UNIVERSITY OF CINCINNATI

June 2, *19* 54

I hereby recommend that the thesis prepared under my supervision by John Ferry Weaver

entitled "Petrology of the Memesagamesing Lake Complex"

be accepted as fulfilling this part of the requirements for the degree of Master of Science

Approved by:

Gerald [illegible] Richmond

Form 668– G.S. and T.C.—1M—4-51

PETROLOGY OF THE MEMESAGAMESING LAKE COMPLEX

A dissertation submitted to the

Graduate School of Arts and Sciences
of the University of Cincinnati

in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE

1954

by

John Ferry Weaver

B. S. St. Joseph's College 1949

Abstract

The Memesagamesing intrusive complex is located in the Canadian shield four miles north of Loring, Ontario, where it intrudes granite gneisses; the intrusive is funnel-shaped. A narrow band of the norite borders Memesagamesing Lake, while a small oval shaped part in the center of the lake forms the core of the intrusive. Aeromagnetic evidence suggests that the conduit may plunge to the east. The norite mass in the center of the lake shows rough circular trends that give possible indications of a funnel-shape. The complex is mostly made up of norite with local olivine norite lenses. Granite pegmatites, quartz diorite, and diabase cut the norite mass. The feldspars and pyroxenes show extensive replacement by hornblende and biotite which are locally intergrown with pyrite, pyrrhotite, and titaniferous magnetite. Clouding of the feldspars is noted in both norite and olivine norite. Coronas are abundant in norite and olivine-bearing rocks.

Extensive jointing followed the consolidation of the intrusive. Granite pegmatites were emplaced in many of the fractures. The norite was subjected to metasomatism by the pegmatites, which resulted in secondary diorite adjoining the pegmatites. This metasomatism may be responsible for extensive biotite, hornblende, and reaction rim formation in the intrusive. Two late-stage faults intersect at the approximate center of the complex.

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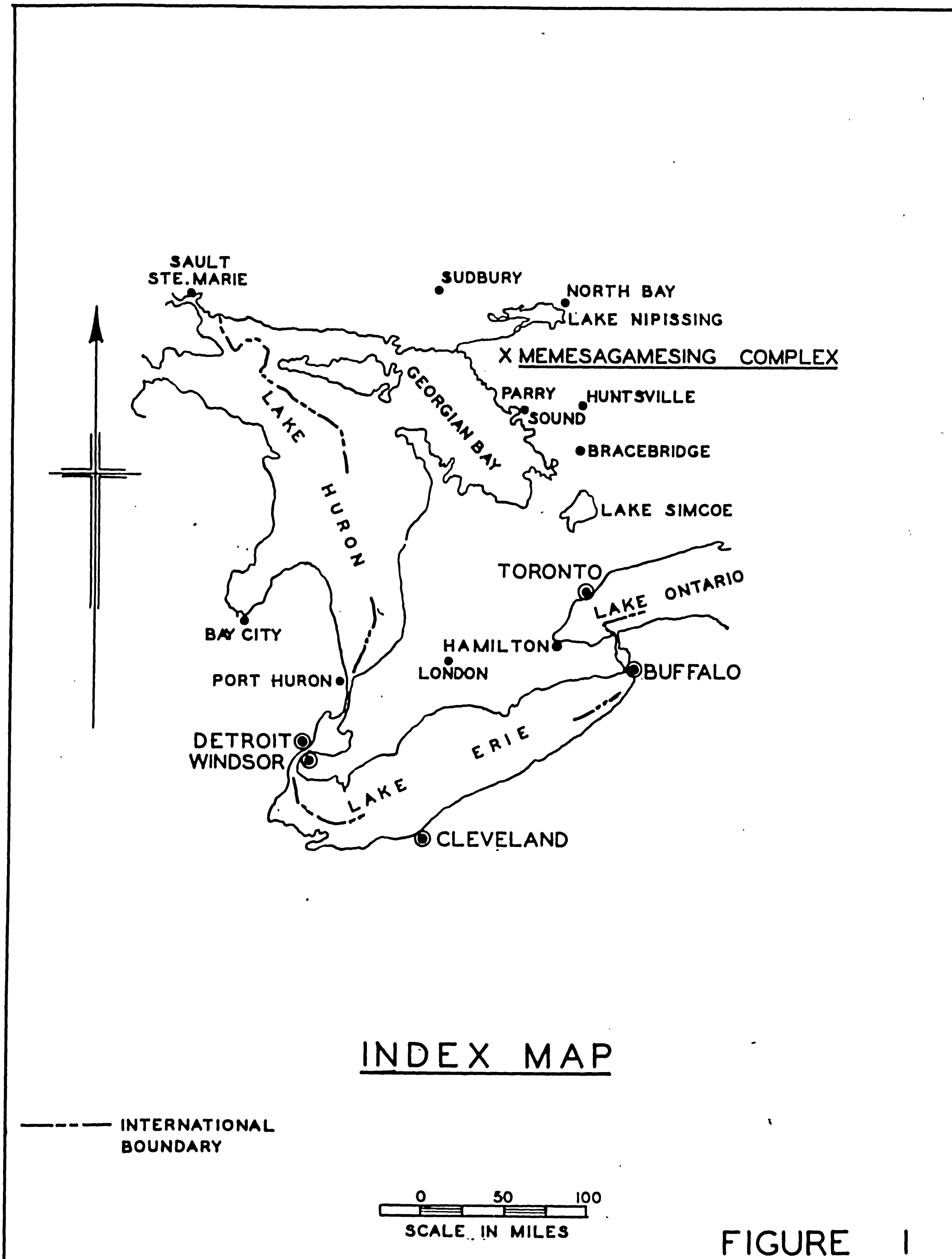


SAULT STE. MARIE
SUDBURY
NORTH BAY
LAKE NIPISSING
X MEMESAGAMESING COMPLEX
LAKE HURON
GEORGIAN BAY
PARRY SOUND
HUNTSVILLE
BRACEBRIDGE
LAKE SIMCOE
TORONTO
LAKE ONTARIO
BAY CITY
HAMILTON
LONDON
PORT HURON
BUFFALO
DETROIT
WINDSOR
LAKE ERIE
CLEVELAND
INDEX MAP
INTERNATIONAL BOUNDARY
0 50 100
SCALE IN MILES

FIGURE 1

List of Illustrations

Introduction

Problem: Little work has been done on the basic intrusions in the Canadian Shield. The only intrusives that have been studied in detail are important ore-bearing bodies such as the Sudbury lopolith. The purpose of this paper is to present a small contribution toward the study of one of the lesser known basic intrusions of the Shield. The study was undertaken after Dr. Gerald Friedman had suggested that the rocks of this intrusive have structural and petrographic characteristics similar to those found in the Bushveld Complex of South Africa and the Sudbury Complex of Ontario. This study pertains to the petrology and general geology of the intrusive.

Location: The Memesagamesing Complex is located in the Canadian Shield in Hardy township, Parry Sound District, Ontario about four miles north of the village of Loring. The intrusive is approximately four square miles in extent. A little more than half of it is covered by Memesagamesing Lake. The Caribou complex described by Friedman (1953, 1954) is located about six miles to the southwest.

Acknowledgments: The author is grateful to Dr. Gerald M. Friedman for his guidance and help in the preparation of this paper. He is also indebted to Dr. Friedman for the 2 V readings on the pyroxenes and the feldspar extinction angles. Thanks are extended to Dr. John L. Rich and Mr. Richard H. Durrell for help in the interpretation of the aerial photographs and the completion of the maps of the intrusive. Appreciation is extended to Mr. Richard R. Bruns and Mr. Richard Meinert for preparing the photomicrographs. To my wife, Betty, I extend my deepest thanks for the hours spent typing and correcting the manuscript and her encouragement to complete my graduate studies.

Method of study: Approximately two weeks were spent in the field, studying the intrusive and the surrounding area. Of these, two days were spent under the guidance of Dr. Friedman. The field work was supplemented by a study of two sets of aerial photographs. One set was prepared by the Ontario Department of Lands & Forests on the scale of 4" = 1 mile and the second set by the Department of Mines & Technical Surveys of Canada on the scale of 1" = approximately 5600 feet. Two maps of the area have been prepared based on field observations and aerial photographs. The overlay method (McCurdy, 1940) with modification by Rich (personal advice) was used in preparing the two maps.

Previous Work

Little previous detailed geological work has been done in the area. Reconnaissance work was carried out by Coleman during the summers of 1899 and 1900 when he reported (1900), "the rock is medium to coarse, grained diabase", and "heavily charged with pyrrhotite, pyrite, and chalcopyrite or of solid masses of these minerals". He further stated (1900) that, "with the exception of the pyrite . . . . this ore greatly resembles some varities of the Sudbury copper nickel ores".

