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**Ontario Geological Survey
Report 189**

**Geology
of the
Upper Manitou Lake Area
District of Kenora**

By

C.E. Blackburn

1979



Ontario

**Ministry of
Natural
Resources**

**Hon. James A. C. Auld
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**Dr. J. K. Reynolds
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Publications of the Ontario Ministry of Natural Resources
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Map Unit, Public Service Centre, Queen's Park, Toronto,
and the
Ontario Government Bookstore, 880 Bay Street, Toronto.
Orders for publication should be accompanied by cheque or money order,
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ISSN 0704 - 2582

ISBN 0-7743-3556-4

Parts of this publication may be quoted if credit is given. It is recommended that reference to this report be made in the following form:

Blackburn, C.E.

1979: Geology of the Upper Manitou Lake Area, District of Kenora; Ontario Geol. Surv. Report 189, 74p. Accompanied by Map 2409, scale 1:31 680 (1 inch to ½ mile).

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GEOLOGICAL MAP

(back pocket)

Map 2409 (coloured)—Upper Manitou Lake, District of Kenora.
Scale: 1:31,680 or 1 inch to ½ mile.

CHART

(back pocket)

Chart A—Table 2.

ABSTRACT

The Upper Manitou Lake area lies between Latitudes $49^{\circ}22'30''$ and $49^{\circ}30'N$ and Longitudes $92^{\circ}45'$ and $93^{\circ}00'W$, and covers 252 km². Upper Manitou Lake is about 40 km south of Dryden.

Bedrock is entirely of Early Precambrian (Archean) age, and consists of thick flow and pyroclastic metavolcanic sequences, a subvolcanic intermediate plug, felsic porphyry dikes, a mafic intrusive body, and granitic rocks marginal to a batholith dome.

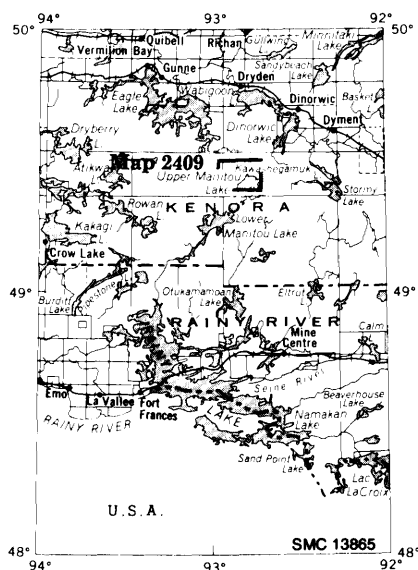


Figure 1—Key map showing location of the Upper Manitou Lake area. Scale 1:3 168 000 or 1 inch to 50 miles.

The metavolcanic sequence is folded into a regional northeast-trending anticline, the Manitou Anticline, and possibly a complimentary syncline on its northwest side. The base of the sequence in the map-area, which occurs in the core of the anticline, is composed of mafic flows. Above the mafic flows lies a sequence of intermediate pyroclastics, and above this, on the flanks of the anticline is a mixed sequence of mafic flows and intermediate pyroclastics.

A subvolcanic intermediate plug intrudes the middle, intermediate pyroclastic, sequence, and was the feeder for much of the pyroclastic debris. Felsic porphyry dikes and a stock-like lens intrude all levels of the volcanic pile, but in particular the middle intermediate pyroclastic sequence.

Syntectonic granodioritic and quartz monzonitic plutonic rocks of the Atikwa Batholith intrude the metavolcanic sequence along its northwestern margin. Voluminous amounts of hybrid dioritic rock occur along the contact zone of the batholith with the metavolcanic sequence. Rafts and xenoliths of flow and pyroclastic metavolcanics, metamorphosed under amphibolite facies conditions, and further areas of hybrid diorites occur within the batholith.

A gabbroic intrusive body that occurs adjacent to hybrid diorites in the batholith-volcanic belt contact zone possibly represents an anatectic remobilizate of the mafic metavolcanic sequence.

During the Pleistocene Epoch, ice from the northeast advanced over and scoured the peneplained Precambrian rocks.

Long-known mineral occurrences include gold reportedly in quartz veins and in sulphide replacements, associated with the middle pyroclastics of the metavolcanic sequence, and molybdenum in quartz and quartzose pegmatite veins that occur marginal to the Atikwa Batholith. Exploration in recent years has been in the form of airborne and ground geophysical surveys directed toward the detection and location of electromagnetic conductors characteristic of base-metal sulphide deposits.

Geology of the Upper Manitou Lake Area

District of Kenora

by

C.E. Blackburn¹

INTRODUCTION

The Upper Manitou Lake area lies between Latitudes 49°22'30" and 49°30'N and Longitudes 92°45' and 93°00'W, in the District of Kenora. The area covers 252 km² being 18.1 km wide by 13.9 km long. Upper Manitou Lake, also formerly called Anzhekuming Lake (see for example McInnes 1902), is about 40 km south of Dryden, the nearest town, situated on the Trans-Canada Highway.

The Manitou Lakes, comprising Upper and Lower Manitou, were the scene of considerable gold prospecting and mining activity during the period 1895 to 1912, and again in the 1930s (Thomson 1933; 1938). A number of gold mines and prospects were located at the northeast end of Upper Manitou Lake (outside the map-area) on the shores of Trafalgar Bay. Only three of these came to production: the Big Master, the Laurentian, and the Elora. Other mines and prospects are scattered in the general vicinity of the Manitou Lakes, and only one of these, the Twentieth Century mine (Blackburn 1976), immediately south of the map-area, came to the production stage. The town of Gold Rock, situated at the north end of Trafalgar Bay, 3 km east of the map-area, was during this brief period a thriving community, though it is now little more than a ghost town.

No mineral production has been reported from the map-area to date. During the 1960s attention turned to geophysical methods of exploration for base metals, and the Manitou Lakes have received some attention by a few companies in this regard. Prior to the 1973 field season the most recent work was the geological map of the Manitou Lakes by Thomson (1933), who surveyed an area of approximately 1300 km² during the summer of 1932.

¹Geologist, Precambrian Geology Section, Ontario Geological Survey, Ontario Ministry of Natural Resources. Manuscript accepted for publication by the Chief Geologist, Feb. 15, 1977. This report is published with the permission of E.G. Pye, Director, Ontario Geological Survey.

Present Geological Survey

The present geological survey was carried out by the author and his assistants during the summer of 1973. Preliminary map P.961 was issued in 1974 (Blackburn 1974). The field map was prepared at a scale of 1 inch to $\frac{1}{4}$ mile (1:15,840) on a base map prepared by the Cartography Section of the Division of Lands from maps of the Forestry Resources Inventory. Field data were plotted on acetate overlays on vertical air photographs at the same scale as the base map. Outcrops were examined along lake shores and pace-and-compass traverse lines run at or nearly at right angles to strike of the formations. At a few places geological boundaries were traced directly in the field by walking along them. The traverse interval was of the order of 400 m in those parts of the area underlain by metavolcanics and metasediments, but widened to 800 m where granitic rocks were encountered.

As a result of abundant rock outcrop and the traverse interval, photo-interpretation played an important part in the preparation of the field map and subsequent preliminary map. Large areas of outcrop have been generalized to include areas where rock outcrop is prevalent, and may include many small rock outcrops. Topographic linears and the traces of faults have been interpreted with the aid of aerial photos at scales of 1 inch to $\frac{1}{4}$ mile (1:15,840) and 1 inch to 1 mile (1:63,360).

Extensive use was made of aeromagnetic map 1153G (ODM-GSC 1961) in traverse planning, and in geological interpretation.

Acknowledgments

The author was ably assisted in the field by senior assistant Robert Buchanan, and junior assistants Richard Barrett, P.J. Meehan, and Gavin Richardson. Mr. Buchanan carried out independent mapping throughout the summer and mapped about half of the map-area. Thanks are due to the late Harry Densmore of Goldrock Lodge for many courtesies and hospitality extended to the field party throughout the field season.

Access

Upper Manitou Lake is at the northeast end of a 55 km chain of interconnected lakes and waterways, including, in southwesterly sequence, Manitou Straits, Lower Manitou Lake, Manitou Stretch, and Esox Lake.

The Manitou Lakes—Esox Lake waterway may be reached by a number of different routes. The most direct route is via a system of lumber roads which extend southward from Dryden, and give direct access to much of the present map-area.

An old 11 km road connecting Gold Rock, at the northeast end of Upper Manitou Lake, with Dinorwic Lake and the town of Dinorwic via Minnehaha

Lake, is in very poor condition, and impassable except in winter.

From the southwest, Manitou Stretch may be reached from Fort Frances via Rainy Lake and a 19 km bush road.

A system of logging roads combined with a number of lakes gives excellent access to most of the northern and western parts, and also provides direct access to Upper Manitou Lake at two points. During the summer of 1973 only part of this system was being used by the Dryden Pulp and Paper Company. The roads date from the mid and late 1960s, when the company was cutting timber to the north of the Manitou Lakes, and are not at present being maintained. Within the map-area, the only road in use by the company in 1973 was the road in the northwest, which provides access to country in the general vicinity of Bunyan Lake, about 10 km west of the map-area. An older road, extending southward from the centre of the northern margin of the area to the waterfalls between Johnar Lake (also known locally as Polly Lake) and Upper Manitou Lake, joins Bunyan Lake access road about 1.5 km north of the map-area. The last 3 km of this Johnar Lake road are only safely passable by 4-wheel-drive vehicle, but provide direct access to Upper Manitou Lake. In the northeast corner of the map-area a road extending southward and reaching Jonas Lake (also known locally as Bell Lake) about 0.5 km east of the map-area, also gives direct access to Upper Manitou Lake. The Jonas Lake road joins the Bunyan Lake access road about 19 km north of the map-area, in the vicinity of Contact Bay of Wabigoon Lake, and this road continues north to Dryden.

Other roads within the map-area that were driveable during the 1973 field season include: a road which branches southward off the Bunyan Lake access road and parallels the western side of the southern end of Wawapus Lake; a road which branches westward off the Johnar Lake road and runs along the northern side of Rubanoe and Big Manitumeig Lakes; and a road along the east side of Kekekwa Lake that joins with the Bunyan Lake access road about 3 km north of the map-area.

Wawapus Lake is accessible from the Johnar Lake road about 1 km north of the map-area. Kekekwa Lake is accessible from the Kekekwa Lake road about 2.5 km north of the map-area. Upper Manitou Lake may be reached from the Big Manitumeig road, via short portages between Big Manitumeig, Noonan, and Johnar Lakes. The unnamed lake in the northeast corner of the map-area is accessible from the Jonas Lake road about 3 km north of the map-area.

Highway 812, presently under construction, which will join Dryden with Highway 11 east of Fort Frances, passes to the east of the Manitou Lakes.

Toponyms

Local usage for place names varies from official usage in a number of important cases. Listed below are alternative names to the official names shown on Map 2409 (back pocket):

<i>Official Usage</i>	<i>Alternate or Local Usage</i>
Johnar Lake	Polly Lake
Jonas Lake	Bell Lake
Big Manitumeig Lake	Donley Lake

Upper Manitou Lake Area

The long, narrow northeast-trending lake, extending north out of the northeast corner of the map-area is known locally as "Long Lake" or "Hoot Lake".

Previous Geological Work

The first geological survey of the Manitou Lakes was undertaken by William McInnes (1896; 1897; 1898) of the Geological Survey of Canada. McInnes' map (1902) shows considerable detail within the present map-area.

Geologists and inspectors of the then Ontario Bureau of Mines made short visits to mines and prospects of the Manitou Lakes area during the period from about 1895 to 1913, when an active "gold rush" was in progress. A.P. Coleman (1894; 1896) and A.L. Parsons (1911; 1912) in the course of inspections for the Bureau, made pertinent geological observations during this period. E.L. Bruce (1925) reported on mining developments in 1925, and on his own field geological observations in the Manitou Lakes area.

The second geological survey covering the Upper Manitou Lake area was made in 1932 by Thomson (1933). At that time an intensive search for gold deposits was being made in the older gold-regions, and the Manitou Lakes were receiving some new attention. In 1933, Thomson (1934) mapped the Straw-Manitou Lakes area, to the southwest of the present map-area, and revised some of the geological interpretations he had made the previous summer. Thomson returned to Upper Manitou Lake in 1937, and reported specifically on developments at Gold Rock (Thomson 1938).

In 1936, F.J. Pettijohn (1937), during the course of studies on Archean sedimentation, carried out geological mapping southeast of the present map-area at Mosher Bay and Uphill Lake.

During the 1963 and 1964 field seasons, A.M. Goodwin (1965; 1970) carried out regional stratigraphic studies, allied with systematic sampling of metavolcanic units, over the Kenora-Fort Frances area, and included the Manitou Lakes in this work.

In 1972, the present author conducted a geological survey immediately south of the Upper Manitou Lake area (Blackburn 1976).

Topography and Drainage

Topography in the Manitou Lakes is typical of that of much of the Canadian Shield. The peneplained surface is dotted with many lakes joined by short rivers and streams. Rock outcrop is plentiful, there being few swamps or muskegs.

The present topography and drainage pattern in the Upper Manitou Lake area is the result of modification by the scouring action of glacial ice of the Pleistocene Epoch upon various bedrock lithologies and structure. Upper Manitou Lake itself is in a depression eroded in the nose of a major anticline. The pres-

ence of numerous small islands in this lake is attributable to the coarse pyroclastic lithology of rocks in this nose, combined with a strong north-trending fracture system. Lakes in the northwest of the map-area are underlain by massive, granitic rock, transected by the same strong north-trending fracture system, and weaker northwest- and northeast-trending fractures, thus accounting for their general irregular shape and long, narrow connecting arms (e.g. Wawapus Lake). In areas underlain by metavolcanics with a strong planar anisotropy the shapes of lakes are controlled strongly by this anisotropy, and tend to be elongate in the direction of the foliation (e.g. Noonan and Johnar Lakes).

Other lakes and topographic features are controlled by local geological features. For example, Mitchell Lake, which has an equant shape, occupies a hollow eroded in the middle of a massive gabbroic body, while Frenchman Island, with its rugged shoreline, is underlain by a massive, subvolcanic core.

A local watershed (McInnes 1902) between a drainage system flowing northward toward Eagle Lake and a system flowing southward via the Manitou Lakes to Rainy Lake lies diagonally across the area in a northeast direction. Wawapus and Kekekwa Lakes and the unnamed lake in the northeast corner of the map-area are part of the northern system, while Big Manitumeig, Manitumeig, Noonan, Johnar, Mitchell and Harper Lakes all flow toward the Manitou Lakes system.

Upper Manitou Lake is approximately 1,224 feet (373 m) above sea level.

GENERAL GEOLOGY

Isotopic ages obtained by various workers in the southern part of the Kenora District, and the adjacent Rainy River District (Goldich *et al.* 1961; Hart and Davis 1969; Wanless 1970; Peterman *et al.* 1972; Birk and McNutt 1977) indicate bedrock to be of Early Precambrian age except for younger northwest-trending diabase dikes (Fahrig and Wanless 1963; Wanless 1970) of Middle to Late Precambrian age. By analogy with isotopic dates from surrounding localities, and in conformity with the Lower Manitou-Uphill Lakes area (Blackburn 1976), bedrock within the Upper Manitou Lake area is considered to be of Early Precambrian age.

The map-area lies on the northwest side of the Manitou-Stormy Lakes metavolcanic-metasedimentary belt, an arcuate structure some 20 km wide and 80 km long, extending from Lower Manitou Lake on the west to Bending Lake on the east, and tapering at either end. To the southwest, the belt is continuous with metavolcanics and metasediments that can be traced uninterruptedly via Kakagi Lake to Lake of the Woods, while to the north the belt joins with metavolcanics that extend northward toward Dryden (Davies and Pyslak 1967). The Manitou-Stormy Lakes area (Thomson 1933) is characterized by a thick volcanic sequence, consisting of mafic to felsic flow and pyroclastic rocks and minor volcanoclastic rocks, and a sedimentary sequence, part of the Manitou "Series" of Thomson, intruded by mafic to felsic rocks of batholithic, stock and sill-like form.

On a regional scale, Thomson (1933) postulated that the Manitou "Series" lay above the metavolcanics, and thereby implied the presence of a major syn-

Manitou-Stormy Lakes belt lies along the supposed axis (Blackburn 1976) and forms the northwest border of Thomson's Manitou "Series" (Thomson 1933; Goodwin 1965, 1970; Davies and Prysak 1967; Blackburn 1976).

During mapping of the Lower Manitou-Uphill Lakes area, the author (Blackburn 1976) found good evidence for the existence and continuation southwestward of Goodwin's Manitou Anticline (Goodwin 1970). Repetition of stratigraphy combined with top determinations in pillowed volcanics, enabled the author to extend the axial plane trace of the Manitou Anticline southwestward to the north shore of Lower Manitou Lake.

In the present map-area, an older mafic flow sequence, occupying the core of the Manitou Anticline, is succeeded upwards by a thick, coarse pyroclastic sequence of predominantly intermediate character. The Upper Manitou Lake basin is eroded in this pyroclastic unit, which thickens in the nose of the Manitou Anticline. At Frenchman Island, massive intermediate to felsic subvolcanic porphyries represent the vent to the coarse pyroclastic sequence. Stratigraphically above and geographically to the northwest of the coarse pyroclastic unit is a mixed sequence of mafic flows and pyroclastics of intermediate composition.

Felsic dikes are interpreted to have been emplaced prior to major regional deformation, and predominantly into the coarse pyroclastic sequence.

The northwestern half of the area is underlain by granitoid rocks of the Atikwa Batholith (Davies 1973), within which are enclosed migmatitic and partially assimilated, xenolithic blocks, lenses and sheets of volcanic origin. Dioritic and quartz dioritic phases within the granitoid rocks, and predominantly at the volcanic/batholithic contact, probably represent volcanic rocks that were partially assimilated by the magmatic phase of the batholith during its emplacement.

A large metamorphosed gabbro body at Mitchell Lake is interpreted to have been emplaced prior to batholithic invasion.

Deformation of the volcanic pile and metamorphism under greenschist to amphibolite facies conditions (Turner 1968) is interpreted to have occurred during the emplacement of the Atikwa Batholith.

During the Pleistocene Epoch glacial ice advanced over the peneplained Precambrian rocks; ground moraine was deposited by the receding glaciers (Zoltai 1961; 1965).

Rock sequences discussed under the headings "Metavolcanics" and "Metasediments" have been assigned names taken from local geographic features, such as lakes and bays. These are not formally defined formations, and may be stratigraphically continuous with sequences assigned different names in the Lower Manitou-Uphill Lakes area (Blackburn 1976). Rock-type designations are given according to the dominant lithologies within each sequence. A summary of the areal distribution of these sequences is presented in Figure 2.

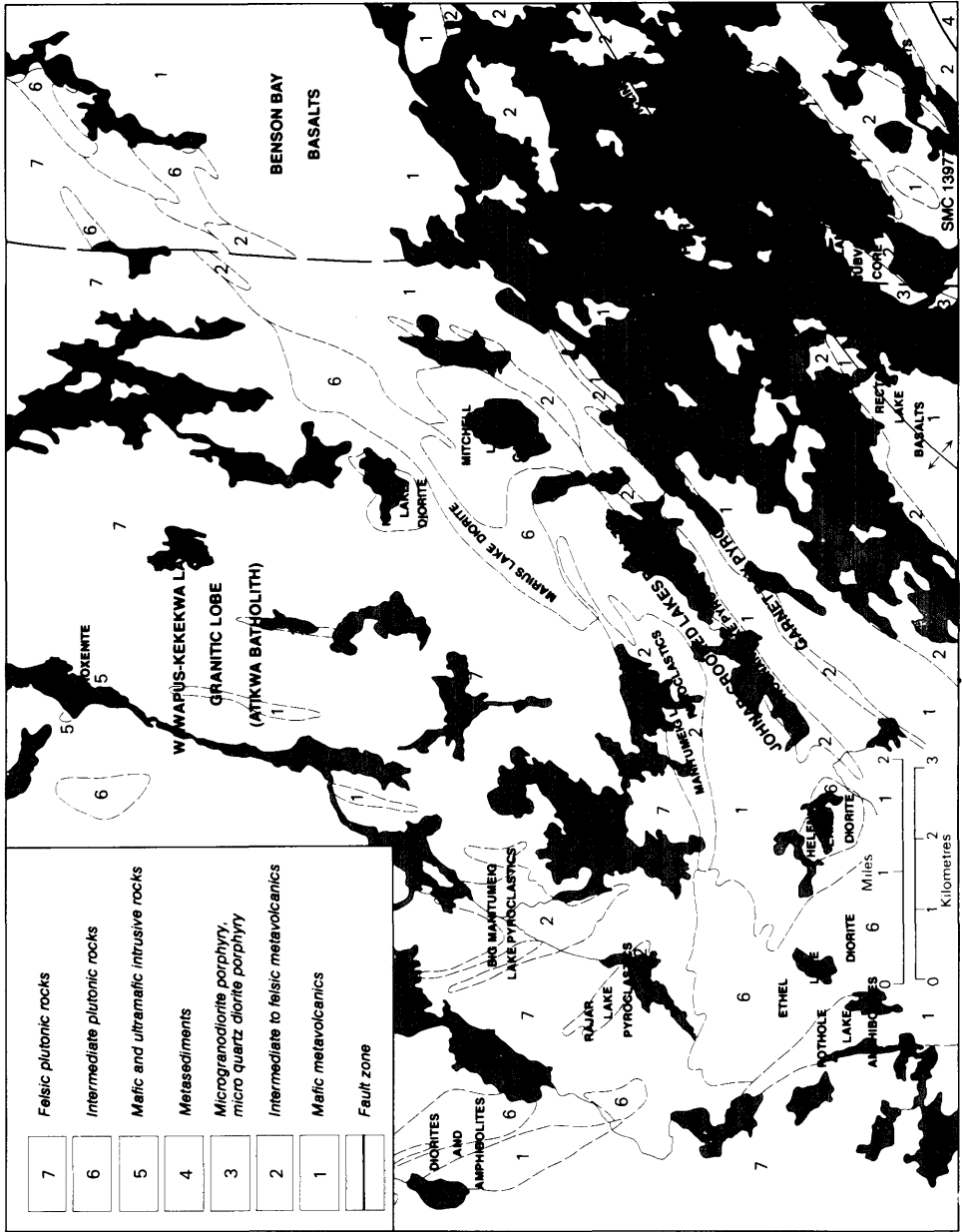


Figure 2--Areal distribution of major rock units in the Upper Manitou Lake area.

Early Precambrian

METAVOLCANICS

Within the Upper Manitou Lake area the metavolcanic-metasedimentary belt is composed predominantly of metavolcanics which exhibit a wide range in chemical composition, mineralogy, structure, and texture. Metamorphism and deformation of the metavolcanics vary in grade and intensity within the map-area, in many places obscuring original textures and mineralogy. It is, however, possible to subdivide the metavolcanics into broad categories based on a combination of texture, structure and mineralogy. In the field, textural and structural criteria were used to assign rocks to either flow or pyroclastic categories, while a combination of such factors as colour of the fresh surface, colour index, hardness, weathering colour, and visible quartz content were used to assign the metavolcanics to mafic, intermediate, or felsic categories.

Ideally, a colour index would be used: mafic rocks are defined as melanocratic rocks with more than 35 percent mafic minerals; intermediate rocks as mesocratic rocks with 15 to 35 percent mafic minerals; and felsic rocks as leucocratic rocks with less than 15 percent mafic minerals. In practice it is frequently found difficult to assess mafic mineral content, especially in fine-grained rocks. Colour on the fresh surface is strongly dependent on metamorphic grade, particularly in intermediate and mafic rocks, where development of chlorite, amphibole, and epidote in various proportions can produce all shades of greens and greys in rocks of similar chemical composition. Presence of visible quartz, suggesting intermediate to felsic types, is not always found to be strictly applicable, as grains of quartz are occasionally found in basaltic rocks. For pyroclastic rocks composed of mixed volcanic rock types, and also various matrix compositions, the overall colour index estimated by inspection of clasts and matrix was used to categorize the rock.

During field mapping it became evident that most of the metavolcanics could be classified as either mafic (colour index greater than 35) flow rocks, or intermediate to felsic (colour index less than 35 and ranging to less than 15) pyroclastic rocks. Partial and complete chemical analyses (Table 2, back pocket, Figure 3) of selected metavolcanics from the map-area reveal a range in composition from basalt to rhyolite, and substantiate the field subdivision of these rocks into two broad categories. Felsic metavolcanics were distinguishable from intermediate metavolcanics in the field, but they constitute a minor portion of the volcanic pile and for mapping purposes they were grouped with the intermediate metavolcanics.

Mafic Metavolcanics

Rocks assigned to this broad class of metavolcanics probably make up half of the volcanic pile within the present map-area, as was determined also for the Lower Manitou-Uphill Lakes area (Blackburn 1976).

