26). In the Saw Lake area the isograd reaction surfaces are east-trending in the northwest corner of the map area but elsewhere are north or northeast-trending (Fig. 18). This swing in trend from east to north-northeast coincides almost exactly with the west boundary of the 60 km wide zone of north-northeast-trending F_2 folds that are prominent in the Churchill structural province adjacent to the older Archean Superior structural province. The assemblages record an easterly increase in M_2 metamorphic temperature from less than 450° C at Wekusko Lake to over 700° C in the centre of the Saw Lake area (Fig. 26), followed by a drop to less than 650° C on the west shore of Setting Lake. Reactions in the Niblock Lake area (Fig. 19) indicate the pressures during M_2 were probably around 3 kilobars (Fig. 26), lower than those recorded in rocks in the Snow Lake area.

TABLE 8
Discontinuous metamorphic reactions identified in pelitic rocks in the Saw Lake Area[1]

1)	chlorite + muscovite + staurolite $\rightleftharpoons$ andalusite + biotite + quartz + staurolite + H_2O	(Andalusite-biotite isograd reaction)
2)	chlorite + garnet + quartz $\rightleftharpoons$ anthophyllite + staurolite + H_2O	
3)	andalusite $\rightleftharpoons$ sillimanite	(Sillimanite isograd reaction)
4)	muscovite + staurolite + quartz $\rightleftharpoons$ sillimanite + garnet + biotite + H_2O	(Sillimanite-garnet biotite isograd reaction)
5)	biotite + sillimanite + plagioclase + quartz + H_2O $\rightleftharpoons$ melt + cordierite + garnet	(Melt-cordierite-garnet isograd reaction)

[1]Reactions are depicted on petrogenetic grid (Fig. 26).

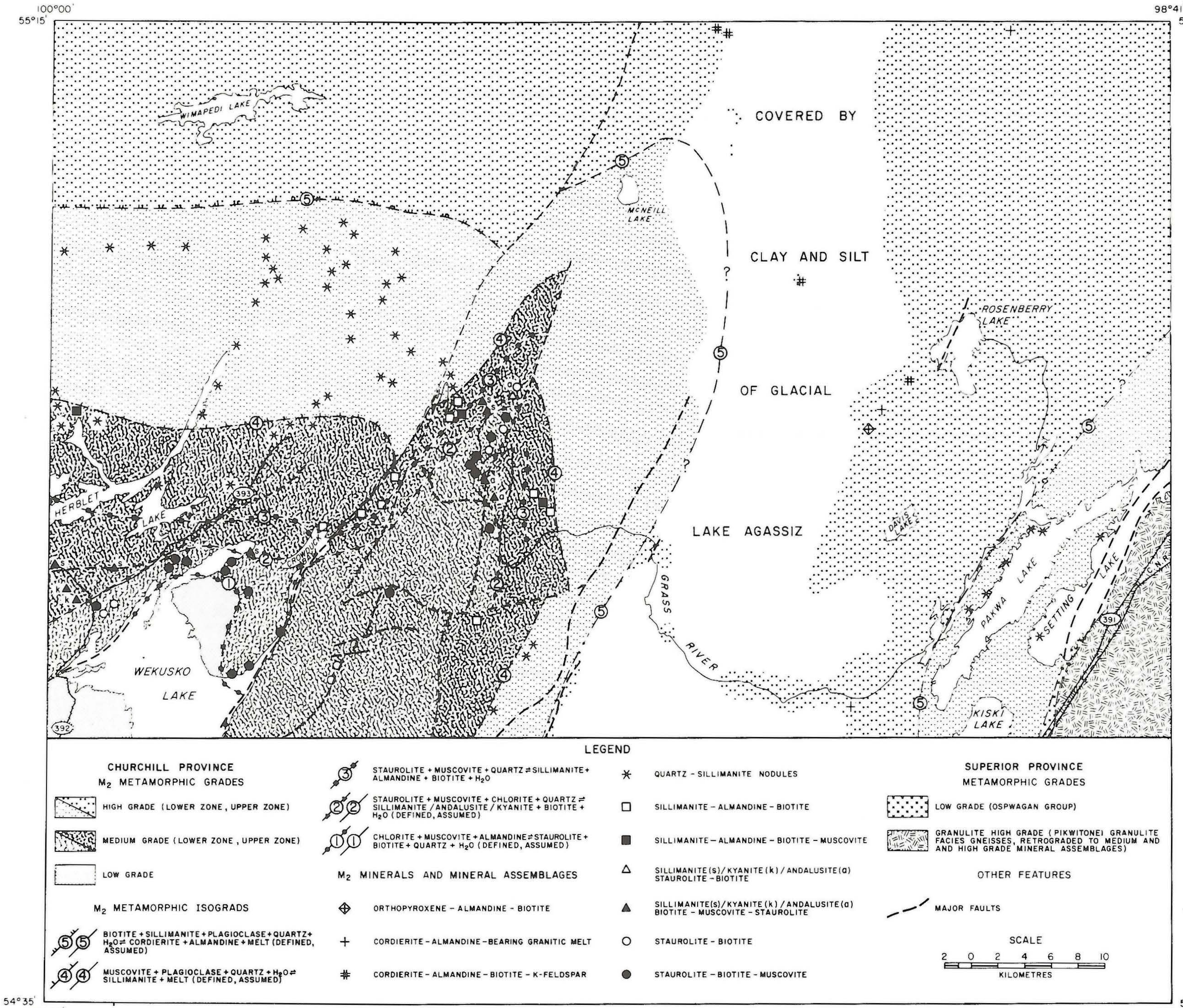


FIGURE 18: Regional metamorphic zonation of M_2 minerals and mineral assemblages in the Saw Lake-Wekusko Lake area.