A mine shaft was sunk by the Parry Sound Mining Company along the southeastern shore of the lake for the purpose of locating copper and nickel sulphides.

Satterly (1943) visited Memesagamesing Lake and obtained a number of grab samples of the disseminated chalcopyrite and pyrrhotite in the norite rocks located in the area of the old mine shaft. Satterly was the first to describe the basic rock as a norite.

General Geology

The area is underlain by Pre-Cambrian metamorphic rocks, of which granitic gneiss is dominant. Satterly (1943) points out that the origin of this gneiss has not been determined, but he believes that it has been formed from the injection or replacement of sedimentary gneisses by granitic material. This gneiss grades from a biotite to a biotite hornblende gneiss.

At the eastern and southeastern edge of the lake a narrow band of norite averaging 30' to 50' in width forms the eastern border of the intrusive. A narrow strip of norite averaging 10' to 20' in width crops out at the western border. The exact location of the northern border cannot be determined since that portion of the intrusive is covered by the waters of the lake.

A large peninsula extending out from the western shore separates the northern and southern parts of Memesagamesing Lake. An oval shaped part of this peninsula, approximately one mile long and one-half mile wide, forms the largest exposed norite mass of the intrusive. A few granite pegmatite dikes cut this norite mass and hold up long narrow ridges. The rest of this peninsula is made up of granitic gneiss. The peninsula as a whole is tied to the mainland by norite strips which have been intruded by granite pegmatites. The latter are probably responsible for the preservation of the ties to the mainland.

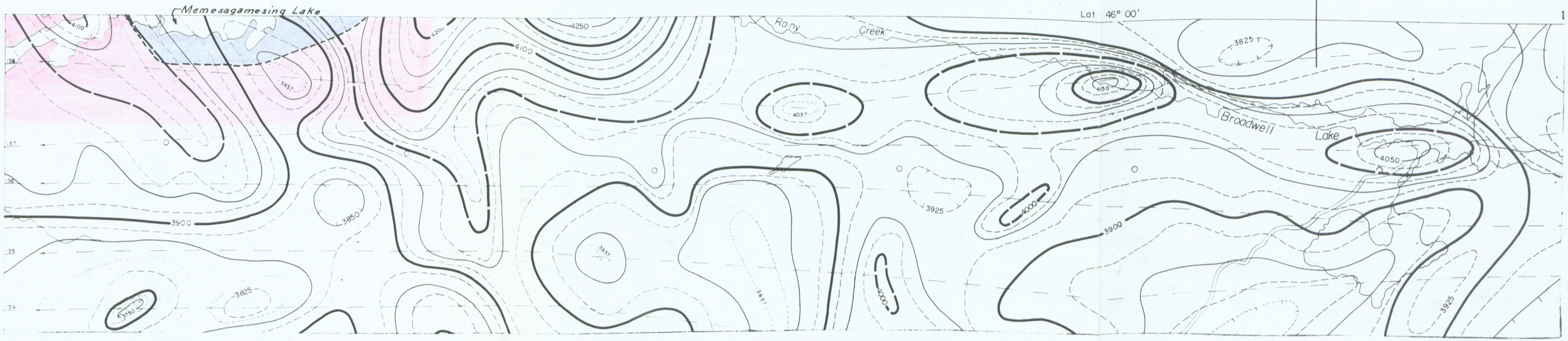
A few scattered islands make up the rest of the exposed part of the intrusive. Three islands consist entirely of olivine norite and one is made up of quartz-diorite. The rest are composed of typical norite.

Topographically the intrusion is located in an area consisting of low rock hills, averaging 650 ft. to 750 ft. above sea level. Satterly (1943) states that the Parry Sound District is located in the northern portion of the central highlands of southern Ontario and the area is sloping in a westerly direction toward the Georgian Bay.

The general pattern of the gneissosity of the surrounding metamorphics conforms with the planar elements of the intrusive. Structural data suggest a funnel-shaped intrusive with its center approximately located on the peninsula in the central part of the lake. The funnel-shape is indicated by the dips and strikes of the planes of foliation of the norite and the gneissosity of the surrounding granitic gneisses. Petrographic data also give suggestion of a funnel-shape; the marginal norite has a more calcic feldspar and a more magnesian orthopyroxene than the norite of the core. Study of aerial photographs indicates a roughly concentric alignment of topographical lows and highs approximately paralleling the structural data obtained in the field. There is a sharp contact between the norite and the country rock. Aeromagnetic interpretation leaves open the possibility that the feeder or conduit may plunge to the east. (Fig. 4)

AEROMAGNETIC MAP

MILLS SHEET
DISTRICT OF PARRY SOUND



LEGEND

500 GAMMA CONTOUR
100 GAMMA CONTOUR
50 GAMMA CONTOUR
25 GAMMA CONTOUR
INTERMEDIATE CONTOUR AS INDICATED
MAGNETIC LOW
NORITE
GRANITIC - GNEISS

1000 0 1000 2000 3000 4000 5000
SCALE IN FEET

MODIFIED FROM MILLS SHEET PREPARED BY
PROVINCE OF ONTARIO DEPARTMENT OF MINES

FIGURE 4

The Memesagamesing Complex has been intruded into an area that was later subjected to considerable post-intrusive block faulting. The faults differ in magnitude. Two faults intersect at the approximate center of the intrusive, however, no appreciable displacement was noted along the contact with the country-rock. They trend in NE - SW and NW - SE directions.

The more prominent of these two faults, the Rainy Creek fault, has a strike of N 76 - 80° W. It can be traced for approximately thirty miles on aerial photographs. The other is the Memesagamesing fault, which strikes N 35 - 45° E and can be traced for ten miles. Other prominent faults in the area are the Caribou Lake fault located approximately five miles to the south west, and the Wolf River fault located two miles south of Memesagamesing Lake. Both of the faults have an east-west strike and can be traced for twenty miles. Many minor faults are also located in the area. In general they have a NE-SW strike and can be traced on the average of five to ten miles.

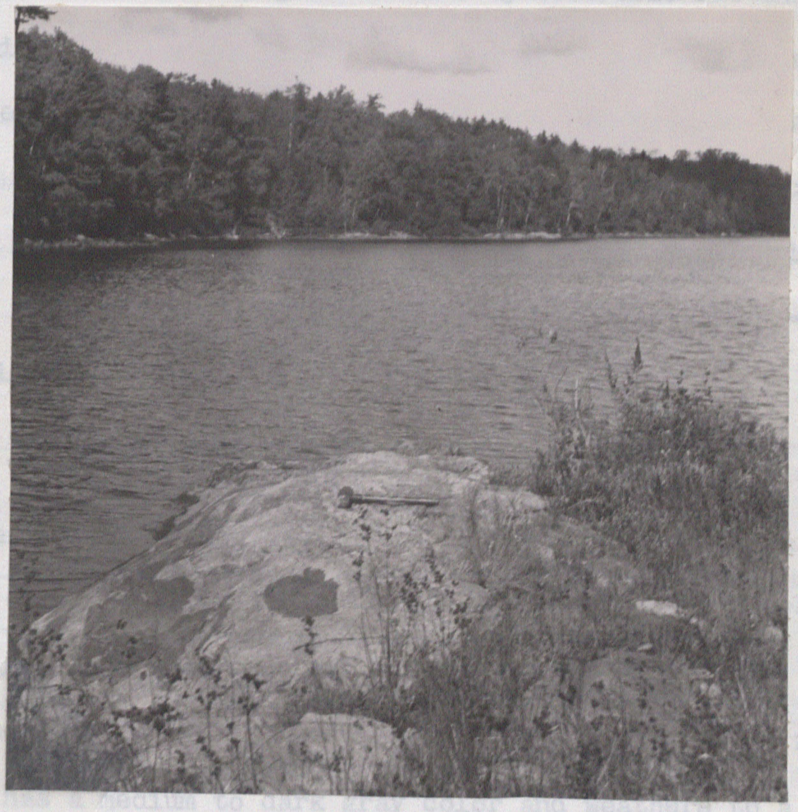
Jointing of the complex is quite evident on the aerial photographs of the area. The joints strike in a northeast direction or at right angles to the intrusive contact. These joints may be termed cross-joints. Most of the jointing is found in that exposed part of the intrusive which is located on the oval shaped part of the peninsula dividing the lake. The joints can be traced across the entire width of this part of the intrusive. This type of jointing occurs late in the cooling history of an intrusive in order to relieve stresses built up in the cooling of the magma. Satterly (1943) points out that well jointed norite was noted at an old abandoned prospect (Plate I). The strike of the joints at this point is N 85° W and their dip is 85° S. Balk (1937) cites a number of examples "to show that cross-joints in igneous masses form during essentially the same period that aplitic and pegmatitic rest-liquids are injected". The joints and fissure openings probably provided passageways for the pegmatites. The pegmatite dikes fill joints cutting the intrusive; widths of the pegmatites varies from 10 ft. to 15 ft. (Plates II & III). The strike of eight of the nine pegmatites measured in the field is N 46 - 65° E. The strike of the major granite pegmatites parallels the strike of the major joints. Metasomatism of the norite by the pegmatites gave rise to a diorite in the contact aureole, which usually has a width of five to ten feet.

