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Geology of the Muskratdam Lake Area

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No 5002

GEOLOGY OF THE MUSKRATDAM LAKE AREA

MARCH 1, 1967

by L.D. Ayres

ONTARIO
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ONTARIO DEPARTMENT OF MINES

Geological Report No.

Geology of

Muskratdam Lake Area.

District of Kenora (Patricia Portion)

by

L.D. Ayres

Submitted Dec. 6, 1966.

Topographic Names

Most of the topographic names shown on the preliminary maps were provisional, and many have since been changed. The new names are used in this report, and name changes are shown in the following list.

Preliminary Maps	Report
Kippen Lake	Red Sucker Lake
Kippen Creek	Red Sucker Creek
Major Lake	Axe Lake
Throop Lake	Hill Lake
Throop Creek	Hill Creek
McCaslin Lake	Small Axe Lake
Cooney Lake	Rain Lake
Laycock Lake	Woodpeck Lake
Hillis Lake	Beaverskin Lake
Hillis River	Axe River
Sagle Lake	Moose Lake
Sagle Creek	Rain River
Watchhorn Lake	Pipe Lake
Marchand Lake	Pike Lake
Kindree Lake	Lookout Lake
Ray Lake	Clear Lake
Legacy Lake	Sick Lake
Legacy Creek	Sick Creek
Columbus Lake	Narrows Lake
Beaumont Island	Sandhill Crane Island
Woodcock Bay	Blackwater Bay
King Bay	Spearfish Bay
Munekun River	Wolf River between Munekun and Misquamaebin Lakes Rain River between Munekun Lake and junction; Tobogan River south of junction
Hindle River	Pike River (in part)
Cupido Island	Small Fish Island
Puttock Creek	Willow Creek
Puttock Lake	Willow Lake
Martyn Bay	Fox Bay
Martyn River	Fox River
Phair Lake	Nekence Lake
Phair Creek	Nekence Creek
Rosie Lake	Namaybin Lake
Tyo Lake	Wagush Lake

Table of Contents

Tables*

* Tables can be found at the rear of this report.

Figures *

* Figures can be found at the rear of this report

Abstract

The Muskratdam Lake area comprises 1700 square miles in the Patricia Portion of the District of Kenora about 150 miles north-northwest of Pickle Lake, the closest road.

Early Precambrian, volcanic, sedimentary, and gabbroic rocks which were variously metamorphosed to the greenschist, almandine amphibolite, and hornblende hornfels facies form two, isoclinally folded belts which underlie thirty percent of the area and are bordered by composite granitic batholiths. The east-trending, Muskratdam Lake belt is at least 65 miles long, ranges in width from 4 to 11 miles, and contains an 18,500-foot thick, metavolcanic-metasedimentary sequence which is characterized by marked facies changes: six formations have been recognized. In the western part of the belt, the major rock types, in order of decreasing abundance, are felsic metavolcanic flows and pyroclastic rocks; mafic metavolcanic flows: metagreywacke and metasiltstone; intermediate metavolcanic flows and pyroclastic breccia; slate; metaconglomerate; marble and calc-silicate rocks; and metamorphosed iron formation and ferruginous metasediments. In the eastern part of the belt, mafic metavolcanic flows form most of the sequence. The north-trending, Rottenfish River belt, which is separated from the west end of the Muskratdam Lake belt by four miles of granitic rocks and by several faults, is at least 15 miles long, has an average width of 2 miles, and contains a 6,000-foot thick, dominantly mafic, metavolcanic sequence.

Slightly differentiated, metagabbro and metadiorite sills which have an average thickness of 2000 feet and a maximum

thickness of 7800 feet intruded the metavolcanic-metasedimentary sequence in both belts. At least one sill was intruded after the initiation of folding.

The belts were intruded by two, composite, granitic batholiths which underlie seventy percent of the map-area, range in composition from diorite to quartz monzonite, and are dominantly trondhjemite and quartz monzonite.

Late, diabase dikes trend north-northeast and west-northwest.

Thick Pleistocene drift covers much of the bedrock. An interlobate moraine, ~~and~~ an end moraine, a complex esker system, and numerous drumlins are all related to a southwesterly-moving, ice lobe.

Twenty-two sulphide mineral concentrations were found but contain only trace amounts of economically important elements. Gold has been reported from the area, but ninety-nine sampled quartz veins contained only trace amounts of gold. Several metamorphosed iron formation units were found, and aeromagnetic data suggest that extensive iron formation units are buried beneath glacial drift.

Muskratdam Lake Area

District of Kenora (Patricia Portion)

by

L. D. Ayres[1]

Introduction

General statement

The Muskratdam Lake area comprises about 1700 square miles in the Patricia Portion of the District of Kenora and is bounded by latitudes 53°10' and 53°35' north and by longitudes 91°00' and 92°30' west. Muskratdam Lake, in the centre of the map-area, is about 150 miles north-northwest of Pickle Lake, about 230 miles north of Sioux Lookout, and about 190 miles north-northeast of Red Lake (Fig. 1).

Contoured, topographic maps at a scale of 1:250,000 (about 1 inch to 4 miles) were issued for a large part of northwestern Ontario in 1964 and 1965 by the federal Department of Mines and Technical Surveys. The Makoop and Opasquia sheets of this series provide topographic coverage for the map-area.

The map-area is in the Red Lake Mining Division. There has been no mineral production, and in 1964 no major mineral occurrences were known.

Acknowledgments

Assistance in the field was provided by V. A. Jones, R. A. MacDonald, and B. Mottershead in 1963 and by C. J. Hodgson, M. H. D'Arcy, J.N.O. Hodgson, and L. P. Menec in 1964. Mr. Jones and Mr. C. J. Hodgson, as senior assistants, were responsible for part of the geological mapping. The basemaps were redrawn by C. E. Blackburn and M. E. Coates.

Conversations with W. Cruickshanks, J. R. Cryderman, N. Firth,

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E. Garvey, and H. McLaughlin, who were prospecting in the area in 1963, enabled the author to ~~examine~~ locate several, previously unknown, mineral showings and outcrops. T. Beardy, who resides at Muskratdam Lake and is the only permanent resident in the map-area, also helped the author find several mineral showings.

Means of access

The only rapid access to the area is by float-equipped aircraft which can be chartered at Sioux Lookout, Pickle Lake, or Red Lake (Fig. 1). In addition, regularly scheduled flights to Sandy Lake (about 75 miles west of Muskratdam Lake) originate at both Sioux Lookout and Red Lake and flights to Round Lake (about 35 miles south of Muskratdam Lake) originate at both Pickle Lake and Sioux Lookout. The aircraft on these flights can be chartered from either Sandy Lake or Round Lake.

Many streams in the map-area can be travelled by canoe, but travel on some of the small streams is time-consuming because of numerous rapids and poorly marked portages. All portages located during the mapping are shown on the geological maps. The Severn River, the major waterway, flows along the axis of the Muskratdam Lake metavolcanic-metasedimentary belt for 35 miles, and there are no major rapids between the east end of Muskratdam Lake and the west end of the belt. The only access to the Rottenfish River belt is via the Rottenfish River from Rottenfish Lake; the first rapid on this route is 20 miles north of Rottenfish Lake.

Field methods

In the 1963 and 1964 field seasons about seventy-five percent of the area was covered by traverses along the major rivers and lakes and by pace and compass traverses in forested areas. In forested areas, the spacing between traverses ranged from 1/2 mile to several miles depending on the outcrop density and geological complexity.

Outcrop density is generally low, but most outcrops can be readily located on aerial photographs. Before traversing, all outcrops were outlined on the photographs, and zig-zag traverses were run from outcrop to outcrop; areas between these outcrops were given only cursory examination. In spite of the wide traverse spacing, the author believes that most outcrops in the traversed areas were located and examined. Outcrops known to exist but not examined on the ground are marked by a special symbol on the geological maps.

3A

The remainder of the area was not traversed because of either inaccessibility or lack of outcrop. In the spring of 1964, a Cessna 180 aircraft was used to confirm the lack of outcrop in some parts of the area and to check for outcrop along the shorelines of several lakes.

The basemap is derived from preliminary editions of the Makoop and Opasquia topographic sheets and was provided by the federal Department of Mines and Technical Surveys at a scale of 1:125,000. For mapping purposes the basemap was enlarged to a scale of 1 inch to 1/2 mile (1:31,680) and was redrawn so that topographic details could be added along lake shores and streams. Geological data were plotted in the field on acetate sheets attached to aerial photographs which were flown in 1954 and 1956. In most parts of the area, the photographs were at a scale of 1 inch to 1 mile, but, in areas of high outcrop density, the photographs had been enlarged to a scale of 1 inch to 1/2 mile. The geological data were later transferred to the basemap by means of a sketchmaster.

The 15th base line and meridians south of the base line were surveyed in 1955 and 1957. Mile posts were located in the field only when they occur on outcrops.

Two, uncoloured, preliminary, geological maps at a scale of 1:125,000 were issued in 1964 (P. 213 and P. 256). Nine, uncoloured, preliminary, geological maps at a scale of 1 inch to 1/2 mile were also issued in 1964 (P. 214 to P. 222)and show all outcrops examined during the 1963 field season (Fig. 2). Two preliminary maps at the same scale were issued in 1965 (P. 214, new edition, and P. 295) and show part of the area mapped during the 1964 field season (Fig. 2). More structural symbols are shown on the 1 inch to 1/2 mile, preliminary maps than on the geological maps accompanying this report.

Natural resources

The map-area is in the Northern Coniferous Section of the Boreal Forest Region (Rowe, 1959) and is poorly drained. Black spruce and balsam fir are the dominant tree species: black spruce is found in all parts of the map-area, and balsam fir occurs everywhere except in swamps and muskegs. Stands of tall timber, which include black spruce, white spruce, balsam fir, trembling aspen, and balsam poplar, are restricted to well drained areas along the shores of major streams and lakes. These well drained areas are commonly less than 1/4 mile wide. White birch occurs in stream valleys and on poorly drained, knob and kettle moraine. Jackpine is restricted to well drained glacial features such as eskers, sandy outwash, drumlins, and interlobate moraine. Tamarack and alder are common in the numerous swamps. Rare mountain maple and mountain-ash were found near the south boundary of the map-area.

Commercial fishing for whitefish and pickerel is carried out annually at Muskratdam Lake and at several other large lakes in the area. Pike and pickerel inhabit many of the lakes and rivers, and lake trout occur in some of the larger lakes. Sturgeon are found in the Severn River.

Wild life observed during the two field seasons include bear, beaver, lynx, mink, moose, otter, and squirrel. Birds, including duck and grouse, are abundant in many parts of the area.

Physiography

Elevations in the map-area range from 830 to 1200 feet. The highest hills are Pleistocene eskers and moraine, and the highest elevation is on the Sachigo interlobate moraine at the west boundary of the map-area. Local relief is commonly less than 100 feet.

Most streams in the map-area are part of the Severn River drainage system, but the Rottenfish River and adjacent streams in the northwest part of the area are part of the Sachigo River system. These two rivers join several hundred miles downstream and eventually flow into Hudson Bay.

In general, drainage is poorly established. A large part of the area is swamp and muskeg which ~~covers~~ has developed on Pleistocene, lacustrine silt and clay. The impervious clay prohibits drainage, and the water table is commonly perched on top of the clay. The clay deposits have been dissected by the Severn River, ~~Severn River has cut into the clay deposits,~~ and, along part of the river, well-drained areas extend as much as 1/4 mile inland. At several places adjacent to the river, however, swamps are perched on top of 10- to 15-foot high clay banks. The river is constantly eroding the clay banks causing slumping of the overlying forest (Photo 1). Many of the small lakes and streams have swampy margins, and, because ~~Because~~ of the swamps, camp sites are rare on Rottenfish Lake and along the upper 15 miles of the Rottenfish River.

Many outcrops along lake shore are low and have a clay capping, but inland most outcrops are 10 to 75 feet higher than adjacent swamp and are commonly well exposed. The inland outcrops appear to have been subjected to Pleistocene wave action which removed much of the original drift cover.

In most parts of the area, bedrock has no noticeable effect on topography other than forming rock hills. East of the Rottenfish River, however, many faults are marked by negative lineaments.

Between the middle of June and the middle of September, the water level of the Severn River decreases about 2.5 feet. All outcrops along the river were located in the fall, and some are below water in the spring. Care must be taken when landing aircraft on the river or on Muskratdam Lake because (1) the river contains much suspended clay and visibility is less than six inches, and (2) mud flats, which in September are covered by less than two feet of water, form 1/3 to 2/3 of the river's width. Other streams and lakes are clear or slightly murky and the drop in water level during the summer is less than on the Severn River.

Previous geological work

Four, previous, reconnaissance surveys have included parts of the map-area. In 1886, Low (1887) travelled along the Severn

River and observed the metavolcanic rocks of the Muskratdam Lake belt. In 1912, Tyrrell (1913) found the east end of this belt during an exploration trip along the Schade River. Satterly (1939), in 1937, mapped the Severn River between Sandy Lake and the west end of the Muskratdam Lake belt and also mapped the area near Rottenfish Lake. In 1960 and 1961, Hudec (1964), while mapping the Big Trout Lake area, northeast of the map-area, briefly visited the northeast corner of the present area.

Nearby areas to the south were mapped by Satterly (1941), Carruthers (1961), and Donaldson (1961) and to the north by Satterly (1938).

Aeromagnetic maps were not available when the mapping was done but were issued in 1966 (G.S.C. - O.D.M., 1966a, b, c, d, e, f, g, h, i, j, k, l, m).

General geology

Introduction

In the map-area, Precambrian metavolcanic-metasedimentary-metagabbroic assemblages form two belts which are bordered by composite, granitic batholiths (Fig. 2, 4). The larger belt, the east-trending Muskratdam Lake belt, has been mapped for a strike-length of 65 miles and generally ranges in width from 4 to 11 miles. At the east edge of the map-area, however, the belt abruptly decreases in width from 8 miles to 1/2 mile, and aeromagnetic data (G.S.C.-O.D.M., 1966 l, m) suggest that the belt extends, as a narrow unit, at least 12 miles further east. At its west end, the belt is 8 miles wide and ends abruptly against granitic rocks; part of the western contact is a fault. North of Muskratdam Lake, the belt bifurcates, and a narrow branch extends for eight miles northwest of the main belt.

The smaller, north-trending, Rottenfish River belt is approximately perpendicular to, and is separated by several faults and by 3 to 5 miles of granitic rocks from, the west end of the Muskratdam Lake belt. It has been mapped for a strike-length of 15 miles and appears to be about 2 miles wide although the western edge was defined only in the northern part of the belt. Neither end was found, and correlation with other belts is hampered by several major faults and by lack of outcrop at the north end and in the south half of the belt. The south part of the belt may join the Sandy Lake belt (Satterly, 1940).

The Rottenfish River belt is composed dominantly of mafic metavolcanics and metagabbro with minor felsic and intermediate metavolcanics and rare ferruginous metasediments and metamorphosed iron formation. Stratigraphy and structure are poorly known, but the metavolcanic sequence appears to be about 6000 feet thick and to have been folded into an isoclinal anticline. This sequence cannot be correlated with the western part of the Muskratdam Lake belt where five formations have been tentatively recognized (Fig. 3).

The Muskratdam Lake metavolcanic-metasedimentary assemblage is isoclinally folded and is characterized by marked facies changes. West of the Windigo River fault, the sequence, from bottom to top, comprises the 4000-foot thick lower mafic metavolcanic formation, the 1500-foot thick lower metasedimentary formation, the 6000-foot thick felsic metavolcanic formation, the 3500-foot thick upper mafic metavolcanic formation, and the 5500-foot thick upper metasedimentary formation (Table 1). The figures given above are maximum thicknesses, and the thickest, continuous section is 18,500 feet (Fig. 3). Felsic metavolcanics are thickest in the centre of this segment of the belt but thin, or are absent, at the margins and near the fault. Conversely, mafic metavolcanics are thickest at the margins of the belt and thin, and locally become intermediate in composition, towards the centre. The lower metasedimentary formation is locally absent in the northwest part of the belt.

East of the Windigo River fault, the upper mafic metavolcanic formation predominates and is at least 16,500 feet thick near Munekun Lake. Felsic and intermediate metavolcanics are rare, and thick metasedimentary units occur only near the base of the section along the north edge of the belt between the fault and Munekun Lake.

In both belts metavolcanics range in composition from mafic to felsic: mafic metavolcanics generally form flows; intermediate types form about equal volumes of flows and volcanic breccia; and felsic units are dominantly pyroclastic. In the metasedimentary formations, metagreywacke and metasiltstone predominate although slate and metaconglomerate are locally abundant, especially in the upper formation. Marble and calc-silicate gneiss and granofels are locally present. ~~at the base of the upper metasedimentary formation.~~

Narrow layers of ferruginous metasediments and metamorphosed iron formation are present in all but the lower mafic metavolcanic formation and the metasedimentary-metavolcanic formation of undetermined stratigraphic position.

Uralitized and metamorphosed gabbro and diorite form at least four sills and one irregular body in the Muskratdam Lake belt and several sills in the Rottenfish River belt. The sills have a maximum thickness of 7800 feet and several have been traced along strike for more than 15 miles.

The metavolcanic-metasedimentary-metagabbroic assemblage has been variously metamorphosed to the greenschist, almandine amphibolite, and hornblende hornfels facies.

Felsic, intrusive activity appears to have been initiated during the period of volcanism and sedimentation because some felsic, porphyry dikes were intruded by metagabbro sills. The composite, granitic batholiths postdate the metagabbro, and the first stage in their development was the local intrusion of diorite, syenodiorite, and mafic-rich trondhjemite. The later, granitic phase of the batholiths ranges in composition from tonalite to quartz monzonite but is dominantly trondhjemite and quartz monzonite.

Rare, post-batholith, diabase dikes form two sets which have slightly different compositions and which trend north-northeast and west-northwest. Several other late, mafic dikes were found, one of which appears to contain altered glass.

Pleistocene deposits which include till, lacustrine clay, interlobate and end moraine, and eskers cover much of the bedrock and hamper the deciphering of the stratigraphy and structure.

Metavolcanic-metasedimentary assemblage

Lithology

Metavolcanic rocks

General Statement

Metavolcanic rocks, including those of pyroclastic origin, form at least seventy-five percent of the metavolcanic-metasedimentary sequence in the Muskratdam Lake belt and most of the sequence in the Rottenfish River belt. They range in composition from mafic to felsic and, on the basis of colour index, can be subdivided into mafic metavolcanics which contain more than 35 percent mafic minerals (clinopyroxene, amphibole, biotite, and chlorite), intermediate metavolcanics which contain 15 to 35 percent mafic minerals, and felsic metavolcanics which contain less than 15 percent minerals. Mafic types form about 70 percent of the metavolcanic sequence, intermediate types about 7 percent, and felsic types about 23 percent.

Mafic metavolcanics

Mafic metavolcanics were derived dominantly from basaltic and andesitic flows and have been metamorphosed to the greenschist, almandine amphibolite, and hornblende hornfels facies (facies defined according to Fyfe et al, 1958). The colour of the weathered suface varies from pale green to dark green, and a deepening in the colour generally indicates an increase in metamorphic grade. On fresh surfaces, colour varies from grey-green to almost black. Mafic metavolcanics are commonly well foliated and, in the hornblende hornfels facies, are locally gneissic; massive varieties are rare.

The major mineral assemblages* in the greenschist facies are (1) albite (range-An_3-An_8; average-An_5) + amphibole ± quartz ± epidote ± carbonate; (2) actinolite + albite (An_0-An_8) + chlorite ± epidote ± carbonate ± quartz; (3) chlorite + albite (An_3-An_9) + carbonate ± quartz ± epidote ± white mica; (4) actinolite + epidote + carbonate ± quartz; (5) albite (An_0-An_9) + biotite + blue-green hornblende ± quartz ± epidote ± carbonate; and (6) chlorite + actinolite + epidote + carbonate + quartz. The almandine amphibolite and hornblende hornfels facies have approximately

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* In this and following sections, the mineral assemblages are listed in order of decreasing abundance with the minerals in each assemblage also listed in order of decreasing abundance.

similar mineralogy, and the major assemblages are: (1) blue-green hornblende + reversely zoned plagioclase (range - An_{20} - An_{47}; average - An_{36}) $\pm$ quartz $\pm$ epidote $\pm$ carbonate; (2) blue-green hornblende + normally zoned plagioclase (range - An_{12} - An_{50}; average- An_{26}) + biotite + quartz $\pm$ epidote $\pm$ carbonate; and (3) normally zoned plagioclase (range - An_{15} - An_{50}; average - An_{36}) + blue-green to dark green hornblende + clinopyroxene $\pm$ quartz $\pm$ epidote $\pm$ microcline. Biotite-bearing assemblages in all facies contain about ten percent quartz, but biotite-free assemblages commonly contain less than five percent quartz. Minor minerals in most of the assemblages are iron-titanium oxide, pyrite, ~~pyrhotite,~~ pyrrhotite, sphene, and locally chalcopyrite, apatite, tourmaline, and garnet.

Flow contacts were only rarely observed, but some flows are at least 150 feet thick. Narrow, interflow layers of felsic metatuff, metachert, and metamorphosed iron formation locally facilitate recognition of flow contacts. Thin flows and the upper and lower parts of thick flows are fine-grained; the central part of thick flows is fine- to medium-grained and texturally resembles metagabbro sills (p. 41) but is finer-grained, more highly recrystallized, better foliated, and locally gradational with pillowed lava. Thick flows are most abundant between ~~Manekun~~ Munekun and Pike Lakes.

In many greenschist facies samples, the primary, randomly-oriented, lath-like habit of plagioclase is preserved through pseudomorphic replacement by single albite grains or by aggregates of tiny albite granules. ~~Plagiollase~~ Plagioclase with primary composition (normally zoned andesine) was found in two samples. In higher grade, metamorphic facies, only rare relics of the primary texture remain.

Porphyritic flows which contain subhedral to euhedral, lath-like, plagioclase phenocrysts as much as three inches long (Photo 2) were found west of the southern part of the Severn River fault and along the Severn River east of Sandhill Crane Island. On the west side of the fault where the metamorphic grade is moderately high (Fig. 5), the phenocrysts are oriented and are commonly bent, fractured, and recystallized. East of Sandhill Crane Island where the metamorphic grade is lower, the phenocrysts are randomly oriented, locally form glomeroporphyritic aggregates (Photo 2), and retain primary composition (oscillatory zoned andesine) although the groundmass is generally recrystallized.

Rare flows contained equant pyroxene phenocrysts as much as three millimetres in diameter which are now pseudomorphed by actinolite.