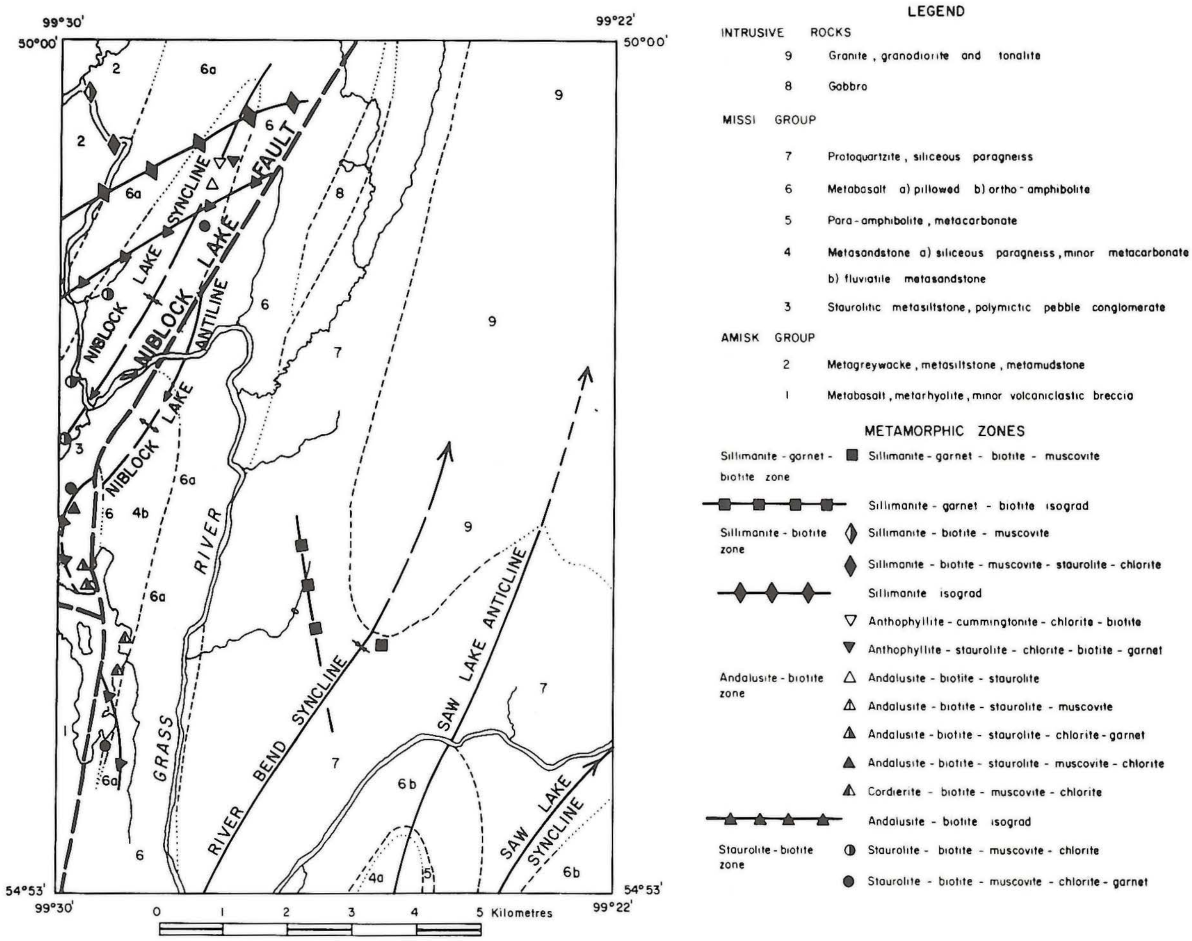


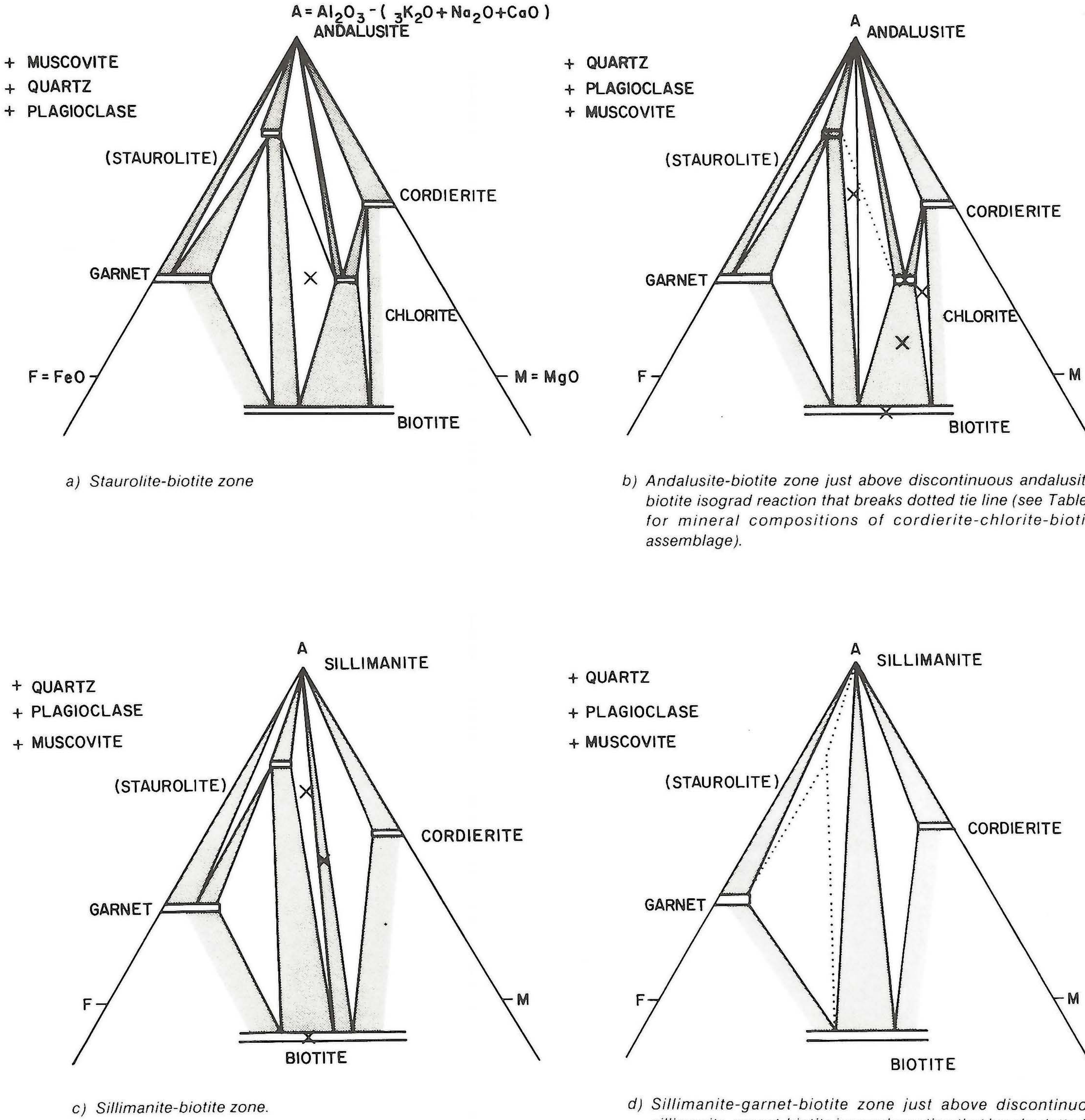
FIGURE 19: Disposition of M_2 metamorphic zones and isograd reactions, Niblock Lake area.

TABLE 9

Composition of minerals[1,2] from cordierite-biotite-chlorite-muscovite-bearing metasandstone (unit 6b), lower andalusite-biotite zone, Niblock Lake

	Chlorite	Biotite	Muscovite	Cordierite	Magnetite
SiO_2	27.23	37.82	45.87	49.23	0.01
$A1_2O_3$	24.03	18.73	34.09	33.36	0.00
FeO[3]	15.03	12.98	3.03	3.76	96.41
CaO	0.00	0.03	0.07	0.00	0.00
MgO	21.00	15.43	1.37	11.16	0.00
Na_2O	0.23	0.47	1.46	0.59	0.00
K_2O	0.33	8.63	9.25	0.02	0.00
TiO_2	0.09	1.17	0.53	0.01	2.39
MnO	0.34	0.15	0.01	0.44	0.11
Cr_2O_3	0.05	0.04	0.03	0.02	0.54
TOTAL	88.35	95.46	95.70	98.59	99.47

NOTE: [1]Mineral assemblage (Specimen 07-6-2167-4).
[2]Electron microprobe analyses by M. Bonardi, Mineralogy Section, Geological Survey of Canada.
[3]Total iron expressed as FeO.



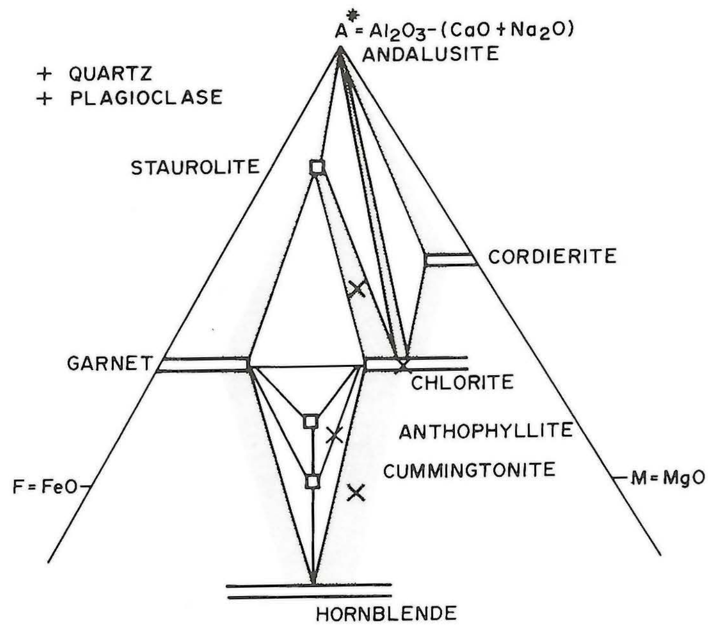
a) Staurolite-biotite zone

b) Andalusite-biotite zone just above discontinuous andalusite-biotite isograd reaction that breaks dotted tie line (see Table 9 for mineral compositions of cordierite-chlorite-biotite assemblage).

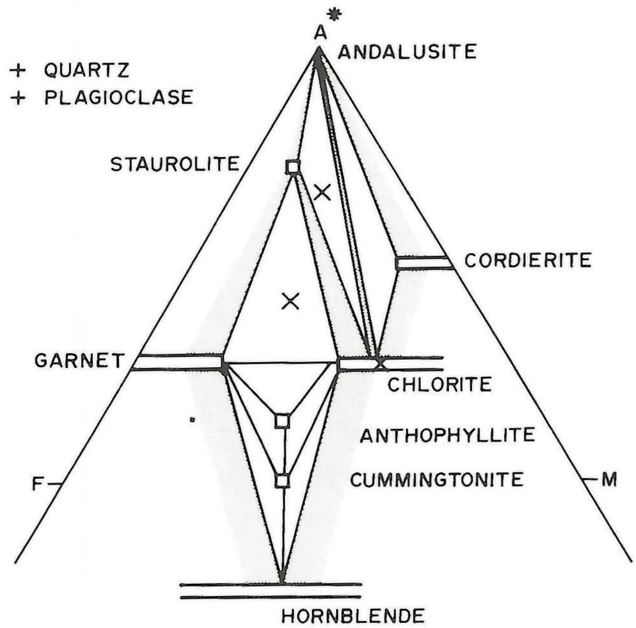
c) Sillimanite-biotite zone.

d) Sillimanite-garnet-biotite zone just above discontinuous sillimanite-garnet-biotite isograd reaction that breaks dotted tie lines.

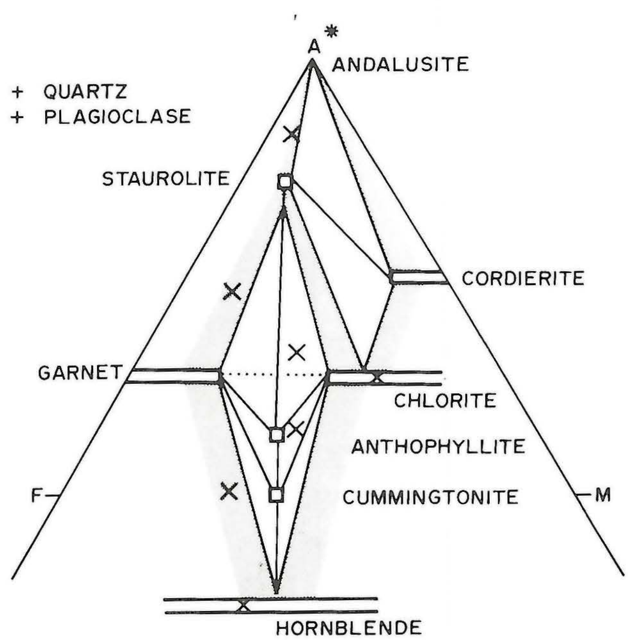
FIGURE 20: Schematic Thompson AFM projections of observed muscovite-bearing assemblages (shown by x), northwest Saw Lake area.



a) Staurolite-biotite zone.



b) Lower andalusite-biotite zone.



c) Middle to upper andalusite-biotite zone above the staurolite-anthophylite forming discontinuous reaction that breaks the dotted tie line.