During the Pleistocene period, the intrusion and the surrounding area were covered by a continental glacier. The advancing ice stripped this portion of the Canadian Shield of all soil leaving the exposed bed-rock. Evidence of the action of the ice is shown by the many glacial striae found at different sites in the main part of the intrusive. In those places where faulting and jointing had weakened the rocks, large masses of bed-rock were removed by the ice. Some of the hills of the area have been partially mantled by glacial debris.

Plate II

Granite Pegmatite dike cutting the Norite.

Plate III



Granite Pegmatite dike cutting the Norite.

Petrography

General Statement: The rocks of the intrusive and surrounding area include: norite, olivine norite, granite pegmatite, diorite, quartz diorite, diabase, granite, and granite gneiss. Of these the norite is most abundant. Olivine norite occurs as three local lenses. Granite pegmatite fills joints that cut the norite mass, while the diorite occurs in the contact aureole adjacent to the pegmatites. Primary quartz diorite outcrops at one locality on a southern island of the lake. The diabase occurs as dikes emplaced along the two major faults cutting the intrusive. Granite and granite gneiss makes up the country-rock surrounding the intrusive.

Norite: The norite which makes up the greater portion of the intrusive is possibly equivalent to a group of basic rocks that has been called the Buckingham series in the original Laurentian area (Wilson, 1941).

The rock has a medium-grained granitic texture. A fresh specimen has a medium to dark gray color and weathers to a reddish brown. Microscopic study shows that the essential minerals are labradorite, orthopyroxene, and clinopyroxene. A little over 50% of the slides examined indicate that orthopyroxene exceeds clinopyroxene in quantity. The norite has undergone cataclastic deformation and locally metasomatic replacement. The essential minerals show abundant granulation and mortar structure. The secondary minerals biotite, hornblende, garnet, quartz, scapolite, pyrite, pyrrhotite, magnetite, and apatite have formed at the expense of the pyroxenes and/or the feldspars.

The labradorite is variable in habit and ranges from large lath-shaped crystals to small jumbled fragments whose boundaries have little relationship to their crystallography. Effects of strain are shown by the following: bent twinning lamellae, strained extinction (?), and obliterated twinning striae. Labradorite crystals are locally clouded as a result of numerous minute inclusions. The significance of clouding in plagioclase has been recently discussed by Poldervaart and Gilkey (1954). Universal stage determinations indicate a variation in the feldspar composition from An_{48} to An_{58}. The more lime-rich plagioclase is found near the margin of the intrusive, while the more soda-rich feldspar occurs in the center.

As stated earlier the orthopyroxene is more abundant than the clinopyroxene. The chief orthopyroxene is hypersthene while the chief clinopyroxene is augite. The orthopyroxene varies in composition from En_{63} to En_{72}, the more magnesian-rich orthopyroxenes are found near the margin of the intrusive and the iron-rich orthopyroxenes are found near the center of the intrusive. Diallage parting is exhibited in the augite. Both pyroxenes generally occur in fairly well-formed crystals, but occassionally are found as interstitial grains between the plagioclase crystals. Intergrowths of pyroxenes, as described by Hess & Phillips (1938), are present in many of the slides examined (Plates IV & V). Oriented plates of orthopyroxene are intergrown in clinopyroxene parallel to the cleavage of the latter. Irregular intergrowth of the clinopyroxene in orthopyroxene occurs in far more cases than intergrowth of orthopyroxene in clinopyroxene. Some clinopyroxene is intergrown in orthopyroxene at almost right angles to the cleavage of the latter. Schiller structure and twinning found in both pyroxenes. Some pyroxene crystals have been bent. Cataclastic deformation has resulted in the presence of finely granular pyroxene fragments bordering large pyroxene crystals. Similar observations have been made on the plagioclase. In a number of slides the orthopyroxene exhibits a deep pink color, while the clinopyroxene is almost colorless. Locally a crude diabasic texture is found as a result of the pyroxene being interstitial to labradorite.

Garnets are found in practically all slides examined. In most cases they form reaction rims with quartz along the borders of pyroxene and plagioclase. The garnet is usually contiguous with the plagioclase, the quartz is near the pyroxene (Plates VI & VII). Garnet is the more prominent of the two minerals. The garnet has formed at the expense of the pyroxene and is also found in association with the other accessory minerals, biotite, hornblende, opaque minerals, and apatite (Plate VIII).

Opaque minerals were found in all slides examined. They are mostly titaniferous magnetite and are found in variable amounts. Apatite and the opaque minerals are usually intergrown with hornblende, biotite, or garnet (Plate IX). Since these minerals are of secondary origin, apatite and the oxides and sulfides must have formed at a late-stage in the history of the cooling of the intrusive. Peach (1947), Moorhouse (1953), and Friedman (1954) in their studies of other areas came to a similar conclusion.

Biotite is an important accessory mineral and occurs as well-formed euhedral greenish brown crystals. The highly pleochroic nature of this mineral is quite evident. It is found associated with other late-stage minerals that have formed at the expense of the pyroxenes. In a few cases it appears in long-narrow spherulitic bundles associated with the opaque minerals and with crystals of hornblende.

Hornblende is present in approximately the same amount in all the slides examined. For the most part is is found as narrow discontinuous rims and plates enclosing the pyroxenes and opaque minerals. It is brown in color, but locally it is of bluish color which indicates an introduction of soda. Bluish hornblende is locally intergrown with the opaque minerals, apatite, and quartz, and shows signs of having been formed from alteration of the pyroxenes (Plate X).

The quartz present in the slides is usually in interstitial anhedral grains in relation to the plagioclase. However, in one or two slides long tabular-shaped vein quartz is present indicating it was introduced at a late stage in the rock. Vermicular quartz in plagioclase was also noted in a few slides. Some quartz was found as inclusions in amphiboles.

The pegmatites have induced metasomatic changes in the norite and brought about the replacement of pyroxene by amphibole and biotite in the contact aureole. These minerals progressively increase in quantity as the pegmatites are approached. This suggests that the secondary silicates in the norites may also owe their existence to the emplacement of the pegmatites. The pegmatites are probably the source of the soda introduced into the bluish hornblende. From these observations it can be concluded that most of the secondary minerals in the norite have formed at a late stage in the cooling history of the norite.

Olivine Norite: The rock is found as three local lenses in the intrusive, making up the bed rock of three small islands located in the northern and southern part of the lake just east of the large norite mass of the peninsula. The fresh rock has a dark greenish gray to black color, which upon weathering changes to a rusty-brown. It has a medium to coarse grained granitic texture. Minerals recognizable in the hand specimen are olivine, in greenish tinted grains which weather red brown; biotite, in dark brown book-tablets; and irregular crystals of grayish-green plagioclase up to 2-3 millimeters wide, which make up approximately 50% of the mineral content, and along with the green tinted olivine, give the rock a grayish-green cast.

A study of three thin sections of the rock shows that the plagioclase is deeply clouded. This clouding is caused by minute inclusions of foreign oxides, probably spinel (Poldervaart & Gilkey, 1954), which give the plagioclase its green color in the hand specimen. The clouding of the plagioclase has obliterated or obscured the twin-lamellae in most cases. Olivine is locally found as inclusions in lath-shaped crystals of plagioclase, which are in turn enclosed in large plates of pyroxene. Cataclastic deformation has resulted in the presence of finely granular pyroxene bordering the lath-shaped plagioclase crystals (Plate XI).

Oriented and irregular blobs of clinopyroxene are intergrown in orthopyroxene parallel to the cleavage of the latter. Locally the clinopyroxene forms narrow borders around large plate of orthopyroxene. The clinopyroxene was formed later than the orthopyroxene and seems to have formed, at least in part, at the expense of the orthopyroxene. The clinopyroxene contains corroded orthopyroxene relicts. Locally the orthopyroxene shows moderate plechroism.