Non-distorted pillows are common in the greenschist facies and are generally balloon-shaped although irregular, spherical, bun- and loaf-shaped pillows are locally present. Pillows range in length from 2 inches to 15 feet and in thickness from 2 inches to 5 feet, but average dimensions are 4 feet long and 2 feet thick. Pillows less than 1 foot in diameter are commonly spherical, but, as the volume of the pillow increases, the length:thickness ratio also increases and in the largest pillows is about 4:1. In the almandine amphibolite and hornblende hornfels facies, pillows are distorted and range in length from 5 to 10 feet but are only 1 to 6 inches thick. Pillow selvages are locally amygdaloidal and range in thickness from ½ inch to 2 inches. Rarely, a highly vesicular zone less than one inch thick occurs immediately below the selvage but is thickest at the top of the pillow (Photo 3).

In general, pillows are closely packed, but at Munekun Lake botryoidal chert (Photo 3) and pyrite locally fill interstices as much as five inches wide between pillows. On the south shore of the Severn River south of Sandhill Crane ~~bland;~~ Island, carbonate and minor quartz fill irregular interstices between pillows and partly replace the edges of the pillows.

Some flows are pillowed throughout their entire thickness, but in other flows pillows are restricted to the upper part of the flow.

Spherical to lenticular amygdules which range in length from ½ millimetre to 5 millimetres are rare in mafic metavolcanic flows but are common in metavolcanic flows of intermediate composition. Most amygdules are composed of quartz which locally contains minor pistacite and hornblende; rare amygdules are composed of carbonate. Composite amygdules which have a quartz core and a pistacite rim were found in intermediate flows south of Fox Bay.

Mafic metatuff was only rarely observed but may have been overlooked in some outcrops because bedding is poorly developed. Most mafic metatuff units are associated with mafic flows.

Metavolcanic breccia composed of lenticular to angular, mafic fragments as much as three feet long in a mafic matrix is rare; in pillowed sequences these breccias locally contain pillow fragments. Sparse, lenticular, felsic fragments which have an average length of 2 inches but are as much as 10 feet long are present in many mafic flows. These fragments are generally concentrated in 2- to 5-foot wide layers near the top of the flow but are locally randomly distributed throughout the flow.

Gneissic layering has developed in most of the hornblende hornfels facies mafic metavolcanics adjacent to the granitic batholiths (Fig. 5) and in most large mafic inclusions in the batholiths. The layers are both continuous and discontinuous, resemble bedding, range in thickness from a fraction of an inch to four inches, and are characterized by differences in both grain size, and mineralogy (Photo 4). In most outcrops the layering reflects differences in the hornblende: plagioclase ratio, and hornblende-rich layers are generally finer grained than hornblende-poor layers. In some outcrops, however, especially along the northwest edge of the Muskratdam Lake belt, clinopyroxene-rich and rare garnet-rich layers have developed and alternate with hornblende-rich layers. The gneissosity probably formed by metamorphic differentiation.

An unusual rock of undetermined origin forms a concordant layer several hundred feet thick in almandine amphibolite facies mafic metavolcanics north of the east end of Muskratdam Lake. The layer is pale green on fresh surfaces, weathers pale brown, and is composed of 90 to 95 percent coarse-grained clinopyroxene with minor ~~interstitral,~~ interstitial, perthitic microcline, sphene, and carbonate. The clinopyroxene is equant, highly strained, and as much as two inches long.

Metavolcanics of intermediate composition

Intermediate metavolcanics have been metamorphosed to the greenschist, almandine amphibolite, and rarely to the hornblende hornfels facies but were probably derived dominantly from andesite, dacite, and rhyodacite. In comparison with mafic metavolcanics, they are characterized by lower colour index (p. 11), ubiquitous quartz, the presence of medium- to coarse-grained, subhedral to euhedral, commonly acicular, amphibole porphyroblasts in some units, and the common occurrence of biotite. They are well foliated and are commonly green, pale green, grey, or brown on both fresh and weathered surfaces.

Intermediate metavolcanics are rare in the Rottenfish River belt, but in the Muskratdam Lake belt they form lenses as much as 500 feet thick in both the felsic and mafic metavolcanic formations, and, on the limbs of the Fox Bay syncline, they locally form the entire thickness of the upper mafic metavolcanic formation.

The major mineral assemblages in the greenschist facies are (1) albite (An_3 - An_5) + chlorite + carbonate + quartz; (2) albite (An_2 - An_7) + blue-green hornblende + biotite + quartz $\pm$ carbonate $\pm$ epidote; (3) albite (An_3) + quartz + chlorite + carbonate + white mica; (4) albite (An_5) + quartz + biotite + carbonate; and (5) albite + chlorite + quartz + white mica + biotite + carbonate. In the almandine amphibolite facies the major assemblages are (1) reversely zoned plagioclase (range - An_{28} - An_{55}; average - An_{35}) + blue-green hornblende + quartz + biotite $\pm$ epidote $\pm$ carbonate; and (2) plagioclase (An_{26}) + quartz + biotite + chlorite + cummingtonite. Minor minerals in most of the assemblages are iron-titanium oxide, leucoxene, sphene, pyrrhotite, pyrite, apatite, and rare tourmaline, chalcopyrite, and garnet.

Intermediate flows are generally fine-grained and equigranular, but, in the greenschist and lower part of the almandine amphibolite facies they locally contain fine- to medium-grained, lath-shaped to stubby, plagioclase phenocrysts. Many flows are amygdaloidal (p. 15) and contain ovoid to lenticular, felsic to intermediate fragments as much as six inches long which locally have a marked reaction rim. Amygdules are rarely concentrated in 2- to 3-foot thick layers which might be flow tops. Narrow flow layers were observed in a few intermediate flows.

Pillows are rare, but, on the north limb of the Sandhill Crane anticline, a thin, porphyritic, intermediate layer in the felsic metavolcanic formation contains ovoid pillows about 3 feet long and 6 inches thick with 1-inch wide selvages. The approximate composition of this layer is 10 percent albite (An_3) phenocrysts, 55 percent groundmass albite and quartz, 25 percent chlorite, 5 percent carbonate, and 5 percent white mica, leucoxene, and pyrrhotite.

Metamorphosed pyroclastic deposits in the map-area have been subdivided into three groups according to Fisher (1961): metatuff, which has a grain size less than 2 millimetres; metalapillistone, which has fragments between 2 to 64 millimetres in diameter; and metamorphosed pyroclastic breccia, which contains fragments larger than 64 millimetres. Most of the intermediate pyroclastic deposits are metamorphosed pyroclastic breccia and coarse-grained metalapillistone which have a metatuff or fine-grained metalapillistone matrix. Rare, thin, metatuff and fine-grained metalapillistone interbeds occur in the breccia.

There are two types of metamorphosed, intermediate, pyroclastic rocks which have approximately equal areal extents: (1) mafic to intermediate fragments in a felsic to intermediate matrix, and (2) felsic to intermediate fragments in an intermediate to mafic matrix. The latter type is generally interbedded with felsic pyroclastic rocks. Fragment population varies from homogeneous to heterogeneous, and the fragments are lenticular to angular and have an average length of 2 inches; the largest observed fragment was 10 feet long. Matrix forms between 10 and 75 percent of these pyroclastic rocks and in many outcrops shows marked variations in composition across strike.

Felsic metavolcanics

Felsic metavolcanics have been metamorphosed to the green schist, almandine amphibolite, and rarely to the hornblende hornfels facies and were derived dominantly from rhyodacite and sodic rhyolite. Potassic varieties such as quartz latite and potassic rhyolite are rare; quartz-poor varieties are absent. Felsic metavolcanics commonly weather white, pale brown, or pale grey but are white, yellow, pale green, brown, grey, or black on fresh surfaces. Most outcrops are well foliated and are locally schistose. Felsic metavolcanics are distinquished from mafic and intermediate metavolcanics by low colour index and the common occurrence of white mica.

In the greenschist facies the major mineral assemblages are (1) albite (An_3 - An_7) + quartz + biotite + white mica $\pm$ carbonate $\pm$ microcline $\pm$ epidote; (2) albite (An_2 - An_4) + quartz + white mica $\pm$ carbonate $\pm$ epidote $\pm$ microcline; (3) albite (An_1 - An_5)

to p. 19a

+ quartz + white mica + chlorite + carbonate ± epidote; (4) albite (An_2 - An_5) +

to p. 20

quartz + biotite ± epidote ± carbonate ± microcline; and (5) albite (An_3) + quartz + white mica + chlorite + biotite + carbonate. In the almandine amphibolite facies the major assemblages are (1) plagioclase (An_{11} - An_{32}) + quartz + blue-green hornblende + biotite ± epidote ± carbonate ± microcline; (2) plagioclase (An_{27}) + quartz + biotite ± epidote ± microcline; and (3) plagioclase (An_{13}) + quartz + microcline + white mica + biotite + epidote + carbonate. Minor minerals in most of the assemblages are leucoxene, iron-titanium oxide, pyrite, pyrrhotite, apatite, and rare zircon, tourmaline, sphene, and garnet.

Felsic flows appear to form most of the felsic metavolcanic formation south of Fox Bay and were locally identified in other parts of the area. In the greenschist and lower part of the almandine amphibolite facies, many flows are porphyritic and contain fine- to medium-grained phenocrysts of relatively uniform size. The phenocrysts consist of lath-shaped to stubby, slightly oriented plagioclase which rarely contain primary oligoclase; minor quartz and microcline; and rare, altered hornblende. No primary groundmass textures were observed.

Flow layers which range in thickness from 1 millimetre to 15 centimetres and are commonly contorted were observed in a few flows. Rare felsic fragments are present in the flows.

The high viscosity of the felsic flows is shown by a thin flow in the upper mafic metavolcanic formation north of the intersection of the Severn River and Rottenfish River faults. The south edge of this flow thins from 100 feet to zero in a lateral distance of about 100 feet.

Felsic pyroclastic deposits are characterized by rapid vertical and lateral changes in both lithology and composition and locally grade into muscovite - bearing metagreywacke which was probably derived from felsic metavolcanics (p. 25). Metatuff and fine-grained metalapillistone predominate, but coarse-grained metalapillistone and pyroclastic breccia are found in many parts of the sequence.

In the greenschist facies, primary clastic texture is commonly preserved, and locally primary, plagioclase composition (oligoclase to labradorite) is also preserved. Primary plagioclase can be recognized by oscillatory zoning, broken zoned grains, and wide range in composition. Sorting is poor, and metatuff contains abundant silt-size quartz and plagioclase (Table 3). Sand-size grains in the pyroclastic rocks consist of randomly oriented, anhedral to euhedral, rounded to angular plagioclase; rounded to angular, locally recrystallized quartz; and lenticular, equigranular to porphyritic, felsic metavolcanic and rare intermediate to mafic metavolcanic fragments. Grains larger than sand are generally metavolcanic fragments.

Bedding is absent in many outcrops but, where present, ranges from thinly laminated to very thick-bedded (bedding thickness is classified according to Dunbar and Rodgers (1957, p.97). Rare graded bedding was found.

Metatuff is well exposed along the Severn River on the south limb of the Sandhill Crane anticline and closely resembles both porphyritic, felsic flows and poorly bedded, muscovite-bearing metagreywacke with which it is interbedded (Table 2). These rock types cannot be differentiated in highly foliated or schistose outcrops. Modal analyses of metatuff (92) and muscovite -bearing metagreywacke (98) are given in Table 3.

There are two other major varieties of metatuff along the Severn River. (1) Thinly-laminated metatuff composed of silt- and clay-size particles forms rare layers less than 10 feet thick; the laminae are discontinuous and lenticular. (2) Biotite-rich, irregularly layered metatuff which contains about forty percent intermediate metavolcanic lapilli and medium- to coarse-grained, andesine-labradorite phenoclasts in a silt- to sand-size biotite-quartz-plagioclase matrix forms units as much as 100 feet thick. This latter type of metatuff may be a mudflow deposit.

Metamorphosed felsic pyroclastic breccia and coarse-grained metalapillistone are interbedded with felsic metatuff and metamorphosed intermediate pyroclastic rocks and form units which range in thickness from less than 10 feet to several hundred feet. Commonly, lenticular to angular, felsic fragments occur in a felsic to intermediate matrix (Photo 5). The largest, observed fragment was two feet long. In metamorphosed pyroclastic breccia south of Munekun Lake, some felsic fragments have a marked reaction rim.

Metamorphosed ash-flow tuff was not positively identifed but may occur in the felsic metavolcanic formation south of Fox Bay. There, several outcrops contain oriented, subhedral, plagioclase phenocrysts and rare quartz phenocrysts in a recrystallized groundmass. The plagioclase phenocrysts, in contrast to phenocrysts in definite felsic flows, have a wide range in grain size.

Metasedimentary rocks

General statement

Metasediments which have been metamorphosed to the greenschist, almandine amphibolite, and hornblende hornfels facies form about twenty-five percent of the metavolcanic-metasedimentary assemblage in the Muskratdam Lake belt but are rare in the Rottenfish River belt. Metagreywacke and metasiltstone predominate, but minor slate, metaconglomerate, marble, calc-silicate gneiss and granofels, ferruginous metasediments, and metamorphosed iron formation are present.

Metagreywacke and metasiltstone

Similar mineral assemblages have developed in metagreywacke, metasiltstone, slate, and metaconglomerate. In the greenschist facies the major assemblages are (1) quartz + albite (An_3 - An_5) + white mica + chlorite + carbonate ± ~~microncline;~~ microcline; (2) albite (An_5) + quartz + biotite + chlorite + white mica ± carbonate; (3) albite (An_6) + quartz + biotite ± epidote; (4) albite + quartz + biotite + white mica + carbonate ± epidote; and (5) albite (An_5) + quartz + chlorite + carbonate + biotite. In the almandine amphibolite and hornblende hornfels facies the major assemblages are (1) plagioclase (range - An_{11} - An_{43}; average - An_{30}) + biotite + quartz + blue-green hornblende ± tremolite (?) ± epidote ± carbonate ± microcline; (2) plagioclase (An_{25} - An_{44}) + quartz + biotite ± epidote ± microcline; (3) plagioclase (An_{25} - An_{33}) + quartz + biotite + white mica ± microcline ± epidote; (4) quartz + oligoclase-andesine + biotite + garnet + white mica ± epidote; (5) quartz +

plagioclase (An_{18}-An_{25}) + biotite + cordierite + andalusite + staurolite + Mg-chlorite ± garnet; and (6) plagioclase (An_{18}) + quartz + biotite + staurolite + Mg-chlorite + white mica + andalusite. ~~and (7) garnet + cummingtonite + quartz.~~ Minor minerals in most of the assemblages are leucoxene, iron-titanium oxide, pyrite, pyrrhotite, apatite, tourmaline (especially in the almandine amphibolite facies), and rare sphene, zircon, allanite, and chalcopyrite.

In the greenschist facies, primary clastic texture is preserved in most metasandstone and coarse-grained metasiltstone, and primary oligoclase-andesine is preserved in a few samples. Metasandstone is generally poorly sorted and has a disrupted framework; the matrix is composed dominantly of silt-size quartz and plagioclase (Table 3). Sand-size plagioclase is rounded to angular and is locally subhedral; sand-size quartz is rounded to angular. Lenticular, sand-size rock fragments occur in many samples but are generally not abundant; equigranular to porphyritic, felsic metavolcanic fragments predominate, but minor intermediate metavolcanic, metachert, and granophyre (plagioclase + quartz) fragments are present.

¶ Most metasandstone in which primary texture is preserved is feldspathic metagreywacke (defined according to Pettijohn, 1957). Lithic metagreywacke was locally found associated with metaconglomerate and felsic metatuff. Quartz metagreywacke, which is the dominant type of metasandstone in the North Spirit Lake Belt, southwest of the map-area (Donaldson and Jackson, 1965), is rare. Most of the metagreywacke is sodic; potassic varieties

to p. 24a

are rare.

Metagreywacke and metasiltstone have been subdivided into three types: (1) muscovite-bearing, in which white mica is more

to p.25

abundant than biotite; (2) biotite-bearing, in which biotite is more abundant than white mica; and (3) amphibole-bearing, which contain more than five percent amphibole. The three types are interbedded but generally one type predominates so that members can be mapped.

Muscovite-bearing metagreywacke weathers pale grey, and is white, cream, or grey on fresh surfaces. It is rare except in the upper metasedimentary formation where it is commonly associated with felsic metavolcanics. This association with felsic metavolcanics, the local gradation into felsic metatuff (p. 21 , Table 2), and a higher lithic metagreywacke to feldspathic metagreywacke ratio than either biotite- or amphibole-bearing metagreywacke suggest that most muscovite-bearing metagreywacke represents eroded felsic volcanic rocks or reworked felsic tuff.

The average grain size of the sand fraction in the muscovite-bearing metagreywacke is coarse to very coarse sand (defined according to Dunbar and Rodgers, 1957, p.161). Beds range in thickness from very thin-bedded to very thick-bedded but are generally thick- to very thick-bedded (2 to 10 feet). Grain gradation is common, but visible gradation is restricted to the basal several inches which locally contains very fine to fine pebbles and to the upper 1 inch to 3 inches where the metagreywacke rapidly grades into metasiltstone and rare slate; the bulk of the bed appears to have a homogeneous texture. Metasiltstone, other than that which forms part of the graded beds, is rare in the muscovite-bearing metagreywacke members. Primary flowage structures and load casts were locally found in ~~the~~ ~~thin~~ thin metasiltstone and slate units beneath very thick metagreywacke beds. Tabular, metashale fragments which range in length from ½ inch to 6 inches were rarely found in this type of metagreywacke.

Biotite-bearing metagreywacke and metasiltstone weather pale grey to grey and are grey on fresh surfaces. This type predominates in all metasedimentary formations and is not genetically associated with felsic metavolcanics. In general, it is finer-grained, thinner bedded, and contains less sand-size rock fragments and more metasiltstone interbeds than muscovite-bearing metagreywacke.

The average size of the sand fraction is very fine to coarse sand. Bedding is well preserved, and beds range in thickness from thinly laminated to thick-bedded but are generally very thin-bedded (about ½ inch). Metasiltstone forms at least twenty-five percent of these members as discrete beds and as part of graded beds. In most outcrops medium- to coarse-grained metagreywacke beds alternate with fine-grained metagreywacke and metasiltstone beds; graded bedding was only locally found. Some of the thicker beds contain rare, fine to very fine pebbles. Three modal analysis are presented in Table 3.

Satterly (1939, p.26) reported andalusite in the lower metasedimentary formation along the Severn River at the southwest corner of the Muskratdam Lake belt. This occurrence was not verified, but andalusite, in association with cordierite and staurolite, was found in the formation south of Fox Bay. Fine-grained, biotite-bearing metagreywacke and metasiltstone at Satterly's locality, however, contain ¼- to 1-inch long, ovoid, pale grey knots which are preferentially developed in certain beds where they form as much as ten percent of the rock. The knots contain more plagioclase and less biotite and potassic feldspar than the host metagreywacke which is quartz-poor and appears to be potassic rather than sodic. The origin of the knots is not known.

Amphibole-bearing metagreywacke and metasiltstone contain 5 to 50 percent amphibole and 5 to 30 percent biotite; weather grey, pale green, green,or dark green; are grey to green on fresh surfaces; and are generally interbedded with biotite-bearing metagreywacke. In bedding thickness and grain size, amphibole-bearing metagreywacke is similar to biotite-bearing metagreywacke, but minor crenulations and small-scale, flow folds are common (Photo 6); these structures are rare in the other types of metagreywacke.

Amphibole-bearing metagreywacke is most abundant in the almandine amphibolite and hornblende hornfels facies zones of the lower metasedimentary formation and the metasedimentary formation at the east end of Muskratdam Lake. It is sometimes associated with calc-silicate gneiss (Blackwater Bay) and with intermediate metavolcanics (east end of Muskratdam Lake). Most of the amphibole-bearing metagreywacke, especially where tremolite(?) is present, probably represent metamorphosed calcareous sandstone and siltstone, but some may represent eroded intermediate volcanic rocks.

~~(1962, p.17) north of Lake Abitibi~~.

Slate

In the greenschist facies part of the upper metasedimentary formation, grey slate which was derived from fine-grained siltstone and claystone is interbedded with muscovite- and biotite-bearing metagreywacke and coarse-grained metasiltstone. The slate is most abundant in an 1100-foot thick member along the Severn River where individual slate units are at least 20 feet thick and form about 50 percent of the member. Bedding is only rarely preserved in the slate units and is defined by thin metagreywacke and coarse-grained metasiltstone beds. The slate has a well developed, pervasive cleavage along which it can be readily split into thin, smooth-sided slabs; the cleavage is generally only slightly discordant to bedding. Many slate outcrops along the Severn River are frost-heaved and slumped.

Black, locally pyritic slate is interbedded with highly schistose felsic flows and breccia in the upper part of the felsic metavolcanic formation along the Severn River. Fine-grained metagreywacke beds (analysis 88, Table 3) as much as one-inch thick occur in the slate and are commonly crenulated. The cleavage is parallel to the axial plane of the crenulations, but the cleavage was itself crenulated by a later stage of deformation. The close association with felsic metavolcanics suggests that this black slate may have been derived from a tuff.

Metaconglomerate

Beds and lentils of polymictic, pebble metaconglomerate, which range in thickness from less than 1 foot to 1000 feet, were found in the three metasedimentary formations and locally in the upper mafic metavolcanic formation near Axe and Munekun Lakes. The metaconglomerate has a metagreywacke matrix and locally contains cobbles and rare boulders; the average, primary diameter of the pebbles was about one inch and the largest observed boulder was one foot in diameter. Bedding is commonly absent and, where present, is defined by 1- to 2-foot thick layers containing fine pebbles and by metagreywacke and metasiltstone interbeds. Thin units locally show graded bedding.

Fragment populations are heterogeneous and vary from unit to unit (Table 4). Most fragments are highly stretched, but quartz, metachert, dolomite, granite, and muscovite-bearing metagreywacke fragments either retain their primary, subrounded shape or are only slightly stretched (Photo 7). Brown weathering, siliceous dolomite pebbles and cobbles are common in the unit along the Severn River, nine miles west of Sandhill Crane Island (Photo 7), but the dolomite has no equivalent in the exposed part of the stratigraphic sequence. Granitic pebbles, cobbles, and boulders were found in several units in the upper metasedimentary formation (Table 4). The only granitic fragment examined in thin section (Table 3) was from the almandine amphibolite facies and has an abnormal composition (quartz gabbro).

Massive pyrrhotite and pyrite occur in the matrix of the metaconglomerate units on Sandhill Crane Island and at the east end of Muskratdam Lake (p. 88, 91).

Marble and calc-silicate gneiss and granofels

An 800-foot thick marble and calc-silicate gneiss and granofels member forms the basal part of the upper metasedimentary formation at the south end of Fox Bay and is also present near the Severn River at the southwest corner of the Muskratdam Lake belt. Minor calc-silicate gneiss and granofels were also found interbedded with hornblende-bearing metagreywacke in the lower metasedimentary formation at the mouth of Blackwater Bay and near the Severn River at the southwest corner of the Muskratdam Lake belt.

