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Western Lac des Mille Lacs Area

By
T. N. IRVINE

Geological Report No. 12

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TABLE OF CONTENTS

Geological Report No. 12

PHOTOGRAPHS

FIGURES

COLOURED GEOLOGICAL MAP
(in map case)

ABSTRACT

The bedrock of the Western Lac des Mille Lacs area, District of Thunder Bay, is entirely Precambrian in age. The oldest units are quartz-biotite paragneiss and metamorphosed basic volcanic rocks, assigned to the Couchiching(?) and Keewatin series respectively. These are intruded by mafic-rich plutons ranging in composition from feldspathic hornblendite to peridotite.

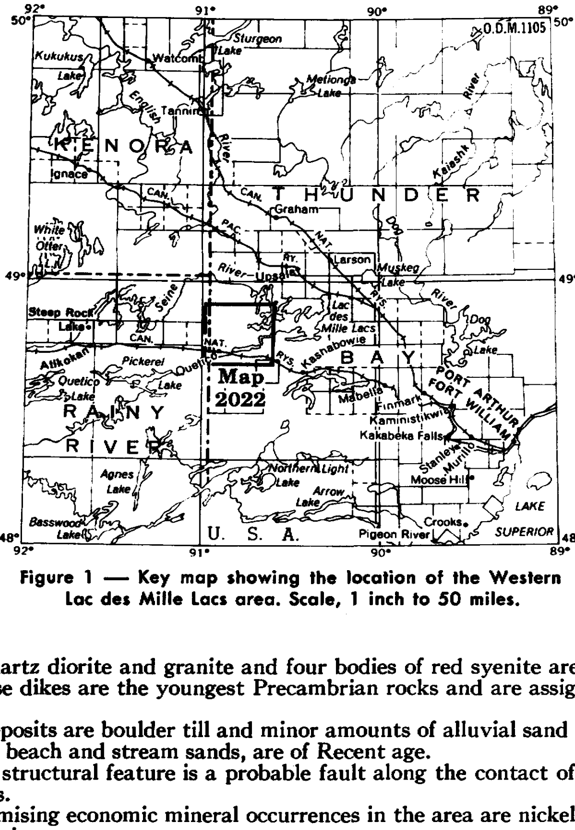

Figure 1 — Key map showing the location of the Western Lac des Mille Lacs area. Scale, 1 inch to 50 miles.

Large masses of quartz diorite and granite and four bodies of red syenite are apparently next in age. Quartz diabase dikes are the youngest Precambrian rocks and are assigned to the Keweenawan.

Pleistocene deposits are boulder till and minor amounts of alluvial sand and gravel. Swamp accumulations, and beach and stream sands, are of Recent age.

The principal structural feature is a probable fault along the contact of the Couchiching(?) and Keewatin rocks.

The most promising economic mineral occurrences in the area are nickel-copper sulphides in the mafic-rich intrusions.

Western Lac des Mille Lacs Area

By

T. N. Irvine[1]

INTRODUCTION

The Lac des Mille Lacs area is about 65 miles west-northwest of the cities of Port Arthur and Fort William. This report deals with the geology of an area of about 220 square miles, which includes the western part of the Lac des Mille Lacs area. To date, mineral deposits of commercial value have not been found in the report-area, although it has apparently been subjected to relatively intensive prospecting. The best prospects are sulphides of nickel and copper occurring in two small mafic-rich intrusive bodies in the west-central part of the map-area. These, however, have been known for many years, having been reported by T. L. Tanton (1938), and results of investigations, including diamond-drilling, have apparently not been encouraging. Gold has not been reported in significant concentrations although the map-area straddles the same belt of metamorphosed sedimentary and basic volcanic rocks that contain the gold deposits at Sabawi Lake (formerly Sapawe Lake), 20 miles west of the area.

The geological survey on which this report is based was carried out during the summer of 1960. As geological data were collected in the field, they were plotted on sheets of acetate (Perfatrace) fitted over vertical air photographs on a scale of 1 inch to 1,320 feet. The procedure in mapping was to visit outcrops on lakeshores by canoe wherever possible, and to make pace-and-compass traverses inland between points that were recognizable on the air photographs. The traverse interval was about 2,500 feet over those areas indicated by Tanton to be underlain by granitic rocks, and about 1,500 feet over other rock types. The field data were traced on plastic foil (Cronaflex) basemaps, also on a scale of 1 inch to 1,320 feet, prepared by the cartography section of the Ontario Department of Mines from maps by the Forest Resources Inventory of the Ontario Department of Lands and Forests. The final map (No. 2022, map case) is on a scale of 1 inch to 1 mile.

On the final map small exposures of bedrock have been designated by heavy dots. In most places, the outline of larger exposures have been generalized from the air photographs. The pattern that has been developed in this way does not show all the bedrock outcrops, but is believed to give a representative picture of the abundance and nature of the exposures. The geological boundaries indicated on the map are consistent with available data but, in some places, because of poor exposure or marked variation in rock type, are only approximate or assumed.

Acknowledgments

The author was ably assisted in the field by D. H. Watkinson, J. V. Wall, A. Esfahani, and G. M. Hughes. Mr. Watkinson acted as senior assistant and carried out about half the mapping. The field party was serviced by aeroplane

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from the Ontario Department of Lands and Forests base at Nym Lake near Atikokan; the co-operation of personnel at that base is gratefully acknowledged. The courteous assistance extended by residents of the area was much appreciated. Particular thanks go to R. V. Wells of Quetico, to J. Kreis and W. Nix of Owakonze, and to D. Icke and other personnel of the Owakonze Boys' Camp on Baril Lake.

T. M. Church of Toronto has kindly provided the aeromagnetic map reproduced (Figure 2).

Chemical analyses and assays were performed by the staff of the Laboratory Branch, Ontario Department of Mines. Thin sections were prepared by H. D. Falkiner of McMaster University, Hamilton, Ontario.

Means of Access

The main freight line of Canadian National Railways crosses the southern part of the map-area, and daily train service is available from Winnipeg and Fort William. Stations are located at Quetico, Owakonze, and Huronian.

Highway No. 11, connecting Atikokan and Fort William, is within a mile of the south boundary of the map-area, and a gravel motor-road joins Huronian to the highway.

Lakes are common in the area, and all parts are accessible by seaplane, the nearest air bases being located at Shebandowan, Atikokan, and the lakehead cities of Port Arthur and Fort William. The area can also be reached by small boats, either from highway No. 11 via Windigoostigwan Lake, or from highway No. 17 at Savanne via Lac des Mille Lacs.

Within the area, a gravel motor-road joins Owakonze to Edar Lake and a little-used wagon-road extends north from Edar Lake to Bedivere Lake. Most logging trails were blocked by undergrowth and could not be used in field traversing.

Previous Geological Work

The early Precambrian of the Rainy Lake area was discussed by Lawson (1913). The Lac des Mille Lacs area was mapped geologically by T. L. Tanton, for the Geological Survey of Canada; his work is shown on the Quetico Sheet (Tanton 1938) at a scale of 1 inch to 4 miles and on the Kenora Sheet (Tanton 1939) at 1 inch to 8 miles. The present map-sheet, on its west side, adjoins that of the Sapawe Lake area mapped geologically in 1928 by J. E. Hawley (1930).

Titles of published works bearing on the geology of the area are to be found under the heading Bibliography at the end of this report.

Topography

The area shows the characteristic features of the Canadian Precambrian Shield. Maximum local relief is in the vicinity of Windigoostigwan Lake and is about 150 feet. Elsewhere the land surface is regular, and hills are small. Elevations of all points, relative to sea-level, are probably between 1,425 and 1,700 feet. Lakes are numerous, and their outlines are partially controlled by the