The majority of mafic metavolcanics are flow rocks, though certain breccias

Upper Manitou Lake Area

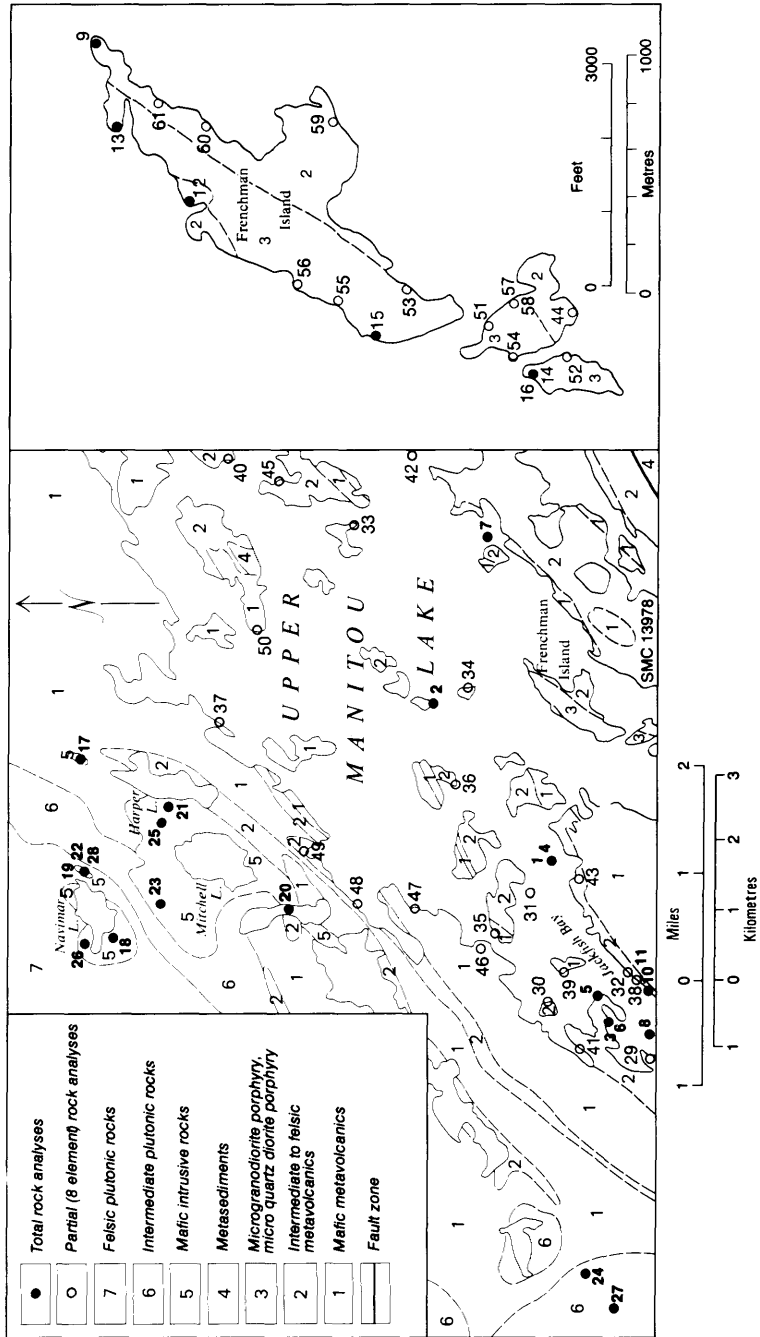


Figure 3—Location of samples taken for chemical analysis. See Table 2 (back pocket) for sample descriptions and analyses. Inset map shows location of samples from the Frenchman Island vicinity. Note that samples 59, 60 and 61 are from felsic dikes intruding intermediate to felsic metavolcanics.

may be of pyroclastic origin. Structures, textures, and mineralogy vary considerably, depending on amount of deformation, grade of metamorphism, and chemical composition. In general, the metamorphic rank of the metavolcanics varies in relation to distance from the Atikwa Batholith in the northwest. Thus amphibolitic metavolcanics occur in the outer parts of the belt, and greenschist facies metavolcanics dominate the more interior areas of the belt. Along the border zone between the metavolcanics and the granitoid batholithic rocks, amphibolites have locally attained temperatures of remobilization. Partial anatexis and palingenesis has occurred, resulting in hybrid dioritic phases indistinguishable from dioritic, grading to quartz dioritic, phases of the batholith itself. Consequently, these diorites have been grouped with the Atikwa Batholith rocks, and are discussed under that heading.

An attempt was made in the field to indicate mafic metavolcanics as being either greenschists or amphibolites, according to the criteria of Spry (1969), and amphibolites were mapped as such. According to these criteria a greenschist is a "fine-grained, foliated, green-coloured schist with an approximately basic chemical composition and containing abundant amphibole and/or chlorite" and "the texture is dominated by ragged and fibrous crystals of actinolite and chlorite and aggregates of small, irregular to possibly polygonal albite, epidote, quartz or calcite" (Spry 1969, p.276). On the other hand, "Typical, medium-grade amphibolite consists of hornblende and plagioclase with various amounts of garnet, epidote-zoisite, and quartz" (Spry 1969, p.276). Using these criteria field observations suggested that the greenschist to amphibolite facies boundary lies approximately from Rector Lake in the southwest, via Stony Island, Harper Lake, and Benson Lake, to the northeast corner of the map-area, with higher grade rocks to the northwest and lower grade to the southeast of that line. Thin-section study suggests that the boundary may be generally appropriate, but that lower-grade assemblages do occur at some localities northwest of the line.

Thus, broadly speaking, mafic metavolcanics stratigraphically lower in the volcanic pile, because of their structural position toward the centre of the belt, are of lower metamorphic rank than those stratigraphically higher in the pile. It is evident that the passage from greenschist to amphibolite facies grade transgresses stratigraphy, so that mafic metavolcanics near Benson Bay, although probably stratigraphically equivalent to those near Johnar Lake, are greenschists while the latter are amphibolites.

Chemical analyses of mafic flow rocks that occur within the present map-area (Table 2, sample 29, and Goodwin 1970), and chemical analysis of one sample from south of the area (Blackburn 1976) but within mafic metavolcanics in stratigraphic continuity with those at Rector Lake, suggest that mafic metavolcanics within the Upper Manitou Lake area are all basalts.

RECTOR LAKE BASALTS

Mafic metavolcanics occupy the broad peninsula at the south end of Upper Manitou Lake, situated between Jackfish and Reliance Bays, and also occur on the southern half of Swede Boys Island. They are a heterogeneous assemblage of massive, pillowed, and porphyritic basalts, metamorphosed to greenschist facies

Upper Manitou Lake Area

grade. Porphyritic and pillowed phases are commonly found along the west shore of Reliance Bay, and at the southern end of Swede Boys Island. A traverse made by the author across the tip of the broad peninsula intersected an interfingering sequence of mafic flow and intermediate pyroclastic rocks, and at one locality, the contact between these two rock types was traced around a tight, isoclinal fold. On Swede Boys Island, tight isoclinal folding of mafic metavolcanics and intermediate pyroclastics can be observed along the east shore line. Interfingering of these rock types on the peninsula is therefore interpreted to be due to folding, and the peninsula has been found, on the basis of this folding and other structural evidence, to lie in the core of a major anticlinal fold, the Manitou Anticline.

Aquagene breccia is not common in these basalts, but occurs in particular near Rector Lake, and along the shore of Reliance Bay, in both cases close to, or at, the top of the basaltic sequence.

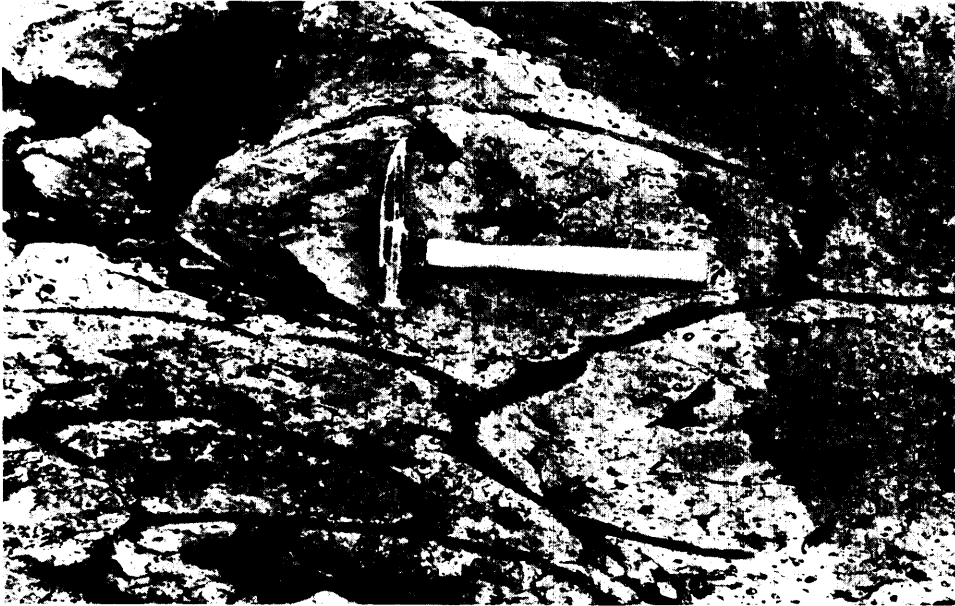
Thin-section study of a massive basalt from the north end of the peninsula, considered to be typical of the sequence, indicated the basalts to be of greenschist facies metamorphic grade. In hand specimen the rock appears to be medium grained, but the cut surface shows a mottled texture, with pale green areas about 1 cm in maximum length set in a dark green matrix. Pale green, weakly pleochroic actinolitic amphibole and granular epidote occupy the darker areas, and granular epidote and chlorite, with interstitial polygonized plagioclase grains, occupy the paler areas, that were probably originally plagioclase phenocrysts or aggregates. The amphiboles are feathery and irregular and do not appear to pseudomorph any original mineral.

UPPER MANITOU LAKE AND MANITOU STRAITS BASALTS

Although coarse, intermediate pyroclastics are the dominant rock types underlying Upper Manitou Lake, its shorelines and islands are lined by extensive intercalated mafic flow rocks. Considered under this heading are only those basaltic rocks that are intercalated within the coarse pyroclastic sequence, as discontinuous lenses and sheets. Those mafic metavolcanics that outcrop almost continuously along the northwest shore of the lake are discussed elsewhere.

Massive, medium-grained basaltic rocks are typical, but minor porphyritic and pillowed phases are located along Manitou Straits (Photo 1) and on the peninsula between Manitou Straits and Upper Manitou Lake, and on the largest unnamed island at the north end of Upper Manitou Lake.

Massive, coarse-grained, porphyritic and glomeroporphyritic basaltic rocks occur on a number of the islands in Jackfish Bay, and also on the immediately adjacent northwest shoreline of Upper Manitou Lake. These have been interpreted to be of flow origin mainly because no intrusive relationships with surrounding coarse intermediate pyroclastics could be found. An interesting feature of these rocks is the very large feldspar phenocrysts that they contain. Examples have been noted up to 15 cm in diameter. At some localities they occur in aggregates, suggesting either a disruption of one single phenocryst to form a number of smaller ones, or a coalescing of smaller individuals (Photo 2). A sample of the coarse-grained matrix of these rocks, from the larger of the islands in the middle of Jackfish Bay, is mottled dark green and milky white, and of 2 to 3 mm grain



OGS 9860

Photo 1—Porphyritic pillowed basalt. Note plagioclase phenocrysts in rims as well as interiors of pillows, and vesicles within pillows, close to rims. Pillow tops face towards top of photograph. Small island on Manitou Straits, northwest side, opposite entrance to Mosher Bay.

size. The dark green areas are composed of ragged to irregular pale green actinolitic amphibole grains that probably pseudomorph original pyroxene, and that are themselves partially altered to granular epidote and chlorite along narrow, irregular fractures. The milky white areas are composed predominantly of irregular aggregates of epidote, with minor interstitial fibrous actinolite and chlorite, and patches of polygonized quartz or plagioclase grains. The mineralogy indicates metamorphism to greenschist facies grade.

The porphyritic basalts at Jackfish Bay have a coarser grained matrix than other porphyritic basalts in the map-area. Evidence for their origin as flows is sparse: unlike the other porphyritic basalts, these contain no pillow structures. However, sheared scoriaceous zones that probably represent flow contacts, occur in a sparsely porphyritic basalt on one of the small islands at the south end of Jackfish Bay (Photo 3).

Coarse-grained mafic rocks interpreted to be extrusive rather than intrusive occur on a number of islands at the northeast end of that part of Upper Manitou Lake within the map-area; in particular on Leuiller, Rochon and Gold Islands. On Leuiller Island some of this rock may be intrusive, but of subvolcanic nature.

Upper Manitou Lake Area



OGS 9861

Photo 2—Glomeroporphyritic basalt. Note individual phenocrysts and aggregates of phenocrysts, e.g. lower centre. Island in Jackfish Bay, Upper Manitou Lake.



OGS 9862

Photo 3—Shear zones in sparsely porphyritic basalts. Shearing has occurred along scoriaceous contacts between flows. Island at south end of Jackfish Bay, Upper Manitou Lake.



OGS 9863

Photo 4—Narrow mafic tuffaceous bed intercalated within pillowed mafic flow sequence. Peninsula at east side of mouth of Benson Bay, Upper Manitou Lake.

BENSON BAY BASALTS

Immediately north of the northern end of Upper Manitou Lake is a thick sequence of predominantly basaltic flow rocks lying stratigraphically above the coarse pyroclastic sequence underlying Upper Manitou Lake. The transition from underlying pyroclastics to overlying flow rocks is marked by the intercalation of mafic and pyroclastic units, and occurs in the vicinity of Benson Bay. At about this same level a number of thin felsic flow or fine tuff units occur, which are discussed under "Pyroclastics of the Manitou Lake-Noonan Lake-Benson Bay Area".

Southeast of a line between the north end of Harper Lake and the south end of the unnamed lake in the northeast corner of the map-area, pillow lavas occur sporadically within the basaltic sequence, and porphyritic phases are relatively abundant. Northwest of this line pillow lavas are less frequently found, porphyritic phases are rare or absent, and amygdaloidal phases are common. The long north-trending fault that passes through Benson Bay and Benson Lake appears to offset the line between these two zones, with a dextral displacement of about 1 km.

Minor mafic breccia, probably entirely pillow breccia, occurs throughout the basaltic sequence. The breccias are characterized by irregular pillow-like structures scattered in a brecciated matrix, and only rarely in contact with each other. The pillow-like structures are rarely longer than 0.3 m in longest dimension. Examples of the breccia in contact with well-formed pillow lavas, some of

Upper Manitou Lake Area

which have variolitic interiors, may be seen along the road to Jonas Lake, west of Kirkby Lake.

Minor narrow mafic tuff bands are interbedded with pillowed mafic metavolcanics, particularly near the transition from the Upper Manitou Lake pyroclastic sequence into the Benson Bay basaltic sequence (Photo 4).

At Jonas Lake basaltic rocks are in general massive, pillow structures being virtually absent. However, discontinuous selvage-like structures occur in otherwise massive basalt. Lack of good outcrop prevents determining whether some of these structures, as seen on the south shore of Jonas Lake, join to define giant pillows that would be in excess of 2 m across.

The transition from greenschist facies to amphibolite facies grade, based on field evidence and criteria outlined at the beginning of this section, occurs from Harper Lake to Benson Lake to the northeast corner of the map-area. A sample of porphyritic basalt collected 0.8 km east of Benson Lake is in thin section mineralogically indicative of greenschist facies metamorphic grade. Equant, ragged, grains of green pleochroic hornblende, intergrown with more fibrous actinolite and partially altered to chlorite, occur in a fine-grained, granular matrix of epidote and plagioclase, and lesser amounts of sheaf-like aggregates of chlorite. Plagioclase is untwinned. Former plagioclase phenocrysts, up to 1 cm in diameter, have been entirely transformed to an epidote-chlorite aggregate with minor amounts of interstitial plagioclase.

Two samples collected near Jonas Lake, both of greenschist facies metamorphic rank, serve to show effects of carbonatization. The first sample, in which carbonate is absent, is a fine-grained basalt, grey-green in colour. It is composed of a felted aggregate, less than 0.1 mm in grain size, of pale green actinolitic amphibole fibres, intergrown with abundant granular epidote, and minute, poorly twinned albitic plagioclase. The second sample, that contains abundant carbonate, is a medium to coarse grained mafic rock, mottled dark green and pale green. Grain size of the original minerals is of the order of 3 mm; dark green areas are pale green amphibole grains almost completely altered to a chlorite matted aggregate. Pale green areas are aggregates of abundant epidote, and lesser amounts of chlorite, carbonate and quartz, that probably pseudomorph original plagioclase. A few grains of untwinned plagioclase remain, or may be of new generation. Carbonate also occurs in larger areas that may have been amygdules, but are now very irregular. Fractures are filled by chlorite fibres that have grown with long axes at right angles to their margins, and granular and euhedral to subhedral sphene is present as accessory.

JOHNAR-CROOKED LAKES BASALTS

Basaltic rocks of this area, although probably stratigraphically equivalent to those at Benson Bay, and immediately overlying Upper Manitou Lake pyroclastics, differ from Benson Bay basalts in a number of respects. Firstly, substantial felsic to intermediate pyroclastic units are intercalated within them, at least three of which (those at Garnet Bay, at Noonan and Johnar Lakes, and at Manitumeig Lake) are of major dimensions. Secondly, pillow lavas appear to be absent in most of the sequence, although porphyritic phases, as in the Ben-

son Bay basalts, are common in the lower part of the sequence.

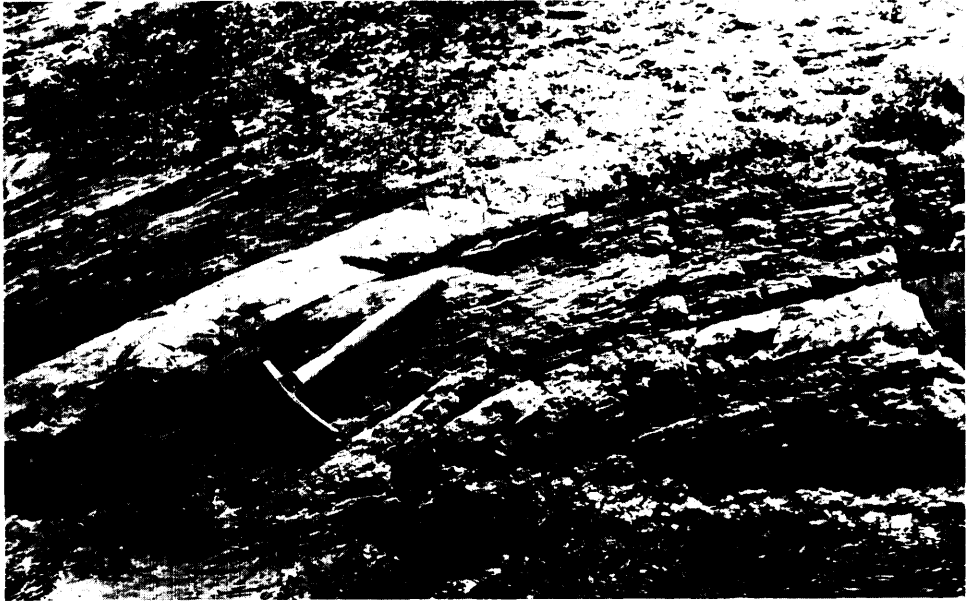
Northwest of Noonan and Johnar Lakes amygdaloidal phases are common, some of which are also pillowed, while porphyritic phases are rare. It is of note that this transition into amygdaloidal basalts occurs at the same stratigraphic level as in the Benson Bay basalts, that is to say about 2 km from the contact with underlying Upper Manitou Lake pyroclastics.

A porphyritic basalt from this sequence, collected 0.8 km south of the south end of Noonan Lake, on the west shore of a small lake, is typical of these mafic metavolcanics. In hand specimen it is dark green, mottled with discrete white areas, interpreted to be plagioclase phenocrysts. Thin section study shows the dark green matrix to be composed of acicular to bladed, strongly pleochroic green hornblende, of 0.3 mm average grain size, in sheaf-like and felted aggregates, with interstitial untwinned plagioclase, and quartz. Amphiboles are subhedral, twinned, and poikiloblastically contain fine plagioclase and quartz grains. Minor amounts of granular epidote, and anhedral to euhedral sphene, are present. A plagioclase phenocryst, about 1.5 cm in longest dimension, has preserved a subhedral six-sided form, and also relict twinning, probably on the albite or Carlsbad law. However, it has been completely recrystallized into a granoblastic aggregate of minute plagioclase grains. Scattered granules of subhedral epidote and hornblende laths occur within, but not as alteration of, the plagioclase. The mineralogy is indicative of amphibolite facies grade metamorphism.

POTHOLE LAKE AMPHIBOLITES AND XENOLITHS IN ATIKWA BATHOLITH

In the southwest of the map-area, at and east of Pothole Lake, amphibolitized mafic metavolcanics lie between granitic rocks of the Wawapus-Kekekwa Lakes lobe of the Atikwa Batholith to their west, and diorites and similar intermediate to mafic rocks of the Ethel Lake area on their east. All of these amphibolites are strongly foliated and in general lineated. Their derivation from volcanic rocks of mafic flow type is inferred from their mineralogy, and they are continuous southward with amphibolites shown to be of metavolcanic origin at Merrill Lake (Blackburn 1976). Their eastern boundary with dioritic rocks is transitional and therefore arbitrary; in fact very similar, foliated to layered rocks, occur well within the dioritic unit. Their western boundary is quite precisely located where granitic rocks occur in lit-par-lit association with amphibolites over a narrow zone (Photo 5) followed westward by granitic rocks with amphibolite inclusions and xenoliths.

Amphibolitic rocks of similar type occur also as enclaves within the granitic, batholithic terrain, mostly associated with pyroclastic rocks similarly metamorphosed to amphibolite facies grade, and hybrid dioritic rocks. A particularly large body of this type, possibly originally continuous with the Pothole Lake amphibolites, but since separated either by granitic emplacement or fault movements along a pronounced north-trending lineament immediately east of Butterfly Lake, is situated west of the south end of Wawapus Lake. Between the southwest arm of Wawapus Lake and Big Manitumeig Lake lies a very irregular body of mixed mafic metavolcanic flow rocks and pyroclastics, all of amphibolite facies metamorphic grade. On the accompanying Map 2409 (back pocket) the northern



OGS 9864

Photo 5—Lit-par-lit layering of amphibolite and granitic rock at contact between Atikwa Batholith and metavolcanic belt. Northeast bay of Pothole Lake.

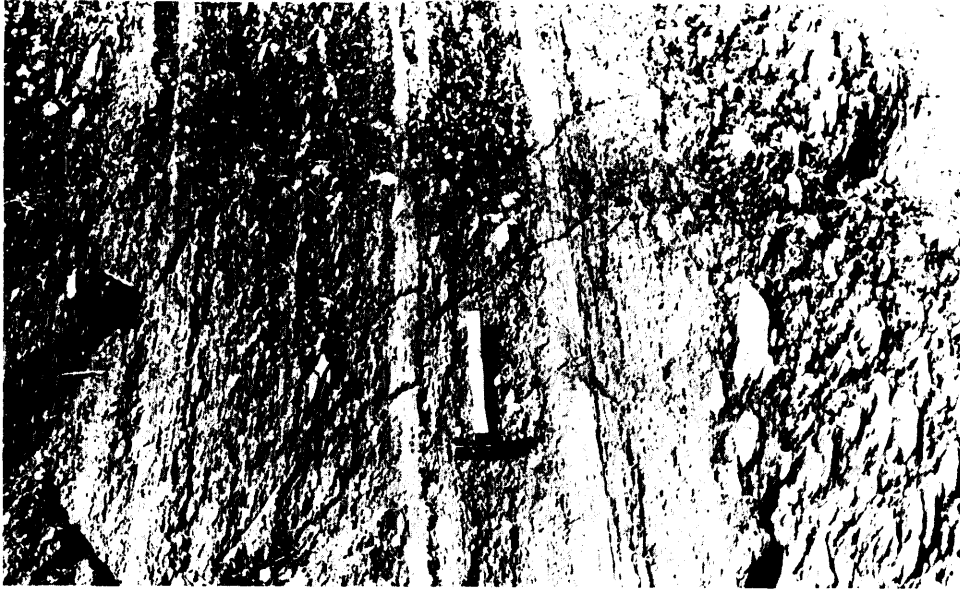
portion of this body is shown as being dominantly composed of amphibolite, but substantial amounts also are interbedded in chaotic fashion with coarse pyroclastics throughout the southern portion.

Intermediate and Felsic Metavolcanics

Metavolcanics in the map-area of intermediate to felsic composition are predominantly pyroclastic. Pyroclastic rocks cover a wide range of chemical composition, from basic, to intermediate, to acidic. Felsic rocks of rhyolitic composition are mostly flows rather than pyroclastics.

The fragment size and mixture classification of Fisher (1966) has been used for pyroclastic rocks in this report.