Olivine is separated from the plagioclase by three and four-shell coronas (Plates XII, XIII, & XIV). Orthopyroxene forms a rim bordering the olivine, followed by a thin veneer of spinel and the outer shell is a symplektite of undetermined composition. A clinopyroxene appears to be included in the outer shell and locally garnets form a fourth corona and border the plagioclase.

Shand (1945) applies the term "corona" to the sheaths or shells separating the different minerals, while other writers call them "reaction rims". He is of the opinion that the term "corona" should be reserved for reaction rims of the discontinuous type, especially those composed of more than one shell. The minerals which compose these shells are called "synantetic" minerals. Shand noted that coronas are not the products of magmatic crystallization. The arguments which he presents seem valid against the older view that the formation of the coronas resulted from late stage magmatic reactions or to the operation of "mineralizing agents". He believes that thermal metamorphism is the answer to the problem and refers to a number of localities throughout the world where this has been borne out. Friedman (1954) points out that Shand's contentions are again confirmed in the Caribou Complex. The writer feels that the necessary thermal metamorphic conditions occurred at Memesagamesing for the development of the coronas. The numerous pegmatite dikes in the area could supply thermal action that would bring about the development of the coronas. It should be stressed that small pegmatite dikes (too small to be mapped) abundantly cut and permeate the norite body.

The opaque minerals are locally intergrown with biotite and a green spinel (Plate XV). The intergrowths are bordered by reaction rims which separate them from the plagioclase. An inner symplektite of undetermined composition surrounds this intergrowth and biotite stringers permeate the symplektite. A second rim lacking biotite is likewise of undetermined composition and the third and outer rim is made up of garnet.

Brownish colored amphibole is found in olivine norite, whereas the amphibole of the norite is commonly green. A blue colored amphibole is found locally, indicating an introduction of sodium. A bluish amphibole has been noted in the diorite and norite. The pegmatites are thought to be the source of the alkalies. Shand (1942) believes that the brown color of hornblende has to do with the degree of oxidation or hydration of the iron present. Friedman (1954) noted that the hornblende of the olivine norite in the Caribou intrusive is brownish- while that of the norite is predominantly green. From this it is apparent that the rocks with the higher magnesium content (olivine norite) carry a brown hornblende, while the hornblende of the more iron-rich (norites) are green.

Granite Pegmatites: The granite pegmatites are coarse-grained dikes which fill joints in the norite. The width of these dikes varies up to twelve to fifteen feet. Essential minerals are microcline, oligoclase, quartz, and muscovite in varying amounts. Muscovite is the predominant mica with biotite appearing locally. In the outer zone of some of the pegmatites small red garnets are abundant. The quartz has a dirty white color and locally occurs interstitually with the other constituents. The feldspar occurs in well-developed euhedral crystals.

The pegmatites are zoned and are restricted to the norite body. These zoned pegmatites have a quartz core followed by a zone composed of feldspar, quartz, and muscovite. An inner feldspar zone can be made out locally. This zone contains minor amounts of quartz and muscovite. An outer zone with abundant mica and minor quartz surrounds this inner core. In the surrounding metamorphic rocks "unzoned pegmatites" (using the nomenclature of Page & others (1953), are abundant.

Corroded xenoliths of basic rock are found in some of the pegmatites. Recrystallization has taken place in the adjacent norite. The planes of foliation of the altered rock parallel the strike of the pegmatites. Friedman (1954) states that chemical analyses of the Caribou Complex show that alkalies have been introduced into the aureole of the pegmatite. The fact that assimilation has taken place between the pegmatite liquid and the country rock is shown by the presence of biotite and garnet in the pegmatites.

Diorite: The diorite is found along the contact of granite pegmatite and norite. It is a secondary diorite that has formed at the expense of the norite as a result of the metasomatism induced by the granite pegmatites and forms a contact aureole. A fresh specimen of the rock has a light gray color and the texture varies from granitic to a slight gneissic and locally diablastic. The ferromagnesian minerals have been grouped together in rough bands or layers. The essential minerals are plagioclase, hornblende, and biotite. Accessory minerals include quartz, epidote, sphene, garnet, pyrite, and magnetite.

Microscopic study of the rock shows that the plagioclase has a much fresher appearance than the plagioclase of the norite. Evidence that the original plagioclase has been subjected to metasomatism is: progressive zoning, and obliteration of twin lamellae (using criteria cited by Emmons & Mann, 1953). The relative amount of hornblende and biotite vary, hornblende is usually more prominent than biotite. Both minerals are found as long tabular subhedral to euhedral crystals with well defined cleavage. The hornblende crystals contain small quartz grains which results in a diablastic texture (Plate XVI). A bluish tint found in some of the hornblende indicates the introduction of soda from the pegmatites.

Garnet reaction rims are found between plagioclase and amphibole. This amphibole replaced an original pyroxene which indicates formation of reaction rims between the pyroxene and plagioclase first, followed by subsequent replacement of pyroxene by bluish hornblende. The accessory minerals epidote, sphene, and the opaque minerals are found intergrown with both hornblende and biotite.

Rock specimens taken near the pegmatite contact show an absence of pyroxenes. A check of specimens taken at some distance from the pegmatites show that pyroxenes appear and increase in abundance with increasing distance from the pegmatites. The diorite gradually grades into the norite.

Quartz Diorite: The quartz diorite outcropping on the most southern island of the lake is believed to be the only primary diorite in the area. However, a certain amount of doubt can be raised as to its primary origin. Fresh-looking feldspar and prismatic hornblende are found in the rock. The quartz is locally abundant and rarely is enclosed in the hornblende. Twinning is absent in the feldspars, while zoning is rare to absent. The hornblende contains small feldspar crystals and very little biotite is found. Gorai (1950), and Emmons & Mann (1953, p. 51) contend that metasomatic action may have brought about the absence of twinning in plagioclase.

Diabase: Labradorite and clinopyroxene are essential primary minerals of the diabase. The accessory minerals include titaniferous magnetite, pyrite, and apatite. Locally micropegmatite and interstitial quartz are found. The diabase is medium-grained and of subophitic texture. Hornblende, biotite, chlorite, serpentine, garnet, and probably some titaniferous magnetite are of secondary origin.

The diabase occurs as dikes that have been emplaced post-faulting along Rainy Creek Fault and Memesagamesing Fault. Three feldspars are found in the rock, which are as follows: (1) 72% An, (2) 60½% An, and (3) 45% An. The first two feldspars are the dominant ones in the rock. The clinopyroxene has a 2 V of 43° indicating a diopsidic augite.

Granite and Granite Gneiss: The surrounding country rock into which the norite intrusive has been emplaced is made up of granite and granite gneisses of variable texture. Satterly (1943) calls the gneisses of this area "hybrid gneisses", but there is some doubt as to their origin. He believes that most of them are derived from the injection or replacement of sedimentary gneisses by granitic material.

Microscopically, the gneiss is found to consist mostly of plagioclase with minor amounts of quartz, biotite, opaque minerals, and garnets. The plagioclase shows evidence of strain or having been subjected to cataclastic deformation. Some clouding of the plagioclase was noted. The biotite and garnet were probably derived from recrystallized basic sediments.

Mineralization

Two prospects have been opened in the area near the east contact with the gneiss. In 1899 and 1900 Coleman reported mineral prospects along the southeastern shore of the lake. The Parry Sound Copper Mining Company had sunk a shaft to a depth of about thirty feet. At the time of Coleman's visit the shaft was full of water. However, an inspection of the rock on the dump revealed norite, heavily charged with pyrrhotite, pyrite, and chalcopyrite and solid masses of these minerals. Coleman stated " . . . . this ore has a striking likeness to the Sudbury copper nickel ore". Satterly (1943) visited the same prospect and took three, five, and twelve-pound grab samples of mineralized norite. The results of the assays are given in table # 1.

Table # 1

Sample	Copper	Nickel
3-pound	0.17%	0.22%
5-pound	0.05%	-----
12-pound	0.68%	0.71%

A second prospect is located on the southeast point of an island in the lake. A pit 10 by 10 feet and 6 feet deep was sunk in rusty-weathering norite. The rock is sparsely mineralized with pyrrhotite and pyrite. Satterly (1943) reports that a grab sample upon assay gave negative results for both copper and nickel.

While the writer was mapping the intrusive a small piece of a drill core was obtained. This sample was taken from the norite, the exact depth of the sample was not available. Thin section study showed the composition of this rock to be identical with norite elsewhere in the area, no indication of mineralization was noted.