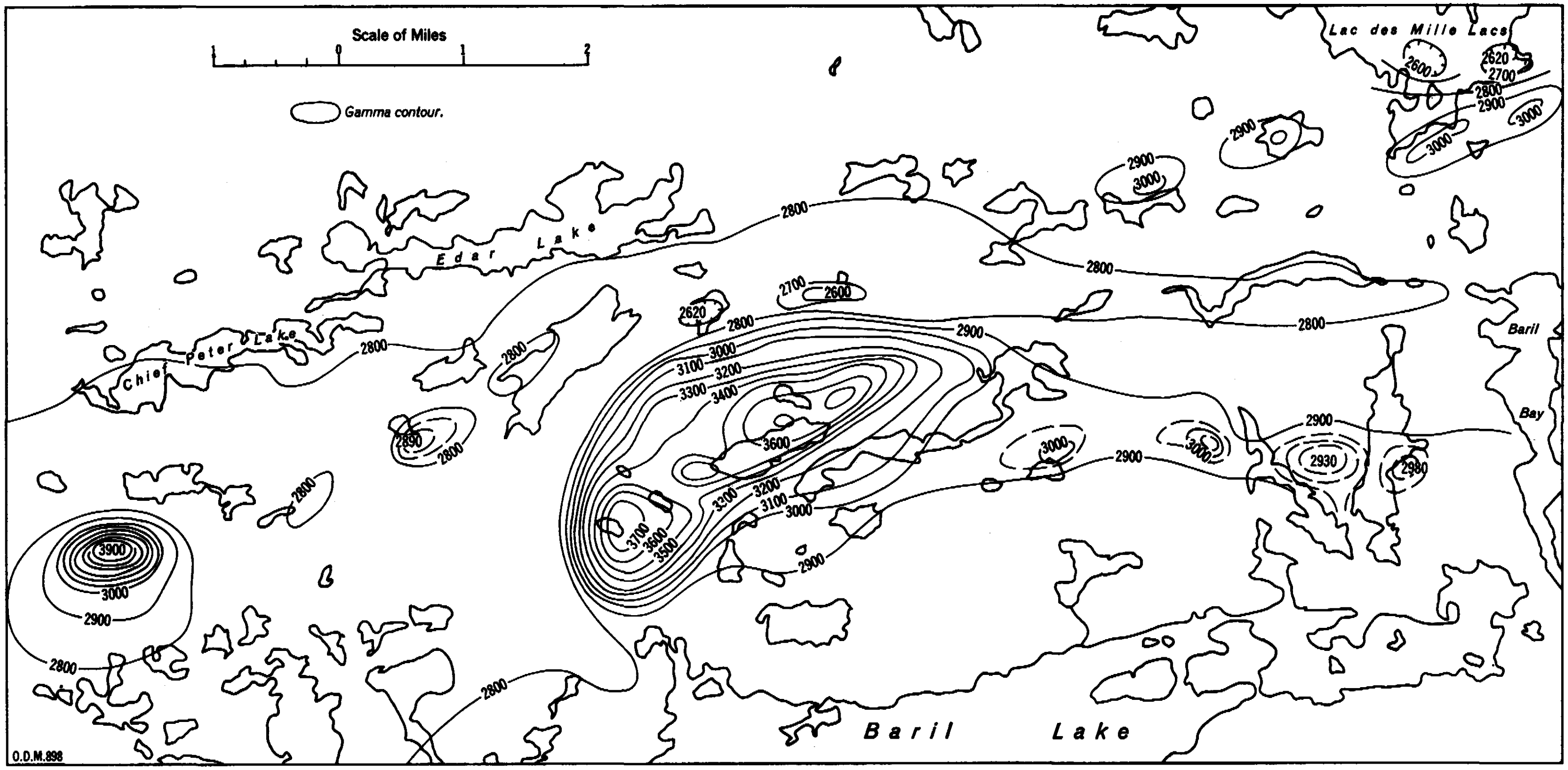


Figure 2 — Aeromagnetic map of a part of the Lac des Mille Lacs area.

(From a tracing by T. M. Church, Kinasco Exploration and Mining Limited)

structure of the bedrock. The height-of-land for this part of Ontario passes through the map-area and, therefore, the drainage is in two directions. The southeastern part of the water system, including Rudge Lake, Fork Lake, and Rolling Lake, drains eastward to Lake Superior. The rest of the drainage is westward, the principal rivers being the Mercutio River, which begins at Bedivere Lake, and the Atikokan River, which includes Edar Lake and Chief Peter Lake. Windigoostigwan Lake is part of the French River system, and Lac des Mille Lacs empties into the westward-flowing Seine River north of the present map-area.

As shown on the geological map (map case), bedrock outcrops are common along the shorelines of the major lakes. The best exposures inland are in the southwest corner of the map-area and in a small area northeast of Bedivere Lake. Elsewhere, glacial drift is extensive, and outcrops are sparse and small.

Natural Resources

FORESTS

The forest cover in the area is dense. The principal trees are spruce and poplar; cedar, balsam, birch, and jackpine are also found. Undergrowth of alder and willow is common.

Lumbering has been an important industry. A large sawmill was once located at Edar Lake, and several smaller ones have operated in the vicinity of Chief Peter and Bedivere lakes. All these operations ceased prior to 1948.

GAME AND FISH

The most abundant game animals are beaver, muskrat, and rabbit. Considerable trapping is carried on by local residents, and beaver pelts are probably the principal product of the area. Bear and moose were seen, during the field season, but deer are seemingly absent. Spruce grouse and ptarmigan are relatively common.

There is no commercial fishing, but the lakes are extensively fished by sportsmen. Pike and pickerel are plentiful; lake trout are rare.

GENERAL GEOLOGY

The bedrock in the area is entirely Precambrian in age. The oldest units are quartz-biotite paragneiss and metamorphosed basic volcanic rocks, assigned to the Couchiching(?) and Keewatin systems respectively. These are intruded by several small mafic-rich plutons ranging in composition from feldspathic hornblendite to peridotite. Extensive masses of granitic rocks and four occurrences of syenite are apparently next in age. Diabase dikes represent the youngest igneous rocks in the area and are assigned to the Keweenawan.

Extensive deposits of boulder till laid down by continental glaciers, and minor deposits of sandy gravel of alluvial origin, are Pleistocene in age.

Swamp accumulations and small amounts of alluvial and beach sands are assigned to the Recent epoch.

The geological succession is summarized in the following table; the rock types within each group are not necessarily in order of age.

TABLE OF FORMATIONS

CENOZOIC	
RECENT:	Peat, river deposits, beach deposits.
PLEISTOCENE:	Boulder till, silt, sand, gravel.
	Great Unconformity
PRECAMBRIAN	
KEWEENAWAN:	Quartz diabase (dikes).
	Intrusive Contact
ALGOMAN(?):	Red hornblende syenite. Quartz diorite, quartz diorite gneiss, granodiorite, migmatitic quartz diorite, pegmatitic granite, granite pegmatite. Grey granite, pink granite, pegmatitic granite, granite pegmatite, migmatitic granite, granite gneiss.
	Probable Intrusive Contact
PRE-ALGOMAN(?):	Peridotite, serpentinized peridotite. Hornblendite, pyroxene hornblendite, biotitic hornblendite. Feldspathic hornblendite, hornblende diorite.
	Intrusive Contact
KEEWATIN(?):	Metabasalt. Metamorphosed pillow basalt. Metamorphosed porphyritic basalt. Meta-andesite, metadacite. Metamorphosed tuff breccia or agglomerate. Tuffaceous schist, locally garnetiferous. Granitized basalt. Chlorite schist, chlorite-muscovite schist.
COUCHICHING(?):	Quartz-biotite paragneiss, garnet-quartz-biotite paragneiss, staurolite-quartz-biotite paragneiss, cummingtonite-quartz-biotite paragneiss Migmatitic quartz-biotite paragneiss. Quartz-muscovite schist.

Couchiching ?

QUARTZ-BIOTITE PARAGNEISS

The quartz-biotite paragneiss that underlies much of the southern half of the map-area is part of a large belt of similar rock that extends west beyond Rainy Lake (Tanton 1939). In the Rainy Lake area, Lawson (1913) has classified this belt as Couchiching, and Tanton has applied that name to the entire belt.

At Lac des Mille Lacs, the paragneiss is clearly delimited on the north by the main band of basic volcanic rocks. The contact of these two units is poorly exposed and, as suggested under Structure and Stratigraphy, may be faulted. It is mostly marked by a narrow zone of chlorite schist that probably grades into the paragneiss over a few tens of feet. In the western part of the map-area, the paragneiss has its greatest continuous width—about 6,500 feet. Eastward, it pinches out, and only a small amount of the rock is present as inclusions in granite. Southward, the paragneiss is complexly intermingled with granitic rock, commonly on the scale of inches. In this southern region, the procedure in mapping has been to designate outcrops by the combined symbols 1a, 5a if paragneiss seemed more abundant than granite, and by 5a, 1a if granite seemed more abundant than paragneiss. Contacts were then drawn to be consistent with the dominant rock type. Thus, in reading the map, it should be remembered that the pattern of rock distribution shown in colour is, at best, somewhat diagrammatic, and that a pattern not unlike that shown for the whole of this part of the map can commonly be seen in a single outcrop.

The paragneiss generally appears in outcrops as a fine-grained weakly schistose rock; near granite, however, it is distinctly coarser owing to recrystallization. It is brownish grey on fresh and weathered surfaces and commonly shows a stratiform foliation with bands 1–3 inches thick. The visible cause of the banding is usually a slight variation in the amount of biotite; in a few places, grain-size gradation was detected in the stratification and is believed to represent graded sedimentary bedding. In fact, where recrystallization is not extreme, the banding generally bears a distinct similarity to sedimentary bedding. Cross-bedding and conglomeratic facies have not been recognized.

Mineral assemblages that have been identified in specimens of the paragneiss by microscopic study are given below. In each assemblage, the most abundant minerals are listed first, and those occurring in amounts less than 5 percent are shown in brackets. The assemblages all indicate a moderately high grade of metamorphism:

quartz-plagioclase-biotite
quartz-plagioclase-biotite-muscovite-(oxide)
quartz-biotite-plagioclase-muscovite-(oxide)
quartz-biotite-plagioclase-muscovite-(garnet)
quartz-plagioclase-(biotite)-(garnet)-(oxide)
quartz-plagioclase-biotite-garnet
quartz-microcline-plagioclase-(muscovite)-(biotite)-(garnet)-(staurolite)
quartz-biotite-plagioclase-staurolite-muscovite-(garnet)-(ilmenite?)
quartz-biotite-plagioclase-staurolite-(garnet)
quartz-biotite-plagioclase-(cummingtonite)-(garnet)-(hornblende)
quartz-plagioclase-biotite-(cummingtonite)-(hornblende)
quartz-plagioclase-biotite-hornblende
quartz-plagioclase-biotite-garnet-(hornblende)-(sillimanite)

Pyrite is a common minor accessory mineral. The oxide mineral in most of the rocks is probably magnetite. Plagioclase is generally oligoclase, and hornblende is the common green variety. Biotite is typically brown or slightly reddish brown; it shows different degrees of preferred orientation, varying from random to marked plane parallelism. Potash feldspar, where present, is microcline, but it is usually absent. Garnet, staurolite, and cummingtonite are present as small porphyroblasts sieved with tiny inclusions of quartz. Staurolite and cummingtonite seem to be most common in an east-northeastern zone through the central part of the main belt of paragneiss. This zone possibly represents a distinctive grade of metamorphism, but more likely, these minerals occur because of slight compositional peculiarities of the original sediment.

Near the granitic rocks, the paragneiss is an equigranular (0.2–0.5 mm.) intergrowth of quartz, plagioclase, and biotite. Much of the plagioclase is replaced by sericite, and biotite is commonly altered to chlorite. Hornblende and garnet are found locally, and sillimanite has been observed in one thin section from paragneiss included in granite.

A specimen from a paragneiss inclusion in the largest syenite body consists of brownish biotite partly altered to chlorite, green hornblende, and plagioclase. Quartz is absent, probably owing to desilication by the syenite, and the development of hornblende may indicate equilibration with the hornblende-bearing syenite.