Pyroclastic rocks occur in essentially three distinct settings within the map-area. One is in the southeast, underlying Upper Manitou Lake, where coarse pyroclastics predominate in an assemblage of intermediate pyroclastic and mafic flow rocks. A second setting is that where pyroclastic units are intercalated with mafic flow units, and these occur in the vicinity of Manitumeig Lake, Noonan and Johnar Lakes, and at Garnet Bay. A third setting is that where pyroclastic



OGS 9865

Photo 6—Bedded pyroclastic rocks. Interlayered tuff and lapilli-tuff to the left, and a thick tuff-breccia bed to the right of the photograph. Preferred orientation of long axes of clasts at right is subvertical. Rochon Island.

rocks occur in xenolithic masses within the Atikwa Batholith, usually in association with mafic flow rocks, as at Rajar Lake and between Big Manitumeig and Wawapus Lakes.

UPPER MANITOU LAKE PYROCLASTICS

Pyroclastic rocks at Upper Manitou Lake constitute a thick assemblage of predominantly coarse, intermediate character, with intercalated mafic flow units. These pyroclastics occur in the nose of a regional anticlinal fold structure, the Manitou Anticline, and the main body of the lake is eroded in this nose. Two arms of the lake, Jackfish Bay and Reliance Bay, are eroded in these pyroclastics where they form flanks of the fold structure.

In outcrop these rocks show a very heterogeneous mixture of size ranges, from tuff-breccia to lapilli-tuff to tuff (Photo 6). Mechanical weathering, particularly of the coarser grained fragmentals, has produced spectacular outcrops (e.g. see Photo 15) in which large clasts stand out against the tuffaceous matrix, or in which certain tuffaceous bands have proven more resistant to weathering, and therefore stand out as ridges.



OGS 9866

Photo 7—Air-fall tuff of intermediate composition. Note cross bedding in 8 cm bed at centre of photograph. McGraw Island, Upper Manitou Lake.

At some localities clastic material in the tuff to lapilli-tuff size range is well-bedded (Photo 6). Intense planar and linear deformation has in some places completely transposed bedding, so that only a foliation which may or may not parallel primary layering remains. At other places the general trend of primary layering may be obtained from alternation of coarse clastic units of various size ranges, or from the distribution of mafic intercalated layers in the pyroclastic sequence.

In general, the lack of well-defined bedding, and the similarity in composition between large clasts and the tuffaceous matrix in which they are embedded, leads to the conclusion that these pyroclastic rocks were deposited rapidly and in an environment where little reworking or winnowing of material either by water or wind occurred. At other places, a bedding in which grading of material may proceed rather erratically from coarser to finer in no regular manner, and in which most material lies within the tuff size range, and is in large part either broken or unbroken euhedral crystals suggests a subaerial deposition of air-fall ash. At some places, cross-bedding occurs in these tuffs (Photo 7), suggesting an increase in wind activity. The grading and cross-bedding are comparable to those in photographs of deposits designated as ashfall beds by Green and Short (1971, plate 176). Rare larger clasts, of lapilli, bomb, and block size are either scattered through the ash deposits (Photo 8), or interbedded in distinct units in the finer ash.

At a number of localities, for example at Rochon Island, the pyroclastic material is well bedded, and a strong flattening and stretching deformation has ac-



OGS 9867

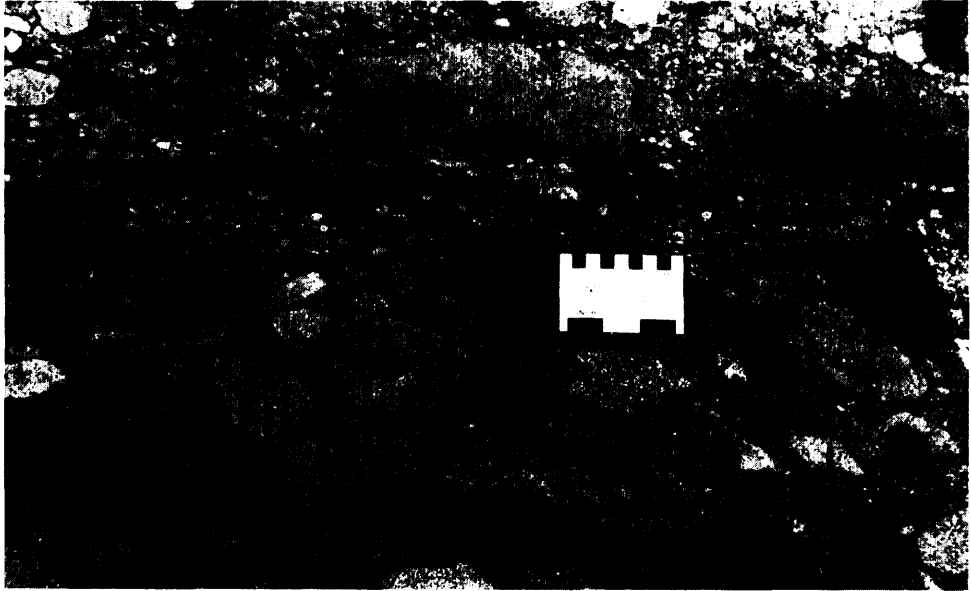
Photo 8—Bombs in bedded air-fall tuff. Northeast peninsula of McGraw Island, Upper Manitou Lake.

centuated the planar feature, and superimposed a pronounced steeply plunging lineation defined in large part by elongation of lapilli- and bomb-sized clasts (see Photo 6). Lack of sorting and grain-size gradation in these well-bedded deposits suggests they were laid down in a subaerial rather than subaqueous depositional environment, by air-fall mechanisms.

At a number of localities, and in particular at Rochon and Gold Islands and along the southeast shore of Upper Manitou Lake between Gold Island and Frenchman Island evidence of reworking of pyroclastic material by water (Photo 9) may be observed: lensoid, discontinuous beds of sandstone, some of which are cross-laminated, occur in coarser clastic debris, suggesting scour channels filled by sandy stream deposits. It is of some significance that basaltic lavas overlie these water-worked deposits and that some of these lavas are of pillowed and pillow breccia type, thus implying a predominantly subaqueous environment at this stage of buildup of the volcanic pile.

Locally, there are outcrops where evidence of reworking by water, in the form of scouring and grading of beds, may be found, but in a dominant sequence of non-reworked pyroclastics. For example such features may be seen during periods of low water on McGraw Island in the bay on the south side of the island, and on the group of islands 0.4 km east of Gravel Gertie Island.

A feature frequently encountered in large bombs and blocks embedded in both dominantly tuffaceous deposits and in coarser assemblages, is a pronounced zoned structure, in which, in general, more interior parts of the clast are epido-



OGS 9868

Photo 9—Water-lain or water-reworked pyroclastic rocks. Note heterolithologic character and tuffaceous or sandy, discontinuous lens-like beds. Southeast shore of Upper Manitou Lake, east of Frenchman Island.

tized. They resemble in both size and texture the epidotic fragments that occur scattered within mafic flow rocks, and in some cases in the centres of pillows. Satterly (1941, p.19) has observed similar features in mafic flows in the Dryden-Wabigoon map-area, northeast of the Manitou Lakes. The selective nature of this epidotization suggests that it was a late, but syngenetic, replacement, probably of deuteric or fumarolic type. Clasts occasionally contain a number of such concentric layers: such fragments may have possessed an original zoning derived by either accumulation about a nucleus during rolling activity in a vent, or during passage through the air. Further variants are clasts that have been wholly epidotized.

A peculiar structure, only seen at low water, on a small island immediately south of Charley Rock Island is shown in Photo 10. Large masses of intermediate composition, with a ropy-looking surface stand out in high relief from tuffaceous matrix material. They are here interpreted to be of pyroclastic rather than flow origin because of their setting in a dominantly pyroclastic sequence, and their intermediate composition, characteristic of most pyroclastic rocks at Upper Manitou Lake.

Pyroclastics at Upper Manitou Lake are in general metamorphosed to greenschist facies grade, except in the vicinity of Jackfish Bay. Based on observations in the mafic metavolcanics, as discussed under "Mafic Metavolcanics", the amphibolite/greenschist isograd appears to pass through Rector Lake, across Jackfish Bay, to Stony Island. Primary pyroclastic structures in rocks in the



OGS 9869

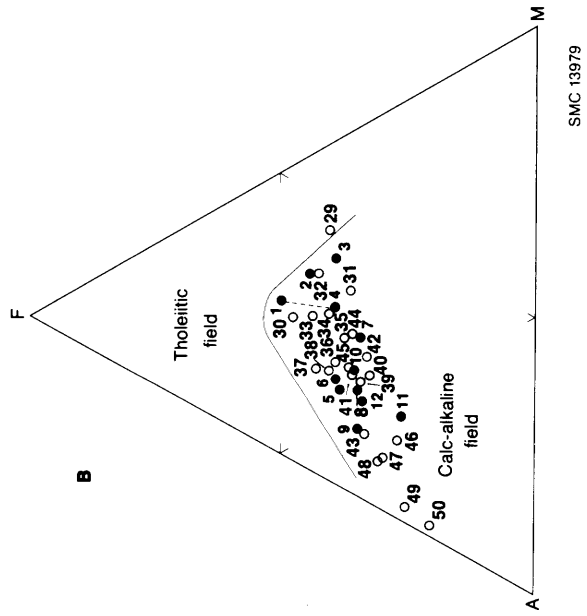
Photo 10—Coarse, ropey, pyroclastic breccia or flow material of intermediate composition, in a tuffaceous matrix. Small island immediately south of Charley Rock Island, Upper Manitou Lake.

southwest end of Jackfish Bay are difficult to recognize, and in particular on the hook-shaped peninsula in the middle of the the bay, the rocks are very massive. They were previously mapped as “altered granite and gneiss” by Thomson (1933) and as “granite” by McInnes (1902), They are interpreted here as being part of the pyroclastic sequence, though they do bear some resemblance to sub-volcanic porphyry at Frenchman Island.

Thin-section study of Upper Manitou Lake pyroclastics shows that recrystallization has everywhere modified the primary pyroclastic textures, but that where recrystallization has occurred in the absence of deformation the textures have been preserved to a great extent. Even where intense shearing and cataclasis has occurred some remnant of the primary texture can be discovered, even in fine-grained, tuffaceous, matrix material. Plagioclase feldspars appear to have best resisted deformation: though they are always recrystallized they retain their original form.

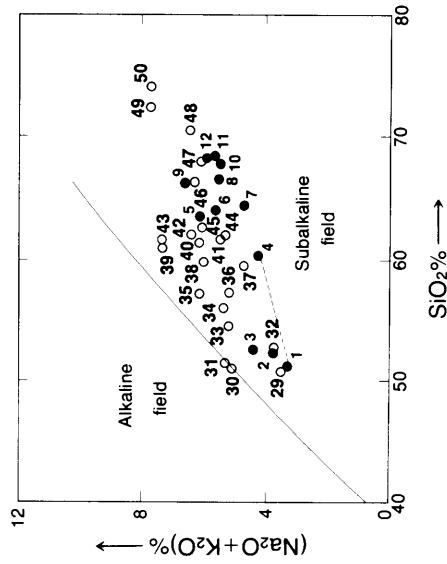
As a generalization, deformation observed in thin section appears to increase from the vicinity of Jackfish Bay and Stony Island eastward toward the east shore of the lake. On the easternmost peninsula of McGraw Island are outcrops of bedded and cross-bedded air-fall tuffs, with larger lapilli, blocks, and bombs (see Photos 7 and 8). A sample of tuff from this locality is of 0.1 mm average grain size. Bedding is defined by variation in biotite, chlorite and epidote content, all of which are secondary, and subtle variations in grain size from 0.1 to 0.3 mm of plagioclase (An_{10}) that make up the bulk of the rock. Quartz, which is in all cases fine grained, and plagioclase, are primary. Plagioclase is twinned pre-

Upper Manitou Lake Area



○ Partial rock analyses;
● Total rock analyses.

A



SMC 13979

B

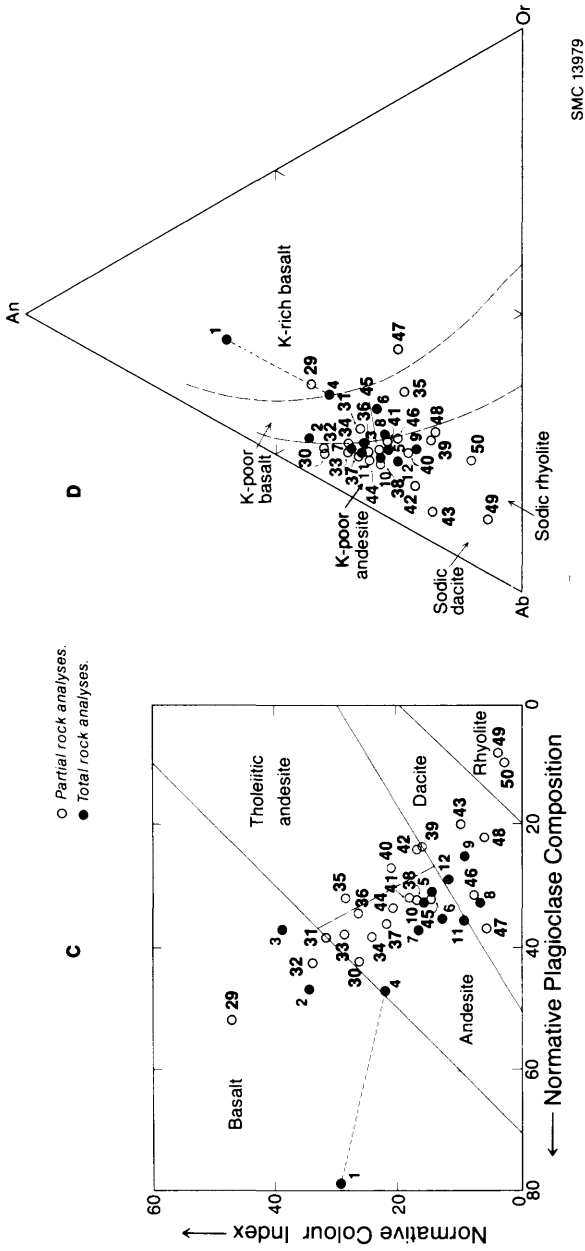


Figure 4-Chemical classification (after Irvine and Baragar 1971) of Upper Manitou Lake pyroclastic and associated rocks. Sample numbers are keyed to Table 2. A tie-line joins a clast (sample 1) and matrix (sample 4) of tuff-breccia. a. Plot of alkalis versus silica. b. AFM plot ($A = Na_2O + K_2O$; $F = FeO + 0.8998 Fe_2O_3$; $M = MgO$). c. Plot of normative colour index versus normative plagioclase composition for subalkaline rock suites (normative colour index = diopside + hedenbergite + enstatite + magnetite + ilmenite; normative plagioclase composition = $100 An/(An + Ab)$). d. Anorthite-albite-orthoclase plot for subalkaline rock suites.

Upper Manitou Lake Area

dominantly on the albite law, but in some grains Carlsbad and pericline twinning are combined. Although plagioclase grains tend to be aligned with their long axes parallel to bedding, secondary minerals are randomly oriented, indicating lack of deformation during metamorphism.

A bomb from the same locality similarly shows no evidence of deformation. Plagioclase (An₇) varies from 3 mm to 0.1 mm in grain size, and forms subhedral to euhedral albite and combined albite-Carlsbad twinned laths, with random orientation, in a fine-grained matrix of granular epidote, platy biotite and chlorite, and discrete, irregular areas of carbonate. The matrix also displays no preferred mineral orientation. The texture approaches trachytoid, and the clast probably therefore is of hypabyssal origin.

In contrast, a sample of andesitic tuffaceous matrix from tuff-breccia and lapilli-tuff on the east shore of Upper Manitou Lake has a strong tectonic fabric. Euhedral, tabular, albite and Carlsbad twinned plagioclase crystals (An₆) of up to 4 mm grain size, many of which have been fragmented, have been rotated into the plane of the foliation defined by minute platy chlorite and sericite in a granular quartz-feldspar matrix. Equant, anhedral, strained, quartz grains of about 1 mm diameter accompany the plagioclase laths. Clusters of granular epidote, accompanied in places by chlorite, indicate former ferromagnesian minerals, possibly amphibole. Chemical analysis of this sample is given in Table 2, Sample 7.

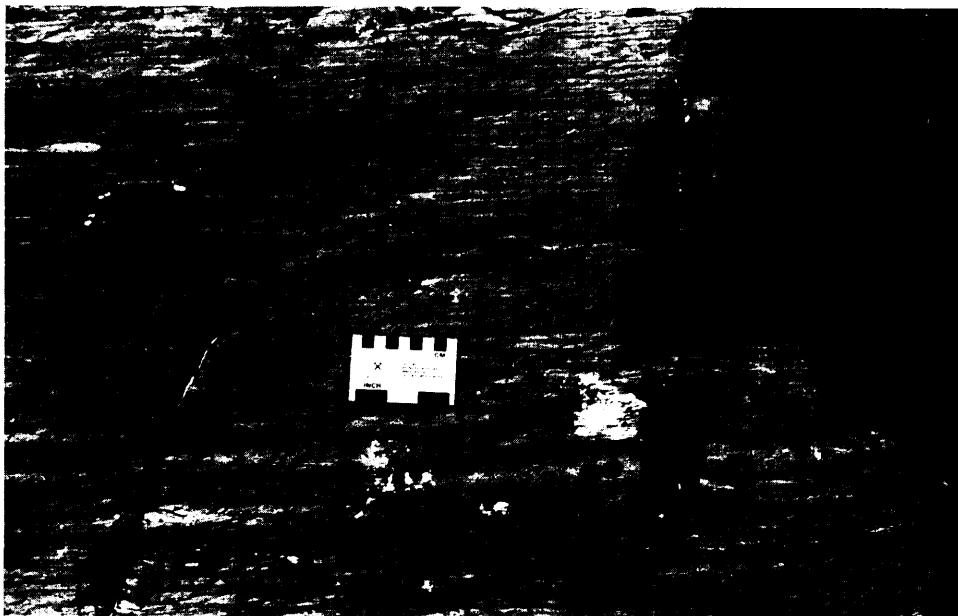
A strong foliation is also present in a sample of lapilli-tuff from the south end of Trout Island. The fabric is defined by abundant chlorite in lenses and bands, and untwinned plagioclases and epidote pseudomorphs, possibly after garnet, have been rotated into the foliation plane. Inclusion trains in some of the plagioclase grains, particularly those that are of equant dimensions suggest a rolling of the plagioclase, with recrystallization of the plagioclase during deformation, i.e., synkinematic metamorphism. Matrix plagioclase is commonly twinned on the albite law, and is of sodic oligoclase (An₁₂) composition. Chemical analysis of this sample (Table 2, Sample 2) shows it to be basaltic.

Chemically, pyroclastics at Upper Manitou Lake show considerable variation (Table 2; Figure 4), from basaltic to dacitic, though their dominant andesitic or chemically intermediate character (Williams *et al.* 1954, p.27) is evident, thus justifying the field classification of intermediate pyroclastics for these rocks.

MANITUMEIG LAKE-NOONAN LAKE-GARNET BAY PYROCLASTICS

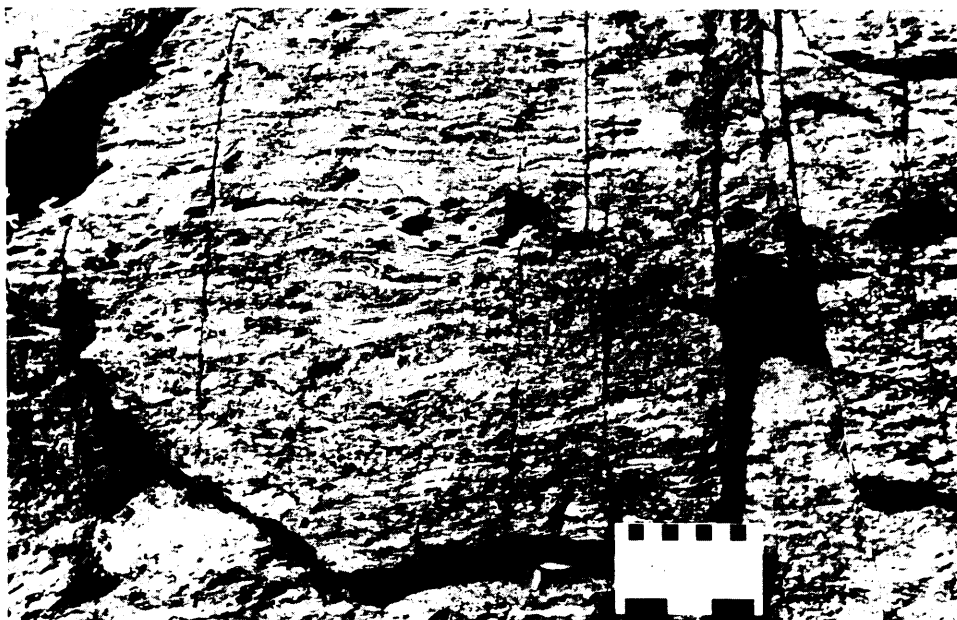
Under this heading are considered three major stratigraphically distinct pyroclastic units, namely those at Manitumeig Lake, those at Noonan and Johnar Lakes, and those extending southwest from Garnet Bay. These units are intercalated between basalts discussed under "Johnar-Crooked Lakes Basalts".

Pyroclastics considered here are predominantly coarse, in the lapilli-tuff to tuff-breccia size range, though finer tuff deposits also occur. Most pyroclastics are of intermediate composition, the coarser varieties being composed of rather a heterolithologic mixture of clasts. However, a discontinuous zone of light-coloured, well-indurated tuff, lapilli-tuff, and lapillistone and, at the northeastern end, flows, all of which are interpreted to be of felsic composition, lies approxi-



OGS 9870

Photo 11—Finely bedded felsic tuff. North end of Garnet Bay, Upper Manitou Lake.



OGS 9871

Photo 12—Garnet in lapilli-tuff. North end of Garnet Bay, Upper Manitou Lake.

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mately parallel to the northwest shore of Upper Manitou Lake, and outcrops on the peninsulas and in the bays, for example at Benson Bay, and in Garnet Bay. At the latter locality, finely bedded felsic tuff (Photo 11) alternates with felsic lapilli-tuff and lapillistone, individual beds being on the order of 0.3 to 0.9 m thick.

Deformation has in large part obscured primary structure, so that in many places the rock has taken on the character of a banded or gneissic rock. For example, in Garnet Bay along the northwest shore of Upper Manitou Lake, red garnet, of probably almandine composition, has developed in associated lapilli-tuff of intermediate composition (Photo 12). This is an unusual occurrence in that garnet has not been found elsewhere within the supracrustal rocks of the map-area except within metavolcanic enclaves in the granitic terrain.

Along the south shore and a little south of Manitumeig Lake felsic flows and tuff are interbedded with intermediate pyroclastics and mafic metavolcanics. Here they are immediately adjacent to and intruded by granitic rocks of the Atikwa Batholith.

Coarse pyroclastics in all respects similar to those of the Manitumeig Lake-Noonan Lake area occur in the northeast of the map-area, close to and along the granite batholith — metavolcanic belt contact, in discontinuous patches, and also as enclaves within the granitic terrain close to the margin of the belt. They can be observed on the road east of Kekekwa Lake, at a number of points about 0.4 km north of Benson Lake.

BIG MANITUMEIG LAKE PYROCLASTICS

Pyroclastic rocks similar in many respects to those associated with mafic flows in the vicinity of Manitumeig Lake — Noonan Lake — Harper Lake, occur in xenolithic masses and screens within the Wawapus-Kekekwa Lakes lobe of the Atikwa Batholith. In these xenoliths they are associated in general with mafic flow rocks, and the grade of metamorphism and degree of deformation has in most places made it difficult to distinguish between pyroclastic rocks that are mostly close to andesites or even basalt in composition, and mafic flow rocks of basaltic or andesitic composition.

Many small xenoliths occur scattered throughout the granitic terrain and in particular close to the contact zone with the volcanic belt. Two large xenolithic masses occur at Rajar Lake and northwest of Big Manitumeig Lake. The Big Manitumeig Lake xenolith is well exposed along the road north of Big Manitumeig Lake. In detail it is a complex of pyroclastic and flow rock, metamorphosed to amphibolite facies grade, extensively intruded by quartz monzonitic and granodioritic phases of the invading batholith. The north side of the mass consists in large part of amphibolite and amphibolitic migmatite, especially where mapped on the shoreline of Wawapus Lake, whereas further south, along the road, pyroclastic rocks of predominantly coarse grained, heterolithologic type are more prevalent (Photo 13). Pyroclastic rocks that outcrop where the Manitumeig Lake road crosses the creek flowing northward from Rajar Lake are well bedded and finer grained (Photo 14).



OGS 9872

Photo 13—Heterolithic tuff-breccia in large xenolithic mass northwest of Big Manitumeig Lake. Along road north of Big Manitumeig Lake. Strong vertical foliation parallel to hammer handle.