*FIGURE 21: Schematic A*FM projections through quartz and plagioclase of constant composition (after Froese, 1969b) of observed muscovite-free assemblages (shown by X) in northwest corner of Saw Lake area. Biotite is present in observed assemblages.*

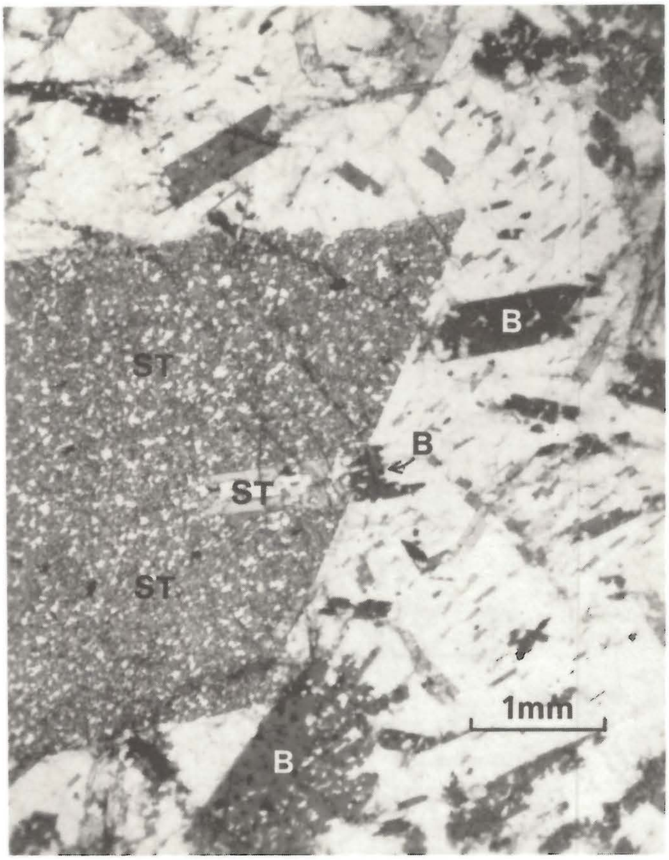
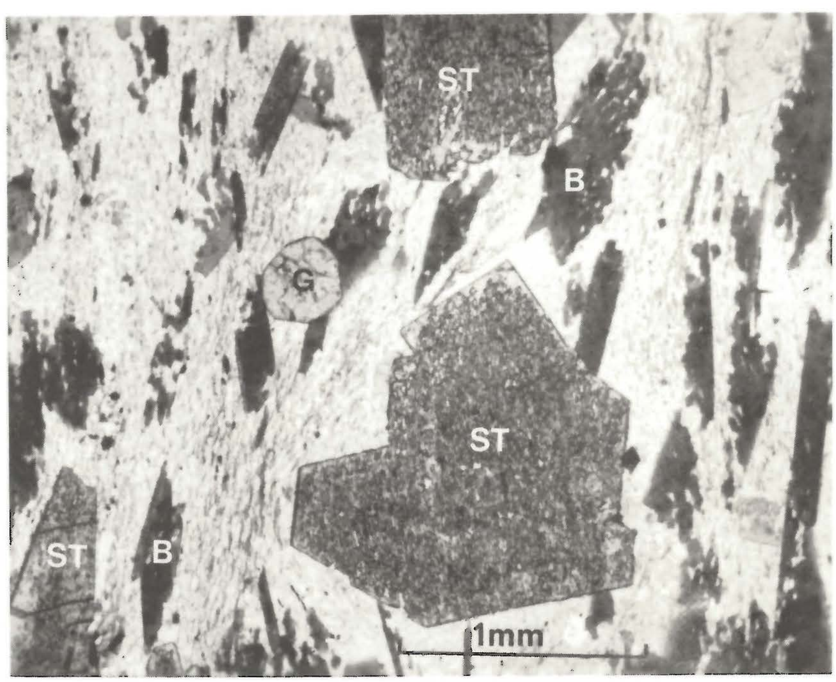


FIGURE 22:
Photomicrograph (plain light) of large euhedral porphyroblast of staurolite (ST) overprinting biotite (B) porphyroblasts and groundmass quartz, plagioclase and chlorite, unit 5, staurolite-biotite zone. Staurolite that has overprinted the groundmass is full of small inclusions of quartz, but staurolite that has overprinted biotite is relatively inclusion-free.

FIGURE 23:
Photomicrograph (plain light) of euhedral porphyroblasts of staurolite (ST), garnet (G) and biotite (B), in a groundmass composed of quartz, plagioclase and S_1-alligned muscovite, unit 5, upper staurolite-biotite zone. Biotite (B) porphyroblasts are alligned, probably during the D_2 event.



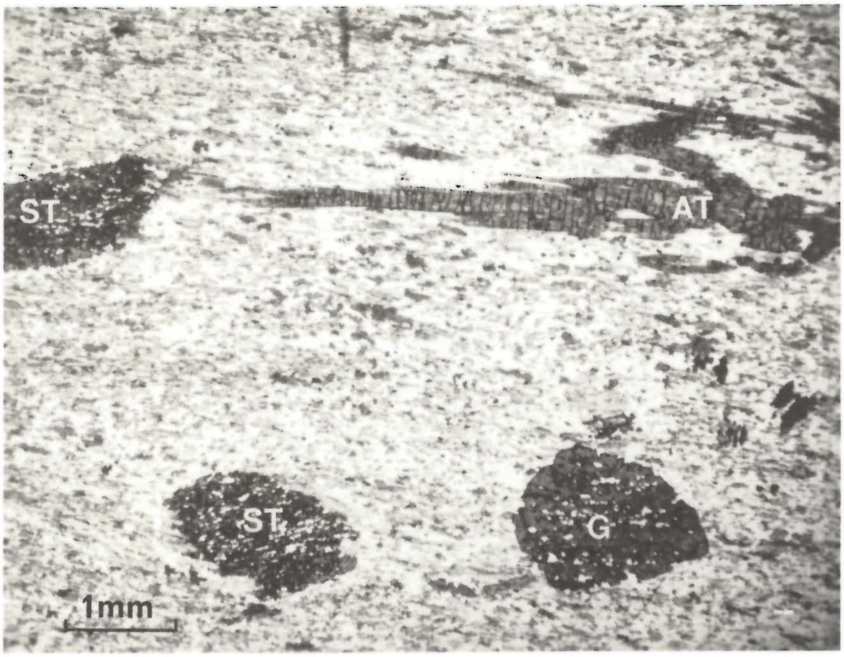


FIGURE 24:
Photomicrograph (plain light) of porphyroblasts of staurolite (ST), anthophyllite (AT) and garnet (G), in a groundmass composed of quartz, plagioclase and S_1-aligned chlorite and biotite, unit 5, andalusite-biotite zone.

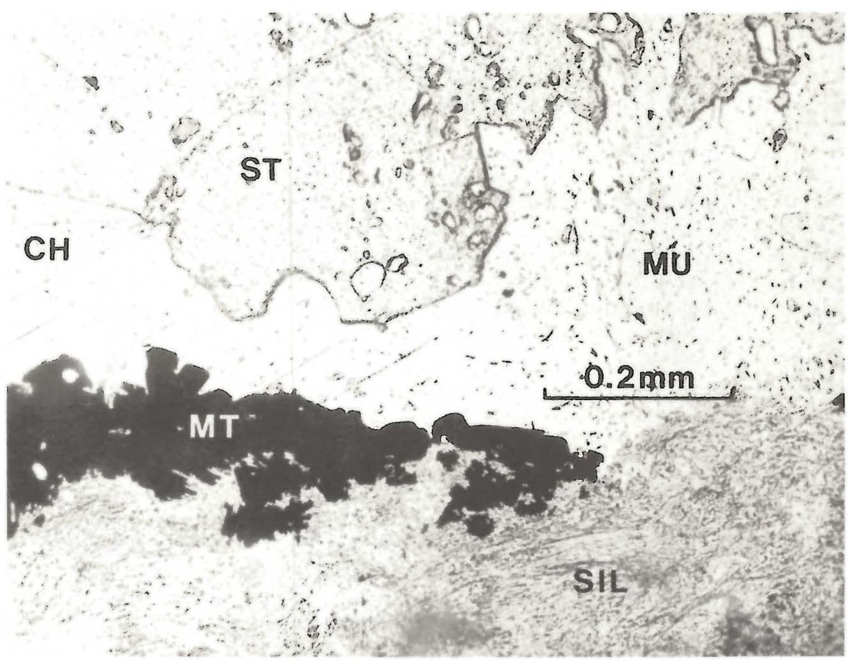


FIGURE 25:
Photomicrograph (plain light) of corroded porphyroblast of staurolite (ST) replaced by prograde muscovite (MU), chlorite (CH), magnetite (MT) and sillimanite (SIL), unit 4a, lower sillimanite-biotite zone.