Some of the paragneiss, composed dominantly of quartz, plagioclase, and biotite, in its most northerly occurrences, shows a relict clastic texture similar to that ascribed to greywacke (Pettijohn 1957, p. 327). The paragneiss, consisting mainly of quartz and biotite, commonly contains very fine-grained (0.05–0.1 mm.) quartz. Metamorphism of the kind represented here generally coarsens the grain-size of quartz; this and the general mineralogy of these rocks suggests that they were derived from a fine-grained sedimentary rock such as a siltstone.

A chemical analysis of a specimen of quartz-plagioclase-biotite paragneiss is given in the accompanying table. The rock is composed of 34 percent quartz, 40 percent oligoclase, 26 percent biotite, and a trace of chlorite. Analyses of shale and greywacke are given for comparison and, as shown, the paragneiss corresponds closely to greywacke. Particularly notable in this respect are the relative amounts of Na_2O and K_2O.

Comparative data for the table is taken from works by Pettijohn (1957, p. 307) and Clarke (1924).

COMPARISON OF THE CHEMICAL COMPOSITION OF QUARTZ-PLAGIOCLASE-BIOTITE PARAGNEISS WITH THOSE OF GREYWACKE AND SHALE

	Quartz-biotite-plagioclase Paragneiss[1]	Average of 23 Greywackes[2]	Average of 78 Shales[3]
	percent	percent	percent
SiO_2	66.66	64.7	58.10
Al_2O_3	15.23	14.8	15.40
Fe_2O_3	0.27	1.5	4.02
FeO	4.02	3.9	2.45
MgO	2.24	2.2	2.44
CaO	2.88	3.1	3.11
Na_2O	4.82	3.1	1.30
K_2O	1.86	1.9	3.24
H_2O+	0.87	2.4	} 5.00
H_2O-	0.01	0.7	
P_2O_5	0.13	0.2	0.17
TiO_2	0.51	0.5	0.65
Cr_2O_3	0.02	——	——
MnO	0.06	0.1	——
V_2O_3	0.01	——	——
CO_2	nil	1.3	2.63
Total	99.59	100.4	98.51

(1)Specimen No. I 60-59, collected 3,000 feet southwest of Chief Peter Lake, Lac des Mille Lacs area. Analysis by the Laboratory Branch, Ontario Dept. Mines, Toronto.
(2)After F. J. Pettijohn.
(3)After F. W. Clarke.

Keewatin ?

METABASALT AND CHLORITE SCHIST

The most distinctive feature of the map-sheet probably is the belt of metamorphosed basic volcanic rocks that extends from west to east across its centre. The width of the belt ranges between 9,000 and 16,000 feet. Most of the rock is greenish grey and is the typical "greenstone" of the Canadian Shield. Massive lava is predominant, but a small amount of agglomerate is present; some of the material examined in thin section shows a relict fine-grained clastic texture and probably represents tuffaceous sediment interbedded with the lava flows. Along the south boundary of the belt, just north of the Couchiching paragneiss, chloritic schist is exceptionally abundant; this, too, may be of tuffaceous origin. The schist has been separated as a map rock-unit, but its limits are not well defined; the unit must, therefore, include a considerable proportion of massive lavas. Distinguishing this unit does, however, emphasize the presence of the schist zone; it should be noted that a similar zone along the same contact has been recognized by Hawley (1930) in the Sabawi Lake area (formerly Sapawe Lake) to the west.

The flow rocks are generally massive or weakly schistose. Pillow structures are rarely observed; if they are common, they are well obscured by the lichen that covers the exposures, most of which are small. Some amygdaloidal lava is present, the amygdules being filled with calcite and, in several places, a distinctive porphyritic variety of the lava (*see* accompanying photos) was observed over a few feet. The rock is composed of large, light-coloured, subhedral phenocrysts of plagioclase, now almost completely altered to a saussuritic intergrowth of clinozoisite and albite, set in a dark fine-grained matrix, probably of basaltic composition. Phenocrysts were observed to range in size from ½ to 4 inches; in contrast, the original grain-size of the matrix was apparently less than one millimetre.

The mineralogy of the rocks in the belt is entirely metamorphic. The mineral assemblages that have been observed in thin sections are given below. The minerals are listed in order of decreasing abundance, and those occurring in amounts less than 5 percent are shown in brackets. The oxide mineral is generally magnetite but may be ilmenite in some rocks. Pyrite is a sparse accessory.

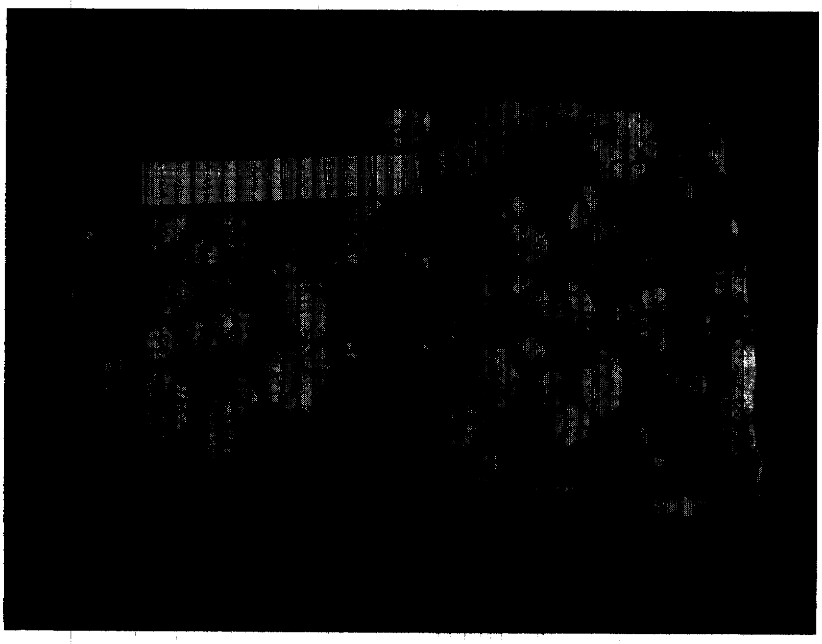
Assemblages in the flow rocks are:

hornblende-andesine-quartz-(oxide)
hornblende-oligoclase-quartz-(epidote)-(oxide)
hornblende-epidote-albite-quartz-(oxide)
hornblende-epidote-albite-(calcite)-(quartz)-(sphene)
hornblende-albite-epidote-chlorite-calcite-(oxide)
epidote-albite-(chlorite)-(calcite)-(oxide)

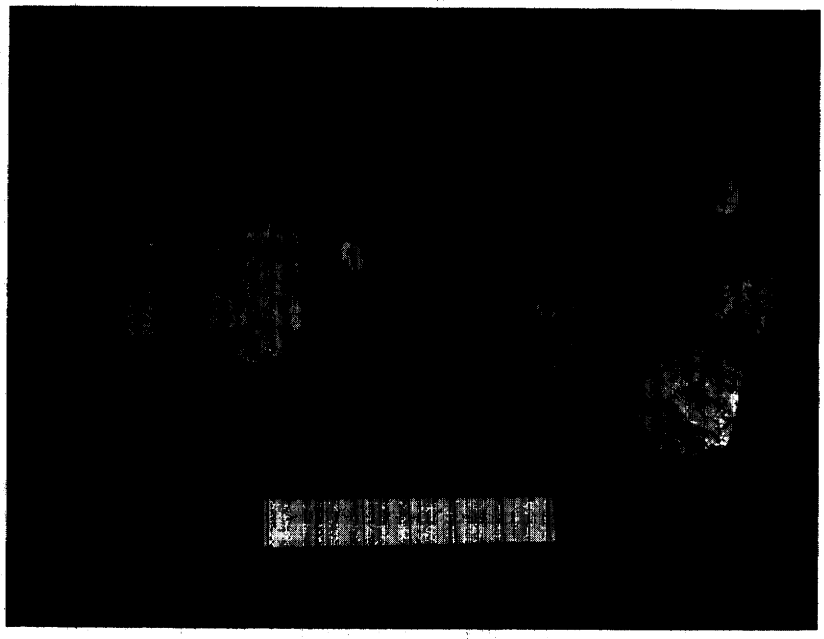
Generally, hornblende makes up 45–65 percent of these rocks. Quartz is present in amounts of about 10 percent.

In the tuffaceous(?) rocks and chlorite schists, the assemblages are:

hornblende-quartz-plagioclase
albite-hornblende-quartz-(sphene)-(oxide)
hornblende-quartz-albite-(chlorite)-(oxide)
hornblende-quartz-albite-(chlorite)-(oxide)
quartz-albite-chlorite-(hornblende)-(oxide)
quartz-chlorite-actinolite-(sphene)-(apatite)
quartz-chlorite-garnet-muscovite
chlorite-quartz-albite-calcite-(sphene)



A large specimen of metamorphosed porphyritic basalt showing phenocrysts of saussuritized plagioclase in a dark, fine-grained matrix. The specimen is from the southwest shore of Boot Bay, Lac des Mille Lacs. Scale divisions are one inch.



Metamorphosed porphyritic basalt showing large, subhedral phenocrysts of saussuritized plagioclase. Specimens are from the southwest shore of Boot Bay, Lac des Mille Lacs. Scale divisions are one inch.

Mineral proportions are more variable in these rocks; quartz, for example, is 10–50 percent.

The basic volcanic rocks are commonly slightly coarser and somewhat biotitic where they are near, or intermixed with, the later granitic intrusions. Otherwise, their metamorphism appeared, in the field, to be relatively uniform, and the distribution of the above mineral assemblages does not suggest marked local variations in metamorphic grade. All assemblages are indicative of medium grade.

Most of the metamorphosed lavas are relatively dark greenish grey, and it is probable that they are basaltic in composition (Satterly 1941, pp. 119–36). In the southern part of the volcanic belt, some of the flow rocks are lighter green than average and may be andesite or dacite.

Pre-Algoman ?