FRENCHMAN ISLAND SUBVOLCANIC CORE

A mappable unit of rocks varying in texture from porphyritic to equigranular, dominantly medium to coarse grained, and varying in composition from mafic to intermediate, occupies approximately the western two-thirds of Frenchman Island, and parts of islands immediately south of it, extending southward a short distance out of the map-area. The body is approximately 2.5 km long as exposed, by 0.4 km wide; its long axis is oriented northeasterly, parallel to the long dimension of Frenchman Island. It forms a prominent ridge along the axis of the island, probably due to the massive nature of the rocks; it is therefore unlikely that the unit extends northeastward beneath the waters of Upper Manitou Lake.

Upper Manitou Lake Area



OGS 9873

Photo 14—Bedded tuff in large xenolithic mass northwest of Big Manitumeig Lake. Along road north of Big Manitumeig Lake. Foliation is parallel to pencil, and at right angles to bedding.

Although the body undoubtedly changes in structure and composition internally, the changes are gradational, with no sharp contacts between various phases. In fact, within very short distances along the exceptionally well exposed shoreline many changes from intermediate to mafic types can be observed.

Intermediate rocks (microgranodiorite porphyry) are pale grey, fine to medium grained, and flecked with small, dark blebs of chlorite. Quartz can be seen with the naked eye, but is usually fine grained, less than 0.5 mm in diameter, and this is intergrown with medium-grained feldspar, of 1 mm grain size. Structure varies from massive to foliate, the more internal parts of the body tending to be wholly massive. A pale yellow colour is frequently imparted by abundant epidote at some localities. In thin section these intermediate rocks are seen to have typically either a porphyritic texture, with quartz phenocrysts, or an equigranular texture in which strained quartz and highly altered (saussuritized) plagioclase are frequently intergrown in graphic form, or in which plagioclase is euhedral, and quartz interstitial. Chlorite occurs in knots and sheaves associated with epidote. In both forms, the chlorite appears to be a late-stage alteration product either of, or associated with, the plagioclase, or of a pre-existing primary mafic mineral, probably amphibole. Of particular note is an intergrowth texture between chlorite and plagioclase or quartz, suggesting deuteric or hydrothermal alteration. In places, abundant narrow seams of epidote transect the rocks, both the intermediate and the more mafic phases; scattered epidote blotches, on the order of a centimetre in diameter, are associated with them.

More mafic rocks (micro quartz diorite porphyry) are greenish in colour, usu-

ally coarser grained, and dioritic in appearance. Plagioclase appears to be intergrown with chloritic alteration blebs, probably after either amphibole or pyroxene, while quartz is usually fine grained and difficult to see with the naked eye. Scattered plagioclase-rich areas give a blotchy appearance to the rock, and also pass into the more intermediate phases. More foliate types show an alignment of chlorite flakes. In thin section, coarser varieties appear to be extensively altered, but a primary mineralogy of plagioclase, amphibole and quartz is indicated. Twinned plagioclase is extensively altered to granular epidote, while chlorite and biotite appear to be secondary after amphibole. Minor amounts of quartz are frequently graphically intergrown with plagioclase.

Total chemical analyses of four samples from Frenchman Island are given in Table 2, and plotted, along with data derived from eight partial chemical analyses from Frenchman Island in Figure 5, for purposes of comparison with volcanic rocks. All samples analyzed are markedly subalkaline (Figure 5a) and calc-alkaline (Figure 5b), and they range in composition from basaltic to dacitic (Figure 5c), but are predominantly andesitic to dacitic. Their potash-poor nature (Figure 5d) is evident from Table 2, though orthoclase does appear in the norm. However, potassic feldspar was not found in any of the thin sections examined. They are here termed quartz diorite and granodiorite because of their andesitic to dacitic chemical affinity.

The Frenchman Island body was first mapped as granite during a regional reconnaissance survey by McInnes (1902), and later as altered granite and gneiss by Thomson (1933), though in his report he states that "granodiorite occurs on Frenchman Island". The extent of the body as mapped by Thomson agrees very closely with that mapped during the present survey, except that no western boundary was delimited by Thomson, the implication being that it lies beneath the waters of Upper Manitou Lake. Along the western shore of Frenchman Island the author observed a number of places where coarse pyroclastics, identical to those on islands west of Frenchman Island, are in contact with rocks of the Frenchman Island body. Pyroclastic fragments at these localities are identical to adjacent rocks of the Frenchman Island body, and the matrix to these coarse pyroclastics is very difficult to distinguish from the clast rock in hand specimen. Differential weathering of the matrix has caused clasts to stand out quite distinctly, a phenomenon never seen within the Frenchman Island body. It was similarly difficult to trace a precise contact on the eastern side of the body, where pyroclastic rocks contain epidote-rich clasts identical to adjacent epidote-rich rocks of the body. Abundant disseminated pyrite is also present at the northern tip of the island.

The similar petrography and chemistry and the presence of abundant epidote in some phases of the body and in adjacent pyroclastics, and also of disseminated pyrite, frequently in association with the epidote, is suggestive of a close genetic association between the body and the pyroclastic rocks. The Frenchman Island body was probably emplaced in a feeder or vent from which much of the pyroclastic material at Upper Manitou Lake was ejected. Close to Frenchman Island much of the pyroclastic material is in the form of very coarse blocks and bombs, indicative of a source close at hand (Photo 15). On the southeast side of Frenchman Island, tuff-breccia adjacent to the massive rocks has been transected by many epidotic veinlets which possibly were deposited by aqueous solutions emanating from the vent during late-stage fumarolic activity.

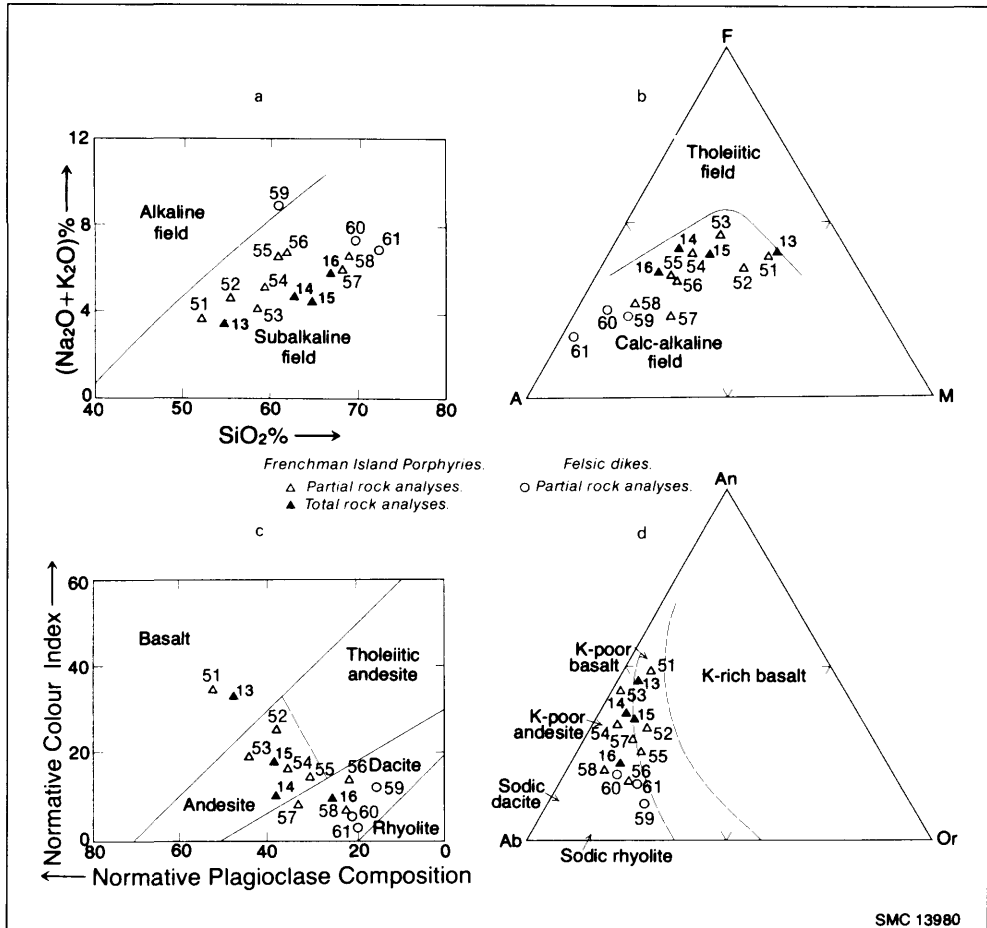


Figure 5—Chemical classification (after Irvine and Baragar 1971) of Frenchman Island porphyritic rocks and felsic dikes. Sample numbers are keyed to Table 2. a. Plot of alkalis versus silica. b. AFM plot (A = Na₂O + K₂O; F = FeO + 0.8998 Fe₂O₃; M = MgO). c. Plot of normative colour index versus normative plagioclase composition for subalkaline rock suites (normative colour index = diopside + hedenbergite + enstatite + magnetite + ilmenite; normative plagioclase composition = 100 An^h / (An^h + Ab)). d. Anorthosite - albite - orthoclase plot for subalkaline rock suites.

METASEDIMENTS

Apart from minor clastic metasedimentary deposits interbedded with meta-volcanics, and reworked pyroclastic rocks, the only metasediments belonging to any thick, extensive, epiclastic sequence in the present map-area are those that occur in the extreme southeast corner, southeast of the Manitou Straits Fault, at Mosher Bay, and that are part of the former Manitou "Series" of Thomson (1933).



OGS 9874

Photo 15—Volcanic breccia, containing very large blocks, on small island immediately west of the central part of Frenchman Island, Upper Manitou Lake.

South of the present map-area, that part of the former Manitou "Series" of Thomson southwest of Mosher Bay has been shown (Blackburn 1976) to consist of a basal pyroclastic suite and an upper sedimentary suite of turbidite facies association. Within the present map-area only the upper, sedimentary, suite occurs. This suite is composed of a mixed assemblage of volcanic-clast and polymictic conglomerate, sandstone, siltstone, and argillite, and minor iron formation, and its occurrence and association southwest of Mosher Bay has been documented by Blackburn (1976). In the present map-area only sandstone, siltstone and argillite have been mapped. Top determinations made within the map-area on grain-size gradation in sandy beds show reversals in the sedimentary sequence, but this is due to small-scale folding on the outcrop scale within the sediments. It is known from data obtained during previous studies (Thomson 1933; Pettijohn 1937; Blackburn 1976) and from continuing studies by P.R. Teal (graduate student, McMaster University, personal communications) that the Manitou "Series" is a homoclinal north- and northwest-facing sequence that has been locally folded on the small-scale only in the vicinity of Mosher Bay, at the structural top of the sedimentary sequence.

Northwest of the Manitou Straits Fault, clastic metasediments interbedded with metavolcanics occur at one locality, in the extreme south of the map-area on the west shore of Reliance Bay. The metasediments have been preserved in contact with and concordant with underlying mafic metavolcanics of pillow breccia.

Upper Manitou Lake Area



OGS 9875

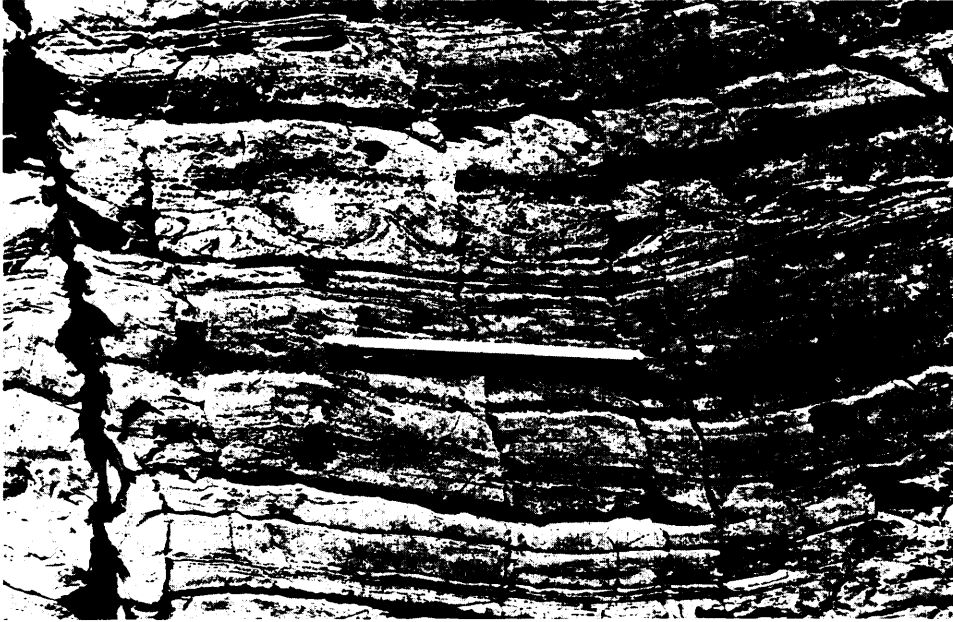
Photo 16—Rhythmic graded bedding in sandstone, west side of Reliance Bay, Upper Manitou Lake. Note faulting of bedding, parallel to pencil, and soft-sediment folding of beds at top of picture.

cia type of the Rector Lake sequence. Similar metasediments also occur just outside the map-area, within the Lower Manitou-Uphill Lakes map-area (Blackburn 1976, but not found during that mapping because water level was high), on the headland opposite the present occurrence. At the former location, scour channels, rhythmic and graded beds (Photo 16), load casts and flame structures (Photo 17), and slump structures, all indicative of epiclastic, subaqueous deposition, occur. A later fracturing has disrupted some of these structures, but the folding (see Photo 16) is here interpreted as being a soft-sediment deformation feature, because it is confined to certain beds, and is not a pervasive structure.

METAMORPHOSED MAFIC AND ULTRAMAFIC INTRUSIVE ROCKS

GABBRO NEAR MCGRAW ISLAND

On two small islands immediately north of McGraw Island occurs a very coarse mafic phase of essentially metavolcanic affinity. At the east end of the southernmost of these two islands a distinct, vertical layering can be seen at low



OGS 9876

Photo 17—Load casts and flame structures in greywacke, west side of Reliance Bay, Upper Manitou Lake. Metasediments face towards top of picture.

water level. The layering strikes northeast, parallel to regional, tectonic, foliation in this vicinity, but is interpreted to be primary. The layering suggests that this coarse mafic rock in particular, and also other coarse phases at Upper Manitou Lake in general, may be intrusive into the pyroclastic sequence. Further evidence that these mafic rocks were emplaced quite late in the volcanic sequence is obtained from the northernmost of these two small islands, where a felsic dike intrudes the coarse mafic rock, but appears to have been itself cut in part by the mafic magma (Photo 18). It is notable that flow-banding in the dike has not been transected by the basic rock, implying that the dike was injected while the gabbro was still mobile, rather than that the gabbro was remobilized, and cut the dike.

MITCHELL LAKE GABBRO

A stock-like body of mafic intrusive rocks, comparatively homogeneous and massive, is centred on Mitchell Lake. In the field, rocks of this body were mapped as metamorphosed gabbro, leucogabbro and minor peridotite. Phases of more intermediate, dioritic affinity, and felsic, granodioritic to quartz dioritic type were also mapped. Inclusions of amphibolitic rock that are probably partially assimilated mafic metavolcanics are scattered through the body.



OGS 9877

Photo 18—Felsic dike intruding gabbroic rock, that has in turn disrupted the dike. Note flow banding in the dike. Island 400 m south of Stony Island, Upper Manitou Lake.

Along the northwest margin of the gabbro body, about 0.4 km south of Navimar Lake, contacts are gradational. Gabbro grades into dioritic and quartz dioritic rocks interpreted by the author as being of hybrid origin. In fact, in this area, dioritic and quartz dioritic and granodioritic phases are intimately mixed, and in mapping, a rather arbitrary dividing line was made between units, based on dominant lithologies. A finger of coarse-grained, mafic rock extends from the southwest end of the Mitchell Lake body under the middle of Marius Lake and into a peninsula projecting into the northeast end of Johnar Lake. At this location the intrusion cuts amphibolites and pyroclastic rocks of the metavolcanic supracrustal sequence, and the contacts are relatively sharp. The contact is also sharp along its southeast margin, south of Mitchell Lake, where it lies along a creek that drains into Harper Lake, and thence along the western shore of Harper Lake. Along this margin the gabbro forms a prominent southeast-facing ridge.

Foliation is in general weakly developed within the body, but is more intense in the southwest-projecting finger. Lineation is only present in the northwestern part. It is thus evident that emplacement of the body predated or accompanied regional deformation.

Thin-section study and chemical analyses (Table 2, Figure 6, Samples 20, 21, 23, 25) of selected samples from the Mitchell Lake gabbroic complex support the field observation of considerable variation in mineralogy and chemical composition between these rocks. A sample of gabbro from the east shore of Marius Lake

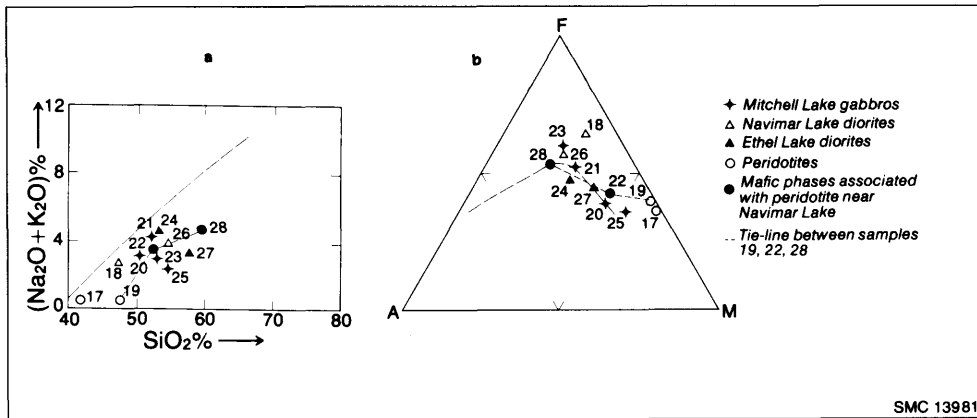


Figure 6—Chemical variation of intermediate, mafic, and ultramafic plutonic rocks. Divisions between fields for (a) subalkaline and alkaline and (b) tholeiitic and calc-alkaline volcanic rocks are after Irvine and Baragar (1971). Sample numbers are keyed to Table 2. a. Plot of alkalis versus silica. b. AFM plot (A = Na₂O + K₂O; F = FeO + 0.8998 Fe₂O₃; M = MgO).

(Table 2, Figure 6, Sample 20) is coarse grained, ophitic in texture and mottled dark green and greenish white. In thin section the dark green areas are seen to be composed of stubby laths and acicular aggregates of green hornblende, and the greenish white areas are epidote-rich saussuritic and plagioclase-rich granular aggregates. Plagioclase appears to be calcic andesine but individual crystals are strained and also zoned, making precise determination difficult.

A sample from the northeast end of the body, close to the west shore of Harper Lake (Table 2, Figure 6, Sample 21) appears in hand specimen to have a porphyritic texture, with 2 to 5 mm long, stubby plagioclase crystals set in a black, finer grained matrix. Thin section study shows the matrix to be composed of randomly oriented green hornblende laths of grain size less than 1 mm and interstitial twinned and untwinned plagioclase. The larger plagioclase phenocrysts have been extensively saussuritized. Limited optical determinations on areas that were not saussuritized and that show combined albite and Carlsbad twinning, and rare pericline twinning, suggest that they are of calcic oligoclase or sodic andesine composition. Weak oscillatory zoning is present in some of these plagioclases. Opaque minerals, which constitute up to 3 percent of the rock, are invariably associated with the green hornblende. The rock is not detectably magnetic, suggesting the opaques are non-magnetic. Many of the larger hornblende grains are weakly zoned, exhibiting cores that are paler coloured than the rims.

A sample from close to the northwest margin of the body (Table 2, Figure 6, Sample 23) is typical of a feldspar-rich phase that is abundant north of Mitchell Lake. On weathered surfaces greenish black amphibole is sharply contrasted against creamy white weathered plagioclase. At some localities less than 10 percent amphibole is present. Grain size is in general coarse, both plagioclase and amphibole crystals frequently being larger than 5 mm in length. The fresh surface is characteristically darker in colour, due to the darker grey, unweathered

plagioclase, that clearly shows polysynthetic twinning. Thin-section study shows the plagioclase to be twinned predominantly on the albite law but also on the pericline and Carlsbad laws, and to be of andesine composition, about An_{46} . The plagioclase is only weakly saussuritized, in small patches less than 0.05 mm across. Apart from the large hornblendes noted in hand specimen, smaller hornblende grains, usually less than 1 mm across occur poikilitically within, and interstitial to, the plagioclase. Isolated grains of opaque pyrrhotite and minor leucoxene occur in the rock, giving it a weak magnetism. Euhedral apatite, appearing as typically six-sided in cross section, and bladed in long section, is scattered either poikilitically within, or at the margins of, hornblende.

Another phase of the Mitchell Lake body is represented by a sample from its northeast end (Table 2, Figure 6, Sample 25). The sample is medium grained and equigranular. The fresh surface is dark green to black, and the weathered surface is mottled in dark green amphibole and grey-white feldspar. In hand specimen it could easily be confused with samples from the coarser mafic flow rock of amphibolite facies grade, which commonly have a similar mottled texture. Thin-section study shows a subophitic relationship between subhedral, columnar, green, strongly pleochroic hornblende, and stubby, euhedral to subhedral plagioclase crystals, twinned on the albite, Carlsbad, and, in a few cases, the pericline laws, and which are in some cases zoned. A paler amphibole, of fibrous habit, and weakly pleochroic, is probably actinolitic, and may have replaced the darker green hornblende, with which it is also intergrown. Chlorite has also developed at the expense of many of the hornblende laths. Untwinned, clear plagioclase that is strained and could easily be mistaken for quartz, is interstitial to all other minerals, and probably represents a final crystallizing phase. Unzoned twinned plagioclase is of andesine composition, close to An_{48} .

PERIDOTITE

Ultramafic rocks occur at several scattered localities within both the mafic metavolcanics and the dioritic and granodioritic intrusive rocks. Their relationship with the host rock is usually difficult to ascertain, and at no place was it precisely defined. One such occurrence is 400 m north of Harper Lake, where a strongly magnetic metaperidotite (Table 2, Figure 6, Sample 17) occurs within a mafic metavolcanic flow sequence. The extent of this ultramafic body was not ascertained, but it was recognized on the basis of a distinct brown weathered surface, and dark green fresh surface. Thin section study clearly shows olivine grains on the order of 1 mm to have been completely pseudomorphed by serpentine and chlorite, while they are enclosed by brown hornblende which is optically continuous around many grains, and is itself also serpentized, and replete with magnetite grains.

A second occurrence of peridotite, within the granitic terrain, is on the north side of a small lake just east of Navimar Lake and comprises a small body enclosed within granodiorite to quartz monzonite, and quartz diorite, right at the edge of the Atikwa Batholith. Two samples from this locality (Table 2, Figure 6, Samples 19 and 22) demonstrate the heterogeneity of the body. Another sample (Table 2, Figure 6, Sample 28), of the enclosing quartz diorite, serves to demon-

strate the distinct chemical difference between the body and its host. The peridotite is markedly different from that north of Harper Lake; it weathers a dull green, and is a dull olive green colour on fresh surfaces, with darker irregular areas. In thin section of Sample 19, the dull green colour is seen to be due to abundant chlorite, intergrown with serpentine, which has pseudomorphed olivine. The darker areas are green amphibole, with abundant tiny, black inclusions. The ratio of pseudomorphed olivine to pre-existing pyroxene is approximately the same as that in the sample from north of Harper Lake, i.e., approximately 3:1. The associated gabbro (Sample 22) is coarse grained (3-5 mm) and has a pegmatoid texture. In thin section, a subophitic intergrowth between green hornblende and saussuritized plagioclase can be seen. Minor interstitial quartz is present. Plagioclase is twinned on the Carlsbad, albite and pericline laws, and limited measurements suggest it has a composition of about An₅₀ (labradorite-andesine). The associated quartz diorite host rock (Sample 28) also contains andesine and shows a subophitic texture (hornblende-andesine), but contains abundant quartz (15 to 20 percent). The similarity of plagioclase composition in gabbro and host rocks may be due to equilibration under amphibolite facies or similar hornfels facies conditions.

PYROXENITE AT WAWAPUS LAKE

Two occurrences of a dark green, massive, dense rock outcrop at the north end of the long north-trending arm of the eastern part of Wawapus Lake, close to the north margin of the map-area. Field relationships indicate that they are inclusions within the granitoid batholithic rocks. Texturally they vary from medium to very coarse grained, and amphibole, chlorite, and biotite form a matted aggregate. Plagioclase and quartz occur only in small amounts; the rocks are ultramafic, and typically have a dark apple-green tint imparted by the abundant chlorite. Thin-section study of a typical sample from each of the bodies shows abundant actinolitic amphibole, chlorite, and olive green biotite. Small pink clots of about 2 mm diameter, that occur in one of the samples, are seen in thin section to be quartz-plagioclase intergrowths, that poikilitically include tiny amphibole laths, but no chlorite or biotite. Pyrite cubes, up to 5 mm across, occur scattered through the more northerly body, on the west shore of the lake. No evidence of a pre-existing, relict texture of pyroxene or olivine is in evidence. It is noteworthy that the two bodies appear to be part of a swarm of xenoliths that have a northerly trend to their long dimensions, and parallel the northeast arm of Wawapus Lake. The xenoliths are principally of recognizable metavolcanic, mafic flow and intermediate pyroclastic origin. The train of xenoliths may continue northward, out of the map-area, towards the east side of Osborne Bay of Eagle Lake where Moorhouse (1939) and Satterly (1941) mapped an extensive metagabbroic and hybrid dioritic body projecting southward into the Atikwa Batholith from the Eagle Lake — Wabigoon Lake metavolcanic-metasedimentary belt (Davies and Prysak 1967).