The oxides and sulfides sampled at the prospects have formed by replacement of the norite. Locally the opaque minerals enclose pyroxene relicts. Most opaque minerals studied in thin sections are anhedral, except for pyrite, which is commonly euhedral. Chalcopyrite locally forms a thin narrow band between the pyrrhotite and pyrite. In the three polished sections studied, magnetite forms small inclusions in pyrrhotite. Garnet and quartz are locally intergrown to form reaction rims which separate the primary norite from the opaque minerals. Biotite and hornblende are found in association with the opaque minerals. This association shows that the ore formed during the late stages of the cooling history of the magma and replaced the norite.

Aeromagnetic Interpretation

The unit of measurement in magnetic exploration is the gauss. A gauss may be defined as the intensity of a magnetic field that will act on a unit magnetic pole with a force of 1 dyne. In geomagnetic work only small changes in the intensity of the earth's magnetic field are measured. For this reason a more convenient unit of measurement, the "gamma", was adopted. This unit has been defined as 1/100,000 part of a gauss of 10^{-5} gauss.

In geomagnetic work the magnetic anomalies at the earth's surface are measured. These anomalies are caused by variations in the distribution of the magnetized material beneath the surface. Certain rocks exhibit the properties of magnets and they super-impose their own magnetic fields on that of the earth. The super-imposed fields are termed major, continental, regional, and local anomalies, depending on the scale of the geologic irregularities which produce them (Jakosky, 1950).

In studying the magnetic anomalies of the basic intrusion at Memesagamesing Lake an aeromagnetic map prepared by the Ontario Department of Mines was used. A map covering the whole area was not available; however, the Mills sheet covers the southern part of the intrusive.

This map shows that the highest anomalies in the area are east of the main part of the intrusive and adjacent to it. Gamma contours of 4000 to 4250 are noted there. More than one explanation can be used to account for these high anomalies. First of all, the feeder of the intrusive could be plunging in a southeasterly direction. Secondly, mineralization of the rocks in that area would bring about a pattern such as is found on the aeromagnetic map. Further investigation of this problem, particularly gravity work and drill coring, is needed to find the reason for the high anomalies.

The map also shows that the anomalies along the Rainy Creek Fault increase as the intrusive is approached from the south east. Field investigation of the area along the fault shows that diabase dikes have been emplaced, post-faulting. These diabase dikes probably account for the high anomalies.

Trace Elements

Spectrographic analyses were made of norite and olivine norite. Although the data are essentially qualitative the trace elements can be estimated within the limits stated beneath table # 2.

Traces of boron were found in the olivine-bearing norite but not in norite. Boron, like beryllium, is characteristic of the late stages of magmatic crystallization (Rankama & Sahama, 1949). Sahama (1945) noted that in the basement complex of southern Lapland the boron content decreases from the ultrabasics to the gabbros and drops to a very small amount in granite. During serpentinization a large amount of boron is introduced. Rankama & Sahama (1949) contend that the boron content increases with the increase of serpentine in the rocks. This line of reasoning could hold at Memesagamesing. While the olivine-norite has been subjected to serpentinization, this is not the case with the norite.

Manganese shows the highest concentration in the olivine-bearing norite and falls off in the norite. This is explained by the higher mafic content in the olivine-norite.

As the table # 2 shows traces of Cr, Co, Cu, Pb, Ni, Ti, and Va were found in both rock specimens. No important conclusions can be drawn from these findings.

Table # 2

Rock	Olivine-Norite	Norite
Location		
Bo	T	ND
Cr	T	T
Co	T	T
Cu	T	T
Pb	T	T
Mn	L	T-L
Ni	T	T
Ti	L	L
Va	T	T

Key to amounts:

L	low	0.1 to 1.0%
T-L	trace-low	0.005 to 0.50%
T	trace	less than 0.10%
ND	none detected	

Looked for but not found in both rocks: Sb, As, Be, Bi, Cd, Ce, Cb, In, Hg, Mo, Ag, Ta, Te, Th, Sn, W, U, Zm, Zr

Clouded Plagioclase

Clouded feldspars were noted in both norite and olivine norite. In the norite the clouding varies from slight to medium. The clouding noted in the olivine norite was very pronounced and renders some of the crystals almost opaque.

Minute particles distributed throughout the crystal are believed to be the reason for this clouding. Close examination of these particles under high powers of magnification show that they appear to be rod shaped rather than spherical. Poldervaart and Gilkey (1954) contend that it is quite possible that the small specks are cross sections of rods. These rod-shaped particles have a somewhat variable orientation. The smallest particles appear randomly distributed throughout the crystal. According to Reynolds (1936) larger particles are oriented parallel to albite composition planes. The intensity of the clouding is regulated by the distribution of the particles, locally the intensity is increased or decreased by irregular distribution.

The exact composition of these particles is difficult to determine even under high powers of magnification; however, it is thought by most petrologists that iron ore usually makes up the particles. At Memesagamesing the particles are thought to be small microlites of spinel. Those particles or microlites that can be determined or identified with ease under medium powers of magnification are generally not included in the phenomenon of clouded plagioclase.

According to MacGregor (1931) the clouded plagioclase is attributed to thermal metamorphism. He is of the opinion that the particles producing clouding probably consist of iron ore minerals. The heating brought about by thermal metamorphism resulted in exsolution of iron originally contained in the plagioclase in solid solution. To MacGregor the clouding was a mark of low-grade thermal metamorphism of pre-existing plagioclase. Many petrologists have accepted MacGregor's theory on the clouding and have even carried it to the point where the occurrence of clouding in a rock is taken as evidence for thermal metamorphism. Recently this phenomenon was restudied by Poldervaart and Gilkey (1954). It is their contention that the strongly clouded plagioclase is produced by diffusion of extraneous material into the crystal after its formation.

At Memesagamesing the conditions are such as to indicate that the clouding of the plagioclase may have been brought about by thermal metamorphism. Numerous pegmatite dikes would develop thermal metamorphic conditions, which MacGregor contends, are necessary for the formation of clouding.

Shand (1945) in discussing the importance of olivine in the formation of coronas introduces information that might add to Poldervaart and Gilkey's theory on clouded plagioclase. He notes that olivine in the course of serpentinization liberates iron ions and these ions travel all the way from olivine to plagioclase. Upon introduction into the lattice of the plagioclase crystals the ions could precipitate out in the form of small particles or microlites, which result in the clouding effect. The formation of the coronas in the olivine norite at Memesagamesing could release the necessary iron ions that later make up the clouding particles in the plagioclase.

Summary of Events

The first major development in the Memesagamesing complex was the emplacement of the intrusive into the surrounding granite gneisses. After consolidation of the intrusive the formation of the joints took place. The granite pegmatite dikes ascended many of the fractures. Metasomatic alteration of the adjoining norite accompanied the emplacement of the pegmatite dikes. Secondary diorite resulted from this metasomatism. The major faults of the intrusive area formed later than the norite.

The last major event of the Memesagamesing complex was probably the emplacement of late-stage diabase dikes along both Memesagamesing and Rainy Creek faults. These dikes show no evidence of fault displacement.

The chronologic sequence of events can be summarized as follows:

1. Emplacement of the Memesagamesing complex;
2. Formation of joints;
3. Emplacement of the granite pegmatites and metasomatic alteration of the norites;
4. Faulting;
5. Emplacement of the diabase dikes.