MAFIC-RICH INTRUSIVE ROCKS

Mafic-rich intrusive rocks of basic to ultrabasic composition have been recognized at about thirty-five places in the map-area. The two largest bodies are situated a mile south of Chief Peter Lake, or 1¼ to 1½ miles north of Quetico. They are shown on the coloured geological map and, in more detail, in Figures 3, 4, and 5. The larger is 2,500 by 1,500 feet; the smaller is 1,300 by 200 feet. Both have been noted on the Quetico sheet by Tanton; with two other mafic intrusions, they show as anomalies on the aeromagnetic map (Figure 2). Most of the other occurrences of the mafic-rich rocks are exposed in only one outcrop. They are widely scattered in the paragneiss and metavolcanic rocks, apparently as small intrusive bodies. In the northern part of the map-area, some ultrabasic rock is present as definite inclusions or xenoliths in the quartz diorite (*see* photograph on page 12) and, therefore, must be the older of these two types. However, the majority of the occurrences, most of which are exposed in the shoreline outcrops at Lac des Mille Lacs, do not yield conclusive evidence with regard to age relations. Several are in linear groups parallel to nearby Keweenawan diabase dikes and transverse to the general trend of the quartz diorite foliation, and it is remotely possible that they represent dikes cutting quartz diorite. A small body of hornblendite, just north of Baril Lake, is cut by dikes of granite and granitic pegmatite and by small quartz veins. Hornblendite inclusions are present in granite near the south end of Baril Bay. Therefore, the granite is believed to be the younger intrusion. Ultrabasic and basic rocks have not been observed in association with syenite.

The rocks may be classified into three general types: peridotite, hornblendite, and feldspathic hornblendite.

Most of the peridotite occurs in the central part of the largest body (*see* geological map opposite). Here it contains 10–30 percent olivine, 35–50 percent clinopyroxene (diopsidic augite), and 20–40 percent hornblende, and perhaps, as such, it should be called hornblende peridotite. Accessory minerals are minor primary magnetite and disseminated nickeliferous pyrrhotite and chalcopyrite. Throughout the body, olivine crystals are about two-thirds altered to serpentine and secondary magnetite; in places, the alteration is complete. As a rule, clinopyroxene is not affected by serpentinization, but it is altered to hornblende. The rock is medium-grained and massive. Its weathered surface is brown and has a distinctive roughness because the serpentinized olivine weathers more rapidly than pyroxene and hornblende. In a fresh surface, pyroxene and hornblende are

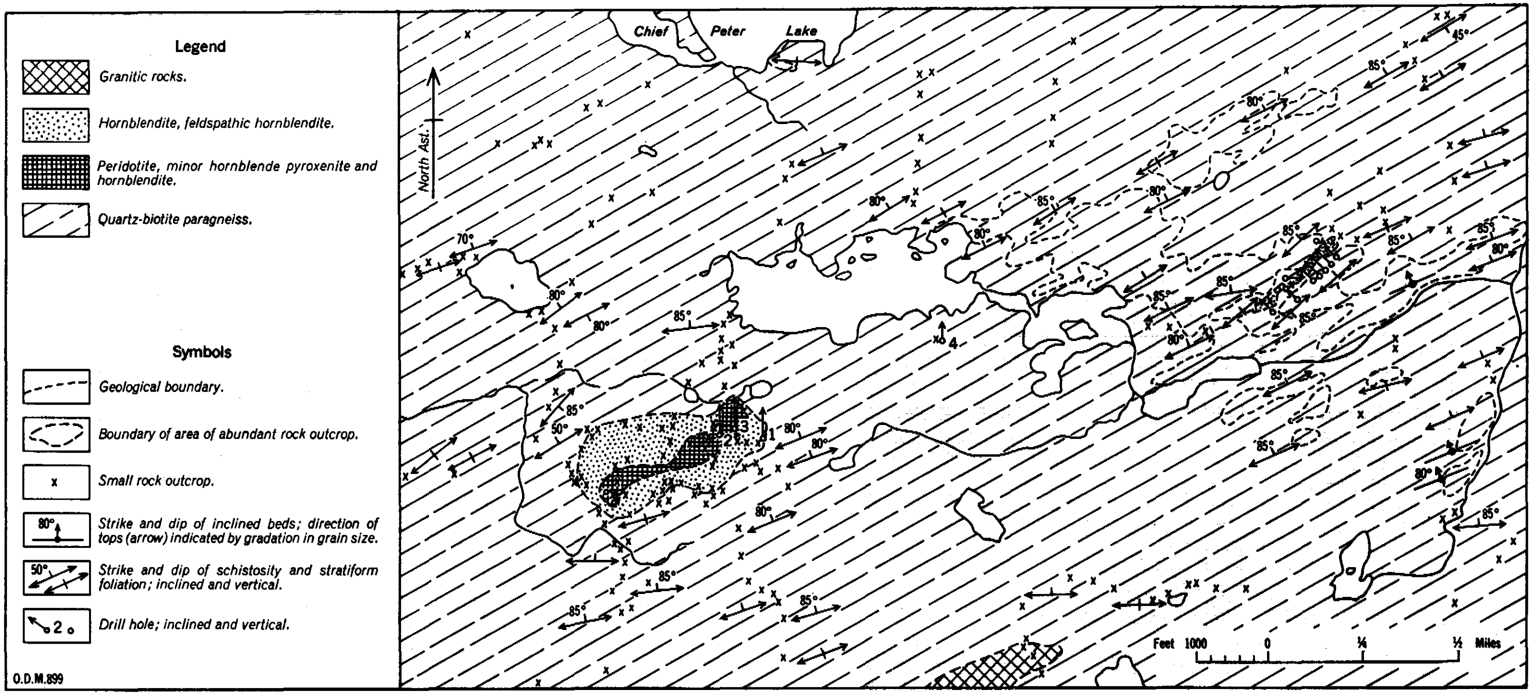
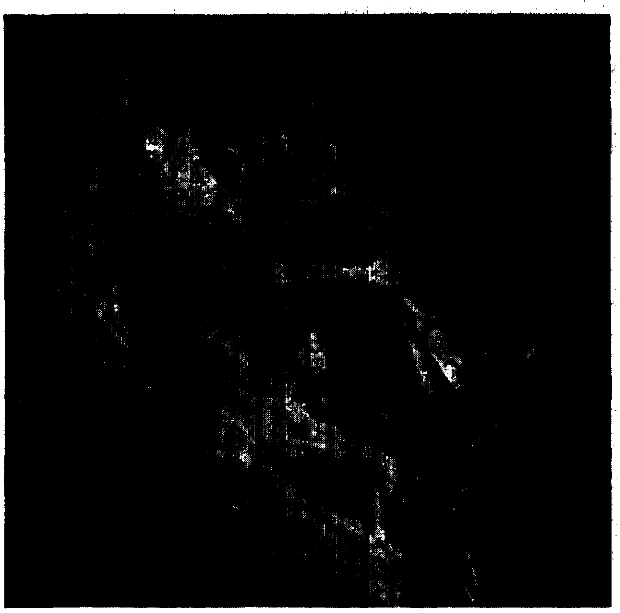


Figure 3 — Geological map showing the mafic igneous rocks near Chief Peter Lake and locations of diamond-drillholes.



Hornblendite inclusions in quartz diorite along the North Arm of Bedivere Lake.

greenish grey, and olivine appears as a dark mottling due to the presence of fine-grained secondary magnetite in the serpentine.

Peridotite in the smaller occurrences is also composed of olivine, clinopyroxene, and hornblende. Hypersthene, virtually absent from the main mass, is present locally. Chlorite, biotite, calcite, iddingsite, talc, serpentine, and magnetite are the main alteration minerals.

Hornblendite is the most widely distributed ultrabasic type. It is medium- to coarse-grained. In places, the rock consists entirely of hornblende, but generally it contains 2–10 percent biotite. Sphene, magnetite or ilmenite, and iron sulphides, are rare accessories, and chlorite is a minor alteration mineral. Gradation from peridotite to hornblendite, as revealed in diamond-drill core, is marked by a gradual decrease and disappearance of olivine and pyroxene. Augite may remain locally but is much altered to hornblende. An exceptional variety of hornblendite is found as a small body just north of Baril Lake and consists of large hornblende crystals enclosing small grains of olivine, augite, and hypersthene. Hornblendite is greenish-grey except in association with peridotite, where it is lighter-coloured.

Feldspathic hornblendite generally contains 10–20 percent sodic plagioclase (oligoclase). The maximum feldspar content is about 40 percent; the minimum is marked by gradation into the non-feldspathic variety. The hornblende is greenish black in hand specimens; in thin sections, it is darker than that in either of the other mafic intrusive rock units. Its common grain-size is ¼ to ½ inch but in a minor pegmatitic variant of the rock, prismatic hornblende crystals have lengths of 2–3 inches. Plagioclase is interstitial and, in most places, is partly altered to sericite. Augite is rare. Sphene, apatite, magnetite or ilmenite, and sulphide minerals, are accessories.

Rock units mapped under the names hornblendite and feldspathic hornblendite probably do not contain an appreciable amount of peridotite. Many of the smaller bodies are composed only of hornblendite, but the feldspathic variety does not seem to occur alone. Drill core from the peridotite unit of the largest intrusion (Figure 4) shows that it consists of a complex intermixture of about equal amounts of peridotite and hornblendite with local feldspathic hornblendite amounting to 3–5 percent.