FELSIC AND INTERMEDIATE INTRUSIVE ROCKS

Felsic Hypabyssal Rocks

Felsic dike rocks of various types intrude all levels of the volcanic pile, though they are most common in the vicinity of Upper Manitou Lake, where they intrude coarse, intermediate pyroclastics. To the south of the map-area it was noted by Blackburn (1976) that felsic dikes were confined to two distinct zones on either side of the Manitou Straits Fault: one northwest of the fault, within the lower mafic flow unit in the core of the Manitou Anticline; the other southeast of the fault, within the upper portion of the volcanic-sedimentary succession (formerly the Manitou Series of Thomson). These distinct zones do not persist into the present map-area. Only a few felsic dikes were mapped to the south in pyroclastic rocks correlative with Upper Manitou Lake pyroclastics.

Most of the dikes within the map-area are narrow and discontinuous, and where found on islands in Upper Manitou Lake, frequently could not be traced inland. Exceptions occur on the large island at the northeast end of Upper Manitou Lake, where one dike can be followed for almost 1 km from Red Rock Narrows in a southwesterly direction across the island. Red Rock Narrows is so named because of the rusty red coloured lichen that grows on the dike where it outcrops on a face overhanging the narrows.

Texturally the rocks vary from aphanitic to porphyritic to granitic, but are all petrographically similar in that felsic minerals predominate. They are not all necessarily of the same age, but their petrographic similarity suggests a chemical similarity and therefore a common source. At no locality were cross-cutting relationships between dikes observed, though dikes are sufficiently separated geographically that such evidence cannot be used to state categorically that they are all of similar age.

Field mapping suggested that there are three different types of dikes: felsite, feldspar-quartz and quartz porphyry, and granitic dikes. By far the most common and widespread are the felsite dikes, which are found scattered throughout the volcanic sequence, but are particularly well developed in the vicinity of Upper Manitou Lake. Porphyries of both types are next in order of abundance, and are similarly widespread in occurrence. All porphyries were mapped under one code, so that it is not possible to comment on relative abundances. It is notable that porphyry dikes were mostly found well toward the margin of the volcanic belt, where it is intruded by plutonic rocks of the Atikwa Batholith, whereas felsitic rocks were relatively less abundant in this outer zone.

Typical felsite in thin section is seen to be composed of a granular aggregate of quartz and plagioclase, of about 0.1 mm grain size, and minor to accessory amounts of chlorite, biotite, sericite, and granular epidote. Quartz is mostly strained, and twinned and untwinned plagioclase can be present. Depending on the amount of deformation and metamorphism, platy minerals may be either randomly scattered, or aligned to define a foliation. Many felsites are not wholly fine grained but may contain generally equant plagioclase or quartz phenocrysts, which in the case of plagioclase, are subhedral to euhedral and twinned, and in the case of quartz, are rounded. A dike-rock from Jackfish Bay, map-

ped in the field as felsite because of its apparent fine-grained texture, upon thin section determination was found to be porphyritic, and composed of abundant plagioclase phenocrysts, with lesser amounts of quartz phenocrysts, up to 1 mm in grain size. Feldspar phenocrysts had been recrystallized by metamorphism approaching amphibolite facies, so that their original euhedral form and sharp boundaries were masked. Matrix material consists of polygonized and granular quartz, and brown biotite in lenses and ribbons defining a foliation. Abundant granular epidote, in clusters, is associated both with the biotite, and also appears to pseudomorph former plagioclase phenocrysts. Granular polygonized aggregates of quartz may represent former quartz phenocrysts. Other felsite dikes in the area may also be metamorphosed porphyry.

Well preserved porphyries typically contain phenocrysts of albite twinned on the albite, Carlsbad and Baveno laws, and rounded to corroded quartz, which is commonly strained. Grain size of the phenocrysts varies considerably, but is predominantly in the range of 2 to 3 mm. The groundmass is very similar to felsite, and contains sericite, chlorite or biotite, either randomly oriented or with a strong orientation, depending on grade of metamorphism and degree of deformation. Sphene, apatite, and pyrite are common accessories. In one such dike on Frenchman Island, the tectonic fabric is very strongly developed: green biotite wraps around plagioclase phenocrysts, and strain shadows at the ends of the plagioclase phenocrysts are filled either by polygonal quartz grains or carbonate.

The long dike that outcrops at Red Rock Narrows is distinctly aplitic in hand specimen, flesh pink to whitish, and sugary in texture. Thin-section study shows it to be a feldspar porphyry. All phenocrysts are plagioclase, twinned on the albite or Carlsbad laws, or forming penetration twins, and their maximum grain size is 1.5 mm. The fine-grained (0.1 mm) matrix is composed of a granular aggregate of quartz and plagioclase twinned on the albite law, with flakes of sericite defining a weak foliation. The pink colouration is due to ferruginous alteration of abundant fine siderite grains scattered throughout, and of similar grain size to, the matrix.

A large mass of grey to pink, medium-grained felsic rock on the south side of the large island at the north end of Upper Manitou Lake mapped by Thomson (1933) as "altered granite gneiss" is here termed granophyre and grouped with the felsic dike rocks. It is variable in texture, but a sample taken from the south shore of the island is typical of the dominant phases. Thin section study shows it to be composed of approximately 60 percent euhedral plagioclase laths of albite (An_6) composition twinned on the albite law and orthoclase twinned on the Carlsbad law, set in a matrix of fan-like aggregates of quartz and feldspar elongate grains, probably of myrmekitic type. Green biotite occurs in irregular patches and long irregular stringers. Epidote is abundant, and occurs with sericitic aggregates. The texture is suggestive of late, deuteric or hydrothermal alteration, or crystallization of a late, acidic residuum.

Intermediate Plutonic Rocks

Dioritic and quartz dioritic plutonic rocks occur both marginally to the metavolcanic-metasedimentary belt, where they were grouped by Thomson (1933)

Upper Manitou Lake Area

as a gneiss complex, and as enclaves within the Atikwa Batholith. In the former situation they are intimately associated with amphibolitic rocks which were originally mafic volcanic flows, and intermediate or even felsic pyroclastic rocks. In the vicinity of Mitchell Lake they pass both across and along the regional northeast-trending strike, into metagabbroic rocks of the Mitchell Lake intrusive body. Where dioritic rocks occur well within the Atikwa Batholith, they are intimately associated with amphibolite, and with granodiorite, quartz monzonite, and trondhjemite of the main batholithic phase, with which in many places they merge imperceptibly. The author considers these rocks to be of hybrid plutonic origin, derived by assimilation, metasomatism and partial melting of primary volcanic and gabbroic rocks by invading granitic magmas of the batholith.

Dioritic and quartz dioritic rocks occur in an almost continuous zone, marginal to, and at Marius Lake projecting into, the metavolcanic-metasedimentary belt. Diorite/quartz diorite at Navimar Lake is separated from the main zone by a narrow strip of granodioritic to quartz monzonitic rocks, with minor inclusions of diorite and quartz diorite, and at least one mafic to ultramafic pod-like inclusion (see "Peridotite").

An extensive area of intermediate to mafic, coarse-grained rock occurs southwest of Big Manitou Lake, around Ethel Lake. These rocks are mostly of dioritic composition, but amphibolite is very common, both as small inclusions, and as large blocks which merge imperceptibly into the dioritic rocks. Leucocratic granodioritic to quartz monzonitic rocks are present locally. Boundaries shown on the geologic map (Map 2409, back pocket) with amphibolitic mafic metavolcanics on its east and west sides, and with granodiorite and quartz monzonite of the Atikwa Batholith to the north are very generalized and could not be surveyed in detail at the scale of mapping. Probably, even at a larger scale of mapping such boundaries could not be defined precisely, due to their gradational nature.

A satellitic body of dioritic rock, which appears to be separated from the main Ethel Lake mass by a thin zone of metavolcanics, is centred on Helen Lake and Crooked Lake, though much of the shoreline of these lakes was not inspected during the present survey.

Enclaves of dioritic and quartz dioritic rock locally intruded by and grading into granodiorite and quartz monzonite, and including and grading into bands and pods of amphibolite and metapyroclastic rock, are scattered through the granitic terrain of the Atikwa Batholith. Examples of these can be seen along the road west of Wawapus Lake at its southern end, and the short road west of the same lake in the north of the map-area. Boundaries to these bodies, at the scale of mapping, were impossible to define precisely, and in many places, for example where brecciated phases are predominant, difficulty was found in deciding which of the four map-unit phases, diorite/quartz diorite, amphibolite, pyroclastic rock, or granitic rock, was predominant.

Thin-section study of representative greenish black, medium-grained samples shows them to have an essential mineralogy of hornblende + plagioclase \pm biotite \pm quartz \pm apatite \pm epidote. Accessories include sphene and zircon. Opaque minerals are usually present, and all seem to be sulphides. The magnetic properties of some samples indicate the sulphide to be pyrrhotite. Pyrite may also be present. All the hornblende is green and pleochroic, in some cases strongly pleochroic from deep green to straw yellow. Plagioclase is invariably

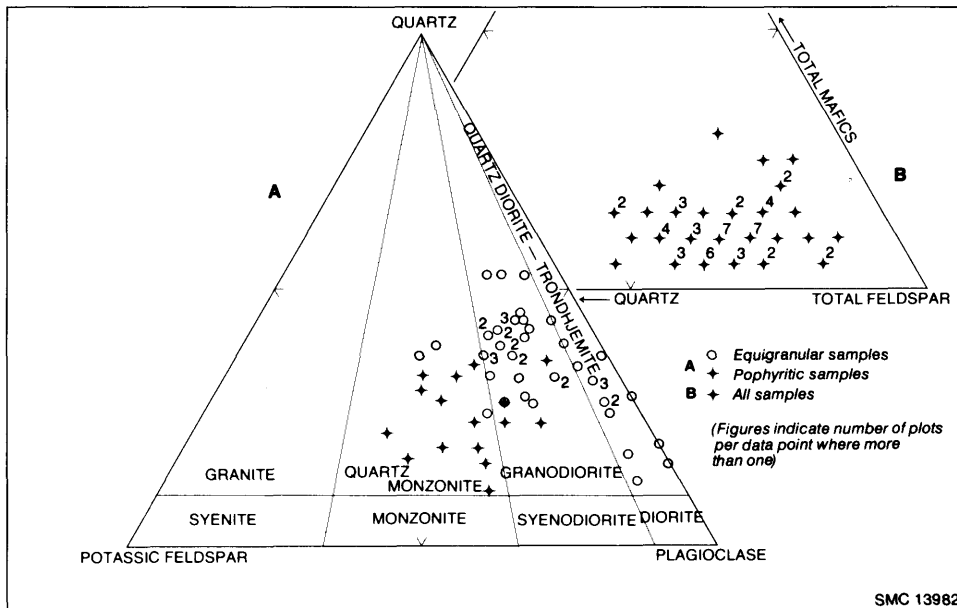


Figure 7—Modal quartz, potassic feldspar, plagioclase and mafic minerals in 62 felsic plutonic rocks from the Wawapus-Kekekwa lobe of the Atikwa Batholith. Percentages determined by visual inspection of stained hand samples.

twinned, on the albite, pericline, and Carlsbad laws, in various combinations. Normal zoning is common, though in many cases not all plagioclase crystals are zoned. Commonly where zoning was observed most of the crystal is of one composition, only the outer rim being of a more sodic variety. Compositions of An_{40-45} (andesine) are usual for central zones, whereas rims are more variable but generally of oligoclase composition, in the range of An_{20-30} . In only one sample examined in thin section, a plagioclase-hornblende rock from the extreme south end of Wawapus Lake, tentatively called an anorthosite, was plagioclase found to be strongly calcic, with bytownitic (An_{73}) cores and labradoritic (An_{66}) rims. Textures of samples examined in thin section vary from hypidiomorphic to allotriomorphic granular to subophitic. Four samples taken for chemical analysis (Table 2, Figure 6, Samples 18, 24, 26, 27) show chemical variation within a restricted range that overlaps with that of the Mitchell Lake metagabbros.

Felsic Plutonic Rocks

The granitic rocks of the Wawapus-Kekekwa Lakes lobe of the Atikwa Batholith (Davies 1973) are predominantly poorly foliated, pink to light grey, quartz monzonite, granodiorite and trondhjemite (Figure 7), varying in texture from medium grained to coarse grained to porphyritic. Inclusions are plentiful,

and where present usually help define the foliation. The proportion of inclusions to plutonic rock decreases toward the northern part of the map-area, more internal to the Atikwa Batholith.

In general the rocks are medium to coarse-grained and equigranular. Porphyritic, mostly coarse grained phases, occur either as an intimate part of the equigranular assemblage, with no evidence of any marked difference in age between them, or as larger areas of dominantly to almost exclusively porphyritic, coarse-grained rocks. One such area, with an ill-defined margin, is located at the east shore of the southwest arm of Wawapus Lake. A second, much larger, area more than 1.5 km wide occurs at the edge of the batholith, adjacent to pyroclastic volcanic rocks, extending 4 km northeast between Big Manitou Lake and Rubanoe Lakes. The margin of this second area is better defined, but not sharp, so that it is probable that this porphyritic phase was contemporaneous with surrounding more equigranular phases. Minor amounts of equigranular rocks everywhere accompany porphyritic phases.

Sixty-two felsic plutonic rock samples were treated on fresh, uncut surfaces with sodium cobaltinitrite solution after etching with hydrofluoric acid following the method of Nold and Erickson (1967), and Reid (1969). Potassic feldspar is stained yellow by this technique, enabling its distinction from plagioclase. A rapid visual estimate of potassic feldspar, plagioclase, quartz, and mafic mineral content was made for each sample. A ternary plot of quartz-potassic-feldspar-plagioclase (Figure 7a) shows a wide scatter, but essentially within the quartz monzonite and granodiorite fields. Sixteen porphyritic samples show a preponderance toward quartz monzonite, while other phases, mostly medium to coarse-grained equigranular, show a preponderance toward granodiorite and trondhjemite. A ternary plot of mafic minerals-quartz-feldspar (Figure 7b) shows all samples to be low in mafic content, with a cluster toward the quartz-feldspar side of the triangle.

As a test of the rapid visual estimate made on stained hand specimens, and as a comparison of this technique with that of modes calculated by point-counting thin sections, six thin sections of selected samples from the Atikwa Batholith, stained for potassic feldspar, were point-counted. Four of the samples are porphyritic, and two equigranular. In all cases except one, the visual hand specimen estimate for quartz was found to be higher than that done by point-counting, by as high as 26 percent quartz content, and as low as 8 percent quartz content. In only one case was the visual estimate for quartz lower than that done by point-counting, and by only 4 percent quartz content. In all cases the visually estimated potassic feldspar to plagioclase ratio was higher than the ratio determined by point-counting, although the deviation was lower for the equigranular samples. This latter observation is not unreasonable in that a thin section does not give a good coverage for a porphyritic, coarse-grained rock. The presence of potassic feldspar phenocrysts indicates that wherever points have been counted in thin-sections that contain the groundmass only, such estimates will be too low in potassic feldspar. Estimates for mafic mineral content by both methods were found to be remarkably consistent, differing by zero to 4 percent. It is concluded that visual estimate of leucocratic minerals on stained hand specimens a) gives a high bias to quartz content, b) gives a closer approximation to the ratio of potash feldspar to plagioclase than does thin section point-counting. Since classification

schemes depend strongly on the potassic feldspar to plagioclase ratio, even visual estimates of stained hand samples are more reliable than tedious thin section point-counts for classification purposes of quartz-rich plutonic rocks.

Thin-section study of the six samples mentioned above shows that all contain microcline as the potassic feldspar, that plagioclase is mostly calcic oligoclase (An_{23-30}), and that biotite is the major mafic mineral. Both twinned and untwinned plagioclase occur in all six samples, and twinning is mostly on the albite law, with Carlsbad, pericline and possibly Baveno twinning in addition. Plagioclase is invariably weakly zoned, in most cases such that routine petrographic determinations are insufficient to detect differences in anorthite content. However, zoning is mostly of the normal type, and in general within the calcic oligoclase range. Cores may be andesine in composition, as was found in only one thin section that had cores of An_{32} , and rims of An_{25} composition. Oscillatory zoning is present, but too weakly developed to measure differences in anorthite content. Chlorite where present appears to be an alteration phase after biotite. In summary, major mineral phases are quartz + plagioclase + microcline + epidote \pm biotite. Accessories include euhedral sphene, apatite, zircon, and opaque minerals. Myrmekite is present in minor, interstitial amounts, never more than 3 per cent, in all thin sections.

Cenozoic

Pleistocene and Recent

In the Upper Manitou Lake area only a thin veneer of till can be attributed to glacial action of the Pleistocene Epoch, while the very minor amounts of swamps and muskegs are attributable to Recent geological activity.

According to Zoltai (1961, p.63), in northwestern Ontario "evidences thus far observed indicate the movements of the latest, or Wisconsin glacier only". Ice movements were from two prominent directions during Wisconsin glaciation: movement of Keewatin ice varied from a northwesterly to westerly direction; Patrician ice came from the northeast. In the present map-area little evidence was found for Keewatin ice activity, since striae, which are abundant on all exposed rocky surfaces, are predominantly oriented northeasterly, parallel to larger scale, glacially moulded bedrock structures, and presumably were produced by movement of Patrician ice. Evidence for at least some influx of Keewatin ice was observed on the southeast shore of Jackfish Bay, where striae were measured with a north-northwesterly orientation. In the Lower Manitou-Uphill Lakes map-area, striae with an easterly orientation were measured at two localities only, similarly suggesting some influx of Keewatin ice (Blackburn 1976).

Ground moraine is present as a thin veneer only, and is characteristically sandy to stoney and the material mainly of local provenance. Such till is referred to in the literature as Patrician "red" drift (Zoltai 1961). Maps prepared by Zoltai (1965; see also 1961, Figure 2) show lacustrine deposits of varved clay and silt to accompany silty and sandy ground moraine deposits in that part of the map-area northwest of an irregular line between Pothole, Big Manitumeig, Navimar

and Kekekwa Lakes. No varved clay or silt deposits were observed during the present geological survey.

STRUCTURAL GEOLOGY

MAJOR STRUCTURE

Thomson's (1933) work suggested an essentially synclinal disposition of the Manitou-Stormy Lakes metavolcanics and metasediments, in that he considered the sedimentary rocks of the Manitou "Series" to lie above the volcanic sequence, and therefore at the centre of the synclorium.

Recent work (Goodwin 1965, 1970; Blackburn 1976) has shown the structure to be more complex than a simple syncline as suggested by Thomson (1933, p.11). Goodwin (1965), on the basis of pillow-top determinations at Upper Manitou Lake, interpreted a major anticlinal fold, that was later named the Manitou Anticline (Goodwin 1970, Table 2). According to Goodwin, the axial plane trace lies in a northeasterly direction, almost coincident with the centre line of the lake, passing through Swede Boys Island and the community of Gold Rock. During the geological survey of the area south of Upper Manitou Lake, the author (Blackburn 1976) extended the fold axis southwesterly almost as far as Lower Manitou Lake, on the basis of apparent repetition of stratigraphy on either side of the proposed axis, and on the evidence of pillow tops southeast of the axis all facing southeast. However, no reliable top indicators were found by the author to the northwest of the proposed axis in the area south of Upper Manitou Lake.

Goodwin (1965) also interpreted a synclinal fold axis to lie near to the northwest margin of the metavolcanic belt, trending in a northeasterly direction and parallel to the Manitou Anticline, through Noonan, Johnar, Mitchell, and Harper Lakes, and thence northeasterly towards the southern end of the unnamed lake in the northeast corner of the map-area. No explanation was provided for the interpretation or positioning of this fold axis. The interpretation of both the Manitou Anticline and this latter syncline have been incorporated by Davies and Pryslak (1967) on the Kenora-Fort Frances compilation sheet.

During the present survey, reliable top determinations were obtained from pillow lavas within mafic flow rocks along the northwest shore of, and to the north of, Upper Manitou Lake, on the peninsula projecting northward into Upper Manitou Lake between Jackfish and Reliance Bays, and along the northwest shore of Manitou Straits. Of the fifteen pillow-top determinations north of Upper Manitou Lake, fourteen indicate flows to face northwestward, and one pillow at the south end of Harper Lake faced southeastward. All four pillow top determinations made on Manitou Straits indicated flows to face southeastward (e.g. Photo 1). The presence of a major northeast-trending anticline at Upper Manitou Lake is indicated by these data, and the positioning of the axis is substantiated to be through the peninsula between Jackfish and Reliance Bays by three pillow-top determinations, and by top determinations made in sedimentary rocks (see Photo 17), on the southern peninsula of Upper Manitou Lake. Top de-

terminations made on pyroclastic rocks reworked by subaqueous processes at Upper Manitou Lake such as on the group of reefs and small islands 1 km southwest of Gold Island, substantiated the above conclusions. Both grain gradation and cross-bedding (see Photo 7) were found in sub-aerially deposited pyroclastic rocks, but could not be used to interpret facing.

Well-preserved pillow lavas are not common in the area west of the south end of Upper Manitou Lake. Top determinations were not obtained in mafic flow rocks here, and no other textures suitable for top determinations were found. Thus no direct evidence for the syncline proposed by Goodwin in this area was found. However, from regional considerations outside the present map-area at least one syncline could be interpreted to lie between the Manitou Anticline and the edge of the metavolcanic metasedimentary belt. The single south-eastward pillow facing at the south end of Harper Lake is not considered to be sufficient evidence for tracing a synclinal axis southeast of Harper Lake, particularly as northwest-facing pillows occur further northeast probably on strike with those at Harper Lake.

The salient of metavolcanics that projects northwestward from the southwest end of the belt within the map-area, and terminates in the vicinity of Butterfly Lake is probably the necked equivalent of amphibolitic, pyroclastic and dioritic xenoliths and screens that are aligned with their long axes in a northwest direction toward the west edge of the map-area. During reconnaissance of the Bunyan Lake access road west of the map-area, similar xenolithic amphibolitic, pyroclastic and dioritic rocks were found about 1.6 km west of the map-area, and on strike with the northwest-trending bodies within the map-area. A similar tapering or necking of mafic metavolcanics occurs south of Eagle Lake (Davies and Pryslak 1967) where a wide belt narrows in a southerly direction, and then turns sharply southeastward as a belt about 1.6 km wide on the north side of Bunyan Lake. This belt may have been continuous with that at Upper Manitou Lake as witnessed by the train of xenoliths described above. Moorhouse (1939) interpreted the tapering mafic metavolcanic unit south of Eagle Lake to be synclinal on the basis of facing of pillows, thus lending support to the interpretation by Goodwin (1965) of a syncline lying between the Manitou Anticline and the northwestern edge of the metavolcanic-metasedimentary belt in the present map-area

FAULTS

As was found in the Lower Manitou-Uphill Lakes area to the south (Blackburn 1976), faulting in the present map-area is of two distinct types, which are probably genetically distinct. The first type is associated with intense shearing, producing broad schistose, phyllitic, and mylonitic bands along which fault movements have occurred. In the present map-area only one zone of this type occurs, in the southeast corner of the map-area, and is a continuation of the Manitou Straits Fault (Blackburn 1976). The second type is more brittle in nature, has no associated schist zones, and fault surfaces are unique movement planes. This type is characterized by the fault that trends south through Benson Bay and across Frenchman Island.

Manitou Straits Fault and Related Schist Zones

Thomson (1933, p.4) recognized that "a fault of considerable magnitude extends through the Manitou Straits and northward to Kabagukski Lake. It may possibly continue southward along the eastern shore of Lower Manitou Lake. A zone of soft fissile schists was developed along the fault". The presence of this fault was confirmed by the author (Blackburn 1976) who applied the name Manitou Straits Fault to this feature, and also found schist zones separated by less sheared rock parallel to the main fault along parts of Manitou Straits and the northeast end of Lower Manitou Lake.

The Manitou Straits Fault passes northeast through the extreme southeast corner of the map-area (Figure 8; Map 2409, back pocket), southeast of the Manitou Straits, along the shore of Mosher Bay. It is marked by a zone of phyllitic and schistose rocks, highly fissile, and no more than 30 m wide. Northwest of the fault, felsic and intermediate volcanic rocks have been strongly sheared, for a distance of up to 0.4 km from the fault (see also Wallace 1975). Along the Manitou Straits, mafic pillowed and porphyritic metavolcanics appear to be generally undeformed and not to have been disrupted by fault movements related to the Manitou Straits Fault. However, northwest of the straits, strong shearing accompanied by carbonatization has severely deformed mafic and intermediate volcanic flow and pyroclastic rocks. This zone of shearing is almost 0.4 km wide at one point within the map-area, at the mouth of a bay in the straits.