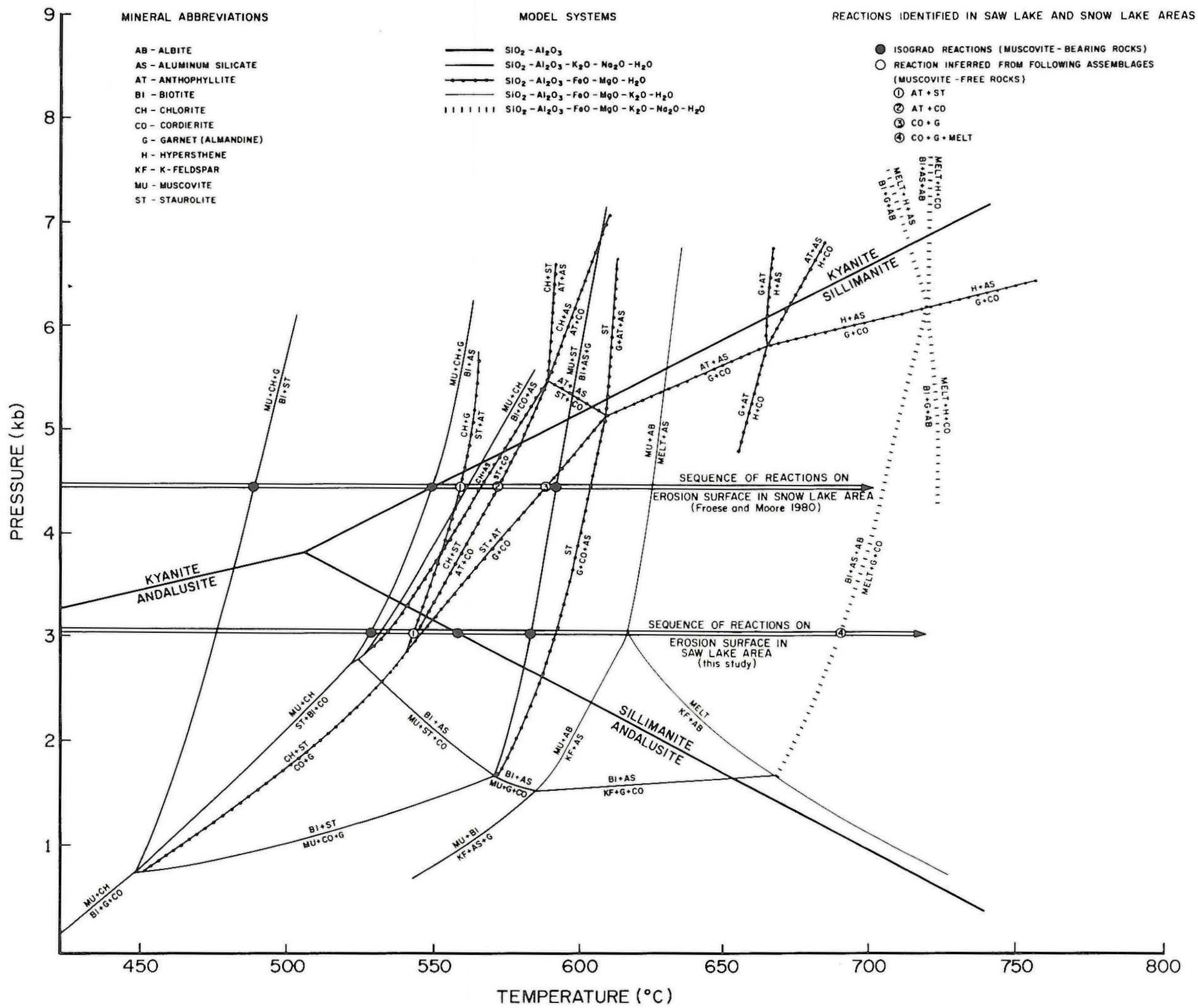


FIGURE 26: Calbirated petrogenetic grid from Hess (1969) and Carmichael (pers. comm., 1978) showing metamorphic reactions identified in metasedimentary rocks of the Saw Lake area.

The change in orientation of M_2 isograds from easterly to north-northeasterly, east of Wekusko Lake, does not appear to be simply a consequence of F_2 folding as M_2 minerals and isograd reactions overprint F_2 folds (Fig. 19). Rather, it also appears to record a fundamental swing in the M_2 paleo-isotherms, which may reflect changing crustal conditions in the Churchill structural province adjacent to its boundary with the Superior structural province. At this time it is not known what caused this change in crustal/tectonic conditions or what significance to attach to it, but obviously the overlap of this zone of north-northeast-trending M_2 isotherms with the zone of north-northeast-trending F_2 folds, both of which parallel the margin of the older Archean Superior Province, must somehow relate to crustal activity related to tectonic impingement of the two provinces upon one another. It is tempting to appeal to a Proterozoic collision of the two structural provinces, as advocated by Gibb and Walcott (1971), Dewey and Burke (1973), Gill (1975) and Baragar and Scoates (1980), to explain the pattern of M_2 isotherms and the disposition of F_2 folds in the Churchill Province rocks of the Saw Lake area.

D_4 faults

North-northeast- and east-trending faults, which postdate F_2 folds and the M_2 metamorphism, have broken the Saw Lake area up into six discrete structural blocks (Fig. 2). These faults are not exposed. They do, however, truncate units (Map GR83-2-1), terminate F_2 folds (Fig. 2), and offset M_2 metamorphic isograds (Fig. 18). This pattern of faulting extends west to Wekusko Lake but has not been described in areas further to the west. Again, like the north-northeast-trending F_2 folds and north-northeast-trending M_2 isotherms, this type of fault pattern appears to be largely confined to the 60 km wide north-northeast-trending belt adjacent to the Superior Province. Some north-northeast-trending faults may be genetically related to major north-northeast-trending faults that occur at the boundary between the Churchill and Superior Provinces.

ECONOMIC GEOLOGY

The Saw Lake area has been actively explored for mineral deposits since the mid-1950's by several major mining companies including Texas Gulf Sulphur Company, Hudson Bay Exploration and Development, Canadian Nickel Company, Selco, and Falconbridge Nickel. No mines and no significant mineral properties have been discovered.

The west half of the map-area was explored for volcanic-hosted massive Cu-Zn sulphide deposits of the type found predominantly in the Amisk Group of the Flin Flon volcanic belt (Fig. 3). However, it is now known that the rocks explored in the Saw Lake area are largely Missi Group metasedimentary rocks and the sulphide deposits are more akin to the massive and disseminated sulphide deposits found in Kisseynew Belt metasedimentary rocks at Sherridon, Manitoba (Froese and Goetz, 1980; Gale, 1980). With this in mind it is possible that the western Saw Lake could now be more effectively explored.

The east half of the map-area was explored for nickel-bearing ultramafic intrusions of the type found prominently in the adjacent Thompson Mobile Belt (Fig. 2). The nickel-bearing ultramafic intrusions are apparently restricted to the Superior structural block, and this appears to be the reason no nickel mineralization was found in the Saw Lake area, which is completely within the Churchill structural block.

The results of exploration work, on claims that have been allowed to lapse, are contained in open assessment files of the Manitoba Mineral Resources Division. The location of airborne and ground electromagnetic anomalies, from surveys in cancelled assessment files, are given on Figure 27 (in pocket). The location of diamond drill holes, trenches, gossan zones and mineral occurrences are also shown on Figure 27. Information on conductive zones and sulphide occurrences intersected by diamond drill holes is summarized in Appendix B.

The western half of the area contains scattered pegmatite bodies which are part of the Wekusko Lake pegmatite field (Černý *et al.*, 1981). In the Wekusko Lake area these pegmatites include Li-bearing varieties. Spodumene has been reported in logs of some drill holes that intersected small pegmatite bodies (Appendix B), but no spodumene was observed in surface exposures of these pegmatite bodies. Uraniferous pegmatites occur at the western end of Dion Lake, 2 km outside the west boundary of the map-area.

A small quarry was established 6 km north of Ponton in a ledge of Paleozoic dolomitic limestones. There is no record of the usage of the quarried rock, but south of the map area quarries in the same rock unit were used as crushed aggregate for road construction.

Sulphide Occurrences

Three types of sulphide occurrences are presently known in the Saw Lake area. They are:

1) volcanic-hosted massive pyrite-pyrrhotite;
2) sediment-hosted sulphide/carbonate facies "iron formation"; and
3) sediment-hosted disseminated sulphides.

All are contained in Missi Group rocks.

Volcanic-hosted massive pyrite-pyrrhotite zones, many of which include graphite, occur abundantly in the subaqueously deposited Missi Group basalts of the Niblock Lake Block and to a lesser extent in the dominantly subaerially deposited Missi Group basalts in the Saw Lake Block. These massive pyrite-pyrrhotite zones are extremely narrow (1 m), do not outcrop at surface and have been intersected in drill holes testing ground and airborne electromagnetic anomalies (Fig. 27). None are economically significant.