Chemical analyses of specimens of the principal rock units and their mineralogy are given in the accompanying table. Chemically, the peridotite is richer

CHEMICAL COMPOSITION AND MINERALOGY OF SPECIMENS OF THE MAFIC-RICH INTRUSIVE ROCKS
(Chemical Analyses by Laboratory Branch, Ontario Department of Mines)

	1	2	3	4	5
	Chemical Analyses (percent by weight)				
SiO_2	41.77	43.46	50.52	45.64	49.99
Al_2O_3	1.99	2.93	2.73	16.12	11.52
Fe_2O_3	5.33	6.21	2.38	1.04	1.42
FeO	8.33	5.20	6.00	7.20	9.26
MgO	27.07	25.56	18.88	12.70	10.60
CaO	9.04	10.61	13.88	10.28	10.35
Na_2O	0.24	0.31	0.80	2.87	2.50
K_2O	trace	0.11	0.21	0.80	0.76
H_2O+	4.10	3.95	0.77	1.00	0.84
H_2O-	0.04	0.02	nil	0.02	0.01
P_2O_5	trace	trace	trace	0.15	0.23
TiO_2	0.18	0.14	0.15	1.26	0.83
Cr_2O_3	0.39	0.43	0.38	0.25	0.08
MnO	0.18	0.18	0.18	0.12	0.14
V_2O_3	0.01	0.02	0.02	0.05	0.04
CO_2	0.39	0.68	1.69	0.57	0.29
Sulphur (S)	—	—	0.20	—	1.14
Totals	99.06	99.81	98.79	100.07	100.00
	Mineralogy (percent by volume)				
Olivine	12.7	8.7	—	—	—
Clinopyroxene	25.7	31.3	—	—	0.1
Hornblende	26.3	35.5	98.6	78.8	62.4
Plagioclase	—	—	—	16.6	33.5
Biotite	—	—	0.6	1.2	0.6
Serpentine	23.7	18.2	—	—	—
Magnetite	11.2	5.7	—	—	—
Chlorite	0.4	0.3	—	2.4	—
Talc	—	0.3	—	—	—
Calcite	—	—	—	0.7	—
Sphene	—	—	trace	0.3	1.6
Apatite	—	—	trace	—	0.6
Sulphide	—	—	0.8	—	1.2
Totals	100.0	100.0	100.0	100.0	100.0

1—Peridotite. Specimen No. I 60-94, from the west mafic intrusion near Chief Peter Lake.

2—Peridotite. Specimen No. I 60-87, from the west mafic intrusion near Chief Peter Lake.

3—Hornblendite. Specimen No. I 60-83, from the west mafic intrusion near Chief Peter Lake.

4—Feldspathic hornblendite. Specimen No. I 60-85, from the west mafic intrusion near Chief Peter Lake.

5—Finer-grained feldspathic hornblendite. Specimen No. I 60-114, from the border zone of the east mafic intrusion near Chief Peter Lake.

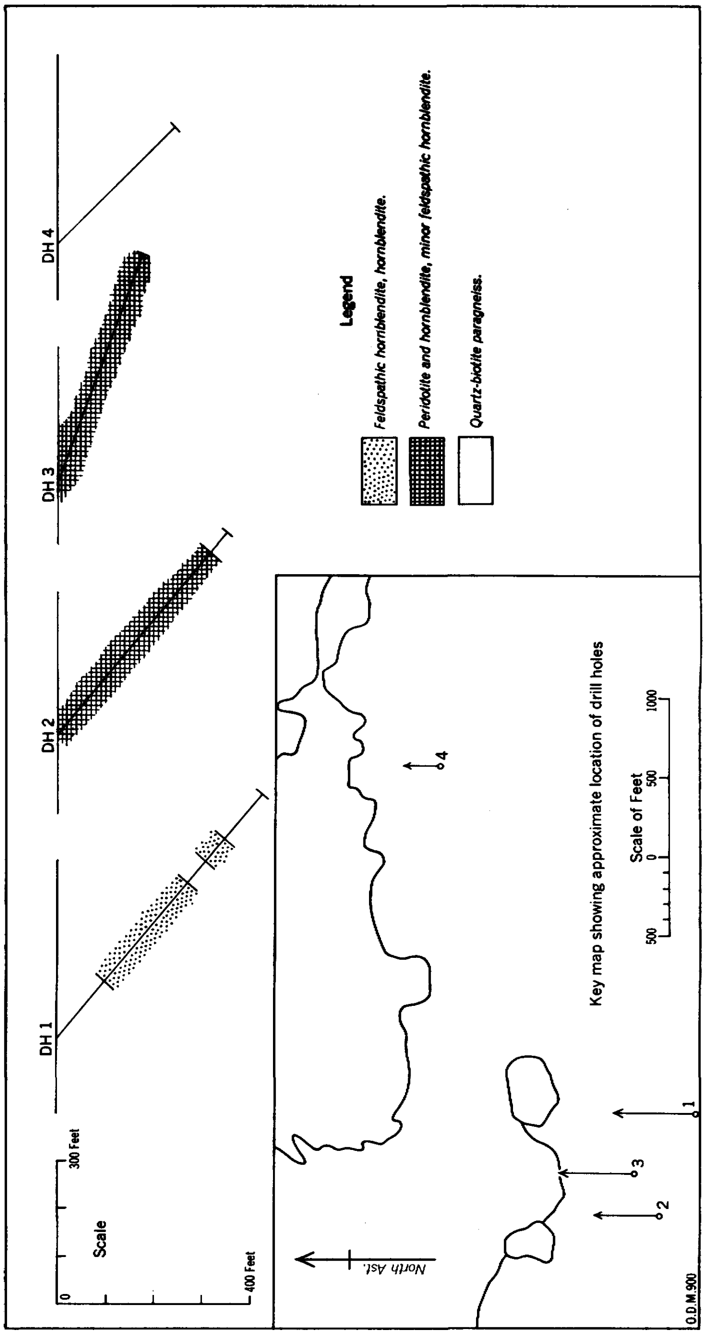


Figure 4 — Graphic logs of diamond-drillholes near the west mafic intrusion.

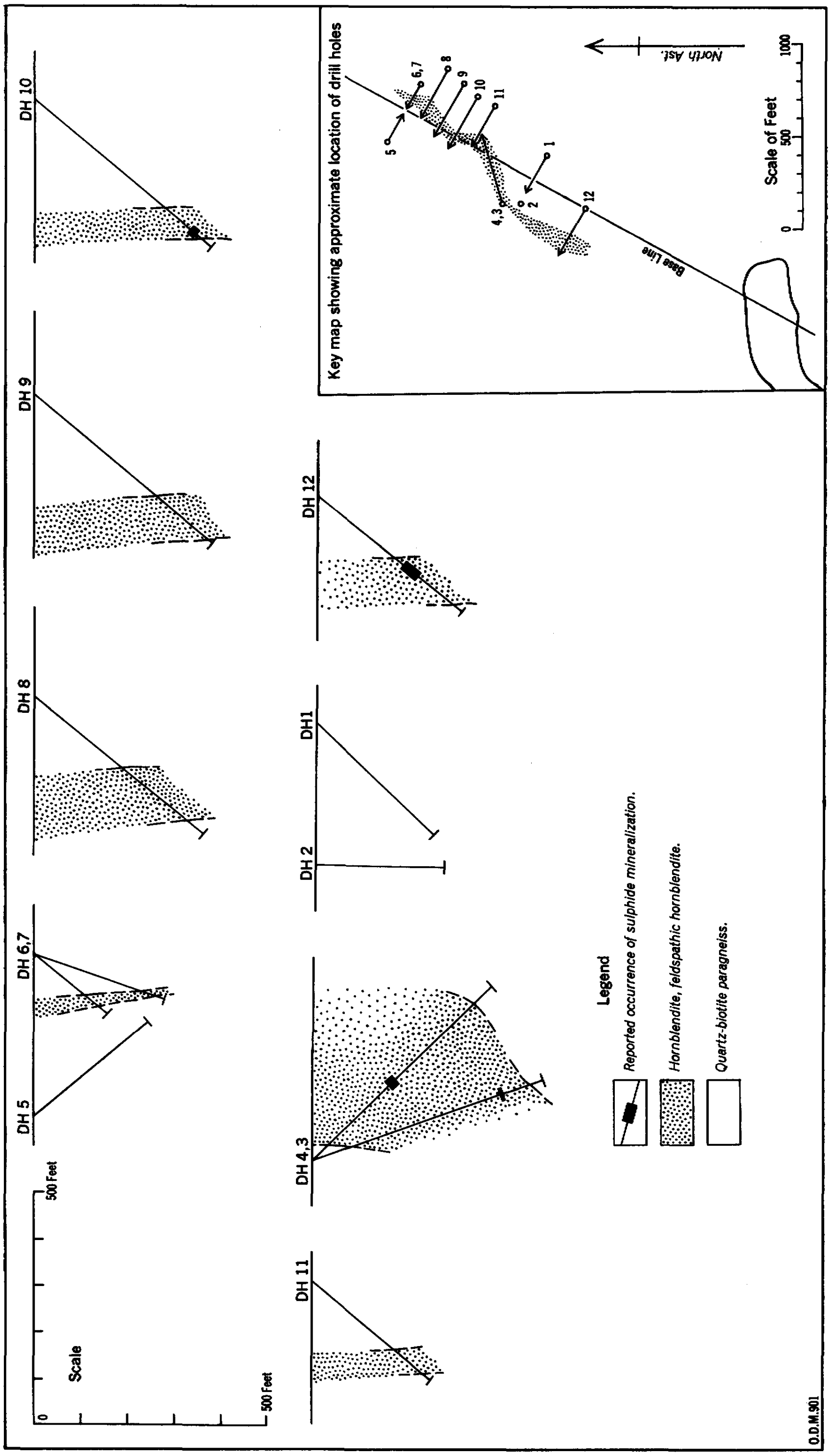


Figure 5 — Graphic logs of diamond-drillholes near the east mafic intrusion.

in CaO than most peridotitic rocks. Hornblendite is similar to the peridotite, except for MgO. The feldspathic hornblendite is much like olivine gabbro but is richer in Al_2O_3. This unit might have been called hornblende gabbro, but that name is not favoured because:

(1) The rock has less plagioclase feldspar and more mafic minerals than normal gabbro.

(2) The plagioclase composition is not typical of gabbro.

(3) The rock is gradational into true hornblendite.

The mineral composition probably developed because the magma had a high water content during solidification.