Marble, which by definition contains more than fifty percent carbonate, is white to pale grey on both fresh and weathered surfaces and forms less than half of the member in the upper metasedimentary formation. Calc-silicate rocks contain less than fifty percent carbonate, contain abundant calcium- and magnesium-silicate minerals such as tremolite, biotite, and diopside, and vary in colour from pale grey to dark green on both fresh and weathered surfaces. Foliation is rare.

The mineralogy of these rocks is highly variable and changes from bed to bed. In the greenschist facies, the common minerals are carbonate, tremolite, quartz, and phlogopite. In the hornblende hornfels facies, diopside, carbonate, potassic feldspar, epidote, quartz, scapolite, biotite, andesine, and hornblende are present in varying proportions.

At Fox and Blackwater Bays bedding is well developed, and beds range in thickness from a fraction of an inch to three inches;

contortion is rare. Differential erosion of the carbonate-rich beds has produced an irregular outcrop surface.

Near the Severn River at the southwest corner of the Muskrat-dam Lake belt, bedding is rare, and many outcrops are brecciated. Breccia fragments are ~~lenticular,~~ composed of relatively pure, bedded marble and rare meta-arkose (?), ~~which~~ are lenticular, ~~and~~ have a preferred orientation, range in length from a fraction of an inch to two feet, and form 10 to 50 percent of the breccia. The matrix ranges in composition from silicate-rich marble (Photo 8) to carbonate-poor, calc-silicate ~~marble~~ granofels (see photograph in Satterly, 1939, p.26).

On the Severn River at the southwest corner of the Muskrat-dam Lake belt, dark green, massive "greenstone" overlies brecciated marble (Photo 8) and contains marble fragments (Satterly, 1939, p.27, and photograph on p.26). This greenstone is composed of approximately equal amounts of diopside and potassic feldspar, minor tremolite and epidote, and accessory scapolite, carbonate, andesine, sphene, pyrrhotite, iron-titanium oxide, and chalcopyrite; it is thus a calc-silicate granofels.

Metamorphosed iron formation and ferruginous metasediments

By definition (Gross, 1965, p.83) metamorphosed iron formation contains more than fifteen percent iron. Layered iron-rich rocks which contain less than fifteen percent iron but which texturally resemble metamorphosed iron formation are here called ferruginous metasediments or ferruginous metachert.

Metamorphosed iron formation units range in thickness from 2 inches to more than 100 feet and were found in the Rottenfish

River mafic metavolcanics, the upper mafic metavolcanic formation east of the Windigo River fault, and the upper metasedimentary formation north of the Severn River fault. The thickest layers are at Munekun Lake (50 feet) and in the northern part of the Rottenfish River belt (30 to 100 feet) and are overlain and underlain by mafic flows. Metamorphosed iron formation layers in the upper metasedimentary formation are less than one foot thick. Aeromagnetic data (G.S.C.-O.D.M., 1966) suggest that many iron-rich units either do not outcrop or were not found. The lateral extent of the mapped layers could not be determined because of poor exposure.

Ferruginous metasediments are associated with metamorphosed iron formation and also form separate units as much as 750 feet thick in the felsic metavolcanic formation. In the units north of the Severn River fault, magnetite content is highly variable and the units range in composition from iron-poor metachert to rare metamorphosed iron formation.

The iron-rich rocks have been metamorphosed to the greenschist and almandine amphibolite facies, and many units are contorted. The units are well layered, and in general white to pale grey metachert layers alternate with grey to black magnetite layers; white to dark green, iron silicate mineral layers are locally present. In several units metachert is rare, and iron-silicate mineral layers alternate with magnetite layers. Metachert layers range in thickness from a fraction of an inch to 6 inches but average ½ to 1 inch; many of the thicker layers have a fine internal lamination. Magnetite layers are as much as 1 foot thick but average $\frac{1}{4}$ inch. Iron silicate mineral layers, which contain grunerite, actinolite, biotite, and several unidentified minerals, are generally less than $\frac{1}{2}$ inch thick. Rare pyrite layers were found near the base of the unit at Munekun Lake.

At the south end of Munekun Lake, metamorphosed iron formation is unconformably overlain by a mafic flow (Photo 9). The contact is irregular and truncates layers in the metamorphosed iron formation. A 5-inch thick metasiltstone layer was found 10 feet below the top of this 50-foot thick unit.

The 750-foot thick, ferruginous metasedimentary unit at the base of the felsic metavolcanic formation south of Fox Bay has an unusual composition. The metachert layers are alumina-rich and contain 20 percent andalusite, 10 percent chloritoid, and 4 percent iron oxide in a granular quartz matrix. Silicate mineral layers contain loosely packed, ellipsoidal, 0.5-millimetre long granules composed of a non-magnetic, opaque mineral, chlorite, and chloritoid. ~~and a colourless silicate mineral.~~ The matrix between the granules is very fine-grained quartz, muscovite, and chloritoid.

Insert p 33a →

The rarity of primary textures and the association with metavolcanics and metagreywacke suggest that most of the metamorphosed iron formation is the Algoma type of Gross (1965).

Non-ferruginous metachert

Narrow layers of thinly laminated, white to pale grey, nonferruginous metachert, which are generally less than six inches thick, were rarely found in metagreywacke and between mafic metavolcanic flows.

Unusual gneissic rocks which contain about 55 percent garnet, 30 percent cummingtonite, 15 percent quartz, and minor iron-titanium oxide and apatite form thin units in biotite-bearing metagreywacke northeast and northwest of the intersection of the Severn River and Rottenfish River faults. Gneissic layers have an average thickness of ½ inch, and alternate layers are composed of garnet-quartz-cummingtonite and garnet-cummingtonite. Crenulations and drag folds are common in these units but are absent in the adjacent metagreywacke. Similar rocks were described by Lumbers (1962, p.17) north of Lake Abitibi. A partial chemical analysis (Table 8) shows that the rock is an aluminous iron formation and that the garnet is almandine. Silica is probably the only major, undetermined oxide.

Stratigraphy

Muskratdam Lake belt

Because of a lack of outcrop in many parts of the belt and the limited time available to examine those outcrops which were found, the fold pattern is not completely known. Thus, because the stratigraphy is dependent on the structural interpretation (e.g. see Billings, 1950), the sequence of formations shown in Figures 3 and 4 and Table 1 is tentative, and detailed work may lead to major revisions. For example, scanty data along the southwest edge of the belt suggest that the axis of an anticline occurs within intermediate metavolcanics south of Fox Bay. If this is true, then the lower half of column 1 in Figure 3 is reversed and is equivalent to the upper part of the column. The tentative stratigraphy, however, provides a framework for the history of the Muskratdam Lake belt.

Because the stratigraphy is tentative, formal, formation names are not used.

Contacts between formations are poorly defined but appear to be conformable and to vary from sharp to gradational; interfingering and interlayering of units are common. On the south limb of the Sandhill Crane anticline, a gradational contact between the felsic metavolcanic and the upper metasedimentary formation appears to reflect a gradual decrease in the intensity of explosive, felsic volcanism and a concomitant increase in the amount of reworking and transport of felsic detritus by sedimentary agents.

Each formation contains many different rock types (Table 1), and in some formations the detailed lithology varies from place to place. The gross composition or lithology, however, is relatively constant, and generally each formation is distinctly different from adjacent formations.

Correlation between the eastern and western parts of the belt is hampered by the Windigo River fault which appears to be a major structural break. A metagreywacke formation at the east end of Muskratdam Lake cannot be traced into other metasedimentary formations but appears to occupy the same stratigraphic position as the upper metasedimentary formation.

In the Muskratedam Lake belt the maximum thickness of the metasedimentary-metavolcanic sequence is 18,500 feet (Fig. 3). The earliest recorded activity was extrusion of a sequence of mafic flows (lower mafic metavolcanic formation) with concomitant greywacke sedimentation in the north-central part of the belt (lower metasedimentary formation). Pillows, which indicate subaqueous extrusion, are rare (or rarely preserved) in the lower mafic metavolcanic formation, and its environment of deposition is unknown.

In the west, cessation of volcanism was followed by expansion of greywacke sedimentation, and in many places the lower metasedimentary formation overlies the lower mafic metavolcanic formation. Greywacke sedimentation was ended by a second volcanic episode which was ~~inititated bl~~ initiated by extrusive and explosive felsic volcanism (felsic metavolcanic formation). This felsic volcanism either did not reach the extreme west end of the belt or its products were removed before deposition of the upper mafic metavolcanic formation.

Felsic volcanism was concentrated in the west-central part of the belt and reached the margins only during the early stages. In these early stages, quiescent periods at the margins of the belt allowed chemical precipitation of thick sequences of ferruginous metachert. During the later stages of felsic volcanism, mafic and intermediate flows and pyroclastic breccia (upper mafic metavolcanic formation) accumulated at the margins of the belt. Felsic and mafic volcanism were thus coeval. Pillows are rare in the upper mafic metavolcanic formation on the west side of the Windigo River fault.

Mafic volcanism apparently ceased before felsic volcanism and was replaced by subaqueous greywacke sedimentation (upper metasedimentary formation). Local deposition of limestone, which was probably chemically precipitated, indicates a quiescent period between the cessation of mafic volcanism and the beginning of clastic sedimentation. In the central part of the belt, felsic pyroclastic activity gradually gave way to greywacke sedimentation, and early greywacke in this part of the belt was derived from the felsic volcanic terrane. The derivation of later greywacke and of most of the greywacke at the margins of the belt is unknown.

Local development of conglomerate during the transition from felsic volcanism to sedimentation probably represents tectonic activity in the volcanic terrane.

In the east, pillowed mafic flows appear to have been extruded subaqueously during the entire period represented by the complex facies changes in the west; interbedded iron formation and greywacke represent local cessation of volcanism. Along the north-central part of the belt, the development of thick greywacke formations reflects local absence of volcanism and the presence of depositional basins. It may also indicate nearby source areas.

Quartz is abundant in the greywacke (Table 3) and could not have been derived from a mafic volcanic terrane. Possible source areas are a plutonic-metamorphic complex, a felsic volcanic terrane, or an older sedimentary formation (Donaldson and Jackson, 1965). Some of the greywacke was derived from a felsic volcanic terrane (p. 25), but the source area for most of the greywacke is unknown. Granitic fragments in the upper metasedimentary formation indicate some pre-existing granitic intrusions.

In northeastern Manitoba about 125 miles west-northwest of the map-area, an unconformity of considerable hiatus separates a dominantly metavolcanic group from an overlying, dominantly metasedimentary group which contains abundant granite pebble metaconglomerate (Quinn and Meinert, 1959; Barry, 1961; Davies et al, 1962; Godard, 1963). Similar relationships were not recognized in the map-area and have not been recognized elsewhere in this part of northwestern Ontario (Satterly, 1938; 1939).

Rottenfish River belt

The structure and stratigraphy of this belt are poorly known. The sequence appears to be about 6000 feet thick and is composed dominantly of pillowed, probably subaqueous, mafic flows. A 1550-foot thick felsic metavolcanic formation occurs within the mafic sequence on the west side of the belt. Numerous interbedded iron formation units indicate quiescent periods in the mafic volcanism.

Garrett Lake belt

Mafic metavolcanic and biotite-bearing metagreywacke outcrops along the Makoop River in the northeast corner of the map-area were mapped by P. P. Hudec (unpublished map on file with Geological Branch, Ontario Department of Mines) in 1961. Hudec (1964, p. 24) stated that these outcrops were part of "a presumably small sharply curving sedimentary and volcanic belt" which he named the Garrett Lake belt. These outcrops were not examined by the author, and contacts with granitic rocks could not be determined because of lack of data.

Age

No isotopic age determinations are available from the map-area. However, on the basis of regional structural synthesis and age determinations from nearby areas, Stockwell (1965) assigned the metavolcanic-metasedimentary sequences in the map-area to the Archaean.

At Weagamow Lake, about 35 miles south of the map-area, biotite from a granitic gneiss gave a potassium-argon age of 2505 million years (Lowdon, 1961, p. 58). At Big Trout Lake, about 65 miles northeast of the map-area, biotite from paragneiss and migmatite gave a potassium-argon age of 2630 million years (Lowdon, 1963, p. 80).

Intrusive rocks

Early, porphyritic, felsic dikes and sills

Porphyritic to rarely equigranular, felsic dikes and sills intrude both metavolcanic-metasedimentary assemblages but are rare. They can be divided into four types: (1) metamorphosed dikes which are intruded by metagabbro, (2) metamorphosed dikes which intrude metagabbro, (3) unmetamorphosed dikes which are spatially associated with granitic batholiths (p. 45), and (4) unmetamorphosed dikes which are not spatially associated with granitic batholiths (p. 44).

Metamorphosed dikes were only rarely identified. Along the Severn River at the southwest corner of the Muskratdam Lake belt, a six-inch wide, pale grey, plagioclase porphyry dike was intruded into marble and was intruded in turn by a one-foot wide metagabbro dike. North and northwest of Lookout Lake, recrystallized, white to pale grey, fine- to coarse-grained, equigranular, garnetiferous, potassic, muscovite granite forms sills, dikes, and pods in metagabbro and locally in adjacent formations; the sills pinch and swell. The granite is composed of 35 percent microcline, 30 percent quartz, 24 percent albite (An_5), 10 percent muscovite, and 1 percent garnet.

Pre-gabbro dikes are probably related to volcanism. Metamorphosed, post-gabbro dikes appear to be spatially associated with metagabbro and may be a felsic differentiate of the gabbro magma.

At Munekun Lake a concordant layer of plagioclase-quartz porphyry which has a maximum thickness of 800 feet has been traced laterally for 11 miles. The porphyry weathers pale grey-green, is grey to dark grey on fresh surfaces, has been metamorphosed to the greenschist facies, and is overlain and underlain by pillowed mafic flows. Phenocrysts are fine- to medium-grained: quartz phenocrysts predominate, have rounded to square outlines, and are locally corroded; plagioclase phenocrysts (An_4) are subhedral, equant to tabular, randomly oriented, and locally concentrated in glomeroporphyritic aggregates. The groundmass is a recrystallized mozaic of biotite, quartz, and albite.

The upper contact was observed in the western part of Munekun Lake. The contact is sharp, and adjacent to the mafic flow quartz porphyry layers alternate with plagioclase porphyry layers. Elsewhere the porphyry is massive and appears to have a uniform composition. No fragments were found.

The origin of the porphyry is uncertain: it may be a sill, a flow, or an ash-flow tuff. An intrusive origin appears to best fit the features described above. East of Munekun Lake in the axial zone of the Munekun Lake syncline, the porphyry appears to be intruded by metagabbro.

Uralitized and metamorphosed gabbro and diorite

Prior to the regional metamorphism, concordant to locally discordant bodies of gabbro and diorite were intruded into the metavolcanic-metasedimentary assemblage in both belts. The sill-like bodies range in thickness from 1 foot to 7800 feet, and several sills have been traced laterally for more than 15 miles.

The sills texturally resemble the fine- to medium-grained interiors of thick mafic flows, but (1) the sills are coarser-grained (2 to 3 millimetres), (2) recrystallization is less intense and the texture is well preserved, (3) primary plagioclase is commonly preserved and primary clinopyroxene is locally preserved, (4) foliation is poorly developed and many sills are massive, and (5) the sills have sharp, locally discordant contacts with adjacent units; the chilled zone is narrow. Some thin sills, especially in the mafic metavolcanic sequences may have been mistaken for thick mafic flows. The sills weather green to dark green and are dark green to black on fresh surfaces.

In the Muskratdam Lake belt, the sills have an average thickness of about 2500 feet. Between Munekun Lake and the west end of the belt, one major sill and locally one or two minor sills were mapped. Near Munekun Lake, however, four major sills were found. The west end of the Fox Bay sill and an irregularly-shaped body on the north side of the Severn River fault are distinctly discordant.

Sills are difficult to distinquish in the Rottenfish River belt, but there appear to be two or three sills which have an average thickness of 1000 feet.

Eight modal analysis are presented in Table 5. The plagioclase is tabular andesine-labradorite which has normal and locally oscillatory zoning and which, in many samples, is highly altered and is locally pseudomorphously replaced by albite. Most of the primary pyroxene is pseudomorphously replaced by pale green actinolite(?). Quartz is common but forms less than ten percent of most samples. In the almandine amphibolite facies (Fig. 5), thin sills and the margins of thick sills are recrystallized to mineral assemblages which are identical to those in almandine amphibolite facies mafic metavolcanics (p. 13).

The texture is generally isogranular (Oppenheim, 1964), but gabbro with subophitic to ophitic texture forms thin zones in the lower part of some sills[1].

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[1] Definitions of these textures, as used in this report, can be found in Ayres (in press, p.).

Most sills contain about fifty percent mafic minerals, but leucocratic, anorthositic gabbro (22.5 to 35 percent mafic minerals) is locally present, especially in the Fox Bay sill. Rare, 6-inch to 10-foot thick lenses and layers of porphyritic anorthosite (analysis 1131, Table 5) are found in the anorthositic gabbro; a 4- to 6-inch wide gradational contact zone separates the two phases. Serpentinized peridotite was found near the top of the sill on the north limb of the Sandhill Crane anticline.

With one exception, differentiation appears to be minor. Neglecting the uppermost, early crystallized zone, there seems to be a slight increase in quartz content and a decrease in mafic mineral content from bottom to top of the sills. No systematic variation in plagioclase composition was found. In the upper Munekun Lake sill, leucocratic tonalite dikes (analysis 414, Table 5) locally intrude the upper, early crystallized zone (Photo 10) and rarely penetrate the overlying rocks. These dikes appear to represent the final stage of differentiation.

North of the Severn River about 10 miles west of Sandhill Crane Island, the upper 500 feet of a 1400-foot thick sill is composed of quartz-rich albite granite (analysis 1122, Table 5). Its texture is granitic and no granophyre was found. The contact between gabbro and granite is gradational and is marked by a 100- to 200-foot thick hybrid zone. Rarely granite intrudes gabbro. Rare, narrow, discontinuous, syenite dikes were found in the granite. The granite and gabbro are probably genetically related but the sill appears to be a composite intrusion.

Metamorphosed potassic granite which intrudes gabbro northwest of Lookout Lake might be a felsic differentiate of the gabbro.

In the central part of most sills, dioritic pegmatite forms ovoid to locally irregular masses which have an average length of 9 inches and are in sharp contact with the adjacent gabbro (Photo 11). The pegmatite has an average grain size of one inch and contains about 45 percent oligoclase-andesine, 20 percent uralitized clinopyroxene, 20 percent primary green hornblende, 10 percent iron-titanium oxide and leucoxene, and 5 percent biotite, quartz, and apatite. The hornblende commonly forms radiating, blade-like grains as much as four inches long (Photo 11). In many of the pegmatite pods, plagioclase has been completely replaced by epidote, and the pods are pale green.

The upper Munekun Lake sill also contains 1- to 6-inch diameter, medium- to coarse-grained, rusty-weathering spheroids in which mafic minerals and iron-titanium oxides are more abundant than in the adjacent medium-grained gabbro.

Contacts were only rarely observed, and primary textures and structures in contact zones are preserved only in ~~contact zones within~~ the greenschist facies. On the Severn River, the Fox Bay sill has a two-foot wide chilled zone against metasiltstone. The metasiltstone weathers white instead of grey in a one-foot wide zone adjacent to the sill, but in thin section no contact metamorphic effects were observed.

The sills predate the regional metamorphism, and the trend of the faint differentiation, the concordant habit, and the great lateral extent suggest that the gabbro was intruded into an essentially horizontal sequence. Local cross-cutting relations, however, show that some, if not all, of the sills were intruded into a moderately folded sequence. This is best documented at the west end of the Fox Bay sill where the sill discordantly intrudes both limbs of the Fox Bay syncline.

Late, porphyritic felsic dikes

Near Munekun Lake, grey to dark grey, unmetamorphosed, porphyritic tonalite dikes and sills have intruded uralitized gabbro and mafic metavolcanics. The tonalite contains 5 to 20 percent, oscillatory zoned, subhedral plagioclase phenocrysts (oligoclase to labradorite), 3 to 10 percent, altered, subhedral to euhedral, hornblende phenocrysts, rare quartz and biotite phenocrysts, 55 to 70 percent groundmass quartz and plagioclase (oligoclase-andesine), 10 to 15 percent groundmass biotite, and minor iron-titanium oxide, pyrite, pyrrhotite, chalcopyrite, sphene, zircon, and apatite.

The dikes range in width from a few feet to 50 feet and have sharp, chilled contacts. At the dike margins, the groundmass is cryptocrystalline, and phenocrysts range in diameter from 1 millimetre to 5 millimetres. In the centre of the wider dikes, the groundmass grain size is 0.1 millimetre, and phenocrysts range in diameter from 2 to 10 millimetres. Phenocrysts are absent in a 2-inch to 3-foot wide zone at the margins of some dikes.

The dikes are probably genetically related to the granitic batholiths, but the reason for their localization near Munekun Lake, three miles from the nearest batholith, is unknown.

Similar dikes were rarely found in the Rottenfish River belt.

Rare, narrow, unmetamorphosed, porphyritic trondhjemite and sodic granite dikes were found in the metavolcanic-metasedimentary-metagabbroic assemblages near the granitic batholiths and are probably genetically related to the batholiths. The dikes contain fine- to medium-grained plagioclase and rare quartz phenocrysts in a very fine-grained plagioclase-quartz-microcline-biotite-muscovite groundmass. These dikes are much less abundant than equigranular granitic dikes which occur in the country rock adjacent to the batholiths.

Quartz monzonite stock

The only granitic stock within the metavolcanic-metasedimentary-metagabbroic belts is north of the east end of Muskratdam Lake. The stock appears to be approximately circular in plan and underlies an area of about 0.3 square mile; its contacts are not exposed. It is composed of pale pink, foliated, medium-grained, equigranular quartz monzonite; a modal analysis is given in Table 6 (sample 246). The plagioclase has discontinuous normal and rare oscillatory zoning.

Granitic batholiths

General statement

Granitic rocks underlie about 70 percent of the map-area (1200 square miles) and completely encompass the metavolcanic-metasedimentary-metagabbroic belts except for about 10 miles at the north and south ends of the Rottenfish River belt and the east end of the Muskratdam Lake belt. Except for a small area on the west side of the Rottenfish River belt, all granitic rocks appear to belong to one composite, intrusive batholith.

The granitic rocks have a wide range in composition, texture, and structure, but one mafic phase and eight felsic phases were distinguished during the reconnaissance mapping (Table 1; Fig. 4). Each of these phases has a wide range in soda : potassia ratio but was differentiated from other phases by mafic mineral content and texture.

The classification of granitic rocks used in this report has been previously described by the author (Ayres, in press, Table).

Early mafic phase

East of Rottenfish Lake, equigranular diorite, quartz-bearing diorite (5 to 10 percent quartz), syenodiorite, and quartz-poor mafic trondhjemite form a stock-like body which is elliptical in plan. The stock has an area of about 4.5 square miles and is bounded on the east by the Hill Lake fault. Two textural types were mapped: a predominant, medium-grained, massive to poorly foliated phase with uniformly distributed mafic minerals (Table 6, analysis 1012), and a coarse-grained phase in which plagioclase is oriented and mafic minerals are concentrated in oriented, lenticular clots. The relationship between the two phases is unknown.