Narrow bands of sediment-hosted massive pyrrhotite and pyrite are abundant, intercalated with Missi Group calc-silicate and quartzite beds (units 7 and 6a). Although only rarely exposed at surface, their presence is delineated by narrow, continuous electromagnetic anomalies that have been extensively drilled northeast of Dion Lake, in both the Dion Lake and Saw Lake Blocks (Fig. 27). Small amounts of chalcopyrite and rare sphalerite occur in these sulphide zones, but nothing of economic significance has been reported. One property, 5 km northeast of Dion Lake, has several of these pyrrhotite-pyrite zones over a small area. Over 20 drill holes (Fig. 27) have been placed into these sulphide zones, but the drilling apparently did not intersect any significant mineralization as the property has been examined by and dropped by Texas Gulf Sulphur Co., Canadian Nickel Co., and Hudson Bay Exploration and Development.

Sediment-hosted disseminated sulphides of no apparent economic value occur locally throughout the marine-deposited metasandstones of unit 6a. Of more significance is disseminated chalcopyrite (with associated pyrite) mineralization that has been observed in two lithologies: 1) metacarbonate and para-amphibolite (units 7a and 7b) south and east of Dion Lake; and 2) fluviatile metasandstones just above the para-amphibolite (unit 7b) 1 km east of Dion Lake (Fig. 27). The metasandstone-hosted chalcopyrite mineralization is more prominent and more economically interesting. Neither variety of mineralization was adequately searched for during this mapping program and thus the extent and significance of both types of Cu mineralization is uncertain. The chalcopyrite mineralization in the metacarbonate and para-amphibolite unit does not exceed 2 per cent and shows no preferential sites of deposition. The sandstone-hosted chalcopyrite mineralization comprised up to 4 per-cent in one locality and is concentrated in sandstones directly east of and stratigraphically overlying the para-amphibolite (unit 7b) 1 km east of Dion Lake (Fig.27). This disseminated chalcopyrite mineralization has no electromagnetic expression, no surface gossan zones and can only be identified by examination of fresh surfaces on broken rock samples. Mineralization of this type has been reported to occur widely in the Kisseynew Belt (Baldwin, 1980; McRitchie *et al.*, 1979). The origin of this mineralization is uncertain, but in the Saw Lake area it is possible that it was deposited by circulating groundwater with the mineralization concentrated at a redox boundary associated with the transition from marine to terrestrial depositional environment of the host sandstones.

Recommendations For Future Exploration

Two areas are recommended for further exploration in the Saw Lake area. They are: 1) marine-deposited Missi Group metasandstones (units 6a and part of unit 6e) which are a good candidate to host Cu-rich massive sulphide deposits; and 2) the terrestrially deposited Missi Group metasandstones (unit 6b) directly east of unit 7b para-amphibolite, 1 km east of Dion Lake, which are a promising host for disseminated Cu-sulphide mineralization.

A moderately high potential for Cu-rich massive sulphide deposits in marine-deposited Missi Group metasandstones (unit 6a and part of unit 6e) is predicted despite the fact that no significant Cu-rich sulphides have been identified in these rocks to date. This is based on the similarity of these rocks to the metasandstones that host the Cu-Zn massive sulphide deposits in the Sherridon area, Manitoba. Both metasandstone sequences are similar as they:

1) contain thick units of metacarbonate and numerous thin beds of quartzite;
2) were deposited in a marine environment; and
3) were accompanied by contemporaneous volcanic activity.

Individually these features are atypical of the Missi/Sherridon Group rocks elsewhere in either the Flin Flon or Kisseynew belts; together they are unique to these two areas. Froese and Goetz (1981) and Goetz and Froese (1982) interpret the Sherridon area deposits as distal volcanogenic, which suggests that a combination of contemporaneous volcanism and subaqueous environment of deposition may be a necessary prerequisite for an area to have potential for the occurrence of this type of metasandstone-hosted Cu-rich massive sulphide deposit.

The disseminated chalcopyrite-pyrite mineralization in terrestrially deposited unit 6c metasandstones east of Dion Lake has no geophysical expression and no associated gossan zone and, consequently, was not located by previous exploration activity in the Saw Lake area, which relied heavily on airborne and ground electromagnetic surveys. Systematic sampling of outcrops is likely to be the most effective procedure for locating this type of mineralization. Since this mineralization appears to be associated with the marine to terrestrial transition in the Missi Group, this is where exploration activity should be concentrated.

REGIONAL SUMMARY AND CONSIDERATIONS

The boundary between the Flin Flon and Kisseynew belts is gradational in the Saw Lake area, as it is in the adjacent Snow Lake area (Froese and Moore, 1980). The position of the boundary has been arbitrarily placed at the biotite-sillimanite-almandine garnet isograd. All the rocks in the Saw Lake area, with the exception of those in the extreme northwest corner of the map area, belong to the Kisseynew belt.

Most of the rocks in the Saw Lake area and the adjacent Wekusko Lake area belong to the Missi Group and the equivalent, more coarsely recrystallized Sherridon Group. They are transitional in rock types between typical Missi Group rocks at Flin Flon, Manitoba, and the type-Sherridon Group rocks exposed in the Kisseynew belt at Sherridon, Manitoba. The thick sections of fluviatile sandstones and the beds of heterolithic conglomerate are comparable to units of the Missi Group at Flin Flon. However, many of the Missi/Sherridon Group rocks at Saw Lake are more heterolithic than at Flin Flon. The more variable lithology is a consequence of two factors: 1) an environment of deposition that included marine as well as the more typical terrestrial conditions; and 2) volcanism that locally modified and interrupted the usual Missi sedimentation pattern by providing periodic influxes of flows and immature volcaniclastic detritus. The coarse recrystallization, the presence of volcanic rocks, and the local units of subaqueously deposited metacarbonate and protoquartzite in the Saw Lake metasandstones are features that these rocks share with the type-Sherridon Group section at Sherridon.

Mukherjee (1971) has interpreted the Missi Group at Flin Flon to be an alluvial fan deposit shed from uplifted portions of the volcanic Amisk Group of the Flin Flon belt. The Sherridon Group most likely represents that portion of the alluvial fan that spread from the eroding volcanic terrain into the adjacent Kisseynew sedimentary basin to be subsequently coarsely recrystallized by the high grade thermal metamorphic event centered in the Kisseynew belt (Bailes, 1971; Goetz and Froeze, 1982). The Sherridon portion of the fan locally prograded into a marine environment as indicated by the subaqueous metasandstone deposits in the Saw Lake and Sherridon areas. Volcanogenic massive Cu-Zn sulphide deposits occur in the marine metasandstones in the Sherridon area (Groetz and Froese, 1982). The association of volcanic activity with the marine metasandstones in the Saw Lake area indicates that these rocks also are potential hosts for volcanogenic massive sulphide deposits.

The transition in Missi/Sherridon Group metasandstones in the Saw Lake area from a marine to terrestrial environment appears to be a significant locus for disseminated chalcopyrite-pyrite mineralization. The mechanism of deposition of this mineralization is not known, but it may have been geochemically trapped from circulating groundwater at redox fronts between rocks deposited under subaerial oxidizing conditions and those that were deposited under reducing conditions in a subaqueous environment. This type of mineralization has not been explored for in the Saw Lake nor in the adjacent Wekusko Lake or Guay-Wimapedi Lake areas.

The 2 km thick sequence of massive, featureless, subaerially deposited Missi Group tholeiitic metabasalt in the Saw Lake area differs geochemically from average Amisk Group metabasalts. With few exceptions, it is richer in TiO_2, Ni and Cr. It likely is part of the sequence of subaerially deposited massive metabasalts exposed prominently east of Wekusko Lake. The latter contain narrow units of welded felsic ash flows (Gordon and Gall, 1982)

The coarse metamorphic recrystallization of Missi/Sherridon rocks, the prominent north-northeast-trending folds and the abundant felsic plutons in the Saw Lake area were originally considered to be late tectonic features that postdated the peak metamorphic and deformational events affecting the Kisseynew belt to the west (Bailes, 1975, 1976). However, it is now known that the peak metamorphic event in the Saw Lake area is the same as that which affected Kisseynew belt rocks to the west. The north-northeast-trending folds and the plutonic rocks in the northwest corner of the Saw Lake area are overprinted by the metamorphic isograds and porphyroblasts indicating that they also are not late tectonic. The confinement of the north-northeast-trending folds and the associated plutonic rocks to a 60 km wide north-northeast-trending belt is still important, however, and must certainly represent some fundamental change in crustal conditions in the Churchill structural province adjacent to its boundary with the older Archean Superior structural province. The dramatic change in orientation of metamorphic isograds (paleo-isotherms) from east to north-northeast-trending at the west boundary of this fold and plutonic belt further substantiates the fundamental tectonic importance of this zone. In this context it is tempting to suggest that the fold and plutonic belt, and the associated change in pattern of metamorphic paleo-isotherms, is a product of the Early to Middle Proterozoic collision event hypothesized to have occurred at the contact between the Churchill and Superior provinces by Gibb and Walcott (1971), Gibb (1975), Dewey and Burke (1980) and Hubregtse (1980).