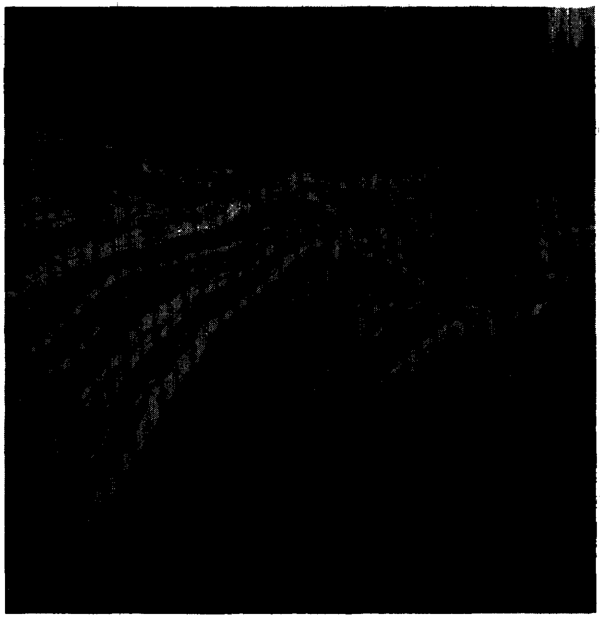
In the available core from diamond-drillholes in the smaller (east) mafic intrusion near Chief Peter Lake (Figure 5), the contact of feldspathic hornblendite and quartz-biotite paragneiss is visible at four places. In two of the exposures, the igneous rock is distinctly finer-grained for a 1-foot width adjacent to the contact; the apparent grain-size is ⅛ to ¼ inch as compared to ¼ to ½ inch within the intrusion. The finer zone may be the result of chilling of the magma and, as such, may have the composition of the magma. The chemical analysis and mineralogy of a specimen are given in column 5 of the table on page 13. Chemically, it is very like olivine basalt or gabbro, but it is not intermediate in all respects to the other analyzed mafic rocks; for example, it is the richest in SiO_2 and the poorest in Al_2O_3. If it does have the composition of the magma, then more siliceous differentiates than the types analyzed must have formed, but they are not known. On the other hand, the rock may owe its composition to the fact that the magma along the contact assimilated some of the paragneiss.

Algoman ?

GRANITIC ROCKS

The areas north and south of the Keewatin-Couchiching belt are primarily underlain by rocks that may be described by the general term, granitic. Although the distinction is not especially obvious in the field, microscopic study of a representative suite of specimens has shown that the rocks in the two areas have markedly different contents of potash feldspar (Figure 6). According to the classification of Williams, Turner, and Gilbert (1954), the northern occurrences are dominantly of quartz diorite composition whereas the southern occurrences are true granite.

The quartz diorite generally is medium-grained and shows a grey weathered surface and a greenish or buff-grey fresh surface. It ranges from massive to markedly gneissic with prominent mafic-rich bands that appear to be relict after paragneiss (*see* photo, p. 17). The specimens of more massive rock that were examined microscopically contain 15–40 percent quartz, 40–65 percent plagioclase (oligoclase-andesine) and, with the exception of one specimen, traces to 6 percent potash-feldspar (microcline). The plagioclase commonly is slightly altered to saussurite. Other minerals were observed in amounts of 4–18 percent and include biotite, chlorite, and epidote with less common hornblende, muscovite, sphene, apatite, and opaque oxide minerals, either magnetite or ilmenite. Potash feldspar is locally more abundant, and at these places, the rock is granodiorite.



Migmatitic quartz diorite gneiss, Rock Bay, Lac des Mille Lacs.

The principal xenolithic inclusions in the quartz diorite are of metabasalt and hornblendite (*see* photograph on page 12). In the shoreline exposures on Boot Bay in Lac des Mille Lacs, the quartz diorite is cut by dikes of Keweenawan diabase.

Most of the granitic rock in the southern part of the map-area is medium-grained, but pegmatitic and aplitic variants are present. The granite is dominantly grey but, locally, particularly on the projected strike of the two elongate syenite bodies, it is buff to pink. The specimens examined microscopically contain 27–33 percent quartz, 23–35 percent albitic plagioclase, and 32–41 percent microcline. Other minerals are biotite, chlorite, muscovite, and magnetite or ilmenite. Their total amount ranges from traces to 6 percent. As mentioned previously, this granitic rock is commonly intermixed with quartz-biotite paragneiss forming a *lit par lit* injection gneiss or migmatite. It is in contact with the metabasalt in the eastern part of the map-area and undoubtedly is younger than the basalt although the contact may be faulted. The ultrabasic rocks are probably older than the granite. Although the age-relationship of granite and syenite is not known, the two rock types are spatially associated, both are rich in potash feldspar, and the granite is pinkest near the red syenite; therefore, they are probably genetically related and close in age.

The relationship of quartz diorite and granite is unknown inasmuch as they have not been recognized in contact, being everywhere separated by the Couchiching-Keewatin belt. Because the two masses are so distinctly different mineralogically, appreciably different ages seem possible. It is interesting that their dating may bear directly on the Couchiching problem (*see* page 20). Thus, it may be argued that the older granitic rock was emplaced in the lower part of the stratigraphic section and caused it to tilt so that the younger pluton could come into contact with the upper part of the section.

RED HORNBLENDE SYENITE

Four major bodies of syenite are shown on the map. The largest and smallest are oval-shaped and are situated just southeast of Edar Lake; the former is approximately 2¾ miles long and 1¼ miles wide. The other two bodies are near the east end of Windigoostigwan Lake. They both are markedly elongate in an east-southeast direction. One is 3 miles long and 500–1,000 feet wide; the other is 2½ miles long and 700–1,500 feet wide. Syenite also exists in a single outcrop along the south side of Baril Bay in the east-central part of the map-area.

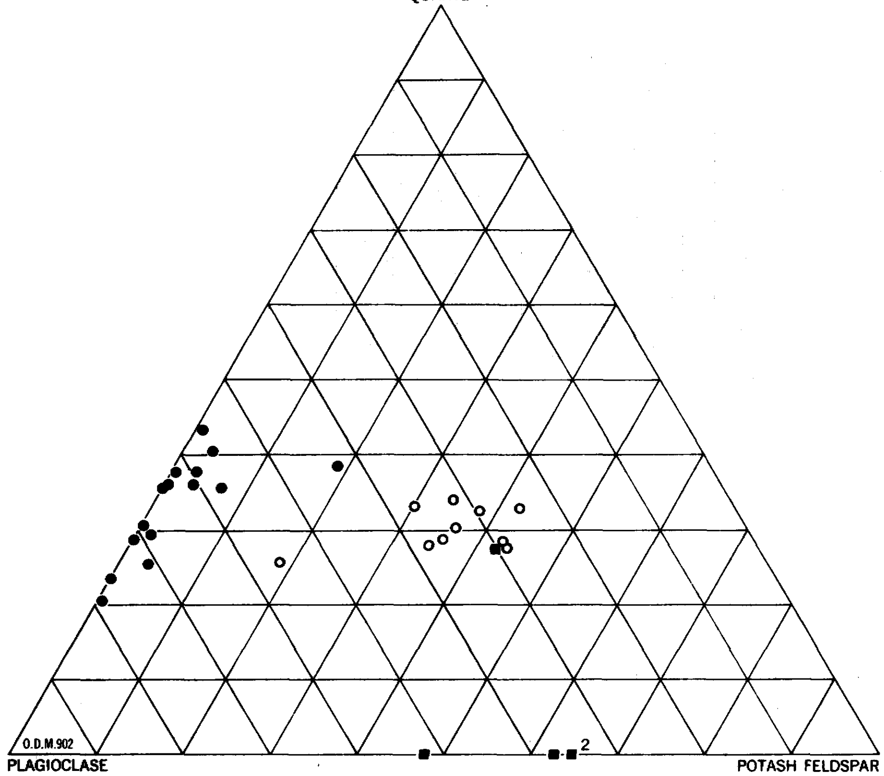


Figure 6 — Comparison of the two areas of granitic rocks, and the syenite on the basis of their volumetric proportions of quartz, plagioclase, and potash feldspar.

The rock is essentially the same in all occurrences. It is pink to red, lightly spotted with dark minerals, and is massive or weakly gneissic. Feldspar is found in amounts of 90–95 percent and, in hand specimens, has a visible grain-size of ⅛ to ¼ inch. Under the microscope, it is seen to consist of microcline and albite, the former making up ½ to ⅔ of the total (Figure 6). The textural relationship of the two kinds varies from a complex perthitic intergrowth to separate subhedral grains. Generally, the coarser grains are surrounded by finely granular albite, or albite and microcline. A light dusting of hematite within and on the surface of grains accounts for the reddish colour of the syenite. Hornblende, extensively altered to chlorite, is the principal dark mineral; epidote, sphene, ilmenite or magnetite, and apatite are accessory minerals. Feldspathoids have not been observed. Quartz is generally absent; however, in the marginal parts of some of the bodies, it is present in amounts as large as 30 percent.

The main bodies of syenite are emplaced partially to wholly in quartz-biotite paragneiss, and they contain sparse inclusions of the paragneiss. The elongate bodies near Windigoostigwan Lake are adjacent to granite, but the contact of the two rock types has not been observed and, therefore, their age relationship is in doubt. They are probably genetically related, for reasons given in the discussion of the granitic rocks. The elongate syenite bodies resemble dikes in the granite and paragneiss and, therefore, may be the youngest of these three rock types.

Keweenawan

QUARTZ DIABASE DIKES

Several diabase dikes are exposed in the shoreline outcrops on Boot Bay. The two larger ones have widths of 100–200 feet; the remainder are generally less than 10 feet wide. Most of the dikes trend north-south and, apparently, they occupy a joint system that is responsible for the topographic location of Blind Bay and the south arm of Baril Bay.

The dike rock is generally medium-grained, massive, and dark greenish-grey. Microscopic examination has shown that, except for the very fine-grained, chilled-looking material, most of the diabase is considerably altered. Apparently, it was originally comprised of a subophitic intergrowth of about equal amounts of plagioclase (An_{45}–An_{55}) and augite, with 5–15 percent interstitial quartz, 5–10 percent titaniferous magnetite, and accessory pyrite. Plagioclase is now largely saussuritized, augite is partly to completely replaced by hornblende, and the magnetite is reduced to a reticular growth of ilmenite and minor sphene. With more extreme alteration, augite and plagioclase are replaced by hornblende, chlorite, epidote, and albite.