Clinopyroxene, which is partly to completely replaced by pale green amphibole, forms as much as thirty-five percent of the stock. Plagioclase is highly strained, fractured, and locally recrystallized. The mafic mineral content appears to decrease and the quartz content to increase toward the margin of the stock, and the stock may grade into adjacent hornblende tonalite and trondhjemite. Contacts with adjacent rocks are not exposed.

The stock contains rare, hornfelsed, mafic metavolcanic inclusions and was intruded by rare, narrow, pink, leucocratic, locally recrystallized, quartz monzonite dikes.

North of the Muskratdam Lake belt, rare, diorite inclusions were found in equigranular and porphyritic felsic phases (Photo 12).

The incipient recrystallization and inclusions in felsic phases suggest that the mafic-rich phase is older than the granitic phases.

Granitic phases

Introduction

The eight granitic phases are discussed below in order of apparent decreasing age. The intrusive history, however, is not completely known and is probably complex; some phases probably have several ages. Except where otherwise specified, the granitic rocks are medium-grained (1 millimetre to 3 millimetres) and are grey, pale grey, white, or pink on both fresh and weathered surfaces.

Foliation is common in the granitic rocks and appears to be a primary flow structure. It is generally parallel to contacts between the major phases and to the contact with the metavolcanic-metasedimentary-metagabbroic belts.

The granitic rocks near Rottenfish Lake were briefly described by Satterly (1939, p. 32).

Equigranular, hornblende-biotite phase

Equigranular, foliated, hornblende-biotite granodiorite, trondhjemite, and tonalite form a distinctive but minor phase which is most abundant north of Rottenfish Lake and north of the western part of the Muskratdam Lake belt (Table 6, analyses 286, 401, and 134). Trondhjemite is the predominant rock type; granodiorite is rare. Quartz-poor tonalite locally forms a contaminated(?), marginal zone adjacent to mafic metavolcanics along the south edge of the Muskratdam Lake belt, but its contacts with mafic metavolcanics are sharp.

Hornfelsed, mafic metavolcanic inclusions are present in many outcrops but are generally not abundant. Eleven miles north-northwest of Sandhill Crane Island, however, mafic inclusions are abundant, and the granitic rock (probably tonalite) has a highly variable hornblende content because of contamination; the foliation is contorted. In the equigranular biotite phase, a narrow, contaminated, hornblende-bearing zone locally surrounds mafic inclusions, especially where inclusions are abundant.

Porphyritic, hornblende-biotite phase

Porphyritic, foliated, hornblende-biotite granodiorite and minor trondhjemite underlie a small area about 18 miles north-northwest of Sandhill Crane Island (Table 6, analysis 798). This unit is characterized by 1/2- to 1-inch long, subhedral, perthitic microcline phenocrysts which have a random or locally preferred orientation. Phenocrysts form as much as 20 percent of the rock but average between 5 and 10 percent; groundmass microcline forms less than 10 percent of most samples. With disappearance of phenocrysts this unit appears to grade into equigranular, hornblende-biotite rocks. Inclusions are rare.

Fine-grained trondhjemite dikes

Narrow dikes of fine-grained (0.5 to 1 millimetre), equigranular, massive, biotite trondhjemite (Table 6, analysis 792) have intruded the equigranular, hornblende-biotite phase about 15 miles north-northwest of Sandhill Crane Island. The dikes form as much as fifteen percent of some outcrops. Although they could not always be distinguished from later, fine-grained granodiorite dikes, the trondhjemite dikes appear to be rare or absent in, and to thus predate, the medium-grained, biotite phases. Near Pike Lake, however, similar fine-grained trondhjemite dikes have intruded the equigranular, biotite phase, and there are thus two ages of these trondhjemite dikes.

Equigranular, biotite phase

Most of the batholith is composed of equigranular, biotite trondhjemite, granodiorite, and quartz monzonite (Table 6, analyses 934, 791, 827, 47, and 893). On the south side of the Muskratdam Lake belt, this phase, where mapped, comprises 60 percent trondhjemite, 25 percent granodiorite, and 15 percent quartz monzonite. On the north side of the belt, the mapped part of the phase consists of 35 percent trondhjemite, 25 percent granodiorite, 40 percent quartz monzonite, and rare sodic syenite. On the west side of the Rottenfish River belt only granodiorite was found. The relationship between the various rock types in the phase could not be determined. In some places the phase has a relatively uniform composition over a large area and appears to gradually grade into other rock types; in other outcrops, however, trondhjemite, granodiorite, and quartz monzonite are intimately interlayered.

Two rare varieties of the phase are (1) porphyritic trondhjemite (Table 6, analysis 769) in which the phenocrysts are 5- to 10-millimetre long, subhedral plagioclase and (2) coarse-grained (5 to 10 millimetres) granodiorite. These varieties appear to grade into the medium-grained, equigranular rocks.

Foliation defined by oriented biotite flakes and aggregates and locally by oriented quartz lenses is common and is generally slightly wavy although contortion is rare. Lineation was found in a few well foliated outcrops. Quartz monzonite is locally massive. Gneissic varieties are local present, and three main types of gneissosity have been distinguished. (1) <u>Intimately</u>

interlayered sodic and potassic phases. Grey sodic layers are generally 1 inch to 2 feet thick, and pink potassic layers, which are locally pegmatitic, have an average thickness of 1 inch; layers pinch and swell and are locally contorted. This type is best developed ~~near Rank Lake~~ south of Pike Lake and on the east side of the Rottenfish Lake fault. Mafic metavolcanic and metasedimentary inclusions are abundant in gneissic outcrops ~~near Rank Lake.~~ south of Pike Lake. (2) Migmatite. Migmatite composed of alternating granitic sills and metasedimentary or mafic metavolcanic layers is locally found adjacent to the metavolcanic-metasedimentary-metagabbroic belts. (3) Mafic schlieren. Hornblende- and biotite-rich schlieren are common in areas where mafic metavolcanic inclusions are abundant, such as south of Pike Lake, and may be modified mafic metavolcanic inclusions. In migmatite, metasedimentary layers locally grade into biotite-rich schlieren. Schlieren are generally less than two inches thick.

Angular, round, and lenticular, hornfelsed, mafic metavolcanic inclusions are ubiquitous and range in length from several inches to hundreds of feet (Photo 13). South of Pike Lake some inclusions are highly stretched and appear to pass into mafic schlieren. The amount of mafic inclusions is highly variable, and there are distinct zones in which inclusions form 10 to 50 percent of the outcrop; these zones resemble intrusion breccias. The granitic phase in these zones is generally trondhjemite which has a variable biotite content and appears to be contaminated. Metasedimentary inclusions are rare and, in general, were found only near metasedimentary formations. Rare, angular, equigranular, hornblende-biotite trondhjemite inclusions as much as 500 feet long were found in biotite trondhjemite. Inclusions which have planar structure have locally been rotated (Photo 13).

At the edges of some equigranular hornblende-biotite trondhjemite units and at the south end of Misquamaebin Lake, hornblende-biotite trondhjemite and biotite trondhjemite are interlayered; the layers have gradational contacts. The presence elsewhere of equigranular hornblende-biotite trondhjemite inclusions in biotite trondhjemite indicates, however, that the biotite phase is slightly younger. Biotite trondhjemite has also intruded porphyritic, hornblende-biotite granodiorite.

Porphyritic, biotite phase

Porphyritic, biotite granodiorite and quartz monzonite (Table 6, analysis 1152) underlie large areas which are elongated parallel to the foliation in the adjacent phases. Quartz monzonite is about twice as abundant as granodiorite. The phase is characterized by subhedral, randomly oriented, perthitic microcline phenocrysts which have an average length of 1/2 inch but which locally are as much as 3 inches long; in some outcrops phenocrysts are aligned. Phenocryst abundance is highly variable and ranges from locally ~~abundant~~ absent to twenty-five percent; the average content is ten percent. Quartz monzonite in this phase and in the equigranular biotite phase locally contains euhedral, magnetite crystals as much as five millimetres in diameter.

The phase is massive to poorly foliated with foliation defined by oriented biotite and locally by aligned phenocrysts. A rare gneissosity is produced by alternation of layers containing abundant large phenocrysts with layers containing sparse small phenocrysts. Inclusions are rare.

About 15 miles north-northwest of Sandhill Crane Island, massive, porphyritic, biotite quartz monzonite was found in sharp, discordant contact with, and is thus younger than, foliated, equigranular, hornblende-biotite trondhjemite. The relationship between the porphyritic and equigranular biotite phases was not directly observed, but the porphyritic phase appears to distort the foliation in the equigranular phase (Fig. 4) and is probably younger.

Fine- to medium-grained granodiorite dikes

Fine- to medium-grained, massive, granodiorite dikes (Table 6, analysis 905) have intruded the equigranular and porphyritic, hornblende-biotite phases and the equigranular and porphyritic, biotite phases in a 15 square mile area north-northwest of Sandhill Crane Island (Fig. 4). The dikes range in width from a few feet to more than 100 feet and locally underlie entire outcrops. The dikes are in sharp contact with the granitic country rocks and locally contain angular country rock inclusions.

The plagioclase has discontinuous oscillatory zoning and is thus distinctly different from the plagioclase in the other granitic phases which has continuous normal or continuous oscillatory zoning or is locally unzoned.

Hornblende-biotite trondhjemite dike

A 50-foot wide, fine-grained, foliated, hornblende-biotite trondhjemite dike appears to intrude porphyritic, biotite quartz monzonite north of the west end of the Muskratdam Lake belt. Contacts are not exposed. The approximate composition of the dike is 57 percent, normally zoned oligoclase-andesine, 25 percent quartz, 3 percent microcline, 9 percent biotite, 3 percent hornblende, and minor pistacite, chlorite, sphene, iron-titanium oxide, pyrite, apatite, and allanite.

The relationship between this dike and the fine- to medium-grained granodiorite dikes is unknown.

Pegmatite and aplite

Pink pegmatite and fine- to medium-grained, leucocratic granodiorite and quartz monzonite (aplite) (Table 6, analyses 1146 and 370) dikes are ubiquitous and have intruded all other granitic phases except possibly the fine- to medium-grained granodiorite and the hornblende-biotite trondhjemite dikes.

Aplite dikes are massive, range in width from a fraction of an inch to more than 200 feet, and have an average width of 3 inches. Contacts are subvertical, sharp, slightly chilled, and straight to curved. Dikes commonly occupy several joint sets but only rarely do dikes in one joint set intrude those in another joint set; the younger aplite is generally grey rather than pink. Aplite varies in abundance from rare to more than fifty percent but generally forms less than one percent of the outcrop. When aplite is abundant, dikes are less than ten feet wide and country rock between the dikes is not rotated.

Pink pegmatite dikes are associated with, but are generally less abundant than, aplite dikes, and the two locally form composite dikes with either an aplite core and pegmatite rim or a pegmatite core and aplite rim. In some outcrops pegmatite intrudes aplite, but in other outcrops pegmatite is intruded by aplite. Pegmatite dikes are straight to curved, have a maximum grain size of two feet, have sharp contacts with narrow, fine- to medium-grained chilled zones, and are generally composed of perthitic microcline, albite, quartz, and biotite; graphic intergrowth of quartz and feldspar is common. The dikes locally contain muscovite and accessory magnetite. Dikes are subvertical, have an average width of 3 feet, but are locally as much as 300 feet wide. Pegmatite forms less than one percent of most outcrops, but in some areas it is the dominant rock type. When pegmatite is abundant, dikes are narrow and country rock is not rotated. Dikes are locally zoned with a quartz-rich core and feldspar-rich wall zones; rarely the wall zones have an outer albite-microcline zone and an inner microcline zone.

In rare outcrops both aplite and pegmatite form narrow lenses parallel to the foliation of the host rock.

Pink pegmatite also forms irregular patches within, and gradational with, medium-grained quartz monzonite. In some outcrops, large microcline grains, which resemble phenocrysts, have a highly irregular distribution throughout quartz monzonite and locally form aggregates. The larger aggregates have associated coarse-grained quartz and are pegmatitic. In the porphyritic quartz monzonite previously described (p. 52), phenocrysts have a relatively uniform distribution and aggregates are rare. The irregularly distributed and aggregated microcline grains thus appear to be porphyroblasts which formed during the pegmatite stage of crystallization.

In several aplite dikes a similar gradation was observed from single microcline grains to small pegmatite patches.

White pegmatite which contains albite-oligoclase, quartz, muscovite, and accessory tourmaline, garnet, magnetite, molybdenite, and apatite forms rare sills, lenses, and dikes in metasediments and metavolcanics. It is most abundant along the north edge of the Muskratdam Lake belt between ~~Major~~ Axe Lake and ~~Bannan Lakes.~~ the Morrison River. The pegmatite has a maximum grain size of six inches, and, on a small island in the Severn River at the entrance to ~~Major~~ Axe Lake, it contains fracture, black, tourmaline crystals as much as four inches long (Photo 14).

Rare, narrow, white pegmatite sills and lenses were found in the granitic rocks, and several of these contain concentrations of magnetite. A 2-foot wide sill about 14 miles north-northwest of Sandhill Crane Island contains about fifteen percent magnetite.

Pistacite veins

Rare, pale green to green, pistacite (epidote) and quartz-pistacite veins as much as 1/2 inch wide fill joints in many granitic outcrops and appear to postdate all of the granitic phases.

Contacts with metavolcanic-metasedimentary-metagabbroic belts

The contacts between the granitic batholiths and the metavolcanic-metasedimentary-metagabbroic belts were observed at several localities and are generally subvertical. In small outcrops the contact appears to be ~~parallel to primary structures and to formational contacts within the belt,~~ concordant, but over large areas contacts are distinctly discordant. Contacts vary from sharp to gradational. Gradational contacts are migmatitic with layers of country rock ranging in width from a few inches to more than 100 feet alternating with granitic sills of similar width; contacts between the two phases of the migmatite are sharp. Discordant granitic dikes are rare in the migmatite zones. Intrusion breccia consisting of angular, country rock fragments in a granitic matrix was not observed at the contact but forms zones of unknown origin within the equigranular biotite phase.

Foliation in the granitic rocks is generally parallel to the contact, but distinctly discordant foliation was found on the west side of the Rottenfish River belt, north of the west end of the Muskratdam Lake belt, and west of Lookout Lake.

Sharp contacts were observed adjacent to metagabbro (1) on the west side of the Rottenfish River belt; adjacent to mafic metavolcanics (2) along part of the northeast edge of the Rottenfish River belt, (3) north of the west end of the Muskratdam Lake belt, (4) at Nekence Lake, and (5) on the Schade River; and adjacent to metasediments (6) on the Windigo River. At these localities, country rock inclusions are rare in the granitic rocks, which ~~the granitic rocks~~ are generally unchilled, and granitic sills are rare and dikes are absent in the country rocks. Near Pike Lake abundant granitic sills and dikes were found in the mafic metavolcanics adjacent to the granitic rocks at two flexures in the contact. At localities 3, 5, and 6, the granitic rocks adjacent to the contact are locally sheared; the shear zone is as much as 500 feet wide and muscovite is common in the sheared granitic rocks (compare with Table 6). A chilled, 50- to 100-foot wide zone of porphyritic tonalite was found at the Windigo River contact.

The Rottenfish Lake fault forms the southeast contact of the Rottenfish River belt. Contact relations along the fault are described in detail in a later section (p. 80).

Migmatitic contacts were observed adjacent to mafic metavolcanics (1) along part of the northeast contact of the Rottenfish River belt (1500 + feet wide), (2) at the west end of the Muskratdam Lake belt (4000 feet wide), (3) near Wapesi Lake (500 feet wide), and (4) about eight miles west of Sandhill Crane Island (1500 + feet wide); and adjacent to metasediments (5) at the northwest corner of the Muskratdam Lake belt (500 feet wide), (6) northeast of Sandhill Crane Island (3000 feet wide), and (7) north and east of ~~Major~~ Axe Lake (500 to 1000 feet wide). At the northwest corner of the Muskratdam Lake belt, metasediments contain as much as thirty percent granitic sills, but a metagabbro sill within the metasediments contains only rare granitic dikes. The mica in the granitic sills is muscovite rather than biotite. This migmatite is in relatively sharp contact with the batholith in which biotite is common and muscovite is rare.

West of Lookout Lake, mafic metavolcanics between the batholith and the quartz monzonite stock contain about twenty percent granitic and pegmatitic sills and rare dikes.

Origin

On the basis of reconnaissance mapping, Donaldson (1961) and Duffell (1963) postulated that many of the granitic rocks immediately south of the map-area were formed by "large-scale granitization." Moxham (1965) further suggested that many of the granitic rocks were regionally metamorphosed to the epidote-amphibolite facies.

In the map-area, many features such as (1) the intrusive relationships between many of the granitic phases, (2) the lack of recrystallization except in the early mafic phase, (3) the igneous-like textures, (4) the rotation of inclusions, (5) the universal but commonly sparse occurrence of angular, hornfelsed, mafic metavolcanic inclusions which have sharp contacts but locally narrow contaminated zones; (6) the locally sharp contacts with the metavolcanic-metasedimentary belts, (7) the lack of gradational contacts, other than migmatite, and (8) the contact metamorphism of the belts, suggest that the granitic rocks crystallized from a magma although the origin of the magma is not known. No evidence of large-scale metasomatism within the granitic terrane was found although minor metasomatism is indicated by a change in composition of some of the inclusions, local development of feldspar porphyroblasts in felsic inclusions, and local development of microcline porphyroblasts in quartz monzonite during pegmatite formation. These features, however, are consistent with a magmatic derivation of the granitic rocks.

Detailed mapping (Ayres, ~~1966)~~ 1967) 75 miles west-southwest of the map-area within the area considered by Donaldson (1961) and Moxham (1965) has shown that the granitic batholiths are composed of many discrete plutons, each of which, except the oldest, has intrusive contacts against older granitic rocks. These batholiths thus resemble other large batholiths of orogenic regions, such as the Sierra Nevada (Bateman et al, 1963).

Late mafic dikes

Lamprophyre

Several, fine-grained, grey to black, mafic dikes which range in width from 4 inches to 5 feet have intruded granitic rocks and are called lamprophyre although some are not noticeably porphyritic. These dikes were found along the Severn River south of the west end of the Muskratdam Lake belt, at Namaybin Lake, north of Sandhill Crane Island, and east of the Windigo River. A similar dike was found in mafic metavolcanics southeast of Munekun Lake.

The dikes are compositionally different from diabase, and the approximate composition is 15 percent blue-green hornblende, 15 to 25 percent biotite, 0 to 20 percent quartz, 40 to 60 percent zoned oligoclase-andesine, and minor pistacite, sphene, pyrite, pyrrhotite, iron-titanium oxide, chalcopyrite, and apatite. Phenocrysts, where present, are medium-grained hornblende or biotite.

Diabase

Five north-northeast- and two west-northwest-trending, post-granitic diabase dikes were mapped. Four of the north-northeast dikes have been traced intermittently across the map-area, but the west-northwest dikes, which were found only in the northwest and southeast parts of the map-area, could be traced for only short distances along strike. Most of these dikes are between 50 and 200 feet wide, but subsidiary dikes which are generally less than 3 feet wide were found near, and parallel to, the main dikes. Contacts are sharp, chilled, and straight, curved, undulating, or slightly irregular; in several outcrops the strike of the contact changes more than 30 degrees within a distance of one mile. The chilled zone is generally less than two feet wide and locally contains thin flow layers. Rare, stoped, granitic blocks were found near the margins of the dike east of

Cable Lake (Photo 15).

The dikes are dark grey to black on fresh surfaces and weather grey or brown. Four modal analyses are presented in Table 7. Quartz is present in all samples but always forms less than ten percent of the dike. Plagioclase has oscillatory zoning and clinopyroxene has normal zoning.

The two dike sets are distinctly different in composition and texture. North-northeast dikes have isogranular texture (see p. 42) and contain accessory pigeonite and rare orthopyroxene. Zoning in plagioclase is locally discontinuous, and medium-grained plagioclase phenocrysts were found in the chilled margin of several dikes. West-northwest dikes have subophitic to ophitic texture and contain minor olivine; about twenty-five percent of the clinopyroxene is pigeonite.

East of Cable Lake, rare, six-inch wide, white, fine-grained, granophyre dikelets are present in the diabase and trend perpendicular to the dike contact. The granophyre contains 70 percent albite (An_0), 20 percent quartz, 2 percent clinopyroxene, 1 percent hornblende, 2 percent pistacite, and rare sphene, allanite, and iron-titanium oxide; granophyric intergrowth forms about 20 percent of the dikelets.

Diorite

On the west side of ~~Hunter Creek~~ a creek about ~~two~~ four miles ~~south~~ east of ~~its junction with the Tobogan River,~~ Moose Lake, several, pale grey to grey, fine-grained (0.5 millimetre), north-trending, diorite dikes were observed in the granitic rocks. The dikes have a maximum width of six inches and their approximate composition is 60 percent, normally zoned andesine (An_{41}-An_{36}), 17 percent clinopyroxene, 10 percent quartz, 4 percent pistacite, 3 percent microcline, 2 percent sphene, 1 percent dark green hornblende, 2 percent devitrified glass(?), and minor apatite, allanite, and pyrite. The dikes have a mineralogical layering parallel to contacts.

The glass(?) generally has a partial or complete pistacite rim and is devitrified to an orange, locally fibrous, birefringent aggregate which has a mean refractive index of 1.529. Rare, curved (perlitic?) fractures were observed in the altered glass.

The presence of devitrified glass indicates that the dikes must have been emplaced much closer to the earth's surface than the granitic rocks in which they occur. The dikes are thus much younger than the granitic batholith.

Metamorphism

The metavolcanic-metasedimentary-metagabbroic belts have been regionally metamorphosed, and the grade of metamorphism ranges from the middle greenschist to the middle almandine amphibolite facies (as defined by Fyfe et al, 1958). The approximate position of the greenschist and almandine amphibolite facies is shown in Figure 5. This figure is based on only 190 thin sections, and detailed work would probably result in considerable revision.

The almandine amphibolite facies zone has a highly variable width and is narrowest west of Fox Bay. In many places, the boundary between the greenschist and almandine amphibolite facies appears to occur within a metagabbro sill and near the side of the sill which faces the almandine amphibolite facies. The coincidence of this facies boundary and metagabbro sills may reflect a lag in metamorphic reaction rates within the coarser-grained parts of the sills. The greenschist facies part of these sills generally retains primary grain size while, in the almandine amphibolite facies part, the primary grains, especially plagioclase, have been recrystallized to aggregates of tiny grains.

On the southeast side of the Rottenfish River fault, upper greenschist facies rocks which occur adjacent to granitic rocks (Fig. 5) are separated from the batholith by the Rottenfish Lake fault, a major structural break. Part of this greenschist facies zone may have been formed by retrograde metamorphism related to the fault.