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APPENDIX A
Whole rock chemical analyses
(weight per cent)

	1	2	3	4	5	6	7	8
SiO_2	47.55	52.55	72.30	78.90	60.65	56.30	70.50	51.15
Al_2O_3	13.10	17.35	14.68	12.33	19.11	19.90	14.68	17.30
Fe_2O_3	3.43	1.77	0.75	0.35	0.48	0.12	0.78	1.00
FeO	13.72	6.67	1.68	0.67	1.74	1.46	1.56	1.48
CaO	10.36	10.62	1.01	0.22	6.49	6.64	2.70	15.04
MgO	5.65	4.44	2.04	0.36	3.35	1.98	0.90	3.62
Na_2O	1.47	2.27	3.25	3.79	3.09	5.19	2.93	2.63
K_2O	0.12	0.16	1.97	3.34	1.66	3.15	3.14	1.07
TiO_2	1.81	1.76	0.47	0.10	0.84	1.33	0.67	1.22
P_2O_5	0.08	0.34	0.17	0.07	0.65	0.54	0.19	0.45
MnO	0.25	0.12	0.02	0.01	0.03	0.03	0.03	0.04
H_2O	1.73	1.04	1.78	0.51	1.02	1.10	1.40	1.17
CO_2	0.21	0.13	0.20	0.13	0.21	1.57	0.87	3.73
S	—	—	tr.	tr.	0.30	0.09	0.13	0.69
TOTAL	99.48	99.24	100.32	100.78	99.62	99.40	100.48	100.59
Ni (ppm)	16	4	—	—	—	—	—	—
Cr (ppm)	24	24	—	—	—	—	—	—

	9	10	11	12	13	14	15	16
SiO_2	59.10	48.80	49.85	50.00	50.95	53.95	48.30	87.15
Al_2O_3	14.91	14.28	13.22	13.44	14.20	15.28	15.52	5.82
Fe_2O_3	0.98	2.81	2.46	1.83	1.55	1.48	1.95	0.13
FeO	4.97	11.62	11.56	11.18	9.51	9.10	9.19	0.95
CaO	9.66	10.73	9.93	8.95	11.63	8.90	12.21	1.56
MgO	2.89	6.20	6.53	7.17	7.38	5.68	4.98	0.91
Na_2O	1.97	2.17	2.12	3.15	1.60	1.43	2.27	0.93
K_2O	1.19	0.20	0.16	0.34	0.15	0.09	0.21	0.68
TiO_2	1.17	1.76	1.75	1.31	0.71	1.32	1.25	0.12
P_2O_5	0.40	0.22	0.14	0.09	0.12	0.09	0.09	0.08
MnO	0.11	0.22	0.22	0.22	0.21	0.09	0.19	0.03
H_2O	1.15	1.59	1.51	1.70	1.80	1.85	1.29	0.88
CO_2	1.57	1.59	0.12	0.25	1.14	0.31	2.11	0.61
S	0.07	nil	nil	0.23	0.01	0.01	0.01	tr.
TOTAL	100.14	100.71	99.57	99.89	100.96	99.68	99.56	99.36
Ni (ppm)	—	88	118	92	88	104	108	—
Cr (ppm)	—	226	226	138	178	232	206	—

	17	18	19	20	21	22	23	24
SiO_2	90.80	51.80	53.75	47.60	48.30	48.60	77.15	77.25
Al_2O_3	4.14	1.61	2.60	10.15	17.32	17.06	11.47	11.67
Fe_2O_3	0.20	5.11	3.04	1.37	1.33	1.74	1.24	0.82
FeO	0.91	6.87	13.06	8.41	6.91	7.42	0.79	0.72
CaO	0.40	1.36	3.13	7.18	11.91	11.56	0.36	0.65
MgO	0.40	28.2	21.2	18.15	8.67	8.92	0.16	0.24
Na_2O	0.80	0.06	0.11	0.49	2.50	2.07	3.11	2.62
K_2O	0.86	0.03	0.01	0.07	0.27	0.25	4.74	4.82
TiO_2	0.13	0.07	0.09	0.07	0.62	0.58	0.20	0.19
P_2O_5	0.08	0.08	0.09	nil	0.11	0.10	0.07	0.07
MnO	0.03	0.21	0.26	0.22	0.16	0.18	0.01	0.02
H_2O	0.63	4.71	2.64	4.99	1.59	1.86	0.40	0.42
CO_2	0.31	0.13	0.25	0.08	0.08	0.18	0.12	0.18
S	0.03	tr.	nil	nil	0.02	0.01	tr.	nil
TOTAL	99.85	100.94	100.98	100.03	99.90	100.56	99.82	99.67
Ni (ppm)	—	658	470	346	136	118	—	—
Cr (ppm)	—	4480	2000	1460	646	96	—	—

Amisk Group Metabasalt (unit 1)

1. Pillowed metabasalt (unit 1), west of Niblock Lake (07-6-180-1).
2. Pillowed metabasalt (unit 1), west of Niblock Lake (07-6-362-2).

Amisk Group Metarhyolite (unit 2) and Metadacite (unit 2a)

3. Felsic lapilli tuff (unit 2), west of Niblock Lake (07-6-181-1).
4. Felsic lapilli tuff (unit 2), west of Niblock Lake (07-6-629-1).
5. Metadacite (unit 2a), island in Niblock Lake (07-6-636-1). Contains 5% 0.5 - 1.0 mm quartz amygdales.

Missi Group Metasandstone (unit 6)

6. Carbonate-bearing feldspathic muscovite-biotite paragneiss (unit 6a), 2½ km south of Dion Lake (07-6-2046-1).
7. Quartz-plagioclase-muscovite-biotite paragneiss (unit 6a), southeast shore of Dion Lake (07-6-121-1). Contains accessory magnetite.

Missi Group Carbonate-Rich Metasediments (unit 7)

8. Granoblastic andesine-diopside-quartz-calcite-microcline gneiss with accessory sphene and pyrite (unit 7a), 150 m south of Dion Lake (07-6-98-1). Partly retrograded to tremolite, zoisite and chlorite.
9. Granoblastic andesine-hornblende-biotite-quartz-diopside-almandine gneiss with accessory sphene (unit 7a), 2 km south of Dion Lake (07-6-94-2). Partly retrograded to mixture of amphibole, chlorite and calcite.

Missi Group Metabasalt (unit 8)

10. Massive metabasalt (unit 8a), 0.8 km east of Niblock Lake (07-6-167-1).
11. Massive metabasalt (unit 8a), 1.5 km northeast of Niblock Lake (07-6-162-1).
12. Massive metabasalt (unit 8a), 5 km north-northwest of Niblock Lake (07-6-194-1).
13. Massive metabasalt (unit 8a), 1.2 km southeast of Niblock Lake (07-6-2545-1).
14. Metabasalt (unit 8), 1 km north of Niblock Lake (07-6-149-1).
15. Pillowed metabasalt (unit 8b), 0.7 km southwest of first falls on Grass River (07-6-2548-1).

Missi Group Protoquartzite (unit 9)

16. Siliceous paragneiss (unit 9), 4 km northeast of Niblock Lake (07-6-201-1).
17. Protoquartzite (unit 9), 7 km north-northeast of Niblock Lake (07-6-199-4).

Early Kinematic Metapyroxenite (unit 10)

18. Oxidized (weathered) orthopyroxenite (unit 10), 7 km east southeast of Niblock Lake (07-6-254-1).
19. Orthopyroxenite (unit 10), 3 km southeast of Niblock Lake on the Grass River (07-6-2135-1).
20. Recrystallized melagabbro (unit 10b), 400 m north of Niblock Lake (07-6-158-1).

Early Kinematic Metagabbro (unit 11)

21. Metagabbro (unit 11), 7.5 km north-northeast of Niblock Lake (07-6-569-2).
22. Foliated metagabbro (unit 11), 5.5 km north northeast of Niblock Lake (07-6-197-1).

Late Kinematic Magnetiferous Leucogranite (unit 19)

23. Magnetiferous hornblende leucogranite (unit 19c), 3.5 km southeast of Dion Lake (07-6-280-1).
24. Magnetiferous hornblende leucogranite, (unit 19c), 3.5 km east northeast of Dion Lake (07-6-108-1).