Pleistocene

The main Pleistocene deposit is boulder till, representing the ground moraine of continental glaciation. The till is apparently thickest in the southeastern part of the map-area. Small deposits of sandy gravel of alluvial origin exist along the road between Owakonze and Edar Lake and have been used for surfacing the road. What is apparently a small esker lies about one mile west of Boot Bay.

The direction of movement of the glaciers, as recorded by striae, was about S. 15°–30° W.

Recent

Recent deposits consist of local swamp accumulations, and beach and stream sands. Excellent beaches are found at Bedivere Lake and at the east ends of Windigoostigwan and Baril lakes.

Structure and Stratigraphy

In most respects, the geological map appears to present a relatively simple structural and stratigraphic picture. The principal map rock-units are easily distinguishable and have discrete occurrence. Except for the quartz diabase dikes, all intrusive bodies are concordant with the foliation in the sedimentary and volcanic rocks. Faulting that is transverse to the general structural trend is apparently not major, although the nature of the bedrock exposure and the detail of the mapping do not permit detection of small displacements. The principal joint systems are probably shown by the pattern of the lakes.

The main problems are in connection with the quartz-biotite paragneiss and the metamorphosed volcanic rocks and are concerned with their contact relationship and the relative ages of their premetamorphic forms. The latter is, again, the Couchiching problem (Young 1960, pp. 1–17)[1]. The Couchiching problem is concerned with the relative ages of rocks in areas west of Lac des Mille Lacs that have been variously assigned to the Couchiching, Keewatin, and Seine series.

In the present map-area, the basic volcanic rocks are bounded on their southern side by paragneiss and by granite. The entire boundary, regardless of rock type, is extremely regular for the full 17-mile width of the map-area and is partially, if not completely, marked by a zone of chlorite schist. In the paragneiss, the stratiform foliation is not everywhere parallel to the contact but commonly trends more northeasterly by 10–40 degrees. Probably much of this discordance is due to deformation by the bodies of syenite emplaced in the paragneiss. However, in the Sabawi Lake area immediately west, Hawley (1930, pp. 1–58) has shown that the same contact of sedimentary and volcanic derivatives is regular and marked by chlorite schist, and he notes a similar discordance in the paragneiss foliation. He believed these features indicate a faulted contact, and the same interpretation applied to the Lac des Mille Lacs area seems reasonable. In this respect, it is notable that silicified-looking rocks that lie in or near the contact zone along Baril Bay appear, in thin sections, to be crushed and partially mylonitized. The direction and extent of relative displacement due to faulting is not known. According to Tanton (1939), the volcanic and sedimentary rocks in this belt maintain a similar spatial relationship for more than 100 miles, and this suggests to the present author that faulting along their boundary, if it has occurred, simply may have followed a stratigraphic contact. If so, definite evidence bearing on displacement could be extremely difficult, if not impossible, to obtain.

Almost all geologists who have reported on the Archean rocks, in the region between Rainy Lake and Lake Superior, have assigned the basic volcanic rocks to the Keewatin, and this procedure is adopted here. Pillow structures in the volcanic rocks were too rare and too poorly exposed to be useful for determining the top of the section. The only evidence gathered in the Lac des Mille Lacs area that indicates the relative age of paragneiss and Keewatin volcanic rocks is the determination of a few tops of beds in the paragneiss, using grain-size gradation. In view of the degree of metamorphism, most of these determinations, if taken individually, are tenuous. However, they all indicate tops to the north. The stratification in the paragneiss is generally vertical or steeply inclined to the north, and evidence of isoclinal folding is absent. These features suggest that the sedimentary sequence was originally beneath the volcanic rocks; therefore, Tanton is followed, and the paragneiss is assigned to the Couchiching. It is noted, however, that Hawley placed the same sedimentary unit in the Seine Series above the Keewatin.

ECONOMIC GEOLOGY

Mineral deposits of commercial value have not been found in the area to date.

The best prospects are occurrences of nickel-copper sulphides in the Pre-Algoman(?) mafic intrusions south of Chief Peter Lake. These, however, have been known for many years, having been reported on Tanton's 1938 map. They

[1]A comprehensive bibliography on the Couchiching problem is given by W. L. Young.

have been investigated by trenching and test-pitting, and some by diamond-drilling, but sufficient mineralization to warrant further development has not been found. Aeromagnetic anomalies over the ultrabasic bodies (Figure 2) seem mainly to be caused by disseminated magnetite. Available information on the of the diamond-drilling is summarized in Figures 4 and 5. The rock names used in the company drill logs have been modified to be consistent with microscopic work on some of the drill core and with the nomenclature used in this report. Unfortunately, complete information is not available on the grade and extent of sulphide mineralization. The results of analyses of grab samples of better-looking material collected from pits are shown in the accompanying table. Ore minerals identified microscopically in these samples are pyrrhotite, chalcopyrite, pyrite, pentlandite, and magnetite. They normally exist as intergrowths disseminated in the mafic-rich intrusive rock. The percentage of actual sulphides in most of the samples is relatively low, but the analyses suggest that they contain a good concentration of nickel and copper. The occurrence of platinum and palladium probably is not economically significant in itself but is notable in that these metals also are present in reportedly sizeable deposits of nickel-copper sulphides associated with peridotite near the west end of Lower Shebandowan Lake (Cross 1920, pp. 225-234: Watson 1929, pp. 128-149). The peridotite near Chief Peter Lake is, in some respects, similar to that occurring at Shebandowan, and the possibility that it may contain more sulphide mineralization at depth is not precluded.

Mineralization of economic interest is not known to occur in association with the syenite. The aeromagnetic map (*see* figure on page 3) shows a broad anomaly over the largest body, but the anomaly is apparently due to disseminated magnetite. Records of surveys of this body by ground magnetometer and self-potential methods, on file in the office of the Resident Geologist at Port Arthur, do not show marked anomalies.

Small amounts of pyrite mineralization have been noted in the area, particularly in the basic volcanic rocks. The localities are denoted on the map by the letter S. Samples were collected from three of these occurrences and were tested for gold, platinum, and palladium. The results showed only a trace of gold in two samples and 0.01 ounces per ton in the third. The other metals were not detected.

ANALYSES OF GRAB SAMPLES OF SULPHIDE-BEARING ROCKS FROM THE MAFIC-RICH INTRUSIONS NEAR CHIEF PETER LAKE
(Analyses by the Laboratory Branch, Ontario Department of Mines)

Occurrence and Sample Number	Rock Type	Copper	Nickel	Gold	Platinum	Palladium
		percent by weight		ounces per ton		
West Intrusion:						
I 60-54	Peridotite	0.81	0.24	trace	0.03	0.04
East Intrusion:						
I 60-104	Hornblendite	1.06	0.26	trace	none	trace (less than 0.01)
I 60-58	Feldspathic hornblendite	2.95	trace	trace	0.30	0.06

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INDEX

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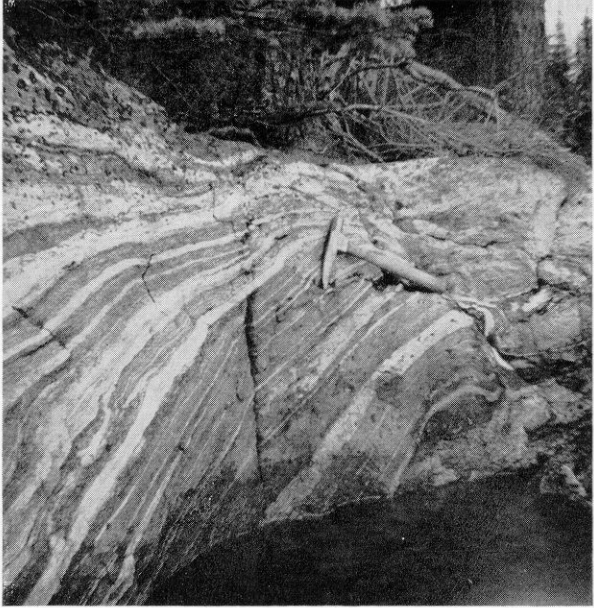
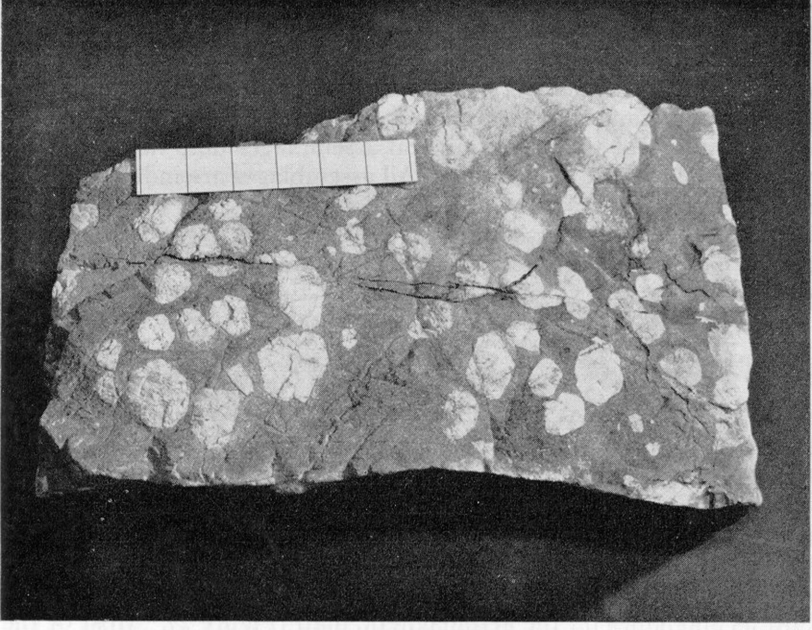
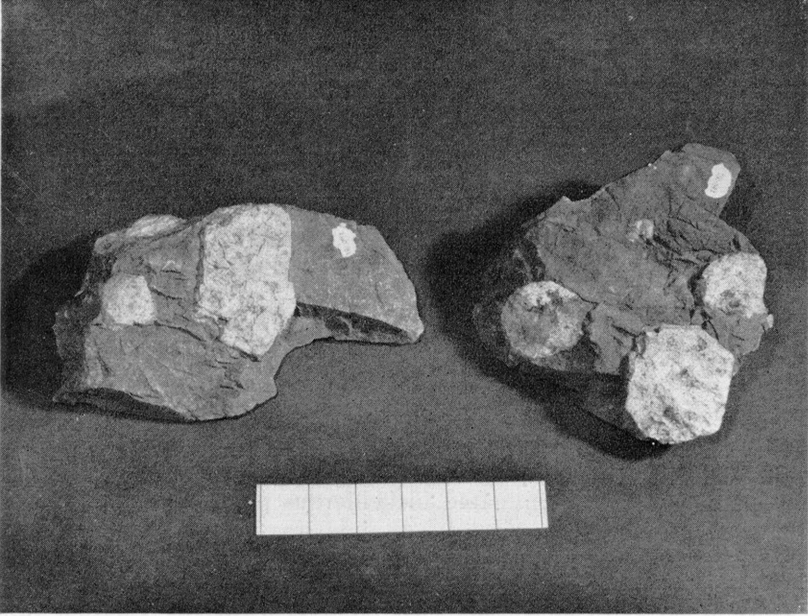