No other schist zones of any magnitude occur in the area, but there are narrow zones, nowhere more than 3 m wide, exposed on the shoreline and islands of Upper Manitou Lake where locally a phyllitic cleavage has been developed in intermediate pyroclastic rocks. Such zones may be seen for example at the northeast end of the large island and on adjacent islands at Red Rock Narrows at the north end of Upper Manitou Lake. Minor folds are present and interpreted to be due to shear. No evidence of fault movement along these zones has been found.

CROSS FAULTS, LINEAMENTS, AND JOINTS

Cross-faults in the Lower Manitou-Uphill Lakes area (Blackburn 1976) were considered to have developed later than the schist zones, as indicated by their brittle nature, and the fact that they offset shear zones where they intersect them. In the present map-area no cross-faults are seen to intersect either the Manitou Straits Fault or related schist zones, but their brittle nature may similarly be used to imply their later development.

Prominent lineaments (mostly interpreted from study of air photographs) combined with known faults (Figure 8) show a pattern of at least two and possibly three fracture sets. The dominant set trends almost exactly north, while a weaker set trends southeast. Possibly a third set trends northeast. The north-trending set is correlatable with and represents a slight deviation from the N20E set found in the Lower Manitou-Uphill Lakes area (Blackburn 1976), and is part of a regional fracture pattern characteristic of the area between the Manitou Lakes on the north and Rainy Lake on the south (Parkinson 1962, Figure 6; Davies and Pryslak 1967; Blackburn 1973).

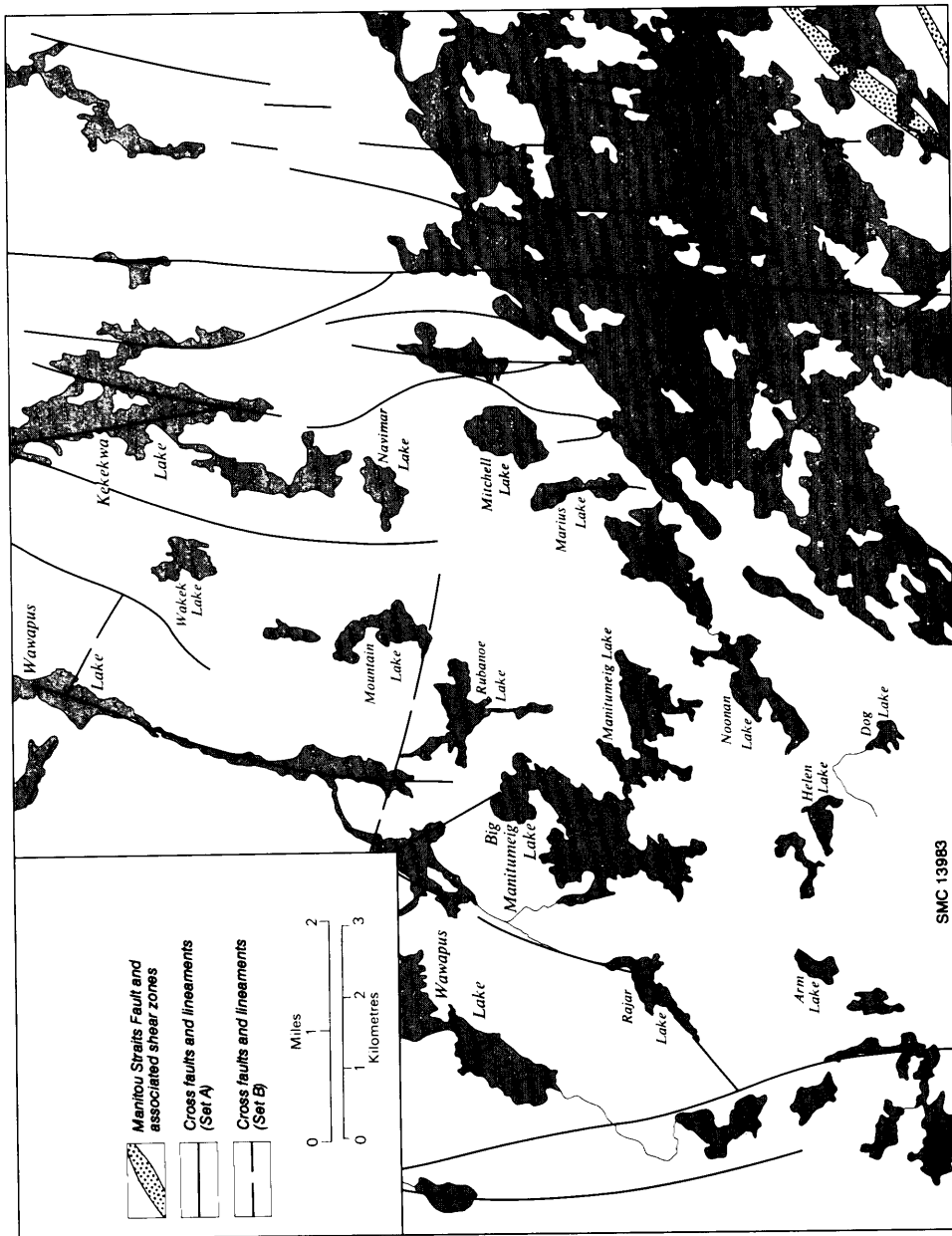


Figure 8—Major fracture patterns in the Upper Manitowish Lake area.

Upper Manitou Lake Area

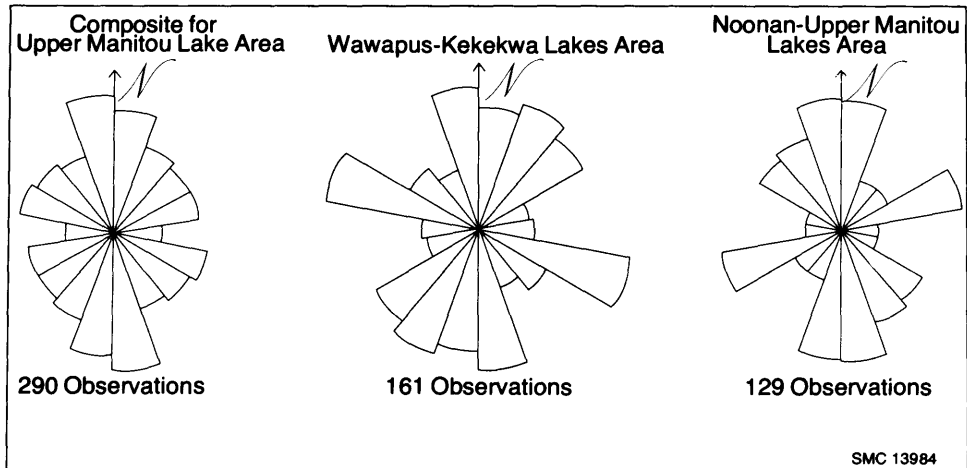


Figure 9—Rose diagram of strikes of joints in the Upper Manitou Lake area.

The second fracture set is weakly developed. Fractures of this set appear to be less continuous, and may be terminated by fractures belonging to the north-trending set. As part of a regional photo geologic survey, Parkinson (1962, Figures 2 and 6) showed a prominent fault zone extending from the Ontario-Manitoba border, near Kenora, in the west, to Ignace in the east, which he calls the Kenora Fault Zone. This second fracture set, with its predominantly southeasterly trend, may be part of Parkinson's set. There is no evidence within the map-area, or within the Lower Manitou-Uphill Lakes area (Blackburn 1976) that any major displacement has occurred along these fractures. However, minor movement, on the order of a few hundred metres, has occurred along southeasterly faults bounding McGraw Island and at Frenchman Island.

During field work, approximately three hundred joint determinations were made throughout the map-area. An attempt was made to give equal coverage of joint measurements over the whole map-area, but very few data were collected in the southwest. A composite plot for the whole area (Figure 9) shows preferred orientation of joints in a northerly direction, and very few joints with an easterly orientation. A correlation therefore appears to be shown between northerly trending joints and northerly trending faults and lineaments. Rose diagrams for the Wawapus-Kekekwa Lakes lobe of the Atikwa Batholith, and for the meta-volcanic-metasedimentary belt similarly both show a preferred northerly orientation but also each show a second preferred orientation at a high angle to the northerly one. In the Wawapus and Kekekwa Lakes lobe there is an east-south-east preferred orientation, which is correlatable with the southeasterly trending second fracture set, that may be more strongly developed in the granitic terrain than in the metavolcanic-metasedimentary rocks. In the Noonan-Upper Manitou Lakes metavolcanics and metasediments a southwesterly second preferred orientation of joints is evident, that may be correlatable with the regional southwesterly foliation in this area.

MINOR STRUCTURES

Within the map-area, minor structures include minor folds, various types of foliations and lineations, and, within highly sheared rocks associated with the Manitou Straits Fault and associated schist zones, well-developed kink bands.

Minor Folds

Minor folds are peculiarly rare in the map-area, as was found also in the Lower Manitou-Uphill Lakes area (Blackburn 1976). An explanation might be the general absence of distinctly bedded lithologies in which minor folds could be seen to have developed. At the northeast end of the large unnamed island at the northeast end of Upper Manitou Lake and on adjacent islands near Red Rock Narrows, tight to isoclinal folding is present in bedded tuff, lapilli-tuff and tuff-breccia deposits with minor amounts of intercalated mafic flow or pyroclastic rocks. This folding is associated with strong shearing in a northeasterly direction, and where this zone of shearing crosses poorly bedded or massive or unbedded pyroclastic deposits, the folding can either only be seen with difficulty or not detected. Sense of movement on these folds where such can be observed, indicates dextral lateral movement along slip surfaces, that may be related either to major folding of the Manitou Anticline or to shearing along local zones (see "Faults").

Minor folds occur in bedded pyroclastic and sedimentary rocks in a small bay on the north side of the peninsula at the south end of Upper Manitou Lake, between Jackfish Bay and Reliance Bay. They are not sufficiently well exposed to comment on their form and orientation, but are probably related to major folding about the Manitou Anticline, as are isoclinal folds at the tip of the peninsula and on Swede Boys Island that involve infolding of pyroclastic and mafic flow units. Strong shearing has disrupted these latter fold structures, so that no determinations were made concerning sense of movement of the folds, though plunge of fold axes is probably shallower than 60 degrees, and to the east and northeast, in all cases. From their position in the axial zone of the Manitou Anticline, and if the assumption be made that they are associated with the major folding, it might be further assumed that the geometry of these minor folds would be that of chevrons rather than S-shaped or Z-shaped folds.

Minor folds are present in metasediments of Thomson's Manitou "Series" southeast of the Manitou Straits Fault, but are not well-developed in the very small portion of that sequence in the present map-area. That the metasediments are folded on a minor scale is confirmed by reversals in facing of graded sandstones (see "Metasediments"). Thomson (1933, p.18) interpreted these to be drag folds associated with movements along the Manitou Straits Fault; no alternate interpretation can be made as a result of the present survey.

Foliation

The term foliation is used here to encompass any mesoscopic penetrative planar structure of tectonic origin (Turner and Weiss 1963). Thus schistosity, slaty cleavage, and gneissosity, all of which occur in the map-area, are all foliations. On the map face (Map 2409, back pocket) a foliation symbol only has been used to designate these structures. This procedure differs from that used in the adjoining Lower Manitou-Uphill Lakes area (Blackburn 1976), where two symbols were used to specifically designate gneissosity and schistosity, and a third symbol to generally designate foliation where the rocks were neither gneisses nor schists but possessed strong, planar, tectonically imposed penetrative discontinuities. In practice, although gneissic structure and schistosity, as defined for the Lower Manitou-Uphill Lakes area (Blackburn 1976), are distinctly different from each other, considerable difficulty is found in defining the passage from gneissosity to schistosity. In the present map-area this was particularly the case where all gradations between gneissosity and schistosity were encountered, though not at any one location. Gneissosity is particularly developed in metavolcanics and associated migmatites of amphibolite facies metamorphic grade, both within the metavolcanic-metasedimentary belt, and in xenoliths and partially assimilated blocks within the Atikwa Batholith. Where metavolcanics are of greenschist facies grade, gneissosity is in general absent, but rocks possess a distinct planar, penetrative cleavage along which they may or may not split. More intense development of this cleavage imparts a fissile nature to the rock, and at a final stage of development, a schistosity. Schistosity is commonly developed in narrow zones, varying from a few centimetres to metres in thickness, throughout those metavolcanics at greenschist facies grade. Wide schist zones are only present in the southeast, on either side of the Manitou Straits. The zone southeast of the Straits marks the location of the Manitou Straits Fault, and considerable, though unknown amounts of, movement are postulated within this schist zone.

Variation in the trend of foliation is systematically related to major structural trends, both within the metavolcanic-metasedimentary belt and within the Atikwa Batholith. Foliation is present in rocks belonging to all major map units, indicating emplacement of all rock units prior to at least the termination of deformation. The parallelism of foliation to contacts of the metavolcanic belt with granitic rocks of the batholith, both in the main part of the belt, and where xenolithic bodies, once continuous with the belt, have been necked and dragged away from the belt, indicates that the foliation was imparted during emplacement of the batholithic rocks. Foliation in general appears to follow stratigraphic contacts, but it cannot be assumed that foliation is always parallel to such contacts, because in the axial zone of the Manitou Anticline it clearly lies parallel to the axial plane, and does not wrap around the fold nose.

Lineation

In both the granitic and the metavolcanic-metasedimentary terrain, all lineations mapped are mineral lineations, defined by elongate amphiboles, feldspars, quartz rodding, and mica trains. Within pyroclastic units, these were al-

ways found to lie parallel or nearly parallel to stretching of clasts, and never at high angles to the long axes of stretched clasts. However, no rigorous treatment was made of the relationship between the orientation of minerals and long axes of clasts, and in practice both mineral lineations and the attitudes of the long axes of clasts were measured. This co-linear relationship between long axes of clasts and elongation of minerals was also found by Wallace (1975). Lineation lies in the plane of regional foliation where developed.

Trend and plunge of lineation varies systematically through the map-area, though minor aberrations occur. In the north and west, within the Atikwa Batholith, plunges are shallow, mostly less than 45 degrees, and trend toward the south and southeast. There is a consistent increase in angle of plunge from the edge of the metavolcanic-metasedimentary belt southeastward towards the Manitou Straits, and also a general change in trend across the same area from southeast, to east, to northeast. Along the Manitou Straits, where foliation is consistently steeply dipping and strikes northeastward, lineations also consistently plunge at very steep angles to the northeast, in the plane of the foliation.

Kink Bands

Kink bands similar in type to those present in the Lower Manitou-Uphill Lakes area (Blackburn 1976) occur along highly sheared zones at Manitou Straits in the southeast of the map-area, and on the large island at the north end of Upper Manitou Lake. A discussion of the genesis of kink bands is given by Blackburn (1976); they are a late stage phenomenon, associated with brittle deformation caused by compression directed at a shallow angle (less than about 30 degrees) to regional foliation, and were possibly developed under the same stress system as that which produced regional fractures and joints.

Wallace (1975), as part of a study of strain parameters in the Manitou Lakes area, similarly determined from kink band geometry that maximum stress was oriented northeasterly in the horizontal plane, intermediate stress was vertical, and that least stress was oriented northwesterly in the horizontal plane.

STRUCTURAL GEOMETRY OF THE MANITOU ANTICLINE

The existence of the Manitou Anticline is now well established (Goodwin 1965; Blackburn 1976, and this study). However, the structural geometry is still not precisely defined. Trend of foliation throughout the area of the fold is consistently northeastward, while dip varies from steeply southeastward in the northwest, to vertical in the southeast, adjacent to the Manitou Straits Fault. It has not been established that this is an axial plane foliation, though it is probable that in the core of the fold the foliation does lie parallel to the fold axial plane. Bedding dip, where observed on limbs of the fold, similarly varies from between 40 to 70 degrees southeastward in the northwest to predominantly vertical in the southeast, and except in the nose of the fold, foliation and bedding are sub-parallel. Hence the fold is an overturned anticline with limbs and axial

plane all dipping southeastward.

The plunge of the fold has not been reliably determined, due to the lack of well preserved and exposed bedding planes around the nose of the fold. It cannot be assumed that variation of trend and plunge of lineation in all cases indicates similar variation in trend and plunge of the fold axis; neither can it be assumed that the plunges of minor fold structures in the nose of the major fold at Swede Boys Island and on the adjacent mainland reflect plunge of the structure precisely. However, the general northeasterly plunge of these minor structures suggests that it is likely that the major fold plunges to the northeast or east, and at a moderate angle.

STRATIGRAPHIC SYNTHESIS OF PRECAMBRIAN ROCKS

Delineation of major lithologic units, and limited analysis of folding and faulting enable an approach to an understanding of the Precambrian stratigraphy. Major rock units have been satisfactorily delineated, but intrusion of a gabbroic body at Mitchell Lake and emplacement of the Atikwa Batholith has disrupted the sequence such that no certainty can be placed upon structural interpretation adjacent to the batholith. However, the existence of the Manitou Anticline, first identified by Goodwin (1965, 1970), has been substantiated by the present survey.

A major fault zone, the Manitou Straits Fault, occurs in the extreme southeast of the map-area. Only a minor portion of the sequence southeast of the fault zone occurs within the map-area. It is part of an extensive sequence of volcanic and sedimentary rocks that may or may not be correlatable, across the Manitou Straits Fault Zone, with those in the present area. The problem has been dealt with by Blackburn (1976), and no further light was shed on it by the present survey.

The sequence northwest of the fault within the present map-area is continuous with, and lies north of, the "Northwest Sequence" of the Lower Manitou-Uphill Lakes area (Blackburn 1976).

Structural considerations outlined elsewhere (see "Major Structure") indicate that Rector Lake basalts lie at the base of the sequence, occupying the nose of the Manitou Anticline. They are continuous southward with a basaltic sequence in the Lower Manitou-Uphill Lakes area, there referred to as Blanchard Lake basalts, and shown to be at least 1200 m thick (Blackburn 1976). A unit of coarse, gabbroic rocks, interpreted to be a sill and lying within the Blanchard Lake basalts was not traced into the present map-area.

Upper Manitou Lake pyroclastics and basalts, lying immediately above Rector Lake basalts, are folded around the Manitou Anticline. On the northwest limb of the fold they are continuous southwestward beyond the present map-area with Early Lake pyroclastics, while on the southeast limb of the fold they are continuous southwestward with Troutlet Lake pyroclastics and basalts, confirming conclusions established by Blackburn (1976) in the Lower Manitou-Uphill Lakes area. The maximum thickness of the Upper Manitou Lake pyroclastics and basalts is unknown, because only a portion of the unit is contained within the map-area; the nose of the Manitou Anticline extends eastward out of the

map-area. Thickness estimates must also ultimately depend on analysis of structural attitudes such as plunge of the Manitou Anticline fold axis, which has not been determined during the present survey. Minimum thickness estimates within the map-area, based on measurements across the narrowest part of the northwest fold limb, in the vicinity of Jackfish Bay, are on the order of 900 m.

Above the mixed pyroclastics and basalt sequence of Upper Manitou Lake is a sequence dominated by basalts, with intercalated pyroclastic units, that may be in excess of 3000 m thick in the absence of any major fold structure. In the southeast, on the southeast limb of the Manitou Anticline the upper sequence is attenuated by the Manitou Straits Fault (see Figure 2). The most complete portion of this part of the sequence lies on the northwest limb of the Manitou Anticline, but the abundant metavolcanic xenoliths, rafts, and schlieren within and near the margins of the Atikwa Batholith indicate that much of it has been removed by intrusion of the batholith.

The Benson Bay basalts in the northeast lie along strike from and are laterally equivalent to the mixed sequence between Jackfish Bay of Upper Manitou Lake and Manitumeig Lake.

DISCUSSION OF AEROMAGNETIC DATA

Comparison of the accompanying geologic map (2409, back pocket) with the Upper Manitou Lake aeromagnetic map (ODM-GSC 1961) shows some pertinent correlations between magnetic intensity and geology. A conspicuous magnetic feature is the pronounced high in the vicinity of Navimar and Mitchell Lakes, directly correlatable with dioritic and gabbroic rocks. Disseminated magnetite appears to be common in these mafic rocks, accounting for magnetic field values in excess of 61,000 gammas.

It is particularly noticeable that magnetic field intensity is lower over pyroclastic rocks at Upper Manitou Lake than over adjacent mafic metavolcanics and associated pyroclastics west of the lake, in the vicinity of Noonan and Johnar Lakes. The latter also are of higher intensity than mafic metavolcanics to the northeast, in the vicinity of Benson Bay and Kirkby Lake. It appears that magnetic field intensity is related to grade of metamorphism. Metamorphic grade is lower (greenschist facies) at Upper Manitou Lake and in the vicinity of Benson Bay and Kirkby Lake than in the metavolcanics to the west (amphibolite facies). Magnetic field intensity is higher still over dioritic rocks in the vicinity of Helen and Ethel Lakes, and over granitic rocks of the Wawapus-Kekekwa Lakes lobe of the Atikwa Batholith.

The relationship of mineral occurrences and showings to magnetic intensities is not evident. Only in the diorites and gabbros of Navimar and Mitchell Lakes are showings associated with an area of high magnetic intensity, and then only indirectly. For example, the molybdenite-bismuthinite occurrence about 0.4 km west of Navimar Lake (see "Navimar Lake Occurrence") is in a quartz vein that cuts dioritic and associated mafic rocks that are responsible for the high magnetic values.

ECONOMIC GEOLOGY

Gold was undoubtedly the first economic mineral to be actively sought for by prospectors in the Manitou Lakes area. Little work had been done up to the end of the Nineteenth Century, though gold had been found, for Coleman (1894, p.66) wrote:

Up to the present Manitou Lake has yielded only specimens, some of them exceedingly fine however. There is no mine and no stamp mill on its shores and the deepest exploration at the time of our examination ... did not go down more than 25 feet [8 m].

During the period 1895 to 1912 the area experienced a high interest in gold with the opening of a number of mines, of which the Laurentian which opened in 1903, and the Big Master which was in operation before 1900, were the only appreciable producers. Both mines are located outside the map-area at the north end of Trafalgar Bay of Upper Manitou Lake, and their development gave rise to the community of Gold Rock. According to Thomson (1933, p.1), "around 1912 practically all mining in the area ceased".

At the opening of the 1930s, further interest in gold was centred on the Manitou Lakes, and a number of new occurrences were opened up, and old properties re-examined. "Following the revaluation of gold in 1933 and 1934 a new interest was taken in the Laurentian, Jubilee, and Big Master mines and adjacent ground. Active development of these properties was resumed in 1934" (Thomson 1938, p.1). Activity at the turn of the century and in the 1930s has been chronicled adequately by Thomson (1933, 1934, 1938).

Economic factors brought the close of all gold mining in the Manitou Lakes area by 1948, and with respect to gold, the area has lain dormant to the present.

Exploration for base metals commenced in the Manitou Lakes area in the 1960s, conducted with the aid of geophysical equipment, both airborne and ground-based. Up to the time of writing, no significant deposits had been discovered.

Mineral deposits found within the map-area to December 1973 include gold reportedly associated with quartz veins and molybdenum in quartz and quartzose pegmatite veins.

Gold Deposits

Gold deposits found within the map-area are of a single recognized mode of occurrence, viz., in quartz veins. Gold-bearing quartz veins occur in subvolcanic porphyries and felsic to intermediate metavolcanic pyroclastics on Frenchman and Swede Boys Islands respectively, and in mafic coarse-grained flows on the northwest shore of Upper Manitou Lake. On Frenchman Island, gold occurs in a 160 m long quartz vein, that varies from 0.3 to 2.5 m in width. On Swede Boys Island, gold reportedly (Thomson 1933) occurs in a number of narrow quartz veins and stringers. The longest of these veins, according to Thomson, is 9 m. At the Gold Rock occurrence (R.S. Rooney property), on the northwest shore of Upper Manitou Lake, gold reportedly (Thomson 1933) occurs in a short, narrow

quartz vein. All of these quartz veins contain minor amounts of pyrite.

RELATIONSHIP OF GOLD DEPOSITS TO GEOLOGICAL FEATURES

Thomson (1933, 1936) has suggested that in the Manitou Lakes to Lake of the Woods region, there is a genetic association between gold and granitic intrusions. Ore-bearing solutions are envisaged as emanating from the granitic magma, and penetrating along faults, fractures, and sheared zones. However, as E.L. Bruce pointed out in discussion (Thomson 1936, p.701):

The assumption of genetic relationship between the veins and the granitic rocks so widely exposed in the [Manitou Lakes to Lake of the Woods] region is open to question. Proximity to such rocks is a doubtful criterion, since, in a region so riddled by intrusive bodies, it would be difficult to find any locality very far removed from some such occurrence.