APPENDIX B
Summary of Diamond Drilling Assessment Work (Open File, December, 1982), Saw Lake Area

Reference No (Fig. 27)	Company Reference Number	Depth of DDH (m)	Date Completed	Name of Company	Claim No.	Accession No.	Significant Results
1	KUS 27			HBED	KUS 256	92245	Graphite zone.
2	KUS 28			HBED	KUS 265	92245	Several zones of graphite and pyrrhotite. Traces chalcopyrite.
3	KUS 34			HBED	KUS 265	92245	
4	KUS 29			HBED	KUS 265	92245	Slight pyrrhotite and pyrite. Local massive graphite.
5	KUS 32			HBED	KUS 275	92245	
6	KUS 48			HBED	KUS 311	92245	4.5 m with weak pyrite mineralization and slight graphite.
7	KUS 47			HBED	KUS 307	92245	3.6 m with pyrite mineralization and slight graphite.
8	KUS 45			HBED	KUS 276	92245	8.1 m of pyrite, pyrrhotite and graphite.
9	KUS 30			HBED	KUS 276	92245	Graphitic zone, near solid pyrrhotite and pyrite zone.
10	KUS 31			HBED	KUS 258	92245	13 m wide graphite zone with pyrrhotite and pyrite mineralization.
11	KUS 35			HBED	KUS 277	92245	Local pyrite, pyrrhotite and graphite-bearing zones.
12	KUS 46			HBED	KUS 306	92245	Sections with pyrite and graphite.
13	KUS 37			HBED	KUS 277	92245	Graphitic zone.
14	KUS 38			HBED	KUS 278	92245	
15	KUS 36			HBED	KUS 262	92245	
16	KUS 39			HBED	KUS 281	92245	Sections with weak pyrite and pyrrhotite mineralization.
17	KUS 41			HBED	KUS 282	92245	Sections with weak pyrite and pyrrhotite mineralization.
18	KUS 43			HBED	KUS 282	92245	Sections with weak pyrite and pyrrhotite mineralization.
19	KUS 42			HBED	KUS 299	92245	Local pyrite and pyrrhotite.
20	KUS 44			HBED	KUS 300	92245	Sections with weak pyrite and pyrrhotite mineralization.
21	KUS 40			HBED	KUS 318	92245	Weakly mineralized with pyrite, pyrrhotite and graphite.
22	KUS 51			HBED	KUS 327	92245	Slight pyrite, pyrrhotite and graphite intersected.
23	KUS 49			HBED	KUS 328	92245	Slight pyrite and graphite intersected.
24	1	67.7	55/9/10	J.K. Exploration	LAST HOPE 2	90610	Zone of massive pyrite, minor chalcopyrite.
25	2	68.3	55/9/11	J.K. Exploration	LAST HOPE 2 MC	90610	6 m with 5% pyrite.
26	3	38.4	55/9/31	J.K. Exploration	LAST HOPE 2	90610	3.4 m massive pyrite, minor chalcopyrite.
27	4	38.4	55/10/9	J.K. Exploration	HOPE No. 2	90610	3.6 m with 5% pyrite.
28	5	78.6	55/10/16	J.K. Exploration	HOPE No. 1	90610	6.7 m with 5% pyrite.
29	1	68.9	55/9/29	Walter Johnson	LAST HOPE	90609	4.6 m masive pyrite.
30	13	81.1	58/3/10	Selco	NIB 92	90079	Several 3 m wide zones of graphite plus pyrite.
31				HBED	KUS 486	91393	
32	KUS 79	94	68/2/11	HBED	KUS 478	91393	Two 10 m wide near solid graphite zones. Chlorite/talc/staurolite-bearing alteration zone.
33	KUS 73	97.2	68/2/15	HBED	KUS 476	91393	6.6 m of graphite schist.
34	11	78	58/2/27	Selco	NIB 84	90079	9.4 m graphite and graphite plus pyrite.
35	19	67.4	58/3/3	Texas Gulf Sul. Co.	BOB 79	90088	0.8 m massive pyrrhotite.
36	KUS 148	59.4	70/4/16	HBED	KUS 862	91389	Several narrow zones with weak pyrite and pyrrhotite mineralization. One 0.5 m zone near solid pyrrhotite plus pyrite.
37	21	53.6	58/5/3	Texas Gulf Sul. Co.	BOB 37	90088	Several narrow zones, up to 20 cm thick, near solid sulphide.
38	17	60.6	58/2/25	Texas Gulf Sul. Co.	BOB 36	90088	4.5 m zone 15% sulphides and 3 m zone massive pyrrhotite and pyrite. Trace sphalerite.
39	KUS 146A	84.4	70/5/10	HBED	KUS 894	91389	33.8 m zone with weak to strong pyrrhotite plus pyrite mineralization. Local graphite. Traces sphalerite.
40	20	61.5	58/3/5	Texas Gulf Sul. Co.	BOB 44	90088	1.5 m zone 10% disseminated pyrrhotite and pyrite.
41	19516	109.7	60/7/26	Canadian Nickel	HOG 136	90604	Slightly mineralized volcanics.
42	24157	291		Canadian Nickel	HOG 40	90606	Local sulphide streaks and specks.
43	24156	294		Canadian Nickel	HOG 40	90606	Local sulphide streaks and specks.
44	16	64	58/2/23	Texas Gulf Sul. Co.	SAW 32	90088	0.5 m impure quartzite with 60% pyrrhotite and pyrite.
45	19510	149	60/6/22	Canadian Nickel	HOG 40	90605	Zones of mineralized tuff.

Reference No (Fig. 27)	Company Reference Number	Depth of DDH (m)	Date Completed	Name of Company	Claim No.	Accession No.	Significant Results
46	19511	151	60/6/29	Canadian Nickel	HOB 39	90604	
47	KUS 143	80	70/3/29	HBED	KUS 859	91389	Traces pyrite, pyrrhotite and graphite.
48	15	60	58/2/22	Texas Gulf Sul. Co.	SAW 32	90088	1 m impure quartzite with up to 80% pyrrhotite and pyrite.
49	KUS 144	140	70/4/4	HBED	KUS 852	91389	Scattered weak pyrite mineralization over several tens of meters.
50	KUS 145	75.6	70/4/6	HBED	KUS 831	91389	Local disseminated pyrite and pyrrhotite.
51	KUS 153	70	70/6/19	HBED	KUS 153	91389	Limey sections with weak pyrite and pyrrhotite mineralization.
52	4A	148	61/4/6	JAY KAY EXPL.	AXE 54	90612	Peridotite intersected in hole.
53	6A	147	61/4/17	JAY KAY EXPL.	AXE 36	90612	2.4 m periodite.
54	5A	146	61/4/11	JAY KAY EXPL.	AXE 36	90612	
55	KUS 136	71.9	70/3/12	HBED	KUS 670	91389	21.7 m quartz biotite-chlorite-talc schist with pyrite-bearing graphitic zones.
56	KUS 150	70.7	70/6/5	HBED	KUS 857	91389	Weak pyrrhotite, pyrite and graphite in local zones over 90 m.
57	KUS 151	57.3	70/6/6	HBED	KUS 857	91389	Weak pyrrhotite, pyrite and graphite mineralization.
58	KUS 152	67	70/6/13	HBED	KUS 857	91389	Traces of pyrite and pyrrhotite.
59	13	62.5	58/2/16	Texas Gulf Sul. Co.	SAW 33	90088	17 m of hornblende-chlorite-garnet schist with minor pyrite, pyrrhotite and graphite.
60	19514	63.4	60/7/15	Canadian Nickel	HOG 40	90605	Zones of mineralized tuff.
61	24155	104.5	63/6/21	Canadian Nickel	HOG 40	90606	
62	19515	150	60/7/21	Canadian Nickel	HOG 40	90605	Zones of mineralized tuff.
63	24154	139	63/6/17	Canadian Nickel	HOG 40	90606	Quartzite and skarn with sulphide streaks.
64	24153	111	63/6/11	Canadian Nickel	HOG 41	90606	Quartzite with sulphide streaks.
65	19513	110.3	60/7/10	Canadian Nickel	HOG 40	90605	Zones of mineralized tuff.
66	24152	106.7	63/6/7	Canadian Nickel	HOG 73	90606	
67	19509	137.5	60/6/16	Canadian Nickel	HOG 40	90605	Local sulphides.
	19504	39.3	60/3/12	Canadian Nickel	HOG 40	90605	Quartzite breccia locally mineralized with sulphides.
68	19512	149.7	60/6/6	Canadian Nickel	HOG 40	90605	Zones of mineralized tuff.
69	10	69.8	58/2/8	Texas Gulf Sul. Co.	SAW 26	90088	15 m quartzite and chlorite schist with 20% pyrite and pyrrhotite.
70	11	62.5	58/2/11	Texas Gulf Sul. Co.	SAW 26	90088	13 m chlorite schist with 60% pyrite and blebs of graphite.
71	9	62.5	58/2/7	Texas Gulf Sul. Co.	SAW 23	90088	2.7 m chlorite schist with 70% pyrite and blebs of graphite.
72	8	67	58/2/5	Texas Gulf Sul. Co.	SAW 17	90088	3.9 m hornblende-chlorite schist and quartzite with bands of near solid pyrite and pyrrhotite.
73	7	61.5	58/2/1	Texas Gulf Sul. Co.	SAW 13	90088	13.6 m altered quartzite with 30% disseminated pyrite.
74	KUS 138	96.9	70/3/18	HBED	KUS 890	91389	
75	1	62.6	58/1/19	Texas Gulf Sul. Co.	SAW 9	90088	18 m zone interbedded hornblende schist, altered mineralized quartzite and local beds of near solid pyrrhotite and pyrite, with blebs of graphite.
76	2	62.5	58/1/21	Texas Gulf Sul. Co.	SAW 9	90088	11.9 m zone interbedded hornblende schist, altered mineralized quartzite and local beds of near solid pyrrhotite and pyrite, with blebs of graphite.
77	3	69	58/1/24	Texas Gulf Sul. Co.	SAW 5	90088	Local narrow bands of near solid pyrrhotite and pyrite in hornblende schist, with blebs of graphite.
78	4	62.7	58/1/26	Texas Gulf Sul. Co.	SAW 2 & 3	90088	Local narrow bands of near solid pyrrhotite and pyrite in hornblende schist, with blebs of graphite.
79	6	62.5	58/1/31	Texas Gulf Sul. Co.	BOB 62	90088	10 m of hornblende-chlorite schist containing narrow bands near solid pyrrhotite and pyrite, local blebs of graphite.
80	5	62.3	58/1/29	Texas Gulf Sul. Co.	BOB 67	90088	13 and 20 m wide zone chlorite (hornblende) schist with 30% pyrite and streaks and blebs of graphite.
81	19517	115	60/8/3	Canadian Nickel	HOG 120	90604	Local bands of sulphide in tuff. Only trace Cu values in sulphide assays.
82	KUS 130	82.6	70/2/21	HBED	KUS 674	91389	4.3 m graphite schist with pyrite mineralization. Trace to weak chalcopyrite mineralization.
83	KUS 131	72.2	70/2/24	HBED	KUS 674	91389	Several seams of graphite schist between intrusions of pegmatite and grandiorite.
84	KUS 133	71.3	70/3/1	HBED	KUS 675	91389	Muscovite-chlorite-calcite schist with 10% pyrite and local graphite.
85	KUS 129	89.3	70/2/16	HBED	KUS 681	91389	20 m of muscovite-hornblende schist with pyrite graphite-rich bands.