The granitic batholiths superimposed hornblende hornfels facies, contact metamorphic aureoles as much as one mile wide on the almandine amphibolite facies zone. These two facies could not always be differentiated, but in mafic metavolcanics the contact aureole is characterized by (1) a deepening in the colour from green or dark green to dark grey-green or black, (2) a decrease in the intensity of foliation and partial development of a granular, hornfels texture, (3) a slight increase in grain size, (4) local development of gneissosity produced by metamorphic differentiation (p. 16), and (5) an increase in the number of narrow, concordant quartz veins. Gneissosity (Fig. 5) is best developed where granitic rocks adjacent to the belt are sheared or where large flexures occur in the contact. At the northwest corner of the Muskratdam Lake belt, a metagabbro sill in migmatitic metasediments has gneissic border zones but a massive to foliated interior.

Clinopyroxene locally occurs in hornblende hornfels facies mafic metavolcanics along the north edge of the Muskratdam Lake belt and in inclusions in the granitic batholith north of this belt.

Pleistocene

Direction of ice movement

Glacial striae are present on most outcrops and in most of the map-area have a relatively consistent southwest trend (Fig. 6). In the southeast corner of the area, however, they trend west-southwest and locally west. The gently sloping, northeast sides and steeply sloping, plucked, ~~northwest~~ southwest sides of many outcrops (~~rouche~~ roches moutonées) indicate that the last movement of the ice was in a southwesterly direction. Glacially polished surfaces are preserved on a few metavolcanic and granitic outcrops.

Straight to rarely curved, ~~linear,~~ drumlins and drumlinoid ridges ~~(Dean, 1953)~~ which have the same trend as nearby striae (Fig. 6) indicate either a southwest or a northeast ice movement direction. They are found in most parts of the area and form an extensive field near, and northwest of, Muskratdam Lake. The ridges were located by examination of aerial photographs and were only locally examined on the ground. They range in length from 1300 to 8000 feet and in width from 200 to 2100 feet; their average length is about 2500 feet and average width about 400 feet. They are seldom more than 20 feet high, and the highest part is near the centre of the ridge rather than at the stoss end as in ~~true~~ most drumlins. [Insert p. 64a] The surface of the ridges is composed of cobbles and boulders which were probably concentrated by wave washing of boulder clay.

Older south-southeast-trending striae which are partly obliterated by the southwest-trending striae were found in hollows on a few outcrops in the eastern part of the area (Fig. 6). The ice movement direction could not be determined. Similar older

Most of the ridges have a length : width ratio between 3:1 and 5:1 and are drumlins (Reed et al, 1962). A few have a length: width ratio of 10:1 and approach drumlinoid ridges in shape (Dean, 1953).

striae have been reported from the Fawn River and Big Trout Lake by Tyrrell (1913) and Hudec (1964). These authors found that the older ice sheet or lobe moved in a northwesterly direction.

South- to south-southeast-trending striae also occur on the west side of the Sachigo interlobate moraine (Satterly, 1937; 1938) but are younger than the southwest-trending striae (Derry and MacKenzie, 1931). None of these striae were mapped.

Moraines

A thin layer of drift mantles much of the bedrock but only the upper surface, which is composed of boulders, cobbles, pebbles, and minor sand, is exposed. This upper part of the drift is probably a concentrate formed by Pleistocene wave washing of the original till. Similar concentrates which are found in rapids and along lake shores are probably Recent wave-washed drift. In the western part of the area where lacustrine varved clay overlies drift (Fig. 6), the drift, where exposed, is wave washed and composed of pebbles, cobbles, and boulders. It forms a thin layer, generally less than one foot thick, between bedrock and overlying clay.

Drift is rare on most outcrops: it was probably originally present but was removed by Pleistocene, lacustrine, wave action. Some rock hills were apparently protected from wave action and still have a drift cover. On these hills outcrop is best exposed on the northeast (stoss) side and the hills are probably crag and tail. Some outcrops, especially south of Axe Lake, are surrounded by a wide boulder and cobble apron which has the same elevation as the outcrop and is probably wave modified ground moraine.

At three localities, boulders and cobbles form definite beach ridges near the top of outcrop hills (Fig. 6). North of Rain Lake, a series of ridges which have a difference in elevation of 3 to 10 feet and are composed of angular to subrounded cobbles and boulders form the crown of a granitic outcrop. When traced along strike the beach ridges pass into extensive boulder fields. All outcrop on the hill is below the lowest beach ridge. East of Cable Lake, narrow beach ridges composed of subrounded pebbles and cobbles rest on outcrop and are separated from adjacent ridges by bare outcrop.

Most of the cobbles and boulders in the drift are angular to subrounded and granitic in composition. Diabase boulders are abundant southeast of Moose Lake near the postulated intersection of two dikes. Fossiliferous, Paleozoic, limestone and dolomite pebbles and cobbles are locally present.

Thick deposits of ground moraine which have a hummocky, knob and kettle, upper surface are locally present and underlie a large area east of Rottenfish Lake. The kettles are invariably occupied by small, swampy ponds.

A low end moraine which is generally covered by muskeg was found by aerial photograph interpretation in the northeast corner of the area (Fig. 6) but was not examined on the ground. The moraine appears to have been wave modified, has a maximum width of 3500 feet, and, along the west shore of Makoop Lake where muskeg is locally absent, appears to have a maximum local relief of 50 feet. Several eskers on the northeast side of the moraine terminate at the moraine.

On ~~the~~ preliminary maps P. 219, P. 221, and P. 222, this moraine was tentatively correlated with the Kawagami moraine which was described by Tyrrell (1913) east of Makoop Lake. Recent air photograph interpretation by the author east of Makoop Lake suggests, however, that the Kawagami moraine is a ground moraine which cannot be correlated with the moraine in the map-area. The moraine mapped by the author is equivalent to the end moraine mapped by Prest (1963) southwest of Wunnummin Lake although there appears to be a 15-mile long gap in the moraine between the south end of Makoop Lake and the Nekikamog River.

Several east-trending sand and gravel hills east of Rottenfish Lake (Fig. 6) may be part of the Agutua end moraine first described by Tyrrell (1913) near Windigo Lake. Prest (1963) has traced this moraine northwestward to latitude 53° north, longitude 92° west where it consists of a series of isolated hills rather than a continuous ridge. One of the hills east of Rottenfish Lake is more than 100 feet high,* and poorly

* Relief taken from the Opasquia 1:250,000 topographic sheet, Department of Mines and Technical Surveys, Ottawa.

developed beaches near the top of the hill indicate that the hill was completely covered by Pleistocene lakes.

A large, north-trending, interlobate moraine which is 150 to 200 feet higher than the surrounding terrain was mapped at the west edge of the area (Fig. 6). This moraine was first described by Satterly (1937, 1938) and was called the Sachigo moraine by Elson (1961). The moraine was not examined on the ground, but well developed beaches were identified on aerial photographs. The distribution of the beaches shows that, at one time, most of the moraine was below lake level (Fig. 6). The moraine is an asymmetric ridge with the east side having a steeper slope than the west side. In the Sachigo Hills north of the map-area, the highest beach on the west side of the moraine is at a higher elevation than the highest beach on the east side.

Large kettle holes are locally preserved along the top of the moraine. At one locality a series of kettles occur along the prolongation of a major negative lineament in the bedrock and probably formed by melting of ice which had been trapped in the valley and covered by the moraine.

The interlobate moraine appears to have formed between an eastern, stagnant lobe of ice behind the Agutua moraine and a later western lobe. These lobes were respectively called Sachigo and Ponask by Satterly (1937, 1938). The asymmetric shape of the moraine and the distribution of the beaches in the Sachigo Hills suggest that the western lobe retreated before the eastern lobe. The western lobe built a prominent, east-trending, end moraine north of Sandy Lake at latitude 53°20' north. Elson (1961) included this end moraine with the Sachigo moraine, but the author believes that it should be given a separate name.

Glacio-fluvial deposits

The drainage pattern of rivers beneath the waning ice is shown by the eskers which are plotted in Figure 6. The convergence of the eskers towards the south edge of the map-area and the tributary pattern indicate a southwesterly river flow.

The eskers are long, locally discontinuous ridges which generally have a relatively uniform crest line and a maximum height above adjacent terrain of 50 feet. They are composed dominantly of sand and pebble gravel and contain about ten percent subrounded cobbles and boulders. The boulders are generally less than 1.5 feet in diameter but some are as much as 6 feet in diameter.

Two sand and silt deltas which probably represent brief halts in the retreat of the ice were found along one esker. The deltas occur at the south end of an esker ridge and are separated from the southerly continuation of the esker by a short gap. Narrow sand and gravel aprons locally flank the main esker ridge and appear to have two origins (Fig. 6): (1) outwash from the glacier, and (2) lacustrine wave modification of the esker. Linear depressions which might be kettles are found in the esker and outwash deposits between Clear Lake and the Windigo River.

In the southwestern part of the area eskers have been modified by Pleistocene wave action (Fig. 6). The less modified eskers retain their ridge shape and locally have beaches. The more highly modified eskers form low, linear, sand and gravel mounds which have a local relief of only a few feet.

A large pit which might be a pothole was found in a granitic outcrop about 18 miles north-northwest of Sandhill Crane Island. The pit is circular in plan, has vertical walls, is 8 feet in diameter and at least 6 feet deep, and is filled with debris. No water was found in the pit which probably indicates subterranean drainage.

Glacio-lacustrine deposits

The presence of abandoned beaches, wave modification of eskers and interlobate moraine, winnowing of ground moraine, and removal of drift from most outcrops indicate that most, if not all, of the map-area was subjected to Pleistocene, lacustrine, wave action. It is not known, however, if the entire area was simultaneously covered by a Pleistocene lake. Because beaches extend almost to the top of the Sachigo interlobate moraine, the lake near the moraine must have been at least 200 feet deep. The abrupt transition from highly wave modified esker to unmodified esker on the west side of the Windigo River and north of Sandhill Crane Island indicates the eastern, ice shore of a former lake. This shoreline approximately coincides with the eastern limit of thick varved clay outcrops.

Calcareous, varved clay which was deposited in a relatively long-lived, glacial lake is generally restricted to the western part of the area (Fig. 6) although it is locally found elsewhere. Elson (1961) and Rutford (1962) consider that the varved clay was deposited in glacial Lake Agassiz.

Varved clay forms banks as much as 20 feet high along the Severn River but good exposures were found only in the lowermost several feet of the bank where it had been subjected to wave and ice erosion. Varves in the lower part of the section have an average thickness of 2 inches (Photo 16) while varves near the top of the bank appear to be about 1/4-inch thick. Each varve comprises a white to pale brown, lower layer which is composed of calcareous silt and clay and is thinly laminated (0.5 to 1 millimetre) and a dark brown, upper layer which is composed of calcareous clay and is not laminated. The pale brown layers form between 2/3 and 3/4 of the varves and have a greater variation in thickness than the dark brown layers (Photo 16). The contact between layers is always sharp, but the contact between the dark brown and overlying pale brown layers is locally scalloped: rare, dark brown, clay chips were found in the lower part of some pale brown layers.

Brown, spherical, ovoid, or pancake-shaped, mudstone concretions which are more highly indurated and more calcareous than the adjacent clay and silt were found in the pale brown layers at three localities near the eastern limit of varved clay outcrops (Fig. 6, Photo 17). The concretions were only found in the lowermost, well exposed parts of the varved clay banks but may occur elsewhere.

The concretions are generally circular in plan, have a flat to rounded base and top, are 1 inch to 2 inches in diameter although one concretion is 6 inches in diameter, and generally occupy the entire thickness of the pale brown layers. The laminae in the pale brown layers extend through the concretions, and the concretions also have vertical, concentric, growth layers which are emphasized by slight variations in the brown colour (Photo 17).

Extending through the central part of most concretions is a 0.5- to 1-millimetre diameter, vertical tube which is generally surrounded by a 3- to 5-millimetre diameter cylinder of grey, reduced silt and clay. The tube is commonly hollow and in the centre of the concretion it rarely contains a fragile, dark grey to black, carbonized(?) plant stem. Locally the tube is partly filled by silica. Rarely the tube is parallel to, or at a low angle to, the bedding, and the concretion is oval in plan.

Concretions do not occur in the dark brown layers, but locally the tube extends through this layer and connects a concretion in one pale brown layer with a concretion in the overlying pale brown layer. The maximum concentration of concretions is about ten per square foot of bedding surface. Nearby concretions locally coalesce.

The concretions are cemented by calcite and hydrous ferric oxide which appear to have been deposited around the stem of an aquatic plant. The concretion localities are near the eastern limit of varved clay outcrops and thus were probably near the edge of Lake Agassiz where the water may have been relatively shallow.

These concretions differ in colour, amount of calcite cement, shape, and internal structure from concretions which are locally found elsewhere in varved clay deposits (e.g. see Tarr, 1935).

Low gravel ridges which have a maximum height of three feet were found on top of three, high, relatively flat, outcrop hills and on one, high, relatively flat ground moraine hill in the southeast part of the map-area (Fig. 6). Only one ridge is present on each hill, and on the moraine hill the gravel ridge overlies angular to subrounded boulders and cobbles from which the matrix has been winnowed by wave action. The ridges are composed of subangular to rounded pebbles and cobbles in a fine to coarse sand matrix; the largest cobble observed was four inches in diameter.

The ridges resemble abandoned beach deposits, but their location suggests that they were formed by bottom currents rather than by surface wave action.

Recent

Recent deposits comprise lacustrine and fluvial clay, silt, and sand which are being deposited in the rivers and lakes, and organic mud which is being deposited in swamps and muskegs. Recent streams and lakes have also formed boulder and cobble deposits by winnowing of Pleistocene drift. Recent sand beaches are rare and have apparently formed only on Pleistocene outwash deposits.

The Severn River and some of its tributaries have a high content of suspended clay and silt because of erosion of Pleistocene varved clay. This clay and silt is probably being deposited in lakes and on the mud flats which flank the river (p. 6). Small silt and clay deltas are locally found at the mouth of tiny rivulets which flow into the Severn River.

Recent swamp and muskeg cover most of the map-area but are best developed on the impermeable Pleistocene clay deposits in the western part of the area (p. 5). Many of the outcrop areas shown on the geological maps, especially within areas underlain by granitic rocks, consist of several, low outcrops which are separated by muskeg. For mapping purposes, the organic deposits have been subdivided into swamp and muskeg; contacts shown on the geological maps are generalized.

Swamps are distinctive topographic features because they are flat, generally open areas in which trees are less than 10 feet high. The three main types of swamp are (1) wet areas in which tamarack is the dominant tree species, (2) string bogs, and (3) relatively open, slightly hummocky areas in which spongy Sphagnum moss, Labrador-tea, black spruce, and tamarack are the dominant plant life and small pools of water occur at the surface.

Muskeg is generally drier, has a greater relief and higher trees, and is characterized by variability in density of tree growth, tree type, tree height, and wetness. The main types of muskeg are (1) relatively dry and open, slightly hummocky areas in which spongy Sphagnum moss, Labrador-tea, and scrub black spruce are the dominant plant life and small pools of water are rare, (2) knob and kettle ground moraine in which the knobs are dry and the kettles contain swampy ponds, and (3) relatively wet areas with a dense, variable growth of alder, black spruce, tamarack, and birch.

Structural geology

Foliation, schistosity, and cleavage

Most of the metavolcanic and metasedimentary rocks have a well developed metamorphic foliation which is produced by subparallel orientation of amphibole, chlorite, biotite, and white mica, and by the stretching of fragments. Foliation is poorly developed in the hornblende hornfels facies and is rare or absent in inclusions in granitic rocks and in mafic metavolcanics in the cross syncline north of the Munekun Lake syncline. Metamorphic foliation is rare in metagabbro except in the almandine amphibolite facies (Fig. 5).

Many of the granitic rocks are also foliated, but the foliation, which is produced by subparallel orientation of hornblende, biotite, and locally plagioclase, quartz, and microcline, appears to be a primary flow structure.

Schistosity is rare and is most common in greenschist facies felsic metavolcanics. Along the south shore of Munekun Lake in the axial zone of the Munekun Lake syncline, however, mafic metavolcanics are schistose and contain abundant carbonate. This schist zone may be a locus along which shearing and flowage were concentrated during folding.

East of the Windigo River fault in the Muskratdam Lake belt, metamorphic foliation is generally parallel to primary structures such as bedding and flow contacts. In many places west of the fault, however, especially south of Fox Bay and northwest of the Severn River fault, the foliation is discordant to primary structures. The discordance is as much as 90 degrees, and the discordant foliation appears to be parallel to the axial plane of the major folds. Discordant foliation was also locally found in the Rottenfish River belt.

In many of the rocks the discordant foliation is a pervasive structure, but, in thick-bedded, muscovite-bearing metagreywacke, the discordant foliation comprises closely spaced cleavages along which there has been a small amount of movement; muscovite is aligned parallel to the cleavages. In some metasediments two foliations are present: (1) an early foliation which is parallel to bedding and (2) a later, discordant foliation.

Slate units have a well developed slaty cleavage (p. 28).

Gneissosity

Gneissosity was found in hornblende hornfels facies mafic metavolcanics (p. 16), in some granitic rocks (p. 51), and rarely in metasediments and felsic metavolcanics. In the mafic metavolcanics, the gneissosity is a secondary structure related to intrusion of the granitic batholiths, and, on the northwest side of the Severn River fault, it postdates the discordant foliation. In the granitic rocks most of the gneissosity appears to be a primary igneous structure, but, on the east side of the Rottenfish Lake fault, gneissosity seems to have been formed in the granitic rocks by movement along the fault.

Lineation

Secondary lineations which comprise minor fold axes, crinkles in foliation, intersection of foliation and bedding, stretching of fragments and amygdules, and preferred orientation of amphibole, mafic mineral aggregates, and quartz aggregates are common in the metasediments and metavolcanics but are rare in metagabbro and granitic rocks (Fig. 4). Secondary lineations which are parallel to lineations in adjacent mafic metavolcanics were found in sheared granitic rocks along the north side of the west end of the Muskratdam Lake belt. Primary flow lineations were rarely found in the granitic rocks.

Except for minor fold axes, lineation types are not differentiated on the geological maps. Minor folds are best developed in amphibole-bearing metagreywacke and in quartz-cummingtonite-garnet ~~metasediments,~~ iron formation.

Many lineations plunge steeply at an angle which appears to be greater than the plunge of the axis of the enclosing fold. Some of these lineations may be a lineations which represent major flowage or movement directions during folding.

Joints

Joints are a ubiquitous, secondary structure throughout the map-area, but only a few strongly developed joint sets were recorded because of lack of space on aerial photographs and basemaps. Granitic rocks south of the Muskratdam Lake belt appear to have fewer joints than those north of the belt. In granitic rocks early joints are occupied by pegmatite and aplite dikes: later joints cut these dikes and locally contain epidote, chlorite and quartz veins. Some of the late joints are stained by hematite.

On the east side of the Rottenfish Lake fault, strongly developed joints are found in many granitic outcrops and are parallel to east-trending faults.

Major folds

The trace of the axial planes of the major folds, as interpreted from available structural and stratigraphic data, are shown in Figure 4; some of the folds are well documented but others are based on scanty data. Two main groups of folds were recognized: (1) upright to slightly overturned, isoclinal folds which trend parallel to the axis of the metavolcanic-metasedimentary belt and are the dominant structural element, and (2) isoclinal cross folds which trend approximately perpendicular to the first group of folds. The first group was locally warped about subvertical axes, possibly during intrusion of the granitic batholiths.

In the Muskratdam Lake belt the first group of folds comprise a syncline on the east side of the Windigo River fault and an anticline and two flanking synclines on the west side of the fault. An isoclinal anticline appears to be the dominant structure in the Rottenfish River belt. Only two major cross folds were recognized, both in the Muskratdam Lake belt. It is not known whether the cross folds are the same age as, or are younger than, the large isoclinal folds.

The large isoclinal folds appear to have a variable plunge: at the east and west ends of the Muskratdam Lake belt they plunge steeply, but elsewhere in the belt the plunge appears to be relatively gentle.

Flowage must have been a major factor in formation of the isoclinal folds, and evidence of flowage includes stretched fragments in metaconglomerate and metavolcanic breccia, well developed lineation, flattened pillows, and a schist zone along the axis of the Munekun Lake syncline. There is no evidence of flowage, however, in the isoclinally cross-folded syncline at Munekun Lake; there, mafic metavolcanics and metagabbro are massive with locally well preserved primary textures, and pillows in the mafic metavolcanics are not distorted (Photo 3).

The major folds apparently began to form before intrusion of the Fox Bay metagabbro sill (p. 44); major fold movement must have ceased before intrusion of the youngest granitic rocks because the discordant, axial plane(?) foliation is obliterated at the edges of the belts by gneissosity which was produced by the granitic batholiths.

Faults

Many faults were recognized, but others were probably overlooked because of the low outcrop density in many parts of the area. Most the faults are subvertical and have diverse trends; the largest amount of movement, however, seems to have been along faults which trend between north-northeast and north-northwest (Fig. 4). Fault movement ranges from a few inches to many hundreds of feet, but the maximum amount of movement is not known.

The following criteria were used to identify faults: (1) negative lineaments, (2) scarps, (3) stratigraphic or structural offset, (4) strongly developed joint sets, (5) subsidiary faults including schist and mylonite zones, (6) schistose wallrock, (7) granulated and recrystallized wallrock, (8) quartz veins along, or parallel to, the fault and in tension joints near the fault, and (9) wallrock alteration including epidotization, hematitization, and silicification. Not all negative lineaments are the surface expression of faults.

The north-northwest-trending Windigo River fault has cut the Muskratdam Lake belt into two segments which are distinctly different in structure and stratigraphy (Fig. 4). Two sheared and silicified outcrops on the Windigo River must be close to the fault, but elsewhere the fault cannot be precisely located because of paucity of outcrop. The vertical component of movement along the fault appears to have been greater than the horizontal component, and the east side apparently moved up relative to the west side.

The northern eight miles of the north-northeast-trending Rottenfish Lake fault forms part of the eastern boundary of the Rottenfish River belt, but the southern part of the fault is entirely within granitic rocks. The northern part of the fault ends against the west-northwest-trending Rottenfish River fault. Granitic rocks adjacent to the fault are highly sheared, granulated, and recrystallized, and, at Rottenfish Lake, the sheared zone is at least 2000 feet wide on each side of the fault. The sheared zone decreases in width northward, and, adjacent to the Rottenfish River belt, it is about 500 feet wide. Shearing is less pronounced in the mafic metavolcanics and metagabbro of the belt and is restricted to a 200-foot wide, highly foliated and locally schistose zone; quartz veins are common in this zone and rare talc and serpentine veins were found. Adjacent to the Rottenfish River belt, the sheared granitic rocks generally form a prominent scarp which is as much as 100 feet high. The shearing at Rottenfish Lake was first recognized by Satterly (1939, p. 32).