In the present map-area, the gold-bearing quartz veins occur either within or in close proximity to felsic to intermediate pyroclastics and subvolcanic porphyries that have been invaded by many porphyry and felsite dikes. There may be a genetic association between these rock types, the porphyries either acting as a heat source for concentration of gold or representing the final stages of volcanic and subvolcanic, acidic activity, in which gold is concentrated as a residual component.

It should be noted that in the Lower Manitou-Uphill Lakes area the author (Blackburn 1976) suggested that "the gold prospects, showings, and old mines seem to be preferentially located within the lower, more mafic, part of the volcanic pile", and some stratigraphic control was therefore indicated, and a volcanogenic origin suggested. The presence of many porphyry and felsite dikes in proximity to the gold occurrences in the Lower Manitou-Uphill Lakes area as in the present map-area, now suggests to the author a closer association of gold to these dikes than to their host rocks.

Molybdenum Deposits

Molybdenum occurs in quartz and quartzose pegmatite veins near Navimar Lake. According to Parsons (1917), the main vein is 76 m long, and 3 to 3.7 m wide. The veins intrude diorite and quartz diorite, and contain, in addition to molybdenite, minor amounts of bismuthinite. The molybdenite occurs as individual flakes scattered through the host vein material.

RELATIONSHIP OF MOLYBDENUM DEPOSITS TO GEOLOGICAL FEATURES

The quartz and quartz pegmatite veins near Navimar Lake occur in close proximity to granitic rocks of the Atikwa Batholith, so that the mineralization may be directly related to this igneous activity.

Sulphide Mineral Deposits

Disseminated pyrrhotite and pyrite, and minor chalcopyrite and sphalerite occur in silicified and carbonatized alteration zones in mafic metavolcanics along the northwest shore of Upper Manitou Lake. The mineralization has been found in cores from diamond drill holes put down to test electromagnetic conductive zones. These sulphide minerals occur, according to drill logs, disseminated over short core lengths to a maximum of 3 m, with a number of shorter more highly mineralized zones.

RELATIONSHIP OF SULPHIDE MINERAL DEPOSITS TO GEOLOGICAL FEATURES

The disseminated sulphide mineralization occurrences along the northwest shore of Upper Manitou Lake lie on a northeasterly trending line that parallels stratigraphic and structural trends. They are associated with a zone of electromagnetic conductors that follows the same line. This zone lies close to the boundary between predominantly felsic to intermediate pyroclastic rocks and predominantly mafic flow rocks. Stratigraphic control is therefore indicated, and a volcanogenic origin for these sulphide minerals is suggested.

Recommendations for Mineral Exploration

Gold has long been known from quartz veins at Frenchman and Swede Boys Islands, and at the Gold Rock mine. The suggestion (this report) that porphyry and felsite dikes have a close genetic connection with gold deposition, coupled with the general observation that gold occurs predominantly in quartz veins in the Manitou Lakes region (Thomson 1933; 1936; Blackburn 1976) leads to the conclusion that future search for economic gold deposits at Upper Manitou Lake should be conducted where quartz veins and porphyry and felsite dikes are concentrated. In view of the fact that quartz veins themselves are notoriously discontinuous and localized, low grade, high tonnage deposits occurring within the host rocks would seem to be the likely exploration target. Regional trace element geochemical prospecting of bedrock might outline suitable anomalously high gold halos.

Molybdenite occurrences are scattered along the metavolcanic-granite contact zone around the eastern end of the Atikwa Batholith (e.g. Parsons 1917; Thomson 1917; Blackburn 1976). They appear to be associated with quartz or quartzose pegmatite veins of either epigenetic or syngenetic origin. These veins, in themselves, do not appear to be of exploitable dimensions but may indicate the presence of disseminated molybdenum within plutonic rocks of the Atikwa Batholith. If such were the case, it might be expected that country rock near to molybdenum-bearing quartzose veins would contain detectable amounts of molybdenum. To test this hypothesis, samples of granitic country rock from near a

similar molybdenite occurrence at Olsen Bay of Lower Manitou Lake (Blackburn 1976) were submitted for qualitative spectrographic analysis to the Mineral Research Branch, Division of Mines, but yielded no trace of molybdenum.

Further search should be made for molybdenum-bearing quartz and quartzose pegmatite veins in the vicinity of the metavolcanic-granite contact zone. Geochemical exploration for trace amounts of molybdenum (see Wolfe 1976) might be made in granitic rocks in the vicinity of known veins.

Results of airborne and ground electromagnetic and magnetic surveys by Kerr Addison Mines Limited and Freeport Canadian Exploration Company indicate a zone of conductors to extend in a northeasterly direction along the northwest shore of Upper Manitou Lake. Drilling to date on these anomalies has so far indicated them to be due to disseminated pyrrhotitic sulphides, with negligible amounts of chalcopyrite. However, there is a good possibility that these disseminated sulphide zones are more continuous than indicated by the geophysical work, and further ground follow-up work might be warranted. The zones may also be stratigraphically controlled, suggesting that further exploration should be carried out along strike to the northeast, toward Benson Bay and Jonas Lake.

Disseminated magnetite and minor pyrrhotite occur in gabbroic and dioritic rocks at Navimar and Mitchell Lakes and give rise to two magnetic anomalies, in excess of 61,000 gammas, one each centred over these lakes, as delineated on aeromagnetic map 1153G (ODM-GSC 1961). Copper-nickel mineralization has not been found in these bodies, but by analogy with similar rocks occurring elsewhere around the margins of the Atikwa Batholith (e.g. Moorhouse 1939; Satterly 1941; Davies and Watowich 1956; Davies 1973), and which do contain these metals, such deposits might be prospected for. Of interest in this regard are the anomalously high nickel values detected in peridotite near Harper Lake (1300 ppm) and Navimar Lake (1060 ppm) (Table 2, back pocket, Samples 17 and 19). In the sample from the former locality, chrome is also anomalously high (1640 ppm).

Description of Properties and Exploration

Information on older occurrences within the Upper Manitou Lake area is contained within reports by Coleman (1896), Parsons (1917) and Thomson (1933). Further information on some of these older properties, and on all the more recent exploration, has been extracted from the Regional Geologist's Files, Ontario Ministry of Natural Resources, Kenora, and from the Assessment Files Research Office, Division of Mines, Toronto.

Properties are titled in this report according to ownership as of December 1973. Names in parentheses, following titles, refer to names by which the property is otherwise known, e.g., R. S. Rooney (Gold Rock Mine, Vaughan Mines Occurrence, Haycock Occurrence).

Areas of exploration are titled according to the company that performed the work. Dates in square brackets following titles indicate date of last major work on parcels of land open to staking as of December 1973, on which no mineral deposit has been discovered; e.g. Kerr Addison Mines Limited [1967].

Upper Manitou Lake Area

Numbers in parentheses following titles of properties and areas of exploration correspond to those on the map-face.

FREEPORT CANADIAN EXPLORATION COMPANY [1970] (1)

During April and May 1970, a combined airborne electromagnetic and magnetic survey was flown by Questor Surveys Limited for Freeport Canadian Exploration Company over Straw Lake, Eagle Lake, and the Manitou Lakes, as a joint venture with Beth-Canada Mining Company (Assessment Files Research Office, Division of Mines, Toronto).

A Super Canso aircraft equipped with a Mark V INPUT airborne electromagnetic system and a Barringer AM-101 proton precession magnetometer was used in which flight lines were run 200 m apart, at right angles to regional structural trends.

Electromagnetic conductors with magnetic correlations have been reported (Assessment Files Research Office, Division of Mines, Toronto) at three places within the present map-area (1 on Map 2409, back pocket). Of these three, the most conductive zone, or zones, was located over the waters of Upper Manitou Lake, close to Stony Island. Two parallel, northeast trending conductive zones, with attendant direct and flanking magnetic correlations were picked up on five adjacent flight-lines run at right angles to the conductive zones. The conductive zones are about 400 m apart: the more northwesterly zone crosses the entrance to Garnet Bay, and partly underlies the northeasterly trending peninsula on the southwest side of the bay; the southeasterly zone lies parallel and adjacent to the northwest side of Stony Island. The northwestern conductive zone appears to correspond or lie close to a conductive zone identified by Kerr Addison Mines Limited by ground electromagnetic survey (see "Kerr Addison Mines Limited").

Two electromagnetic conductors were located on one flight line that crossed the Manitou Straits, close to the southeast corner of the map-area. A direct magnetic correlation was found associated with one of these conductors, and flanking magnetic correlations were located on each of the adjacent flight lines.

Another conductor, with a direct magnetic correlation, was located on one flight line at the east margin of the map-area, less than 400 m inland from Upper Manitou Lake, about 1200 m south of Jonas Lake.

There is no record of a follow-up program carried out on these anomalies or on any other of those in the Manitou Lakes part of the venture. The claims staked in 1970 to incorporate the conductive zones lapsed in 1972.

L. HAMPE — CHARLES MERRILL ESTATE (SWEDE BOYS ISLAND OCCURRENCE) (2)

The two islands lying immediately northeast of the peninsula between Reliance and Jackfish Bays of Upper Manitou Lake were formerly referred to as the Swede Boys Islands, though the name is now reserved for the larger of the two islands only. According to Thomson (1933, p.36):

On the larger of these islands (H.P.259) an old shaft is located on a quartz vein, which strikes N. 50 degrees E. and dips 75 degrees S.E. The vein is about 2 feet [0.6 m] wide and may be traced about 15 feet [5 m] to the southwest. There are some old pits along the strike to the northeast, but no vein material can be observed. The wall rock of the vein is chlorite schist carrying a little pyrite. Native gold was observed in the schist. A grab sample of the ore on the dump assayed \$8.80 per ton in gold¹.

East of the shaft on the shore of a small bay a stockwork of small quartz stringers and schist occurs across a width of 6 feet [2 m] and may be traced along the shore a short distance. The quartz and schist carry a little sulphides.

Another old shaft is located on the smaller island (H.P. 260) to the northeast. It was sunk on a small lens of milky-white quartz in massive agglomerate and tuff. The quartz lens is about 2 feet [0.6 m] in width and may be traced 30 feet [9 m]. It contains a trace of pyrite and chalcocopyrite. A grab sample of the material on the dump assayed 80 cents¹ in gold per ton.

The present writer was unable to locate any of the shafts and pits referred to by Thomson.

As of December 1973, Swede Boys Island was held under two patented claims, K3810 and K3811, being parts of mining location HP259. The smaller island, former mining location HP260, was not held under patent, and is open to staking.

KERR ADDISON MINES LIMITED [1967] (3)

During the summer of 1967 and the following winter, Kerr Addison Mines Limited (3 on Map 2409, back pocket) carried out ground electromagnetic surveys on seven groups of claims, designated A to G, in the Manitou Lakes area (Assessment Files Research Office, Division of Mines, Toronto). Of these seven, only group G lay wholly within the present map-area, while the northern end, and most of claim group B lay within the map-area. Group A lay some 6 km east of the map-area. Claim groups C to F, and the southern end of claim group B, lay south of the present map-area and were discussed by Blackburn (1976).

The surveys were carried out with a Crone Junior V.L.F. electromagnetic unit, along picket lines spaced at 60 m intervals and cut at right angles to regional structure. Conductive zones were located on both groups B and G within the present map-area.

Group B comprised a parcel of 42 claims strung out in a northeasterly direction from Merrill Lake, south of the present map-area, and thence along the west shore of Jackfish Bay, and the western shore of Upper Manitou Lake, to a point on that shore south of Mitchell Lake. Thirty-three of the claims (K40252 to K40266; K40459 to K40470; K42365 to K42369; K42405) lay wholly within the map-area, while three others (K40249 to K40251) lay partially within the map-area, but mostly within the Lower Manitou-Uphill Lakes map-area (Blackburn 1976).

An elongate intermittent zone of conductors was located over a distance of 8 km along the full length of the claim group, that is, in a northeast direction. Diamond drill holes were put down at a number of points along the zone of conductors. Within the present map-area, four holes were drilled on claim K40255, and one hole was drilled on each of claims K40264, K40265, K40468, K42368, and K42369.

¹In 1933, the price of gold was \$28.60 per ton.

Upper Manitou Lake Area

On claim K40255, that lay north of and tied on to patented mining location D140, a total footage of 285 m was drilled over four holes, all of which were sunk to the northwest, at an angle of 45 degrees to intersect a conductive zone at depth. The collars were not located by the present survey. According to the diamond drill record, logged by R.H. Schwandt for Kerr Addison Mines Limited, all four holes intersected quartz-hornblende-biotite gneiss, and andesite with quartz-carbonate veining and short silicified and altered sections. Pyrite and pyrrhotite mineralization, with minor chalcopyrite, reportedly characterized the short silicified and altered sections. The mineralized sections were intersected at depths between approximately 30 m and 60 m, did not exceed about 2 m in width, and averaged less than 10 percent sulphide minerals by volume. Chalcopyrite mineralization, where present, was only a minor portion of that amount. Sphalerite was reported in one hole only, in "slight" amounts accompanying 20 percent pyrrhotite over 0.4 m width, and in "weak" amounts accompanying 10 to 15 percent pyrrhotite, and "weak" pyrite and chalcopyrite over a 0.6 m width. Assay values for copper, gold, silver and zinc showed at a maximum only trace amounts of those elements. (Assessment Files Research Office, Division of Mines, Toronto).

On claim K40264, that lay close to the shore of Jackfish Bay, 1.5 km east of the south end of Noonan Lake, a diamond drill hole was sunk 45 m toward the northwest at 45 degrees dip to intersect a conductive zone at depth. The collar was located during the present survey. According to the diamond drill record, logged by J.W. Campbell for Kerr Addison Mines Limited, the hole intersected andesite, and quartz-hornblende-biotite gneiss. Narrow stringers of pyrite and pyrrhotite with very slight amounts of chalcopyrite, reportedly constituted an estimated 1 to 5 percent of a 3 m width at a depth of about 21 m. Assay of these sections gave zero values for gold, trace amounts of silver, 0.01 percent nickel, and an average of 0.025 percent copper (Assessment Files Research Office, Division of Mines, Toronto). On adjacent claim K40265 to the east, a diamond drill hole was sunk 45.7 m toward the northwest at a dip of 45 degrees to intersect the same conductive zone, but further to the northeast, at depth. The collar was located during the present survey. Sixty percent pyrrhotite was intersected over a 1.2 m width at a depth of about 21 m, according to the diamond drill record, logged by J.W. Campbell (Assessment Files Research Office, Division of Mines, Toronto).

On claim K40468, that lay at the northeast tip of the peninsula 0.8 km west of Stony Island, a diamond drill hole was sunk 44.8 m toward the northwest at a dip of 45 degrees to intersect a conductive zone at depth. The collar was not located by the present survey. The conductive zone appears to correspond with or lie close to a conductive zone identified by Freeport Canadian Exploration Company during a combined airborne electromagnetic and magnetic survey (see "Freeport Canadian Exploration Company"). According to the diamond drill record, logged by J.W. Campbell, the hole intersected intermediate metavolcanics alternating with coarse-grained amphibolite bands and silicified zones. Forty percent pyrite and pyrrhotite were intersected over a 0.6 m width at a depth of about 12 m, and 80 percent pyrrhotite with flecks of chalcopyrite were intersected over a 0.6 m width at a depth of 30 m (Assessment Files Research Office, Division of Mines, Toronto).

Company maps on file for assessment credit indicate that one diamond drill hole was sunk on each of two short, parallel conductive zones on claims K42368 and K42369 at the shore line of Upper Manitou Lake about 0.8 km north of Stony Island. The collars to these holes were not located by the present survey. There are no diamond drill logs on file for these holes (Assessment Files Research Office, Division of Mines, Toronto).

Group C comprised a parcel of four claims immediately southwest of Noonan Lake, on which were located two short, parallel conductive zones, oriented east-northeasterly, and approximately parallel to the intermittent zone of conductors located on claim group B. A diamond drill hole was sunk 52.7 m toward the north at a dip of 45 degrees to intersect the more northerly of these two conductive zones at depth. The collar was located during the present survey.

According to the diamond drill hole record, logged by R.H. Schwandt, the hole intersected andesite that at depths between 30 and 38 m contained narrow sections, up to 1 m wide with between 30 and 90 percent pyrrhotite and pyrite mineralization (Assessment Files Research Office, Division of Mines, Toronto.)

All claims had lapsed prior to the 1973 field season.

JAMES MCNEIL (FRENCHMAN ISLAND OCCURRENCE) (4)

Little is known about the history of the gold occurrence on Frenchman Island (also formerly called Frenchmen Island). The present writer could only find one reference to it in the literature (Thomson 1933, p.31):

At least three quartz veins occur on this island, but development work has been confined to a vein that runs in a southeast-northwest direction across the central part of the island (claim P.150). Test pits have been sunk at intervals along the vein, which may be traced about 525 feet [160 m] but is rather poorly defined. The strike varies from E.25 degrees S. to E. 40 degrees S., and the dip is about 70 degrees S.W. The vein lies in granodiorite and varies from 1 to 8 feet [0.3 to 2.4 m] in width. It consists of sugary white quartz and contains a little fine-grained pyrite. The wall rock is sericite schist, which sometimes carries pyrite and chalcopyrite. At its western extremity the vein outcrops on a cliff, and the well-defined sheared zone may be seen in vertical sections. A chip sample was taken across 3 feet [1 m] of quartz and mineralized schist at this place. This assayed \$3.80 per ton in gold¹.

On Map 42c, Thomson shows three quartz veins located within "altered granite and gneiss" underlying Frenchman Island. The vein referred to in the above quotation and shown on the geological map (back pocket) is the middle of the three. The present writer located this vein where it outcrops at the base of the cliff, and collected grab samples of pyrite-bearing quartz for assay. Only trace amounts of gold were found on assay (Mineral Research Branch, Division of Mines).

The quartz vein at the south end of the island is a barren, white massive quartz vein, about 0.6 m wide, and exposed right at the shore line, and cannot be traced inshore. The third vein shown on Thomson's map, on the northwest side of the island, was not located by the present writer.

¹In 1933 the price of gold was \$28.60 per ounce.

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Abandoned and scattered drill core was found by the writer a little inshore from the bay on the southeast side of the island and is probably representative of diamond drilling on the island, though no collars were found on the island by the present survey. No significant quartz veining or mineralization was noted in the drill core.

As of December 1973, the whole of Frenchman Island was included in a 10-claim group staked in 1972.

NAVIMAR LAKE OCCURRENCE (ORO PLATA OCCURRENCE, PIDGEON OCCURRENCE) (5)

Molybdenite and bismuthinite have long been known to occur about 400 m east of Navimar Lake. According to an account of Eardley-Wilmot (1925), the occurrence was staked in 1915 by E.D.G. Pidgeon, of Wabigoon. It is sometimes referred to as the Pidgeon occurrence. According to an account of Parsons (1917, p.304):

The molybdenite occurs in a very quartzose pegmatite dike, striking about northeast, and with a width at both ends of 10 to 12 feet [3 to 3.7 m], and a total length of about 250 feet [76 m]. This dike consists almost entirely of quartz, which in some places is green in colour, but contains as well lesser amounts of chlorite, orthoclase, molybdenite, bismuthinite, and green and bronze-coloured mica. The molybdenite occurs in intimate association with the chlorite, which is in the form of masses in the middle of the dike. These clumps of chlorite, in all probability, are altered horses of the country rock. This dike outcrops over the summit of a hill about 30 feet [10 m] in height, at the top of which it separates into two stringers about two feet [0.6 m] wide. The outcrop of the dike is best seen at both ends, where it shows its full width of 10 to 12 feet [3 to 3.7 m] on the sides of this hill. The dike is somewhat more pegmatitic at the southwest end than elsewhere. The neighbouring rock is very basic, consisting almost entirely of hornblende, and is apparently a highly altered pyroxenite. This rock changes to a diorite about 100 feet [30 m] to the east, which again gives way in a few hundred yards further east to a porphyritic quartz diorite.

In 1939, Oro Plata Mining Corporation Limited investigated the occurrence. A number of trenches 4.6 to 6 m apart were excavated. Assays of twenty-four samples gave zero to trace amounts of molybdenum. A bulk sample from a pit on the original find is reported to have averages of 1.48 percent molybdenum (File of Mineral Resources Division, Dept. of Energy, Mines and Resources, Canada, *on file with* Geoscience Data Centre Files, Division of Mines).

The author visited the occurrence in the summer of 1973, and failed to locate the quartzose pegmatite dike that meets the description of Parsons. However the author did locate a 30 m long, 3 to 4 m wide quartz vein that contains minor amounts of feldspar and strikes approximately northwest. In addition to the minerals mentioned by Parsons, minor amounts of pyrite are present. The vein occurs within dioritic rocks at the contact between granitic rocks of the Atikwa Batholith and mafic metavolcanics. Some phases of the diorite are very mafic, being hornblende rich as Parsons states. The molybdenum appears to be confined to a small portion of the vein, and no molybdenum was noticed in surrounding country rocks. It is probable that the dike described by Parsons, and the vein found by the author, are one and the same, and that the length and azimuth given by Parsons are in error.

As of December, 1973, the occurrence was open for staking.

R.S. ROONEY (GOLD ROCK MINE, VAUGHAN MINES OCCURRENCE,
HAYCOCK OCCURRENCE) (6)

A gold prospect, locally known as the Gold Rock mine, on mining location D141, on the west shore of Upper Manitou Lake, about 1.5 km southwest of Stony Island, was worked on before the turn of the century. A.P. Coleman visited the location in 1896, and following is his account (Coleman 1896, p.84):

The most important camp on the lake when we were there was that of Mr. Haycock, who represents an enterprising Ottawa company consisting of Messrs. C.W. Mitchell, H.F. Brady and E.B. Haycock. The company owns locations 138, 139, 140, 141D on the Upper Manitou, their house and mill being prettily situated on the shore of 141D. The camp is one of the cleanest and neatest to be found in the region. The mill house contains a two stamp Tremaine mill which cost, laid down, about \$1,800. The buildings are made of logs and whip-sawn lumber, the whole cost of outfit, including house, mill, stable and blacksmithshop, being about \$2,500. The mill can treat about six tons per day, according to Mr. Haycock, who served as millman, and ran in all seventy hours, treating about eighteen tons of "job lots" from various veins in the neighborhood, the average value secured being about \$25 per ton. The mill is stated to have worked excellently. Nine men were employed on the average during the season; but work had just stopped, all the men but one being paid off the day before we arrived, July 27.

Deposits of various kinds are found on 141D, and shafts have been sunk from ten to twenty feet [3 to 6 m] on two veins near the mill, the nearest being small and irregular but very rich. The "Big Mill" vein a few rods away is a sheared band of quartz and grey schist, nine feet [3 m] wide with a strike about east and west and a dip of 75 to 80 degrees to the south. It is in a fine grained, massive, green gray diabase. The quartz is often white, contains iron pyrites of two colors and copper pyrites, and looks like Rode's vein on Little Turtle lake.

A dike of grey granite forty feet [12 m] wide runs northeast and southwest through a green grey schist and contains many small quartz veins and stringers, said to carry gold. The granite itself is often impregnated with sulphides and is stated to pan gold at times, but a specimen assayed at the School of Science, Toronto, contained none. Masses of slender black tourmaline crystals occur frequently in the quartz of some of these veins.

In the late 1920s, the Gold Rock Mining Syndicate, Limited optioned mining location D141 from the Haycock Estate, along with four other claims from the Manitou Lakes area. Then, according to Thomson(1933, p.32),

[Gold Rock Mines, Limited] was organized in 1929 and took over five groups of claims from the Gold Rock Mining Syndicate, Limited. Practically all work was done on the old Haycock property (Claim D. 141) on the west shore of Upper Manitou Lake during 1928 and 1929. Camps were erected to accommodate 40 men, and all necessary mine buildings, including a 2-stamp mill, were completed. The old shaft was deepened and a crosscut was driven 170 feet [52 m].

The rocks in the vicinity of the mine are chiefly altered quartz diorite with lesser amounts of andesite and agglomerate. It is impossible to state whether the quartz diorite is a coarse-grained phase of a lava or an intrusive. About 400 feet [122 m] west of the mine buildings there is a small mass of intrusive granite.

At the shaft the vein is covered by the dump and mine timbers, but it is exposed in a pit east of the dump and may be traced a distance of 25 feet [7.6 m] to the lake shore. The vein, which is 1½ feet [0.5 m] wide, is well defined and consists of white quartz with a little green schist, which carries some pyrite and a trace of chalcopyrite. Native gold was observed in the quartz at the lake shore. A sample chipped across the vein in the pit assayed \$2.20 per ton in gold¹.

A second vein occurs 125 feet [38 m] west of the shaft. This has a general strike of N.40 degrees E. and dips 65 degrees S.E. The vein ranges from 2 to 8 feet [0.6 to 2.4 m] in width and may be traced about 200 feet [60 m] from the lake shore. It consists of rather sugary quartz and a little included

¹In 1933 the price of gold was \$28.60 per ounce.

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schist, and contains only a trace of sulphides. A representative sample taken across the width of the vein in a test pit gave no gold values. A few other small lenses of quartz occur on the property.

It is apparent that the surface showing did not justify the considerable expenditure on equipment, and there is little reason to believe that this mine could be profitably reopened.