Reference No (Fig. 27)	Company Reference Number	Depth of DDH (m)	Date Completed	Name of Company	Claim No.	Accession No.	Significant Results
86	DAT 1	68	65/9/3	Noranda Expl. Co.	DAT 8	90208	Weakly disseminated pyrite and pyrrhotite in quartz hornblende gneiss and quartzite. One 0.2 m wide graphite zone.
87	DAT 5	107	65/9/12	Noranda Expl. Co.	BET 1	90208	Quartz hornblende garnet gneiss with minor chalocopyrite mineralization.
88	DAT 14	52	65/10/4	Noranda Expl. Co.	DAT 1	90208	0.5 m solid graphite zone with minor pyrite.
89	KUS 140	76.2	70/3/21	HBED	KUS 893	91389	Minor pyrrhotite over 3.4 m.
90	8B	150	61/4/25	JAY KAY EXPL.	AXE 108	90612	73 m of pyrite, pyrrhotite and graphite.
91	7B	148.4	61/4/17	JAY KAY EXPL.	AXE 108	90612	80 m pyrite, pyrrhotite and graphite.
92	9B	152	61/5/3	JAY KAY EXPL.	AXE 107	90612	Pyrite-graphite zones in basalt sequence.
93	10	79.6	61/8/12	JAY KAY EXPL.	AXE 95	90608	5 m peridotite.
94	15B	90.5	59/12/16	JAY KAY EXPL.	AXE 100	90611	4 m serpentine, 4 m graphite schist and pyrite.
95	14B	83.5	59/12/7	JAY KAY EXPL.	AXE 100	90611	0.6 m pegmatite with spodumene.
96	3B	112	59/8/4	JAY KAY EXPL.	AXE 30	90611	3.4 m pegmatite with spodumene, 4.6 m chlorite-schist with pyrite and graphite.
97	12B	70	59/11/21	JAY KAY EXPL.	AXE 94	90611	3.7 m graphite schist with pyrite and some chalcopyrite.
98	11B	83.5	59/11/14	JAY KAY EXPL.	AXE 94	90611	2.4 m graphite schist with some pyrite and chalcopyrite.
99	KUS 147A	135	70/4/19	HBED	KUS 841	91389	Minor pyrite, pyrrhotite, graphite throughout hole, trace of chalcopyrite and sphalerite.
100	8B	115.5	59/10/11	JAY KAY EXPL.	AXE 71	90611	
101	7B	112.2	59/8/28	JAY KAY EXPL.	AXE 70	90611	
102	8	106.9	57/7/28	JAY KAY EXPL.	AXE 88	90608	7 m with minor pyrite, graphite and some chalcopyrite.
103	7	106	57/7/22	JAY KAY EXPL.	AXE 88	90608	10.7 m altered peridotite, 14 m graphite schist and pyrite with some chalcopyrite.
104	9	106.4	57/8/4	JAY KAY EXPL.	AXE 93	90608	
105	A	110	60/4/24	JAY KAY EXPL.	AXE 84	90608	10.4 m altered serpentinite, 10 m graphite schist with pyrite.
106	9B	85	59/11/3	JAY KAY EXPL.	AXE 84	90611	
107	10B	80.5	59/11/8	JAY KAY EXPL.	AXE 84	90611	15 m serpentine rock.
108	5B	111	59/8/21	JAY KAY EXPL.	AXE 69	90611	
109	6B	106	59/8/14	JAY KAY EXPL.	AXE 69	90611	
110	3A	103	60/5/12	JAY KAY EXPL.	AXE 68	90608	
111	2A	69	60/5/6	JAY KAY EXPL.	AXE 68	90608	
112	1A	104	60/4/24	JAY KAY EXPL.	AXE 68	90608	
113	3B	112	59/8/4	JAY KAY EXPL.	AXE 30	90611	
114	4B	116	59/7/25	JAY KAY EXPL.	AXE 30	90611	
115	B2	104	59/7/14	JAY KAY EXPL.	AXE 11	90611	
116	1B	82.6	59/7/8	JAY KAY EXPL.	AXE 19	90611	
117	3A	146.6	61/3/30	JAY KAY EXPL.	AXE 10	90612	
118	4	88	57/6/30	JAY KAY EXPL.	AXE 8	90608	
119	2	99	57/6/17	JAY KAY EXPL.	AXE 8	90608	
120	3	105	57/6/27	JAY KAY EXPL.	AXE 8	90608	
121	1	102	57/6/2	JAY KAY EXPL.	AXE 8	90608	
122	1A	119	61/3/11	JAY KAY EXPL.	AXE 10	90612	2.1 m peridotite.
123	2A	131	61/3/20	JAY KAY EXPL.	AXE 9	90612	24 m peridotite.
124	6	87.5	57/7/16	JAY KAY EXPL.	AXE 45	90608	
125	19534	26	60/8/31	Canadian Nickel	HOG 107	90604	Hole abandoned in overburden.
126	19533	26	60/8/29	Canadian Nickel	HOG 107	90604	Hole abandoned in overburden.

Reference No (Fig. 27)	Company Reference Number	Depth of DDH (m)	Date Completed	Name of Company	Claim No.	Accession No.	Significant Results
127	S50	128	69/3/9	Falconbridge Nickel	BA 336	91591/2	
128	S78	96	70/3/27	Falconbridge Nickel	BA 336	91591/2	
129	S86	51	70/3/31	Falconbridge Nickel	BA 336	91591/2	
130	S49	192.6	69/3/5	Falconbridge Nickel	BA 339	91591/2	40 m mylonite zone.
131	S53	128	69/3/1	Falconbridge Nickel	BA 336	91591/2	
132	S85	154.5	70/3/24	Falconbridge Nickel	BA 336	91591/2	
133	S79	99.4	70/3/17	Falconbridge Nickel	BA 342	91591/2	2.4 m highly magnetitic pyritic graphite schist.
134	S51	129	69/3/3	Falconbridge Nickel	BA 342	91591/2	2.4 m mylonite zone.
135	S48A	129.8	69/2/26	Falconbridge Nickel	BA 345	91591/2	
136	S80	92	70/3/24	Falconbridge Nickel	BA 344	91591/2	Hole abandoned in overburden.
137	S52	143	69/2/24	Falconbridge Nickel	BA 352	91591/2	
138	S54	129.8	69/2/20	Falconbridge Nickel	BA 347	91591/2	
139	S81A	158.5	70/3/22	Falconbridge Nickel	BA 351	91591/2	44.5 m and 10.6 m wide sections of black ultrabasic.
140	S81	63	70/3/18	Falconbridge Nickel	BA 351	91591/2	Hole abandoned in overburden.
141	S82	93.6	70/3/23	Falconbridge Nickel	BA 350	91591/2	Hole abandoned in overburden.
142	S55	128	69/3/8	Falconbridge Nickel	BA 366	91591/2	
143	S83	123.7	70/3/27	Falconbridge Nickel	BA 362	91591/2	6.7 m basic to ultrabasic complex.
144	S84	150.3	70/4/1	Falconbridge Nickel	BA 373	91591/2	4.8 and 4.9 m sections of graphite schist with pyrite.
145	S11	216	69/2/18	Falconbridge Nickel	BA 387	91590	170 m amphibolite and amphibolite-biotite gneiss.
146	S12	122	69/2/15	Falconbridge Nickel	BA 387	91590	42.7 m and 16.5 m amphibolite.
147	S13	192	69/2/9	Falconbridge Nickel	BA 382	91590	9.1 m ultramafic.
148	S15	196	69/2/2	Falconbridge Nickel	BA 414	91590	47.5 m amphibolite.
149	S10	196	69/2/1	Falconbridge Nickel	BA 415	91590	21 m amphibolite.
150	S9	165	69/1/22	Falconbridge Nickel	BA 428	91590	
151	S8	443	69/1/23	Falconbridge Nickel	BA 437	91590	419.4 m of hematized serpentinite.
152	12	79.5	58/2/14	Texas Gulf Sul. Co.	SAW 33	90088	0.6 m of 50% pyrite and blebs of graphite, 9.2 m mineralized quartzite with bands of solid pyrite and pyrrhotite.
153	14	57	58/2/19	Texas Gulf Sul. Co.	SAW 34	90088	6.7 m wide hornblende-chlorite schist with up to 20% streaks pyrite.
154	13	81	58/3/8	Selco	NIB 92	90079	2.1 and 0.3 m wide graphite schist zone.