At the fault, the granitic rocks have been completely granulated and recrystallized to a granular mozaic of 0.1-millimetre grains and are locally thinly layered. A few feet away from the fault, the rock is only partly granulated, and granulation is concentrated along foliation planes and microscopic fractures; non-granulated grains are highly strained and fractured. Rocks containing abundant microcline are more highly granulated than those lacking microcline. Phenocrysts in porphyritic granitic rocks have been sheared into ovoid augens.

On the east side of the Rottenfish River belt, the sheared granitic rocks are gneissic with quartz-rich, microcline-rich, plagioclase-rich, and mafic mineral-rich layers, and range in composition from tonalite to quartz monzonite; the various rock types are intimately interlayered. The gneissosity and interlayering appear to be the result of differentiation which was caused by movement along the fault. At the exit from Rottenfish Lake, the sheared granitic rocks have a more uniform composition although the mafic minerals have been concentrated into very thin, crenulated layers and lenses. Greatly lenticular, mafic metavolcanic inclusions are common in all of the sheared granitic rocks.

The north-trending Hill Lake fault is a branch of the Rottenfish Lake fault and has also produced a similar, wide, sheared zone in its granitic wallrocks. Several 2- to 3-foot wide, north-trending shear zones within the early mafic granitic phase appear to be related to this fault.

The wide, recrystallized, granulated zone and the differentiation of the granitic wallrocks within this zone suggest that both the Rottenfish Lake and Hill Lake faults are relatively early, deep-seated faults. All granitic phases adjacent to the faults are sheared, but, because a higher proportion of aplite dikes are concordant to the foliation than elsewhere in the batholiths, shearing may have been initiated during intrusion. Shearing probably continued for a long period of time, and late movement along the Rottenfish Lake fault is suggested by the presence of the scarp. The greenschist facies zone in the Rottenfish River belt adjacent to the Rottenfish Lake fault (Fig. 5) may be a retrograde zone related to movement along the fault.

The Rottenfish Lake fault is offset by several, east-trending faults which appear to have brittle movement. The wallrock is altered, hematitized, and locally epidotized but is not granulated. Strong joints which locally contain quartz and epidote veins parallel the faults, and 1- to 3-foot wide, layered, mylonite zones were found near, and parallel to, several faults.

Other than the schistose zone in mafic metavolcanics in the axial zone of the Munekun Lake syncline, no major, orogenic shear zones were recognized within the metavolcanic-metasedimentary belts. During granitic intrusion, however, some shearing apparently occurred along the Rottenfish Lake and Hill Lake faults and locally along the margins of the batholiths (p. 57). Most of the faults which were recognized have post-orogenic, brittle movement.

Economic geology

General statement

There are no known, economic, mineral concentrations in the map-area although quartz veins are abundant and twenty-two sulphide mineral concentrations were found (Fig. 7). Metamorphosed iron formation was found at several localities, and aeromagnetic data suggest that iron formation is more abundant than the few outcrops that were found would indicate. Prospecting is hampered by the paucity of outcrops, the thick drift cover, the lack of aeromagnetic maps prior to 1966, and the great distance from existing roads and railways.

Prospectors have been active in the area since at least 1937, and, during the 1963 and 1964 field seasons, twelve prospectors worked in the area. The only evidence of exploration which was found, other than surface prospecting, are two pits of unknown age at the west end of Muskratdam Lake. In 1964, nineteen claims were staked on the east side of the Windigo River but these have since lapsed. There are currently (1966) no claims in the map-area, and no data has yet been submitted for assessment work.

Because of the reconnaissance nature of the survey, sulphide mineral concentrations and mineralized quartz veins could not be examined in detail and thus cannot be properly evaluated. As an aid to future prospecting, however, ~~all~~ most observed sulphide concentrations and some mineralized quartz veins are described even though the majority contain only trace amounts of economically important elements.

Quartz veins

Concordant and discordant quartz veins are present in all rock types but are rare in late mafic dikes.

Concordant veins are generally lenticular; their average width is less than 1 inch, but some veins are as much as 3 feet wide. In the Muskratdam Lake belt, they are most abundant in the contact metamorphic aureole adjacent to the granitic batholiths, especially in the gneissic mafic metavolcanics north of Pike Lake and in the metasediments along the north edge of the belt. In the Rottenfish River belt, they appear to be most abundant near the Rottenfish Lake fault. On islands in the western part of Muskratdam Lake, pillowed mafic metavolcanics contain lenticular quartz pods which are as much as 6 feet long and range in width from 6 inches to 3 feet. A grab sample collected by the author from one pod gave upon assay 0.01 ounces of gold per ton (Fig. 7). Many of the concordant veins appear to be genetically related to contact metamorphism.

In the Muskratdam Lake belt discordant quartz veins are most abundant near faults, in felsic metavolcanics south of Fox Bay, and in the Munekun Lake metagabbro sills in the axial zone of the Munekun Lake syncline; they are rare in the Rottenfish River belt. Discordant veins pinch and swell but can generally be traced for long distances along strike. The veins are generally less than one foot wide and near the faults locally form stockworks. Rare en echelon vein systems were found.

Both types of veins are generally white or pale blue, transparent to translucent, and fine- to coarse-grained. The quartz is commonly anhedral, but euhedral crystals were found in one vein in granitic rocks about three miles northwest of Blackwater Bay. Rusty-weathering veins which contain minor pyrite and rare chalcopyrite are locally found.

Grab samples were collected by the author and his assistants from ninety-nine quartz veins (Fig. 7). These samples were fire assayed for gold and were tested for twenty-nine other elements by qualitative spectrographic analysis. Most samples contained trace amounts of gold, but only three samples contained as much as 0.01 ounces of gold per ton (Fig. 7). Each of these three veins is in a different host rock, but all are in the Muskratdam Lake belt near the boundary between the greenschist and almandine amphibolite facies (compare Figures 5 and 7).

The qualitative spectrographic analyses showed trace amounts of copper, manganese, and titanium in forty percent of the samples and trace amounts of chromium, lead, nickel, vanadium, and zirconium in several samples. One sample from a rusty-weathering vein in mafic metavolcanics in the Rottenfish River belt contained 0.1 percent copper (Fig. 7). Veins within metagabbro appear to contain a higher concentration of trace elements than veins in other rock types.

On the north bank of the Severn River near its outlet into Muskratdam Lake, an 8-foot by 8-foot pit had been sunk through 4 feet of clay to expose the contact between a black quartz vein and metagabbro. The quartz vein is at least five feet wide, trends N30°W, and contains disseminated pyrite. Two grab samples collected by the author gave upon assay trace amounts of gold, copper, and lead. Twenty feet west of the pit, a 15-foot long by 3-foot wide trench had been sunk to a depth of 4 feet in clay;

no bedrock is exposed in the trench.

Quartz veins formed throughout a long period of time. Fragments from early veins are found in some of the metaconglomerate units. Late veins are found in granitic rocks and diabase dikes and along some of the late, brittle faults.

Gold

In 1937, J. O. Lingman prospected in the Rottenfish River belt and panned gold from several quartz veins east of the river (written communication to J. Satterly, 1937). In an unsuccessful attempt to find these gold-bearing quartz veins, the author and his assistants collected grab samples from twenty-two veins within this belt (Fig. 7). These samples contained only trace amounts of gold, but a grab sample collected by the author from a chalcopyrite-pyrite-rich quartz lens in metagabbro gave upon assay 0.02 ounces of gold per ton (Fig. 7). As previously mentioned three veins in the Muskratdam Lake belt contained 0.01 ounces of gold per ton.

Sulphide mineral concentrations

General statement

Trace amounts of pyrite, pyrrhotite, and rarely chalcopyrite are found in most rocks within the metavolcanic-metasedimentary-metagabbroic belts, but concentrations of sulphide minerals, dominantly pyrite and pyrrhotite, are rare (Fig. 7). Rocks containing between 1 and 10 percent sulphide minerals were found at seventeen localities, and rocks containing more than 10 percent sulphide minerals were found at only five localities (Fig. 7). Most of these sulphide mineral concentrations are within the greenschist facies zone (compare Figures 5 and 7), and the greatest density of sulphide mineral concentrations is along the north side of the eastern part of Muskratdam Lake.

Felsic metavolcanics locally contain 1 to 2 percent, disseminated, subhedral pyrite and have rusty, weathered surfaces. These occurrences are not plotted in Figure 7 but are most abundant north of the Severn River about 10 miles west of Sandhill Crane Island. The black slate unit along the Severn River about seven miles west of Sandhill Crane Island also locally contains disseminated pyrite and rare, narrow, pyrite veins.

In the following sections, the sulphide mineral concentrations plotted in Figure 7 are described in geographic order, beginning at the west side of the area.

Rottenfish River belt

The northern occurrence is a narrow, rusty-weathering, felsic metavolcanic unit which occurs between two thick, mafic flows and contains about five percent disseminated pyrite. A grab sample collected by the author from this occurrence gave upon assay trace amounts of gold and copper.

The central showing is a rusty-weathering, mafic metavolcanic flow which contains 1 to 5 percent pyrrhotite as disseminations and narrow veins; no sample was collected for assay.

The southern locality is in a metagabbro sill where a 2- to 3-inch wide quartz lens contains 5 to 10 percent pyrite and rare ~~pyrrhotite;~~ chalcopyrite; disseminated sulphides also occur in the metagabbro adjacent to the lens. As previously mentioned, a grab sample collected by the author from this lens gave upon assay 0.02 ounces of gold per ton and also contained 0.2 percent copper and trace amounts of nickel.

North of Severn River fault

A sheared felsic dike which intruded metagabbro north of the Severn River fault contains about five percent disseminated pyrite. A grab sample collected by the author from this dike was assayed but contained no precious or base metal elements.

Fox Bay

At the west end of Fox Bay, an amygdaloidal metavolcanic flow of intermediate composition contains 2 to 3 percent pyrite and rare chalcopyrite; the pyrite is concentrated near the quartz amygdules. A grab sample collected by the author from this flow contained 0.1 percent copper and trace amounts of gold and nickel.

On the south shore of the bay, disseminated pyrite, pyrrhotite, and rare chalcopyrite were found in calc-silicate rocks and marble adjacent to a one-foot wide, unmineralized, discordant, quartz vein which trends N55°W. Three grab samples collected by ~~Mr.~~ V.A. Jones, the author's senior assistant, from the quartz vein and mineralized wallrock gave upon assay trace amounts of gold and copper.

Between Fox Bay and the Severn River, disseminated pyrite and rare chalcopyrite were observed in interbedded felsic metavolcanics and muscovite-bearing metagreywacke. No samples were collected for assay.

Sandhill Crane Island

The matrix and rarely the pebbles of metaconglomerate exposed at the northwest corner of Sandhill Crane Island have been replaced by disseminated to massive pyrrhotite and by concordant lenses of massive pyrite as much as two inches wide; ~~occur throughout~~

~~the metaconglomerate, and~~ rare chalcopyrite is associated with both the pyrite and pyrrhotite. The amount of sulphide minerals is highly variable, but the mineralized zone is exposed along strike for at least 300 feet. The surface of the outcrop is only locally rusty, and the rust appears to be related to ferruginous chert pebbles rather than to the sulphide mineralization. Three grab samples collected by the author from the metaconglomerate contained trace to 0.1 percent copper and trace amounts of gold and nickel.

Severn River

On the south side of the Severn River east of Sandhill Crane Island, metagabbro of the Muskratdam Lake Sill contains 2 to 3 percent, disseminated pyrite and rare chalcopyrite. No samples were collected for assay.

Windigo River

Two sulphide mineral concentrations were found in a metagabbro sill east of the Windigo River. At the north locality, 5 to 10 percent disseminated pyrite, sparse, 1- to 2-millimetre wide pyrite veins, and rare chalcopyrite are associated with numerous, poorly mineralized, quartz lenses as much as two feet wide in a sheared phase of the sill. The mineralized zone was traced along strike for several hundred feet. Two grab samples collected by the author from this zone gave upon assay trace to 0.1 percent copper and trace amounts of gold and nickel.

About two miles south of the above locality, rare lenses of massive pyrite and chalcopyrite as much as six inches long were found in the sill. A grab sample collected by the author from one lens contained 1.22 percent copper and a trace amount of gold.

Pillowed mafic metavolcanics in an isolated outcrop between Red Sucker Lake and the Windigo River locally have a rusty weathered surface and contain about five percent disseminated pyrite and rare chalcopyrite. No samples were collected for assay.

Blackwater Bay

Near the mouth of Blackwater Bay, a two-foot thick, rusty-weathering metasedimentary unit, which is interbedded with hornblende-bearing metagreywacke, contains 5 to 10 percent pyrite as thin, concordant lenses. A grab sample collected by the author from this unit gave upon assay trace amounts of gold and copper.

Eastern part of Muskratdam Lake

Numerous sulphide mineral concentrations occur along or near the north shore of the eastern part of Muskratdam Lake (Fig. 7) in a cross folded area characterized by rapid vertical and lateral changes in lithology.

The western occurrence is a garnetiferous, mafic metavolcanic flow on the lake shore which contains 1 to 2 percent, disseminated arsenopyrite. A grab sample collected by the author from this flow contained trace amounts of cobalt, copper, lead, nickel, and zinc.

Also on the lake shore but six hundred feet east of, and stratigraphically above, this flow, a metavolcanic breccia outcrop of intermediate composition contains about five percent, disseminated pyrrhotite and pyrite. A grab sample collected by the author from this unit gave upon assay trace amounts of cobalt, copper, lead, and nickel.

Five hundred feet east of, and 400 feet stratigraphically above the breccia, a porphyritic, felsic metavolcanic outcrop on the lake shore contains 2 to 3 percent disseminated pyrite. A grab sample collected by the author from this outcrop contained trace amounts of copper, lead, and nickel.

Interbedded felsic metavolcanic flows and pyroclastic rocks, which occur about 3500 feet northeast of the previous locality and are part of the same felsic unit, locally weather rusty and contain trace to ten percent disseminated pyrite and pyrrhotite. The mineralization occurs throughout the felsic metavolcanic part of the outcrop but is most abundant in pyroclastic breccia. No samples were collected for assay.

On a point about 1.5 miles east of the previous lake shore occurrence, mineralized, locally rusty-weathering metaconglomerate forms units as much as 20 feet thick within unmineralized, interbedded metagreywacke and slate. The matrix and rarely the pebbles of the metaconglomerate were replaced by disseminated to massive pyrite and rare pyrrhotite; concordant lenses of massive pyrite as much as 2 inches wide and 1 foot long are locally present. Mineralized metaconglomerate units are exposed for about 1500 feet along the shore of the lake, but the amount of mineralization is highly variable. Five grab samples collected by the author and his assistants from the metaconglomerate gave upon assay trace amounts of gold, cobalt, copper, lead, nickel, and zinc. Except for the higher pyrite to pyrrhotite ratio and the more varied trace element content, this mineralized metaconglomerate resembles the previously described occurrence on Sandhill Crane Island.

On the south shore of the eastern part of Muskratdam Lake, a small, isolated, rusty weathering, metaconglomerate outcrop contains 10 to 20 percent, disseminated pyrite and pyrrhotite, rare chalcopyrite, and possibly galena. A grab sample collected by ~~Mr.~~ V.A. Jones, the author's senior assistant, from this outcrop gave upon assay trace amounts of gold, silver, copper, and nickel; no lead was found.

Rain Lake

About 1/2 mile east of Rain Lake, minor disseminated pyrite and rare chalcopyrite were found in mafic metavolcanics near the contact with a diabase dike. No samples were collected.

Two miles northeast of Rain Lake, small irregular areas in a garnetiferous, biotite-bearing, metagreywacke and metasiltstone outcrop weather rusty. These areas contain 1 to 3 percent, disseminated pyrrhotite and rare pyrite while the rest of the outcrop contains only trace amounts of sulphide minerals. No samples were collected.

Munekun Lake

On a small, mafic metavolcanic island in the western part of Munekun Lake, massive pyrite was found in the interstices between pillows and in a six-inch wide vein which trends N50°E. No samples were collected.

Summary

The greatest density of sulphide mineral concentrations is in the greenschist facies zone in the eastern part of Muskratdam Lake where a major syncline is complicated by a synclinal cross fold. This area is characterized by rapid lateral and vertical changes in lithology, and within an area of two square miles the following rock types were found: metaconglomerate, metagreywacke, metasiltstone, slate, felsic metavolcanic flows and pyroclastic rocks, intermediate metavolcanic pyroclastic breccia, and mafic metavolcanic flows. Sulphide mineral concentrations are most abundant in felsic metavolcanics and metaconglomerate but contain only trace amounts of economically important elements.

In comparison with sulphide mineral concentrations elsewhere in the map-area, those in the eastern part of Muskratdam Lake have a greater variation in trace element content (Fig. 7).

The greenschist facies zone in this area of complex lithology in the eastern part of Muskratdam Lake warrants detailed prospecting. Prospecting would be hampered, however, by lack of outcrop on many of the islands and along the south shore of the lake.

Copper

Of ninety-nine quartz veins and fourteen sulphide mineral concentrations sampled, only one quartz vein and two sulphide mineral concentrations contained more than 0.1 percent copper (Fig. 7), and only one of these contained more than 0.2 percent copper.

As assay of 1.22 percent copper was obtained from a six-inch long, massive, pyrite-chalcopyrite lens in a well exposed, metagabbro sill on the east side of the Windigo River (p. 89). Several of these small, massive sulphide lenses were found during a rapid examination of this part of the sill, and detailed prospecting might lead to the discovery of larger lenses.

Lead and zinc

In 1938 S. Staunton (written communication to J. Satterly, 1938) found a 1- to 2-foot wide vein containing galena and sphalerite at a portage on the Severn River near the east end of Muskratdam Lake. The vein was reported to be 60 feet long. Portages at the east end of Muskratdam Lake are no longer in use, and neither the portages nor the vein were found during a short search. Trace amounts of lead and rarely zinc, however, were found in the sulphide mineral concentrations in the eastern part of Muskratdam Lake.

Iron

Concentrations of iron, in the form of magnetite, were found in metamorphosed iron formation and in white pegmatite sills.

Metamorphosed iron formation units were described in a previous section (p. 31-33). No assays were made, but the thickest and most iron-rich units were found at the north end of the Rottenfish River belt (30 to 100 feet thick) and on the south shore of Munekun Lake (50 feet thick) and appear to contain about twenty percent iron; iron content is highly variable within each unit. Iron formation in the Rottenfish River belt has been metamorphosed to the almandine amphibolite facies and iron formation at Munekun Lake has been metamorphosed to the upper part of the greenschist facies.

Aeromagnetic and ground magnetic data suggest that extensive metamorphosed iron formation units are buried beneath glacial drift between Munekun and Axe Lakes (p.).

Several, narrow, white, pegmatite sills within the granitic batholiths contain concentrations of magnetite (p. 56). The largest observed concentration was in a 2-foot wide sill about 14 miles north-northwest of Sandhill Crane Island; this sill contains about 15 percent magnetite.

Sand and gravel

Concentrations of gravel occur in the Pleistocene eskers and end and interlobate moraines, but concentrations of sand are restricted to large outwash areas near eskers (Fig. 6).

Because a large part of the map-area is covered by swamp and muskeg, any future road construction will be difficult unless the roads trend northeast along one of the eskers or north along the Sachigo interlobate moraine.

Clay

Extensive deposits of Pleistocene varved clay which are as much as 20 feet thick occur in the western part of the area (Fig. 6). No samples were collected for testing, but a sample which was collected by Hurst (1930) from similar deposits on the north side of the West Arm of Sandy Lake was tested by R. J. Montgomery of the Ceramics Department, University of Toronto who reported (in Hurst, 1930, p. 84; also in Satterly, 1939, p. 39) that "unless it [the clay] is near some centre of population it would have very little economic value."

Recommendations for future mineral exploration

Only minor amounts of gold were found by the author, but, because the three veins and one sulphide mineral concentration which were found to contain more than trace amounts of gold occur within the greenschist facies zone, this zone should be examined for other, possibly richer, gold-bearing veins. The greenschist facies zone in the Rottenfish River belt, especially near the Rottenfish Lake fault, should be examined in detail because of the reported occurrence of gold in this belt. Other areas which may be favourable loci for gold mineralization are the schistose axial axial zone of the Munekun Lake syncline along the south shore of Munekun Lake and the sheared nose of this fold which is exposed six miles east of Munekun Lake.

As previously mentioned (p. 92-93), the most favourable area for sulphide mineralization appears to be the greenschist facies zone in the eastern part of Muskratdam Lake. The reported galena-bearing vein in this area should be sought and examined for possible silver content. Another favourable area appears to be the thin gabbro sill on the east side of the Windigo River.

The large aeromagnetic anomalies in the Rottenfish River and Muskratdam Lake belts reflect buried iron formation. It was impossible to determine, however, whether the anomalies were caused by thick iron formation units or by a large number of thin units such as cause the large anomaly in the Sandy Lake area (p.).

References cited

Ayres, L. D.

1967: North Trout Lake; Ontario Dept. Mines, Preliminary Map. P. .

in press: Townships 30 and 31, Ranges 19 and 20, District of Algoma; Ontario Dept. Mines Geol. Rept. No. , p.

Barry, G. S.

1961: Geology of the Gods Narrows area; Manitoba Mines Branch, Publication 60-1, 33p.

Bateman, P. C., Clark, L. D., Huber, N. K., Moore, J. C., and Rinehart, C. D.

1963: The Sierra Nevada batholith, a synthesis of recent work across the central part; U. S. Geol. Surv. Prof. Paper 414-D, 46p.

Billings, M. P.

1950: Stratigraphy and the study of metamorphic rocks; Geol. Soc. America Bull., V. 61, p. 435-448.

Carruthers, C. A.

1961: Geology, North Caribou Lake, Ontario; Geol. Surv. Canada, Map 18-1961.

Davies, J. F., Bannatyne, B. B., Barry, G. S., and McCabe, H. R.

1962: Geology and mineral resources of Manitoba; Manitoba Mines Branch, 190p.

Dean, W. G.

1953: The drumlinoid landforms of the "Barren Grounds", N.W.T.; Canadian Geographer, No. 3, p. 19-30.

Derry, D. R. and MacKenzie, G. S.

1931: Geology of the Ontario-Manitoba boundary (12th Base Line to Latitude 54); Ontario Dept. Mines, V. XL, pt. 2, 1931, p. 1-20.

Donaldson, J. A.

1961: Geology, North Spirit Lake, Ontario; Geol. Surv. Canada, Map 50-1960.

Donaldson, J. A. and Jackson, G. D.

1965: Archaean sedimentary rocks of North Spirit Lake area, northwestern Ontario; Canadian Jour. Earth Sciences, V. 2, p. 622-647.

Duffell, S.