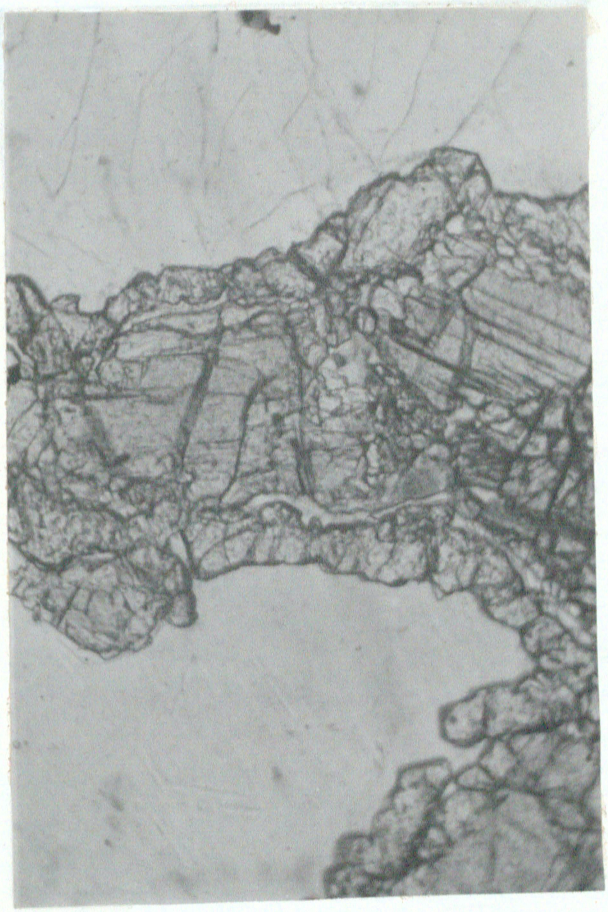
Plate IV

Norite: Intergrowth of Orthopyroxene and Clinopyroxene. Crossed Nicols. x 85

Plate V

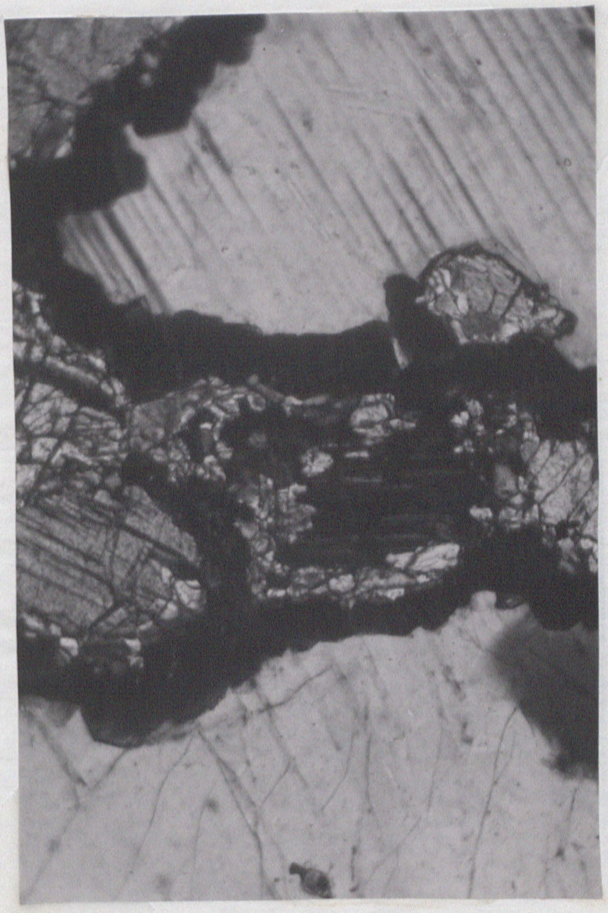
Norite: Intergrowth of Clinopyroxene and Orthopyroxene. Crossed Nicols. x 85

Plate VI



Norite: Reaction Rim of Garnet and Quartz Separating Pyroxene from Plagioclase. Plain Light. x 85

Plate VII



Norite: Reaction Rim of Garnet and Quartz Separating Pyroxene from Plagioclase. Crossed Nicols. x 85

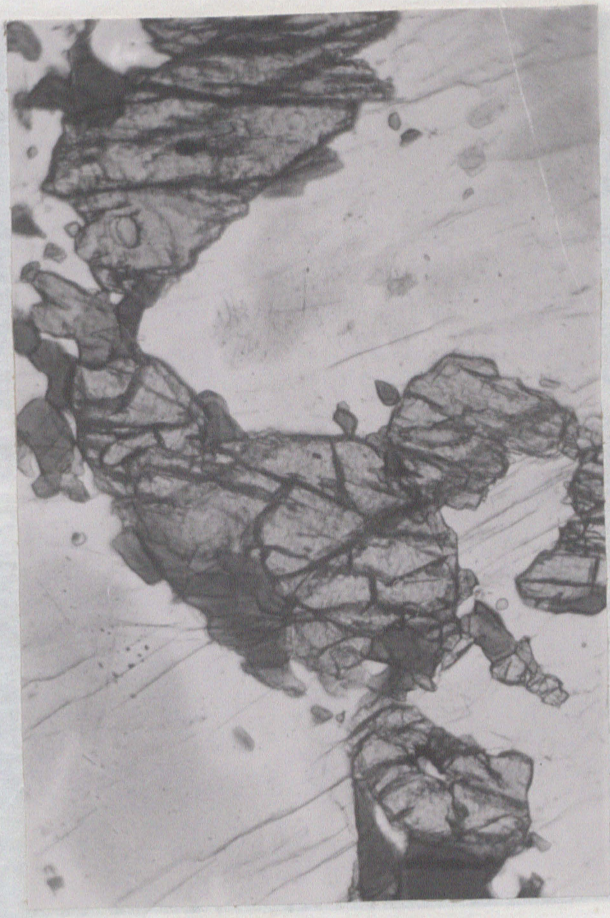
Plate VIII

Norite: Garnet Reaction Rim, Intergrowth of Biotite and Opaque Minerals. Clouded Plagioclase. Plain Light. x 85

Plate IX

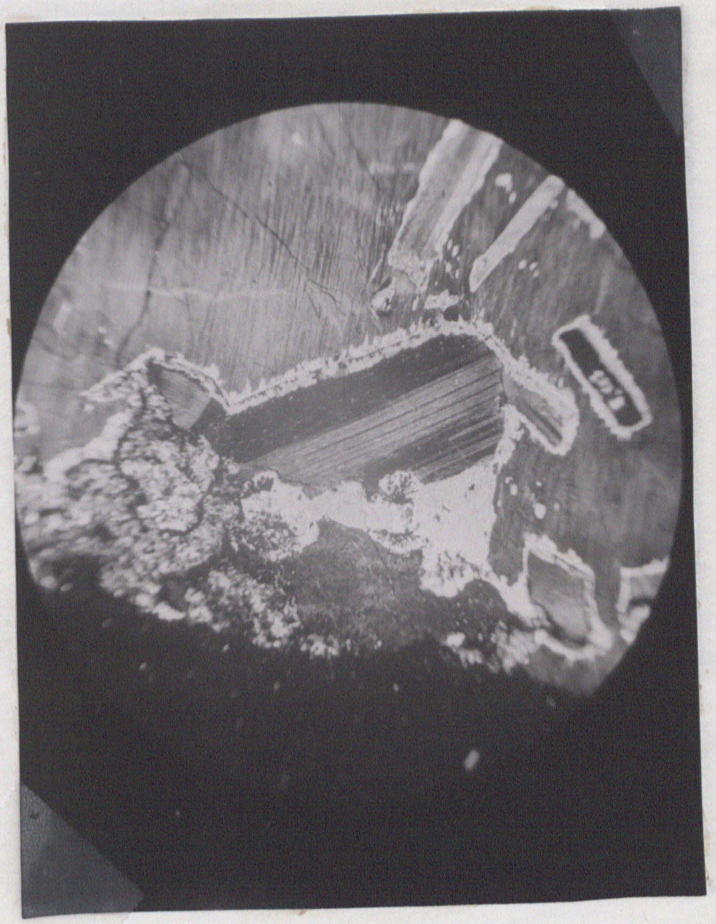
Norite: Replacement of Pyroxene by Opaque Minerals and Formation of Garnet Reaction Rims. Plain Light. x 85

Plate X



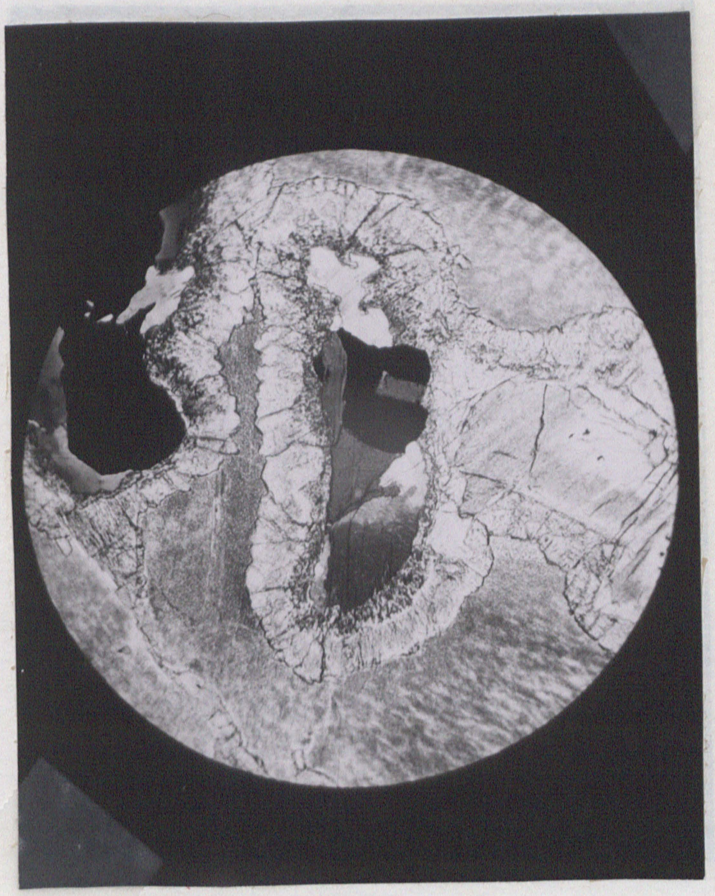
Norite: Marginal Replacement of Pyroxene by Hornblende. Slight Clouding of Plagioclase. Crossed Nicols. x 85