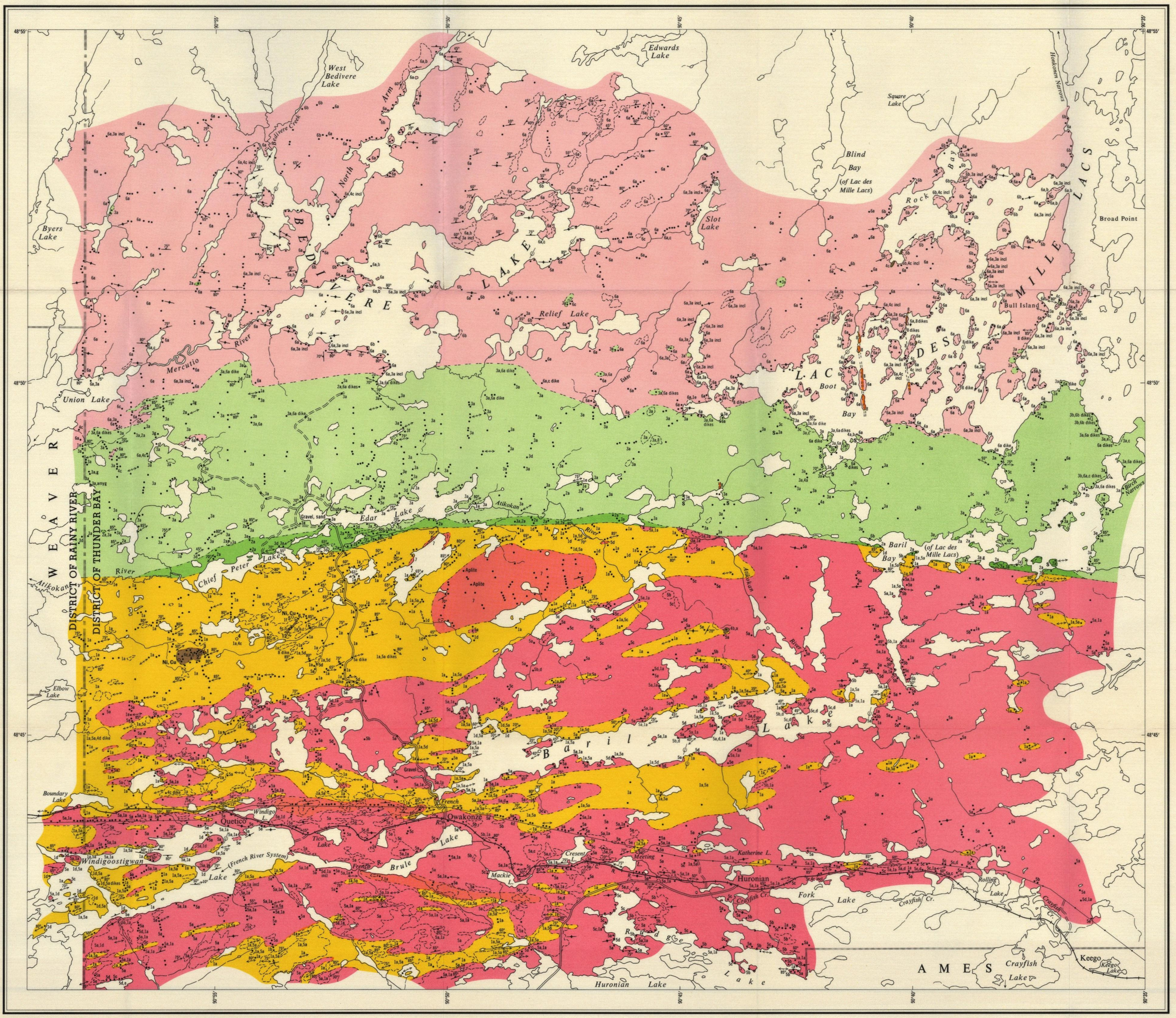


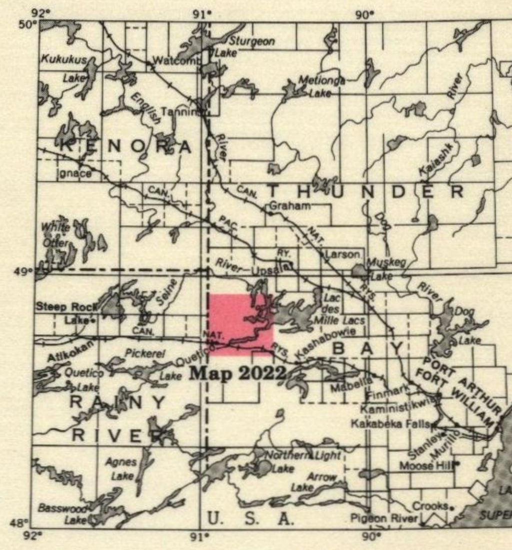


Map 2022
Western Lac des Mille Lacs Area

ONTARIO
DEPARTMENT OF MINES

HON. G. C. WARDROPE, *Minister of Mines*
D. P. Douglass, *Deputy Minister* M. E. Hurst, *Director, Geological Branch*





Scale 1 inch to 50 miles

SYMBOLS

- Muskeg or swamp with boundary.
- Railway.
- Electric power transmission line.
- Motor road.
- Wagon road.
- Glacial striae.
- Small rock outcrop.
- Boundary of rock outcrop.
- Geological boundary.
- 85° Strike and dip of bedding, direction of top unknown.
- Direction in which inclined beds face as indicated by gradation in grain size.
- Direction in which lava flows face as indicated by shape of pillows.
- 70° Strike and dip of schistosity and stratiform foliation.
- Strike of vertical schistosity and vertical stratiform foliation.
- Strike of schistosity and stratiform foliation, dip unknown.
- 80° 10° Strike and dip of schistosity; trend and plunge of lineation.
- 75° Strike and dip of gneissosity.
- Strike of vertical gneissosity.
- Horizontal gneissosity.
- 60° 15° Strike and dip of gneissosity; trend and plunge of lineation.
- 80° 15° Strike of vertical gneissosity; trend and plunge of lineation.
- 30° Lineation plunge known, plunge unknown.
- Drag-folds. Arrow indicates direction of plunge.
- Building.
- Gravel pit.
- o3 Drill hole, inclined, with number.
- S Sulphide mineralization.
- q.v. Quartz vein.

LEGEND

CENOZOIC

RECENT
Peat, river deposits, beach deposits.

PLEISTOCENE
Boulder till, silt, sand, gravel.

GREAT UNCONFORMITY

PRECAMBRIAN

KEWEENAWAN

8 *Quartz diabase.*

INTRUSIVE CONTACT

ALGOMAN (?)

7 *Red hornblende syenite.*

6c *Pegmatitic granite, granite pegmatite.*
6b *Migmatitic quartz diorite, quartz diorite gneiss.*
6a *Quartz diorite, minor granodiorite and granite.*

5e *Migmatitic granite, granite gneiss.*
5d *Pegmatitic granite, granite pegmatite.*
5c *Pink granite.*
5b *Pinkish-grey granite.*
5a *Grey granite, minor granodiorite and quartz diorite.*

PROBABLE INTRUSIVE CONTACT

PRE-ALGOMAN (?)

4c *Feldspathic hornblendite, local hornblende diorite.*
4b *Hornblendite, pyroxene hornblendite, biotitic hornblendite.*
4a *Peridotite, serpentinized peridotite.*

INTRUSIVE CONTACT

KEEWATIN (?)

3a *Metabasalt.*
3b *Metamorphosed pillow basalt.*
3c *Metamorphosed porphyritic basalt.*
3d *Meta-andesite, metadacite.*
3e *Metamorphosed tuff breccia or agglomerate.*
3f *Tuffaceous schist, locally garnetiferous.*
3g *Granitized basalt.*

2a *Chlorite schist, chlorite-muscovite schist.*

COUCHICHING (?)

1a *Quartz-biotite paragneiss.*
1b *Garnet-quartz-biotite paragneiss.*
1c *Staurolite-quartz-biotite paragneiss.*
1d *Migmatitic quartz-biotite paragneiss.*
1e *Quartz-muscovite schist.*
1f *Cummingtonite-quartz-biotite paragneiss.*

SOURCES OF INFORMATION

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Cartography by F. W. Love, Ontario Department of Mines, 1961.

Base map derived from maps and photographs of the Forest Resources Inventory, Ontario Department of Lands and Forests with additional information by T. N. Irvine.

Magnetic declination approximately 3° East, 1960.

Published 1962

Map 2022

WESTERN LAC DES MILLE LACS AREA

DISTRICT OF THUNDER BAY

Scale 1 : 63,360 or 1 Inch to 1 Mile

Chains 80 40 0 1 2 3 4 5 Miles
Feet 10,000 0 10,000 20,000 Feet
Metres 1000 0 1 2 3 4 5 6 Kilometres