1963: Bedrock geology, p. 7-10 in Duffell, S., MacLaren, A. S., and Holman, R. C., Red Lake-Landsdowne House area, northwestern Ontario: Bedrock geology, geophysical and geochemical investigations; Geol. Surv. Canada, Paper 63-5, 15p.

Dunbar, C. O. and Rodgers, J.

1957: Principles of stratigraphy; John Wiley, New York, 356p.

Elson, J. A.

1961: Soils of the Lake Agassiz region, p. 51-79 in Legget, R. F. (ed), Soils in Canada; Roy. Soc. Canada, Special Publication No. 3, 229p.

Fisher, R. V.

1961: Proposed classification of volcaniclastic sediments and rocks: Geol. Soc. America Bull., V. 72, p. 1409-1414.

Fyfe, W. S., Turner, F. J., and Verhoogen, J.

1958: Metamorphic reactions and metamorphic facies; Geol. Soc. America, Memoir 73, 259p.

Godard, J. D.

1963: Geology of the Island Lake-York Lake area; Manitoba Mines Branch, Publication 59-3, 45p.

Gross, G. A.

1965: Geology of iron deposits in Canada: Vol. 1, General geology and evaluation of iron deposits; Geol. Surv. Canada, Economic Geology Rept. No. 22, 181p.

G.S.C.-O.D.M.

1966a: Fidler Lake, Ontario; Geol. Surv. Canada, Geophys. Paper 3670.

1966b: 53 F/7, Ontario; Geol. Surv. Canada, Geophys. Paper 3671.

1966c: 53 F/1, Ontario; Geol. Surv. Canada, Geophys. Paper 3678.

1966d: 53 F/8, Ontario; Geol. Surv. Canada, Geophys. Paper 3679.

1966e: 53 F/9, Ontario; Geol. Surv. Canada, Geophys. Paper 3680.

1966f: Sakwaso Lake, Ontario; Geol. Surv. Canada, Geophys. Paper 3686.

1966g: Muskratdam Lake, Ontario; Geol. Surv. Canada, Geophys. Paper 3687.

1966h: 53 G/12, Ontario;Geol. Surv. Canada, Geophys. Paper 3688.

1966i: 53 G/3, Ontario; Geol. Surv. Canada, Geophys. Paper 3698.

1966j: Munekun Lake, Ontario; Geol. Surv. Canada, Geophys. Paper 3699.

1966k: Asipoquobah Lake, Ontario; Geol. Surv. Canada, Geophys. Paper 3700.

1966l: Nikitowa Lake, Ontario; Geol. Surv. Canada, Geophys. Paper 3710.

1966m: Makoop Lake, Ontario; Geol. Surv. Canada, Geophys. Paper 3711.

Hudec, P. P.

1964: Geology of the Big Trout Lake area, District of Kenora (Patricia Portion); Ontario Dept. Mines, Geol. Rept. No. 23, 35p.

Hurst, M. E.

1930: Geology of the area between Favourable Lake and Sandy Lake, District of Kenora (Patricia Portion); Ontario Dept. Mines, V. XXXVIII, pt. 2, 1929, p. 49-84.

Low, A. P.

1887: Preliminary report on an exploration of country between Lake Winnipeg and Hudson Bay; Geol. Surv. Canada, Annual Rept., V. II, pt. F, 24p. (p.8-19 reprinted in Ontario Bur. Mines, V.XXI, pt. 2, 1912, p. 94-106 [route maps, which were not part of the original report, were added to the reprint]).

Lowdon, J. A.

1961: Age determinations by the Geological Survey of Canada: Report 2, Isotopic ages; Geol. Surv. Canada, Paper 61-17, 127p.

1963: Age determinations by the Geological Survey of Canada: Isotopic ages, Report 3, p. 1-120 <u>in</u> Lowdon, J. A., Stockwell, C. H., Tipper, H. W., and Wanless, R. K., Age determinations and geological studies; Geol. Surv. Canada, Paper 62-17, 140p.

Lumbers, S. B.

1962: Geology of Steele, Bonis, and Scapa Townships, District of Cochrane; Ontario Dept. Mines, Geol. Rept. No. 8, 50p.

Moxham, R. L.

1965: Distribution of minor elements in coexisting hornblendes and biotites: Canadian Mineralogist, V. 8, p. 204-240.

Oppenheim, M. J.

1964: Basalt textures from the southeastern Lower Galilee, Israel; Geol. Mag., V. 101, p. 548-557.

Pettijohn, F. J.

1957: Sedimentary rocks; Harper and Brothers, New York, 718p., 2nd edition.

Prest, V. K.

1963: Red Lake-Landsdowne House area, northwestern Ontario: Surficial geology; Geol. Surv. Canada, Paper 63-6, 23p.

Quinn, H. A. and Meinert, R. J.

1959: The Island Lake Series: Precambrian, V. 32, No. 4, p. 15-22, 24, 25, 34.

Reed, B., Galvin, C. J. jr., and Miller, J. P.

1962: Some aspects of drumlin geometry: American Jour. Science, V. 260, p. 200-210.

Rowe, J. S.

1959: Forest regions of Canada; Dept. of Northern Affairs and National Resources, Forestry Branch, Bull. 123, 72p.

Rutford, R. H.

1962: The geography of the Sandy Lake and Sachigo Lake area, northwestern Ontario; unpublished M.A. thesis, University of Minnesota.

Satterly, J.

1937: Glacial Lakes Ponask and Sachigo, District of Kenora (Patricia Portion), Ontario; Jour. Geol., V. 45, p. 790-796.

1938: Geology of the Stull Lake area; Ontario Dept. Mines, V.XLVI, pt. 4, 1937, p. 1-31.

1939: Geology of the Sandy Lake area; Ontario Dept. Mines, V.XLVII, pt. 7, 1938, p. 1-43.

1940: Patricia sheet, Ontario: Ontario Dept. Mines, Map 1940a.

1941: Geology of the Windigo-North Caribou Lakes area; Ontario Dept. Mines, V.XLVIII, pt. 9, 1939, 32p.

Stockwell, C. H.

1965: Tectonic map of the Canadian Shield: Geol. Surv. Canada, Map 4-1965.

Tarr, W. A.

1935: Concretions in the Champlain Formation of the Connecticut River Valley; Geol. Soc. America Bull., V. 46, p. 1493-1534.

~~Tilley, C. E.~~

~~1938: Cummingtonite-bearing rocks from the Lewisian; Geol. Mag., V. 75, p.76-~~ .

Tyrrell, J. B.

1913: Hudson Bay exploring expedition, 1912; Ontario Bur. Mines, V.XXII, pt. 1, 1913, p. 161-209.

Table 1

Table of Formations

Cenozoic		
	Recent	organic mud; lacustrine and fluvial clay, silt, and sand
	Pleistocene	till, lacustrine varved clay and silt, fluvial sand and gravel, beach sand and gravel
		unconformity
Precambrian (?)		diorite
		intrusive contact (?)
Precambrian		quartz-bearing diabase, olivine diabase, and granophyre
		intrusive contact (?)
		lamprophyre
		intrusive contact
		granitic batholiths
		- granitic phase: pegmatite and aplite; porphyritic, biotite quartz monzonite, granodiorite, and trondhjemite; equigranular, biotite quartz monzonite, granodiorite, and trondhjemite· porphyritic, hornblende-biotite granodiorite; equigranular, hornblende-biotite granodiorite, trondhjemite, and tonalite
		intrusive contact
		- early mafic phase: diorite, syenodiorite, and mafic-rich trondhjemite
		intrusive contact (?)
		late, porphyritic, felsic dikes
		intrusive contact
		uralitized and metamorphosed gabbro, diorite, albite granite, and albite syenite
		intrusive contact
		early, porphyritic, felsic dikes
		intrusive contact
		metavolcanic - metasedimentary assemblage

Muskratdam Lake belt

metasedimentary - metavolcanic formation of undetermined stratigraphic position[1] (0-9000')

- metagreywacke, metasiltstone, metaconglomerate, metavolcanic flows and breccia of intermediate composition, and felsic metavolcanics

upper metasedimentary formation (0-5500')

- metagreywacke, metasiltstone, slate, metaconglomerate, marble, calc-silicate gneiss and granofels, felsic metavolcanics, and ferruginous metasediments

upper mafic metavolcanic formation (0-16,500')

- mafic and intermediate metavolcanic flows, metamorphosed pyroclastic rocks of intermediate composition, felsic metavolcanics, metamorphosed iron formation, and ferruginous metasediments

felsic metavolcanic formation (0-6000')

- metamorphosed felsic and intermediate pyroclastic rocks; felsic, intermediate, and mafic metavolcanic flows; metagreywacke; slate; metamorphosed iron formation; and ferruginous metasediments

lower metasedimentary formation (0-3000')

- metagreywacke, metasiltstone, metaconglomerate, calc-silicate gneiss, and ferruginous metasediments

lower mafic metavolcanic formation (0-4000')

- mafic metavolcanic flows, and metamorphosed volcanic breccia of intermediate composition

Rottenfish River belt[2]

metamorphosed iron formation; and ferruginous metasediments

felsic metavolcanic flows and pyroclastic rocks

mafic and intermediate metavolcanic flows

[1] possibly part of the upper metasedimentary formation

[2] stratigraphic sequence unknown; relationship to sequence in the Muskratdam Lake belt is also unknown

Table 2

Field criteria used, in the greenschist facies, to distinguish between felsic metatuff, porphyritic felsic flows, and poorly bedded, muscovite-bearing metagreywacke[1]

Felsic metatuff

1. Abundant sand-size, lenticular, felsic fragments.
2. Rare sand-size, lenticular, mafic fragments.
3. Abundant angular, sand-size plagioclase.
4. Rare sand-size quartz.
5. Rare felsic metavolcanic lapilli.
6. Abundant, wispy, very fine-grained, quartz-plagioclase-white mica matrix.

Porphyritic felsic flows

1. Sand-size rock fragments absent.
2. Rare metavolcanic lapilli.
3. Subhedral to euhedral, locally oriented, fine- to medium-grained, plagioclase phenocrysts.
4. Rare fine- to medium-grained, quartz phenocrysts.
5. Abundant very fine-grained, locally aphanitic, quartz-plagioclase-white mica groundmass.

Muscovite-bearing metagreywacke

1. Rare visible, sand-size rock fragments.
2. Abundant sand-size quartz
3. Abundant angular to rounded, sand-size plagioclase.
4. Sand-size quartz and plagioclase appear to form an intact to slightly disrupted framework; visible matrix is rare.
5. Rare quartz, metachert, and felsic and mafic metavolcanic pebbles.

[1] most of these criteria are more easily recognized on weathered surfaces than on fresh surfaces.

Table 3

Modes of metasedimentary rocks

	88	92	98	711	323	715
Sand-size quartz	33.7	4.6	24.6	23.2	32.8	52.0
Sand-size plagioclase	8.1	19.1	17.1	32.8	25.2	36.7
Sand-size microcline	*					
Sand-size rock fragments		31.7	25.2	2.0	2.7	
Silt-size quartz and plagioclase	35.7	18.0	15.9	23.0	20.2	
Biotite		*		9.3	18.7	
Chlorite	11.9	1.3	1.0	1.9	0.1	1.4
Muscovite	0.6	18.4	11.8	1.3		*
Carbonate	8.8	3.1	3.9	6.2		0.2
Epidote		3.8			0.1	1.2
Actinolite						8.4
Opaque minerals	1.2	*	0.5	0.2	0.2	*
Others[1]		*	*	0.1	*	0.1
Plagioclase composition	An5	An5 to An40	An3	An5	An6	labradorite

1 Apatite, zircon, allanite

* trace

Location and description

88 to 323 - from the Fox Bay syncline, about 8 miles west of Sandhill Crane Island. Arranged in order of decreasing age.

88 - metasandstone lens in ~~metatuff,~~ black slate felsic metavolcanic formation

92 - metatuff, felsic metavolvolcanic formation

98 - reworked (?) metatuff, felsic metavolcanic formation

711 - feldspathic metagreywacke, upper metasedimentary formation

323 - feldspathic metagreywacke, upper metasedimentary formation

715 granitoid fragment from metaconglomerate layer in upper metasedimentary formation, north of Severn River, 1.5 miles west of Sandhill Crane Island. Probably contains introduced quartz.

Table 4

Estimated fragment populations of the major metaconglomerate units

Fragment type	1	2	3	4	5	6
equigranular felsic metavolcanics	A	P		A	P	P
porphyritic felsic metavolcanics	P				x	
fine-grained, equigranular mafic metavolcanics	x			A	A	
medium-grained, equigranular, mafic metavolcanics or metagabbro						P
porphyritic mafic metavolcanics					x	
felsic metatuff or muscovite-bearing metagreywacke		P			P	A
biotite-bearing metagreywacke and metasiltstone		A	A			P
dolomite					A	P
metachert	P	A	A		P	P
ferruginous metachert		P	P		x	
granite		x		P		x
medium-grained quartz				x	x	P

A - abundant (greater than 10%)

P - present (1 - 10%)

x - trace (less than 1%)

Location

1. Metasedimentary formation, eastern part of Muskratdam Lake.
2. Upper metasedimentary formation, island in western part of Muskratdam Lake.
3. Upper metasedimentary formation, Sandhill Crane Island.
4. Upper metasedimentary formation, north of Severn River, 1.5 miles west of Sandhill Crane Island.
5. Upper metasedimentary formation, Severn River, 9 miles west of Sandhill Crane Island.
6. Upper metasedimentary formation (2-foot thick beds in muscovite-bearing metagreywacke), Severn River, 2.3 miles downstream from southwest edge of Muskratdam Lake belt.

Table 5

Modes of uralitized gabbro and metagabbro

	121	326	1131	414	425	448	832	1122
Plagioclase + alteration products	43.1	69.3	91.3	63.3	48.8	50.0	37.4	44.6
Quartz	7.0		0.1	14.3		0.8	0.2	45.7
Clinopyroxene						6.8		
Actinolite	33.6	30.0		19.2	45.0	33.4	59.7	
Chlorite	1.2	0.4	2.8	0.2	2.3	0.1	0.2	4.0
Biotite	14.1				0.9		2.0	4.9
Muscovite			0.2					0.4
Pistacite				0.2		6.2		*
Carbonate	0.4		4.4					
Opaque minerals[1]	0.4	0.1	1.0	0.2	3.0	2.6	0.3	0.2
Others[2]	0.2	0.2	0.2	2.6	*	0.1	0.2	0.1
Plagioclase composition	67→30	80→65	4[3]	41→22	56→35	8[3]	74→47	3

* trace amount

1 iron-titanium oxide, leucoxene, minor pyrite, rare pyrrhotite

2 apatite, sphene, and zircon

3 composition is secondary

Location of samples

121, 326, 1131	Fox Bay Sill
414, 425, 448	Upper Munekun Lake Sill
832, 1122	unnamed sill 10 miles west of Sandhill Crane Island

In Tables 5, 6, and 7, plagioclase composition is given in percent anorthite component. When plagioclase is zoned (→), both core and rim composition are given with core composition stated first.

Table 6

Modal Analyses of Granitic rocks

	1012	286	401	134	934	769	792	798
Plagioclase	53.9	57.1	39.1	54.2	55.9	59.2	58.9	48.7
Quartz	7.2	21.1	34.7	21.4	35.1	27.1	30.2	31.2
Microcline	2.1		1.5		4.0	1.1	1.4	12.0
Clinopyroxene	0.1							
Hornblende	22.9	10.5	14.7	3.3				1.2
Biotite	12.4	9.5	9.4	17.4	4.6	11.2	5.9	5.5
Chlorite	0.1	0.1			*	0.2	0.6	0.1
Muscovite					*	0.4		0.1
Pistacite	0.2	1.3	0.4	2.4	*	*	1.4	0.5
Opaque minerals[1]	0.1	*	*	0.3	0.4	0.4	1.2	0.1
Others[2]	1.0	0.4	0.2	1.0	*	0.4	0.4	0.6
Plagioclase composition	40→27	29→36	28	31→25	28→18	24→23	30→21	23→21
Microcline / Total feldspar	0.04	0	0.04	0	0.07	0.02	0.02	0.20

* trace

1 Fe-Ti oxide and rare pyrite

2 Apatite, sphene, allanite, and zircon

Description of samples

1012 - Quartz-bearing diorite, east of Rottenfish Lake

286 - Tonalite

401, 134, 934 - Trondhjemite

769 - Porphyritic trondhjemite

792 - Fine-grained trondhjemite dike

798 - Porphyritic hornblende-biotite granodiorite

791, 827 - Granodiorite

1152 - Porphyritic granodiorite

905 - Fine-grained granodiorite dike

47, 893 - Quartz monzonite

246 - Quartz monzonite from small stock north of Muskratdam Lake

1146, 370 - Fine-grained, leucocratic quartz monzonite

Table 6 - page 2

791	827	1152	905	47	893	246	1146	370
46.4	40.1	43.9	43.0	35.2	24.9	33.0	28.6	22.7
34.8	36.4	30.7	31.3	35.5	38.8	30.3	32.3	32.2
10.0	18.9	16.1	18.8	23.0	35.2	31.5	36.5	42.3
7.8	3.3	7.1	5.2	5.0	0.1	3.8	1.5	1.6
*	0.3	0.2	0.1	0.2	0.6		0.4	0.2
0.1	0.5	0.2	0.3	0.7		1.0	0.2	0.1
0.8		0.2	0.7	0.2	0.3		0.3	0.2
*	0.4	1.0	0.4	0.1	0.1	0.3	0.2	0.7
0.1	0.1	0.6	0.2	0.1	*	0.1	*	*
25→22	21→19	27→24	35→19	27→23	17→16	23→15	18	24→20
0.18	0.32	0.27	0.30	0.39	0.59	0.49	0.56	0.65

Table 7

Modes of diabase dikes

	440	550	559	768
Plagioclase + alteration products	54.2	54.0	47.8	57.5
Quartz	4.9	5.4	6.6	2.1
Olivine + alteration products				2.5
Clinopyroxene	23.5	27.0	26.0	27.4
Amphibole	6.0	6.4	9.8	0.6
Biotite	6.3	2.6	3.4	4.9
Chlorite	0.4	0.5	1.9	*
Opaque minerals[1]	4.3	4.0	4.2	5.0
Apatite	0.4	0.1	0.3	*
Plagioclase composition	60 → 33	63 → 44	68 → 45	68 → 40
Granophyre	5.7	4.0	6.0	1.2

* trace

Location of samples

440, 550, 559 — easternmost, major, north-northeast-trending dike

768 — west-northwest-trending dike

[1] Fe-Ti oxide, minor pyrite, rare pyrrhotite

Table 8

Partial chemical analysis of garnet - cummingtonite rock

Al_2O_3	12.2
Total iron as Fe_2O_3	32.9
MgO	2.92
CaO	1.65
MnO	0.32
TiO_2	0.3*
Cr_2O_3	<0.1*
V_2O_3	<0.1*

*qualitative analysis

Analysis by Laboratory Branch, Ontario Dept. of Mines

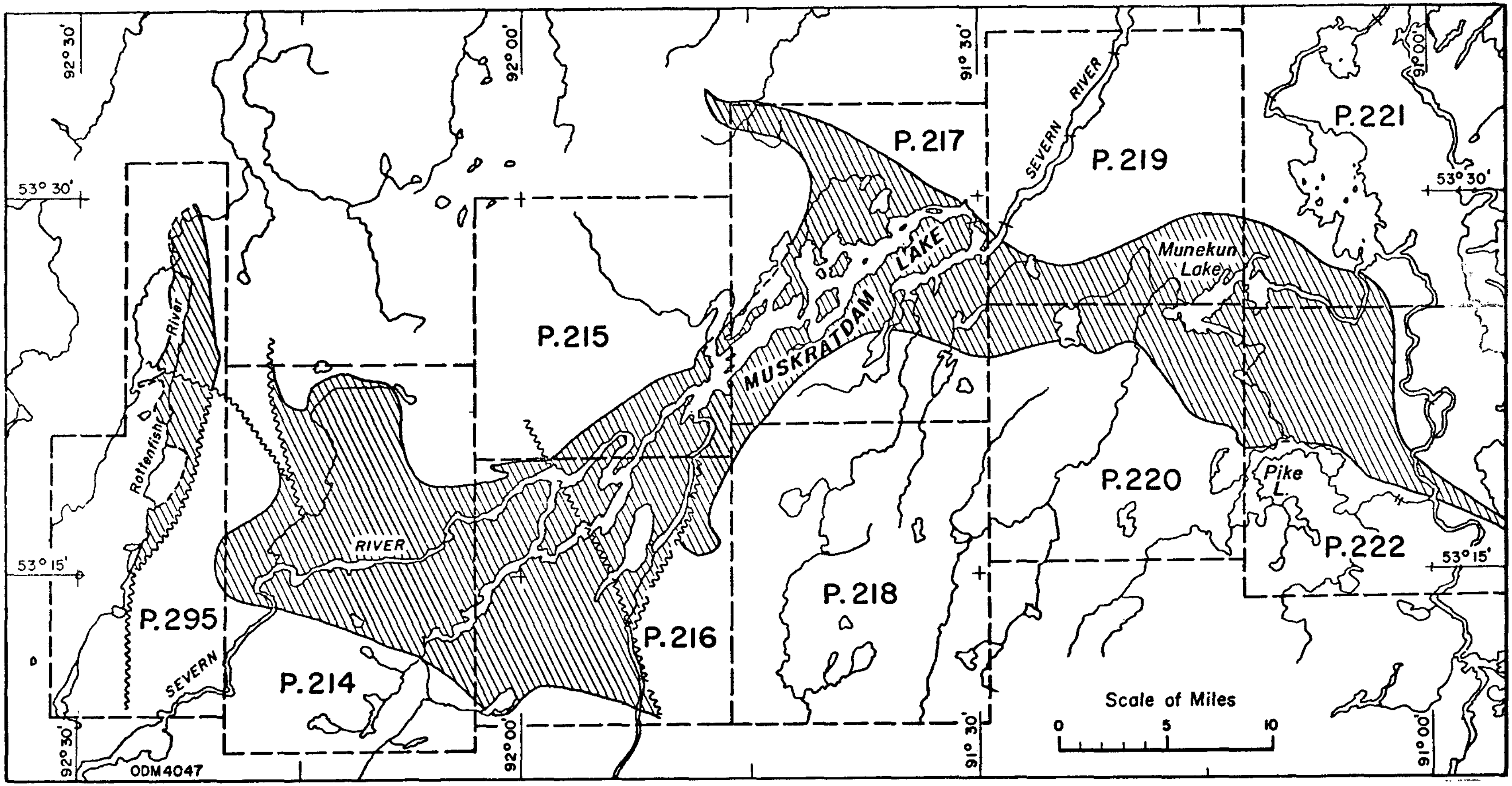

92° 30'
92° 00'
91° 30'
91° 00'
53° 30'
53° 15'
P. 221
P. 217
P. 219
P. 215
P. 295
P. 214
P. 216
P. 218
P. 220
P. 222
SEVERN RIVER
MUSKRATDAM LAKE
Munekun Lake
Pike L.
Rottenfish River
RIVER
SEVERN
Scale of Miles
0
5
10
ODM4047

Figure 2

Figure 3

Legend

G- Location of metagabbro and metadiorite sills

Upper metasedimentary formation

Biotite-bearing metagreywacke, metasiltstone, and slate

Muscovite-bearing metagreywacke and slate

Metaconglomerate

Marble and calc-silicate gneiss

Upper mafic metavolcanic formation

Mafic metavolcanic flows

Metamorphosed breccia of intermediate composition

Metamorphosed felsic sill (?)