Plate XI



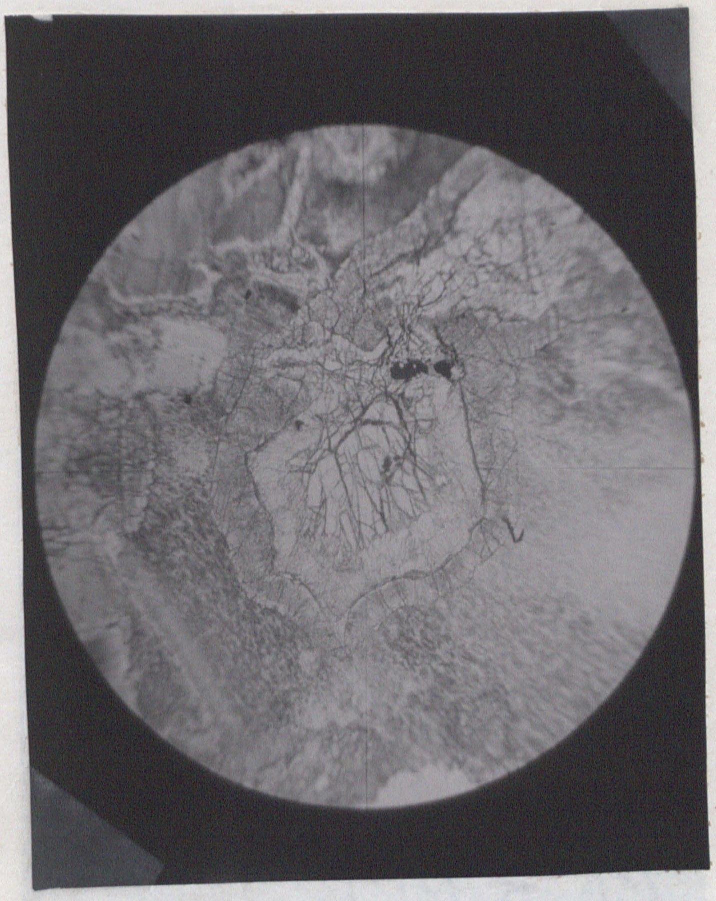
Olivine Norite: Plagioclase surrounded by narrow Reaction Rim, Olivine inclusions in lath-shaped crystals of Plagioclase, which are in turn enclosed in large plates of Pyroxene. Crossed Nicols. x 28

Plate XII



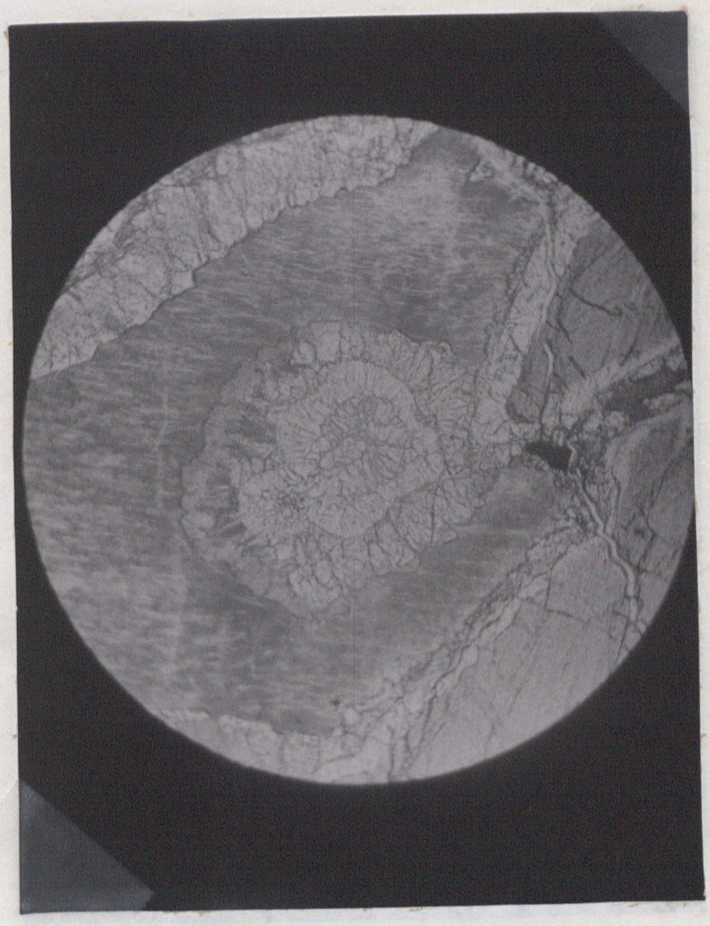
Olivine Norite: Corona with Olivine, Opaque Minerals and Biotite as central core, followed by shell of undeterminable composition, outer shell consists of Garnets. Plain Light. x 28

Plate XIII



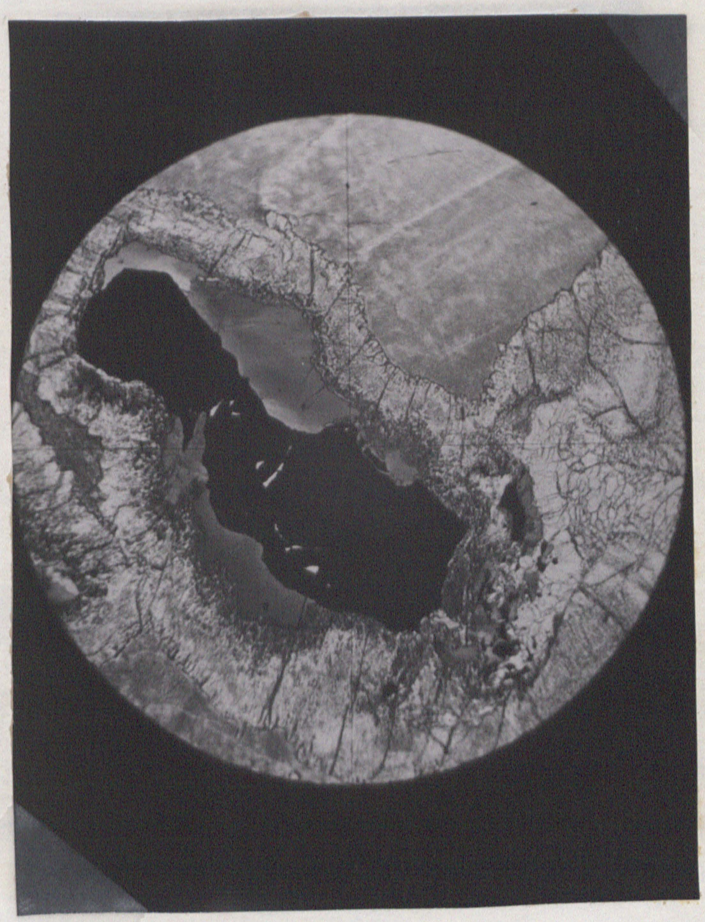
Olivine Norite: Complex Corona in Plagioclase with Pyroxene core surrounded by shell of Garnets. Plain Light. x 28

Plate XIV



Olivine Norite: Same as Plate XIII. x 42

Plate XV



Olivine Norite: Corona with Opaque Mineral core in association with Biotite, followed by a shell of undeterminable composition, outer shell of Garnets. Plain Light. x 28