In 1929, 300 tons of ore were milled as a test run, yielding 35 ounces of gold, and 5 ounces of silver, to a total value of \$726 (Statistical Files, Ontario Geological Survey).

There is no record of further work having been done at the Gold Rock prospect.

The author visited the prospect in the summer of 1973. None of the mine buildings are left standing, though the mine dump can be seen from the lake. A selection of mafic rock samples from the dump were submitted for assay, and yielded only trace amounts of gold and silver. Only a few pieces of quartz-vein material were found on the dump. The vein mentioned by Thomson at the dump could not be found. Country rock in the vicinity of the prospect is porphyritic, coarse-grained basalt, metamorphosed to amphibolite facies grade. The author concurs with the view of Thomson that it is impossible to state whether this is an intrusive or extrusive rock, but it has been mapped as metavolcanic as it has affinity with rocks elsewhere proven to be extrusive by the presence of pillows.

As of December, 1973, mining location D141 was held under patent.

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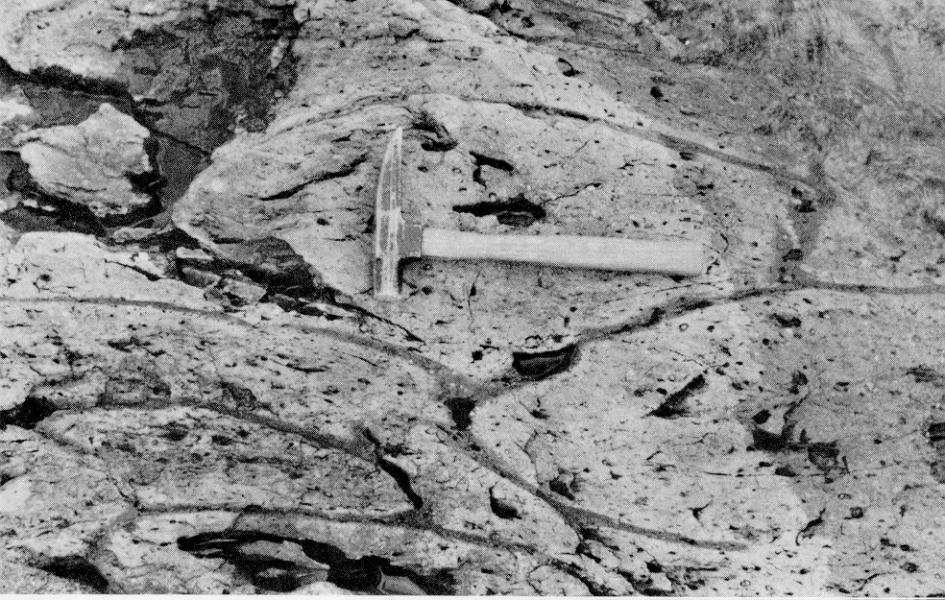
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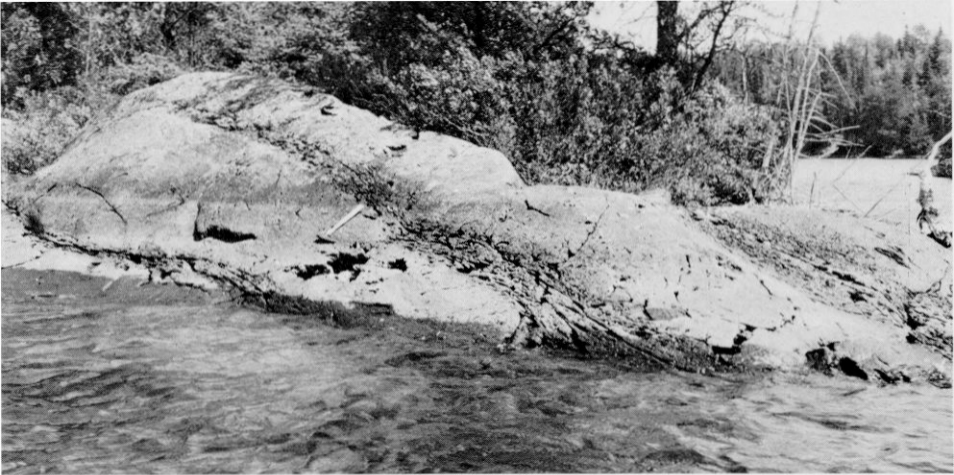
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Upper Manitou Lake Area

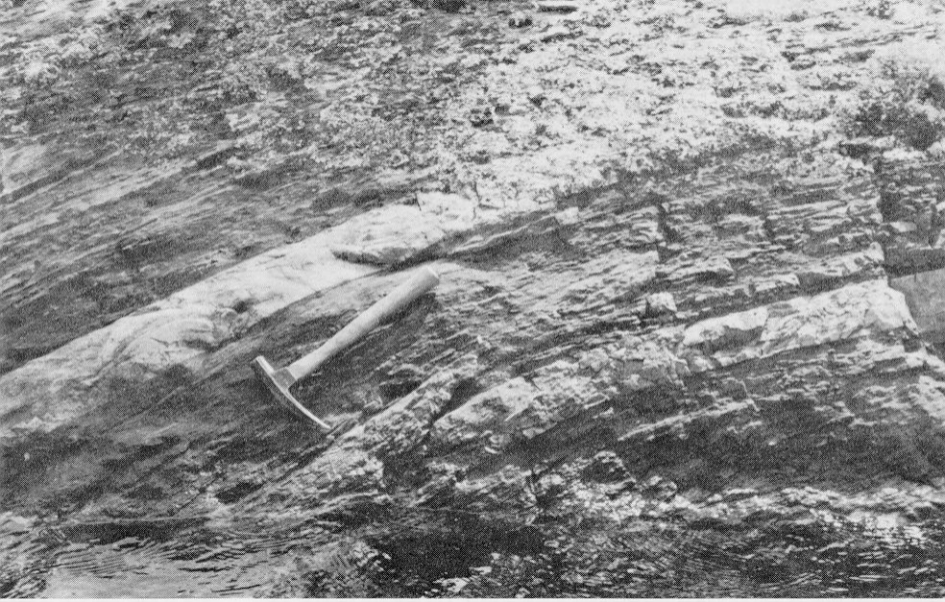
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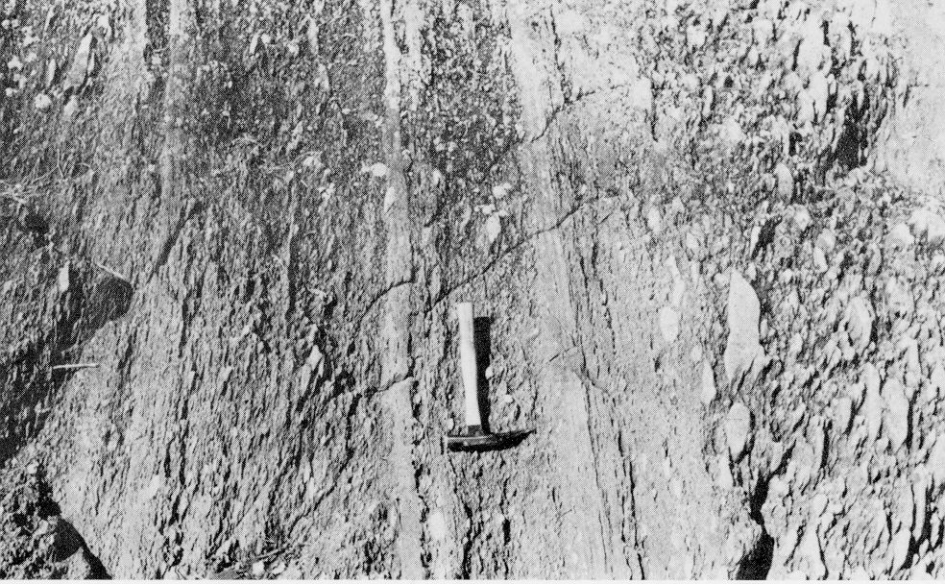


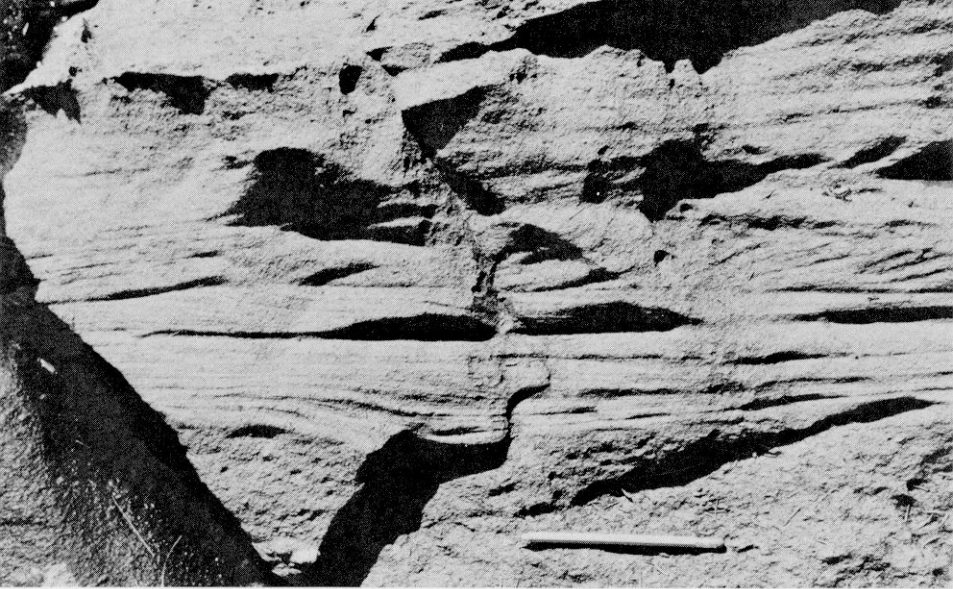




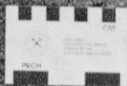










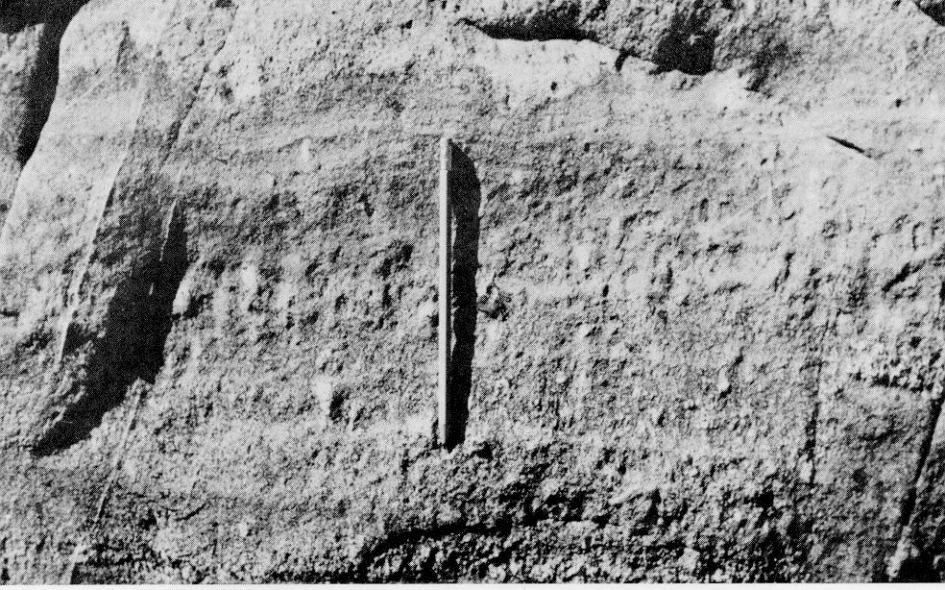


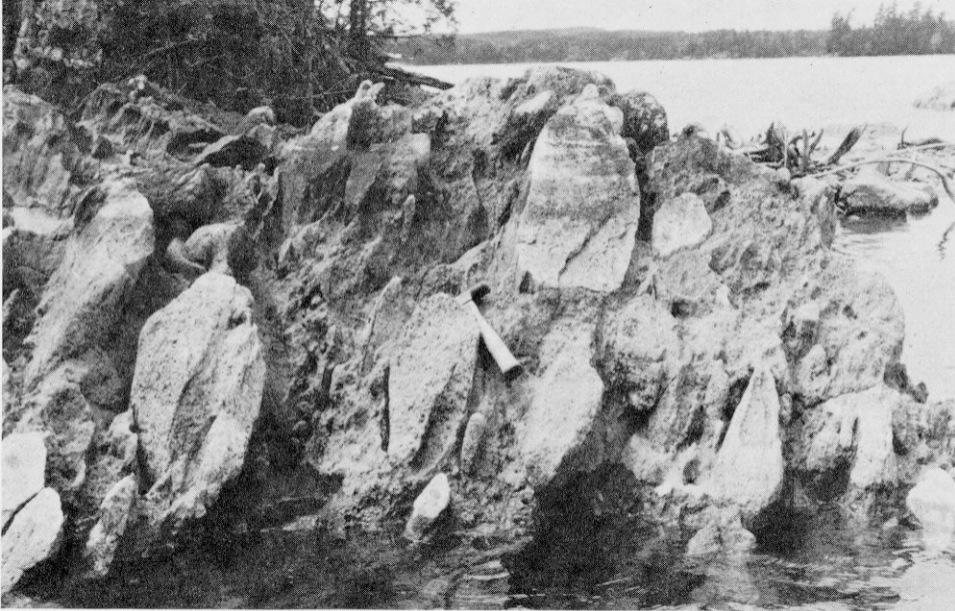






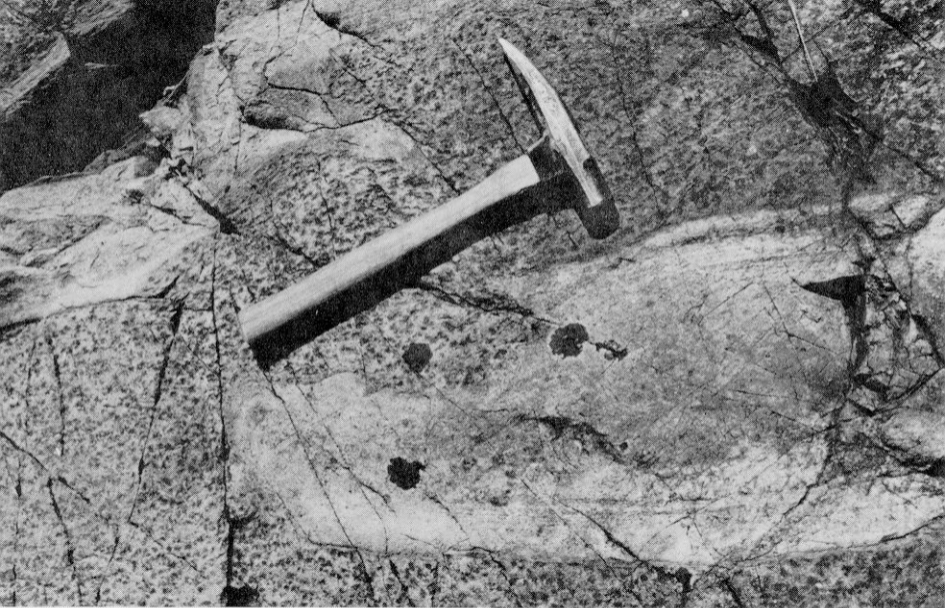














Scale: 1 inch to 50 miles
 N.T.S. Reference: 52F/7

- SYMBOLS**
- Glacial striae.
 - Small bedrock outcrop.
 - Area of bedrock outcrop.
 - Bedding top unknown; (inclined, vertical).
 - Bedding, top indicated by arrow; (inclined, vertical, overturned).
 - Lava flow; top (arrow) from pillows shape and packing.
 - Foliation; (horizontal, inclined, vertical).
 - Kink folding; showing sense and orientation of subvertical kink bands.
 - Lineation with plunge.
 - Geological boundary, observed.
 - Geological boundary, position interpreted.
 - Fault; (observed, assumed). Spot indicates down throw side, arrows indicate horizontal movement.
 - Lineament.
 - Jointing; (horizontal, inclined, vertical).
 - Anticline, syncline, with plunge.
 - Drill hole; (vertical, inclined).
 - Vein.
 - Road.
 - Trail, portage, winter road.
 - Township boundary, baseline or meridian, with milepost; approximate position only.
 - Mining property, surveyed; approximate position only.
 - Surveyed line; approximate position only.
 - Mineral occurrence; mining property, unsurveyed.

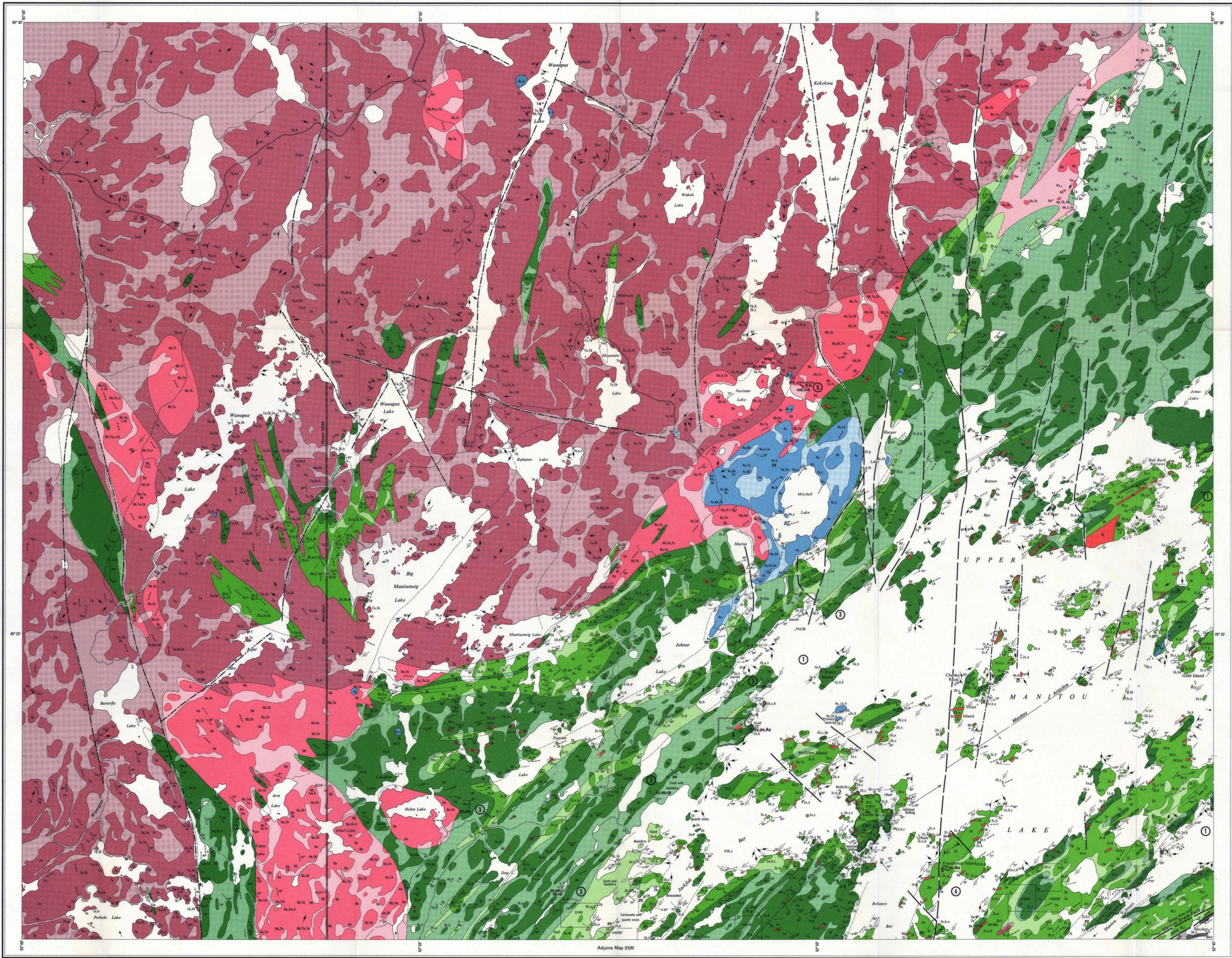
PROPERTIES, MINERAL DEPOSITS

1. Freeport Canadian Exploration Co. (1970).
2. Hampe, L., Merrill, Charles, Estate. (Swede Boys Island occurrence).
3. Kerr Addison Mines Ltd. (1967).
4. McNeil, James. (Frenchman Island occurrence).
5. Navimar Lake occurrence.
6. Rooney, R.S., (Gold Rock mine)

Information current to 31 December, 1973.
 Only former properties on ground now open for staking are shown where exploration information is available—date in square brackets indicates last year of exploration activity. For further information see report.

SOURCES OF INFORMATION

Geology by C.E. Blackburn and assistants, Geological Branch, 1973.
 Geology is not tied to surveyed lines.
 Ministry of Natural Resources (ODM): Map 42c, Manitou-Stormy Lakes Area, 1953.
 Aeromagnetic map 1153G, (ODM-GSC).
 Preliminary map (ODM) P.961, Upper Manitou Lake, issued 1974, scale 1 inch to 1/4 mile.
 Cartography by P.A. Wisbey and assistants, Surveys and Mapping Branch, 1977.
 Base map derived from maps of the Forest Resources Inventory, Surveys and Mapping Branch, with additional information by C.E. Blackburn.
 Magnetic declination in the area was approximately 5° East in 1973.



LEGEND

- CENOZOIC***
- QUATERNARY**
PLEISTOCENE AND RECENT
 Sand, gravel, muck.
 UNCONFORMITY
- PRECAMBRIAN***
EARLY PRECAMBRIAN
(ARCHEAN)
- FELSIC AND INTERMEDIATE INTRUSIVE ROCKS**
- FELSIC PLUTONIC ROCKS**
- 1 Unsubdivided.
 - 7a Equigranular biotite quartz monzonite, granodiorite, trondhjemite.
 - 7b Porphyritic biotite quartz monzonite, granodiorite.
 - 7c Pegmatite, apfite.
- INTRUSIVE AND GRADATIONAL CONTACTS**
INTERMEDIATE PLUTONIC ROCKS
- 6 Unsubdivided.
 - 6a Hornblende diorite, quartz diorite.
 - 6b Biotite-hornblende diorite, quartz diorite.
- INTRUSIVE CONTACT**
FELSIC HYPABYSSAL ROCKS*
- 5 Unsubdivided.
 - 5a Feldspathic quartz porphyry, quartz porphyry.
 - 5b Feltsite.
 - 5c Granite, granophyre.
- INTRUSIVE CONTACT**
METAMORPHOSED MAFIC AND ULTRAMAFIC INTRUSIVE ROCKS*
- 4 Unsubdivided.
 - 4a Gabbro.
 - 4b Leucocratic gabbro.
 - 4c Pyroxenite, peridotite.
- INTRUSIVE CONTACT**
METASEDIMENTS*
- 3a Siltstone, argillite, slaty argillite.
 - 3b Sandstone.
- METAVOLCANICS***
INTERMEDIATE TO FELSIC METAVOLCANICS
- 2 Unsubdivided.
 - 2a Intermediate lithic-crystal tuff.
 - 2b Intermediate lapilli-tuff.
 - 2c Intermediate tuff breccia.
 - 2d Felsic crystal tuff.
 - 2e Felsic lapilli-tuff.
 - 2f Felsic tuff-breccia.
 - 2g Flows.
 - 2h Quartz-feldspar (biotite) schist, gneiss.
 - 2i Sericitic schist.
 - 2j Microgranodiorite porphyry, micro quartz diorite porphyry.
- MAFIC METAVOLCANICS**
- 1 Unsubdivided.
 - 1a Medium to fine-grained basalt.
 - 1b Coarse-grained basalt (gabbroic).
 - 1c Pillowed basalt.
 - 1d Porphyritic basalt.
 - 1e Porphyritic, pillowed basalt.
 - 1f Breccia.
 - 1g Porphyritic gabbroic basalt.
 - 1h Amphibolite basalt.
 - 1i Amphibolite.
 - 1j Amphibolitic migmatite.
 - 1k Diorite, quartz diorite.
 - 1l Chalcitic schist.
 - 1m Garnet amphibolite.

- Au Gold
- bm Bismuthinite
- cp Chalcopyrite
- hem Hematite
- mag Magnetite
- mo Molybdenite
- py Pyrrhotite
- py Pyrite
- q Quartz
- sp Sphalerite

*Unconsolidated deposits. Cenozoic deposits are represented by the lighter coloured parts of the map.
 Bedrock geology. Outcrops and inferred extensions of each rock map unit are shown respectively in deep and light tones of the same colour. Where in places a formation is too narrow to show in colour and must be represented in black, a short black bar appears in the appropriate block.
 *Rocks grouped under these headings are not necessarily all the same age.
 *No age relationships are inferred by the order of the rock units within these groups.
 *Rocks of the Frenchman Island subvolcanic core.

Ontario Geological Survey
 Map 2409
UPPER MANITOU LAKE
 KENORA DISTRICT

Scale 1:31,680 or 1 inch to 1/2 mile