Felsic metavolcanic formation

Undifferentiated

Metatuff and muscovite-bearing metagreywacke

Metamorphosed felsic flows

Lower metasedimentary formation

Lower mafic metavolcanic formation

Assumed correlation lines

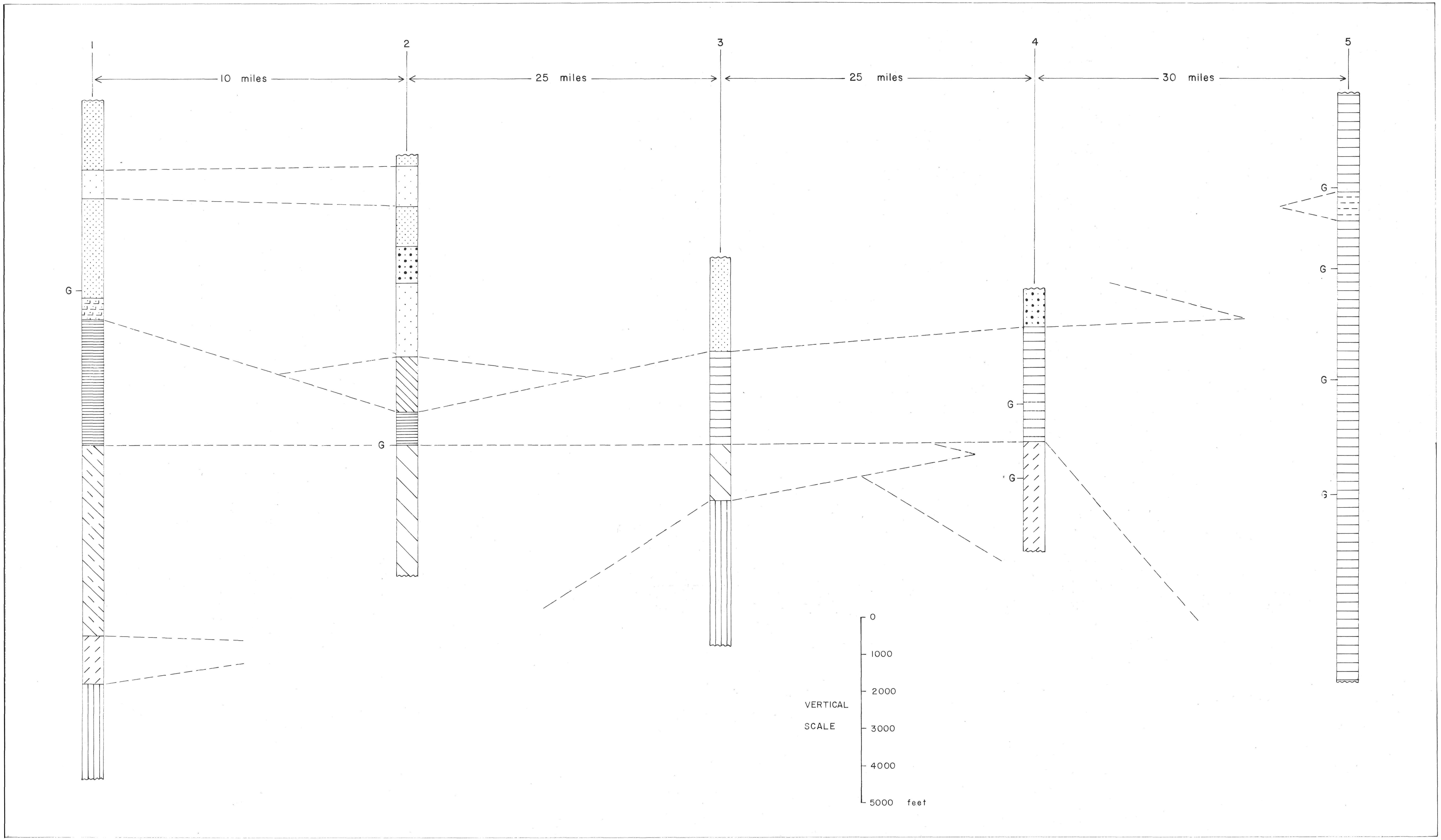

1
2
3
4
5
10 miles
25 miles
25 miles
30 miles
G
G
G
G
G
G
G
G
G
VERTICAL
SCALE
0
1000
2000
3000
4000
5000 feet

Figure 3

Figure 4

Legend

Lower Precambrian

11 Granitic batholiths

11a Diorite, quartz-bearing diorite, syenodiorite, and mafic-rich trondhjemite

11b Hornblende-biotite trondhjemite, tonalite, and granodiorite

11c Porphyritic, hornblende-biotite granodiorite

11d Equigranular, biotite trondhjemite, granodiorite, and quartz monzonite

11e Porphyritic, biotite trondhjemite, granodiorite, and quartz monzonite

11f Pegmatite

10 Metagabbro and metadiorite

Muskratdam Lake Belt

6 Metasedimentary-metavolcanic formation of undetermined stratigraphic position (possibly part of the upper metasedimentary formation)

6a Metasediments

6b Metavolcanic flows of intermediate composition

6c Metavolcanic breccia of intermediate composition

6d Felsic metavolcanics

Rottenfish River Belt

9 Felsic metavolcanics

8 Metavolcanics of intermediate composition

7 Mafic metavolcanics

Figure 4

Legend

| 5 | Upper metasedimentary formation

| 4 | Upper mafic metavolcanic formation

4a Mafic metavolcanics

4b Metavolcanic flows of intermediate composition

4c Metavolcanic breccia of intermediate composition

| 3 | Felsic metavolcanic formation

3 Undifferentiated

3a Metamorphosed, felsic, pyroclastic rocks

3b ~~Meta-arkose~~ Muscovite-bearing metagreywacke

3c Felsic metavolcanic flows

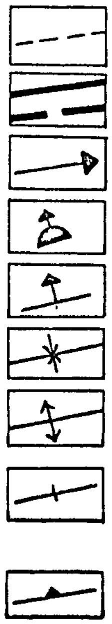
3d Metavolcanic flows of intermediate composition

| 2 | Lower metasedimentary formation

| 1 | Lower mafic metavolcanic formation

Figure 4

Symbols



Geological boundary

Fault (defined, assumed)

Lineation

Top of lava flow from pillow shape

Top of graded bed

Syncline, trace of axial plane

Anticline, trace of axial plane

Trend of foliation and gneissosity in mafic metavolcanic rocks

Trend of foliation and gneissosity in intrusive rocks.

Basemap modified from preliminary edition of the Makoop and Opasquia topographic sheets, Department of Mines and Technical Surveys, Ottawa.


ROTTENFISH RIVER BELT
MUSKRATDAM LAKE BELT
Rottenfish River
ROTTENFISH RIVER FAULT
HILL LAKE FAULT
Rottenfish Lake
SEVERN RIVER
Severn River
SANDHILL CRANE ANTICLINE
FOX BAY SYNCLINE
FOX BAY SILL
SANDHILL CRANE SILL
MUSKRATDAM LAKE SILL
Muskratdam Lake
WINDIGO RIVER FAULT
Windigo River
Windigo FAULT
limit of fine- to medium-grained granodiorite dikes
Misquamaebin Lake
Munekun Lake
LOWER MUNEKUN LAKE SILL
UPPER MUNEKUN LAKE SILL
MUNEKUN LAKE SYNCLINE
Pike Lake
Schade River
53° 30'
53° 15'
92° 30'
92° 00'
91° 30'
91° 10'
0 2 4 6
MILES

Figure 4

Figure 5

Legend

Granitic rocks

Metagabbro and metadiorite

Metasediments

Felsic metavolcanics

Mafic and intermediate metavolcanics

Greenschist facies zone

Almandine amphibolite and hornblende hornfels facies zone

Layered hornblende hornfels facies zone

Geological boundary

Approximate boundary between metamorphic zones

Fault (defined, assumed)

BELT
LAKE
MUSKRATDAM
RIVER
BELT
ROTTENFISH
Misquamaebin
Lake
Severn
River
Muskratdam
Lake
Munekun
Lake
Pike Lake
Schade
River
Rottenfish
River
Windigo
River
Severn
River
Rottenfish
Lake
53° 30'
53° 15'
92° 30'
92° 00'
91° 30'
91° 10'
0
2
4
6
MILES

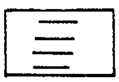
Figure 5

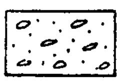
Figure 6

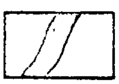
Legend


Glacial striae: direction of movement known or inferred; direction unknown

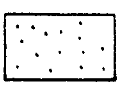

Drumlin or drumlinoid ridge


Interlobate moraine with only minor wave modification


Wave-modified end and interlobate moraine


Esker with only minor wave modification


Wave-modified esker and large sand and gravel deposits of unknown origin (may include some end moraine)


Deltaic and outwash deposits


Linear gravel ridges on top of outcrop and moraine hills


Gravel beaches on outcrop and ground moraine hills


Varved clay outcrops


Concretion localities


Sachigo Interlobate Moraine
Rottenfish River
End
Moraine ?
Rottenfish Lake
Severn River
Windigo River
Muskratdam Lake
Severn River
Misquamaebin Lake
End Moraine
Munekun Lake
Schade River
Pike Lake
B
B
B
C
C
C
53° 30'
53° 15'
92° 30'
92° 00'
91° 30'
91° 00'
0
2
4
6
MILES

Figure 6

Figure 7

Legend

Granitic rocks

Diorite, quartz-bearing diorite, syenodiorite, and mafic-rich trondhjemite

Metagabbro and metadiorite

Metasediments

Felsic metavolcanics

Metavolcanics of intermediate composition

Mafic metavolcanics

Geological Boundary

Fault (defined, assumed)

Sampled quartz veins:

nil to trace amounts of gold

0.01 ounces of gold per ton

trace amounts of chalcopyrite

Sulphide mineral occurrences:

1 to 10 percent sulphide minerals

more than 10 percent sulphide minerals

0.02 ounces of gold per ton

trace to 0.1 percent copper

more than 0.1 percent copper

trace amounts of silver

trace amounts of lead

trace amounts of nickel

trace amounts of zinc

trace amounts of arsenopyrite


ROTTENFISH RIVER BELT
MUSKRATDAM LAKE BELT
Rottenfish River
Rottenfish Lake
Severn River
Muskratdam Lake
Windigo River
Severn River
Misquamaebin Lake
Munekun Lake
Pike Lake
Schade River
53° 30'
53° 15'
92° 30'
92° 00'
91° 30'
91° 10'
0 2 4 6
MILES

Figure 7

Marginal Notes

Location: Muskratdam Lake, in the centre of the map-area, is about 150 miles north-northwest of Pickle Lake, about 230 miles north of Sioux Lookout, and about 190 miles north-northeast of Red Lake. Float-equipped aircraft can be chartered at these towns. Regularly scheduled flights to Sandy Lake (about 75 miles west of Muskratdam Lake) originate at both Sioux Lookout and Red Lake, and flights to Round Lake (about 35 miles south of Muskratdam Lake) originate at both Pickle Lake and Sioux Lookout; planes can be chartered from either Sandy Lake or Round Lake. Many streams in the area can be travelled by canoe.

Mineral Exploration: Intermittent mineral exploration has been carried out for at least thirty years, but poor rock exposure makes exploration difficult. At the present time, there are no recorded claims.

General Geology: Stratigraphy and structure are complex. Metavolcanics appear to be the oldest rocks; metasediments overlie the metavolcanics and are also locally found below and interlayered with the metavolcanics.

In the eastern part of the Muskratdam Lake belt mafic volcanic flows predominate, but in the western part felsic volcanic flows and pyroclastic deposits are abundant. Mafic metavolcanics range from very fine-grained, light green to green, quartz-albite-epidote-chlorite rocks (greenschist facies) to fine-grained, green to dark green, quartz-oligoclase-amphibole rocks (amphibolite facies). In the mafic metavolcanics foliation and pillow structure are common, but schistosity is rare. Near granitic rocks narrow mafic-rich and mafic-poor layers, which superficially resemble bedding, have developed in the mafic metavolcanics. The felsic metavolcanic unit is composed of tuff, lapilli tuff, agglomerate, and domes and narrow layers of lava, some of which may be intrusive. Both foliation and schistosity are common in the felsic metavolcanics. Amygdaloidal andesite and dacite are locally associated with the felsic metavolcanics.

Conglomerate and arkose are closely associated with felsic metavolcanics, and the arkose, which is probably derived from felsic flows and from pyroclastic rocks, locally grades into lapilli tuff of almost identical composition. Most of the metasedimentary sequence is composed of interbedded greywacke, siltstone, and slate, but rare, narrow, marble and calc-silicate intercalations occur. The slate unit along the Severn River was possibly derived from tuff.

Layered iron formation, which forms units up to 100 feet thick and which is composed of recrystallized chert, magnetite, and iron silicate minerals, is associated with both mafic and felsic metavolcanics and with metasediments.

Pre-metamorphism sills, dikes, and irregular bodies of gabbro and diorite were intruded at several horizons in the metavolcanic-metasedimentary sequence and have been subsequently metamorphosed. The sills, which have a maximum thickness of 1.5 miles and which can be traced laterally for at least 15 miles, appear to be only slightly differentiated. The only exception is north of the Severn River where a silicic differentiate has developed in a narrow sill. In the Rottenfish River metavolcanic belt it is difficult to distinguish intrusive gabbro from medium-grained mafic flows.

The metavolcanic-metasedimentary sequence has been intruded by concordant to discordant, probably composite, batholiths composed predominantly of massive, foliated, and gneissic quartz diorite, trondhjemite (oligoclase quartz diorite), granodiorite, quartz monzonite, pegmatite, and aplite. Gradational and intrusive contacts between the various phases indicate a complex intrusive history. Pyroxene syenodiorite, diorite, and gabbro east of Rottenfish Lake are probably an early phase of the batholith. Grey to pink, equigranular, biotite trondhjemite, granodiorite, and quartz monzonite are the main rock types in the batholith, but amphibole-bearing and porphyritic varieties of these types are common. Syenodiorite, diorite, and quartz diorite are locally found at the margins of the intrusions. Metavolcanic and metasedimentary inclusions are ubiquitous, and locally migmatite has formed. Pink pegmatite is common, but white, locally tourmaline-bearing, muscovite pegmatite was found only in the metavolcanic belt north and east of Muskratdam Lake.

Late diabase and gabbro dikes have a maximum width of 200 feet.

Extensive Pleistocene clay, sand, and gravel deposits, and recent swamp and muskeg cover much of the bedrock. The Sachigo interlobate moraine is at least 200 feet thick.

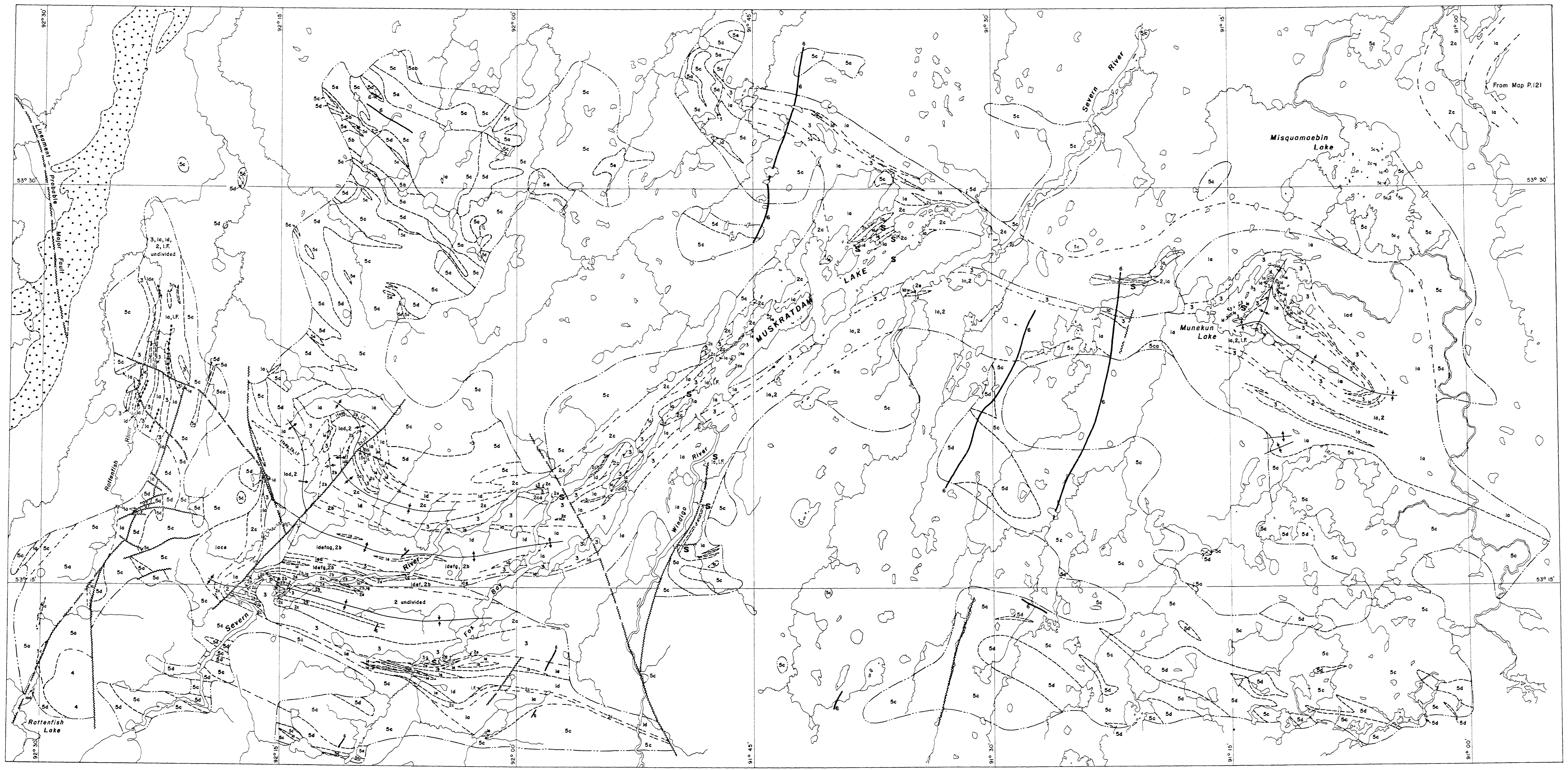
Structural Geology: In the east the Muskratdam Lake belt has been folded into an isoclinal synclinorium, but in the west the fold pattern consists of a medial anticline and two flanking synclines. Cross-folds have caused complexities in the structure. The fold pattern in the Rottenfish River belt is unknown.

Many faults have been recognized in the west part of the area, but in the east part lack of outcrop and monotony of the volcanic sequence hampers fault recognition. North-trending faults near the Rottenfish River have shear zones at least 2,000 feet wide.

Economic Geology: In 1937 gold was reported from the Rottenfish River belt, but no gold was found during the field season. Concordant quartz veins, quartz lenses, and quartz stockworks are found in all rock types, but discordant quartz veins are rare; grab samples collected by the author from 105 veins gave upon assay only trace amounts of gold.

Sulphide occurrences are indicated on the map. Traces of pyrite, pyrrhotite, and chalcopyrite were observed in many parts of the area. Along the north shore of Muskratdam Lake and on the large island in the Severn River, massive pyrrhotite and pyrite containing traces of copper, gold, and nickel are found in the matrix of conglomerate. East of the Windigo River, a metagabbro sill contains disseminated chalcopyrite and rare lenses of massive pyrite and chalcopyrite. Traces of chalcopyrite were also observed in amygdaloidal andesite south of Fox Bay. In 1938 sphalerite and galena were reported from a vein at a portage on the Severn River; this vein was not found.

A large magnetic anomaly occurs along the Rottenfish River belt. Maxims in the anomaly were located by compass deviations and are shown on the map.



ONTARIO DEPARTMENT OF MINES

PRELIMINARY GEOLOGICAL MAP NO. P.256

MUSKRATDAM LAKE AREA

DISTRICT OF KENORA (PATRICIA PORTION)

SCALE 1:125,000

N.T.S. Reference parts of 53 F/E½, 53 G/W½

LEGEND

CENOZOIC

PLEISTOCENE[1]

7 Sachigo Moraine

PRECAMBRIAN

LATE MAFIC INTRUSIVE ROCKS (DIKES)

6 Gabbro and diabase

FELSIC INTRUSIVE ROCKS

5a Amphibole-biotite diorite, quartz diorite, and trondhjemite
5b Porphyritic amphibole-biotite granodiorite
5c Equigranular biotite trondhjemite, granodiorite, and quartz monzonite
5d Porphyritic biotite granodiorite and quartz monzonite
5e Pegmatite and aplite

MIDDLE MAFIC INTRUSIVE ROCKS

4 Gabbro, diorite, and syenodiorite

EARLY MAFIC INTRUSIVE ROCKS

3 Gabbro, diorite, and pegmatite

METASEDIMENTS

2a Conglomerate
2b Arkose, feldspathic sandstone, and siltstone of equivalent composition
2c Feldspathic greywacke and siltstone of equivalent composition
2d Slate
2e Marble and calc-silicate rocks

IF Iron Formation

METAVOLCANICS

1a Mafic metavolcanics (predominantly basalt, possibly includes some early mafic intrusive rocks)
1b Mafic metavolcanics (predominantly andesite and dacite)
1c Porphyritic mafic metavolcanics
1d Felsic metavolcanic flows, possibly includes some hypabyssal intrusive rocks
1e Agglomerate and volcanic breccia
1f Lapilli tuff
1g Tuff and volcanic sandstone

IF Iron Formation

[1] Deposits, other than Sachigo Moraine, are not indicated on the map.

Note: Unmapped areas predominantly underlain by Pleistocene deposits.

SYMBOLS

Geological boundary, approximate.
Geological boundary, assumed.
Synclinal axis.
Anticlinal axis.
Fault, defined.
Fault, indicated or assumed.
S Sulphide mineralization.
Edge of mapped area or edge of outcrop area.
Crest of magnetic anomaly.

SOURCES OF INFORMATION

Geology by L.D. Ayres and assistants, 1963, 1964.

Base map derived from preliminary edition of Makoop Lake and Opasquia topographic sheets, Department of Mines and Technical Surveys, Ottawa.

Magnetic declination in centre of area about 2° East.

Issued 1964.