Plate XVI

Diorite: Hornblende with Diablastic
Quartz. Plain Light. x 85

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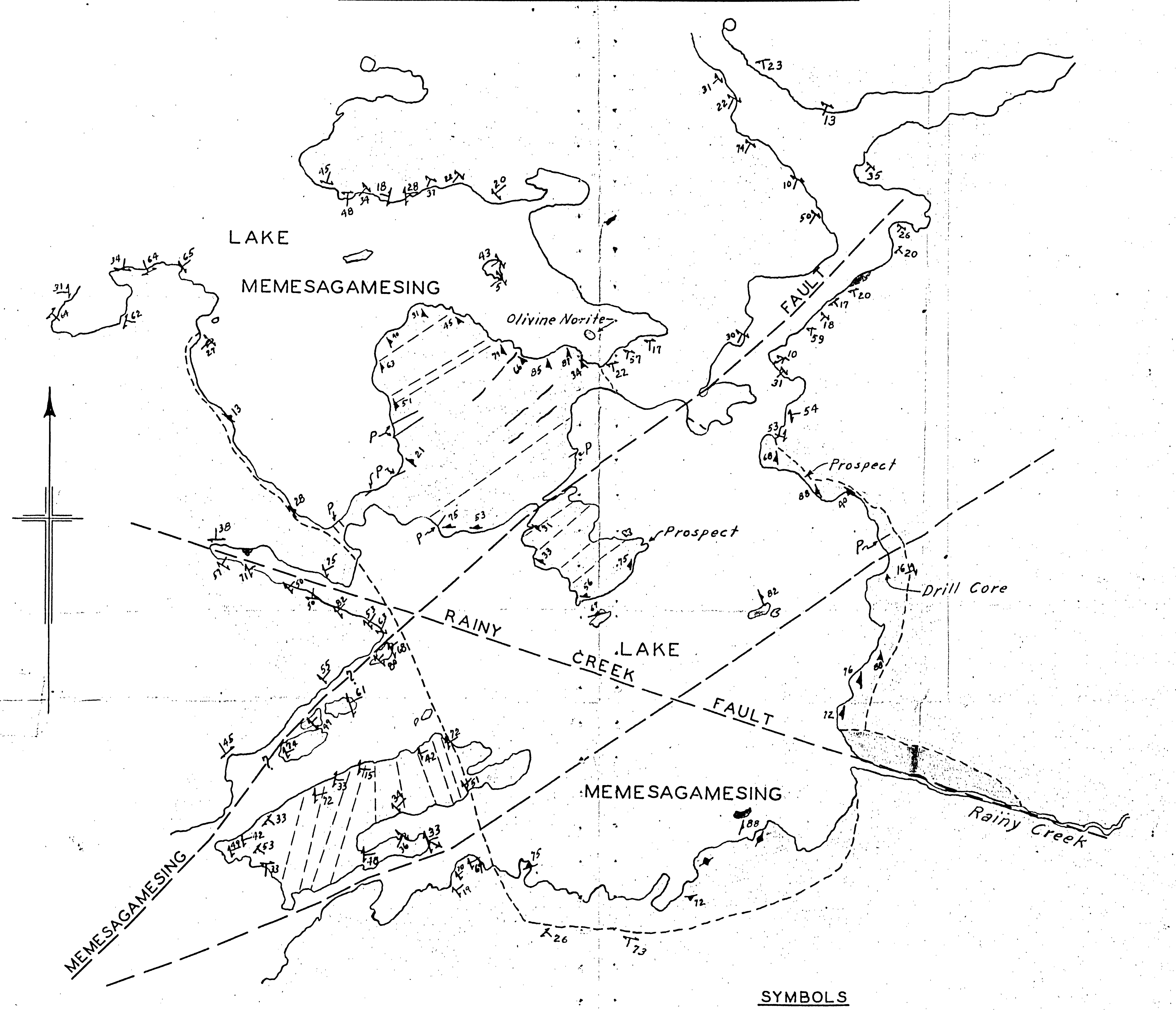
GEOLOGIC MAP OF MEMESAGAMESING LAKE COMPLEX



LEGEND

GRANITE - GNEISS
OLIVINE NORITE
NORITE
GRANITE PEGMATITE
QUARTZ DIORITE
DIABASE

SYMBOLS

GEOLOGIC BOUNDARIES
FAULTS
JOINTS OR SHATTER BELTS
TRENDS-APPARENT ON AERIAL PHOTOS
STRIKE & DIP
STRIKE & VERTICAL DIP
GNEISSOSITY - INCLINED
GNEISSOSITY COMBINED WITH LINEATION

0 1/2 1
SCALE IN MILES

FIGURE 2

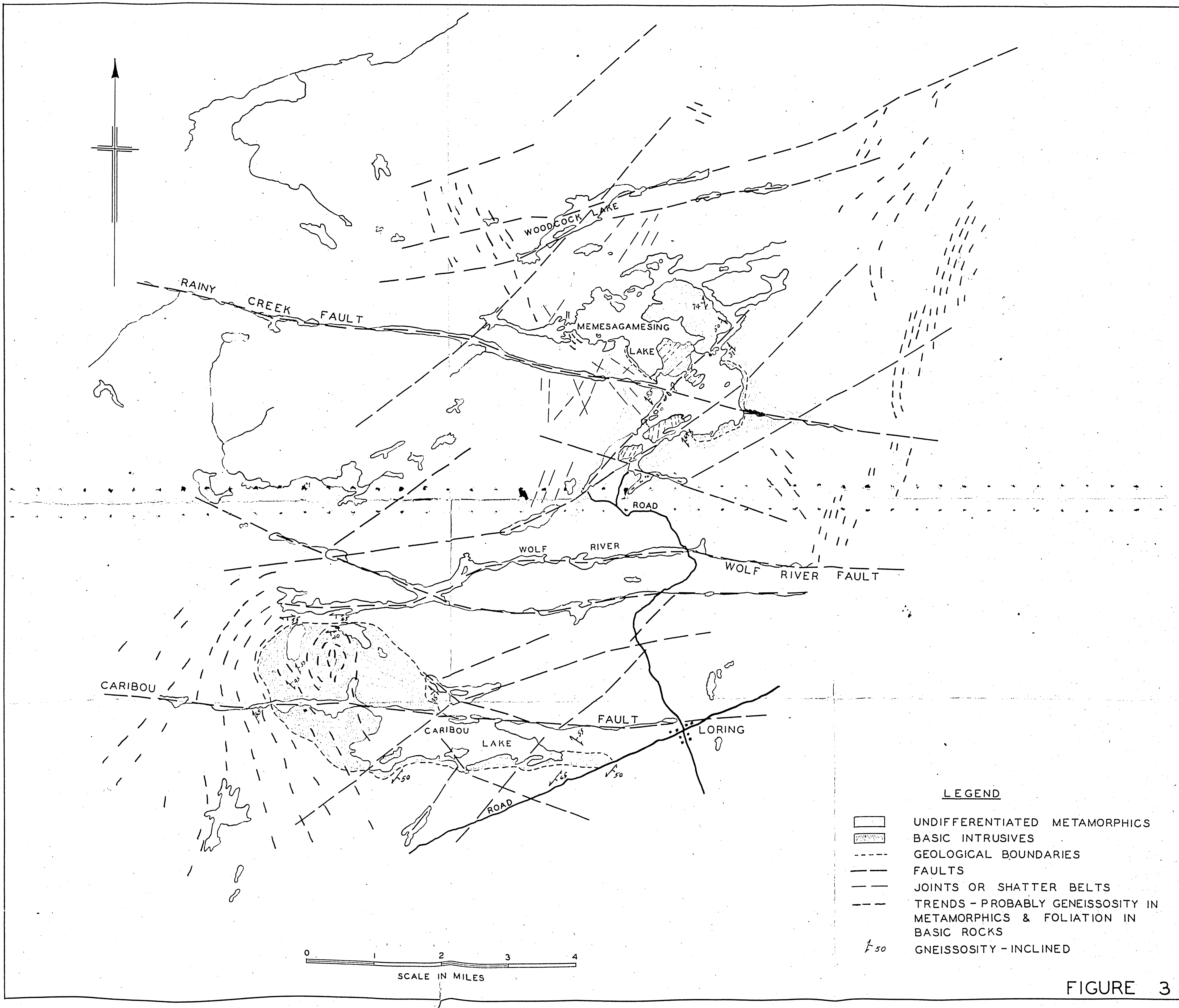

WOODCOCK LAKE
RAINY CREEK FAULT
MEMESAGAMESING LAKE
ROAD
WOLF RIVER
WOLF RIVER FAULT
CARIBOU FAULT
CARIBOU LAKE
LORING
ROAD
LEGEND
UNDIFFERENTIATED METAMORPHICS
BASIC INTRUSIVES
GEOLOGICAL BOUNDARIES
FAULTS
JOINTS OR SHATTER BELTS
TRENDS - PROBABLY GENEISSOSITY IN METAMORPHICS & FOLIATION IN BASIC ROCKS
GNEISSOSITY - INCLINED
0 1 2 3 4
SCALE IN MILES

FIGURE 3