GEOLOGICAL INVESTIGATIONS OF THE LYNN LAKE BASIC INTRUSIVE BODY NORTHERN MANITOBA

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TABLE OF CONTENTS

CHAPTER I

INTRODUCTION

Page

CHAPTER II

PETROLOGY

CHAPTER III

STRUCTURE

CONTENTS (continued)

CHAPTER IV

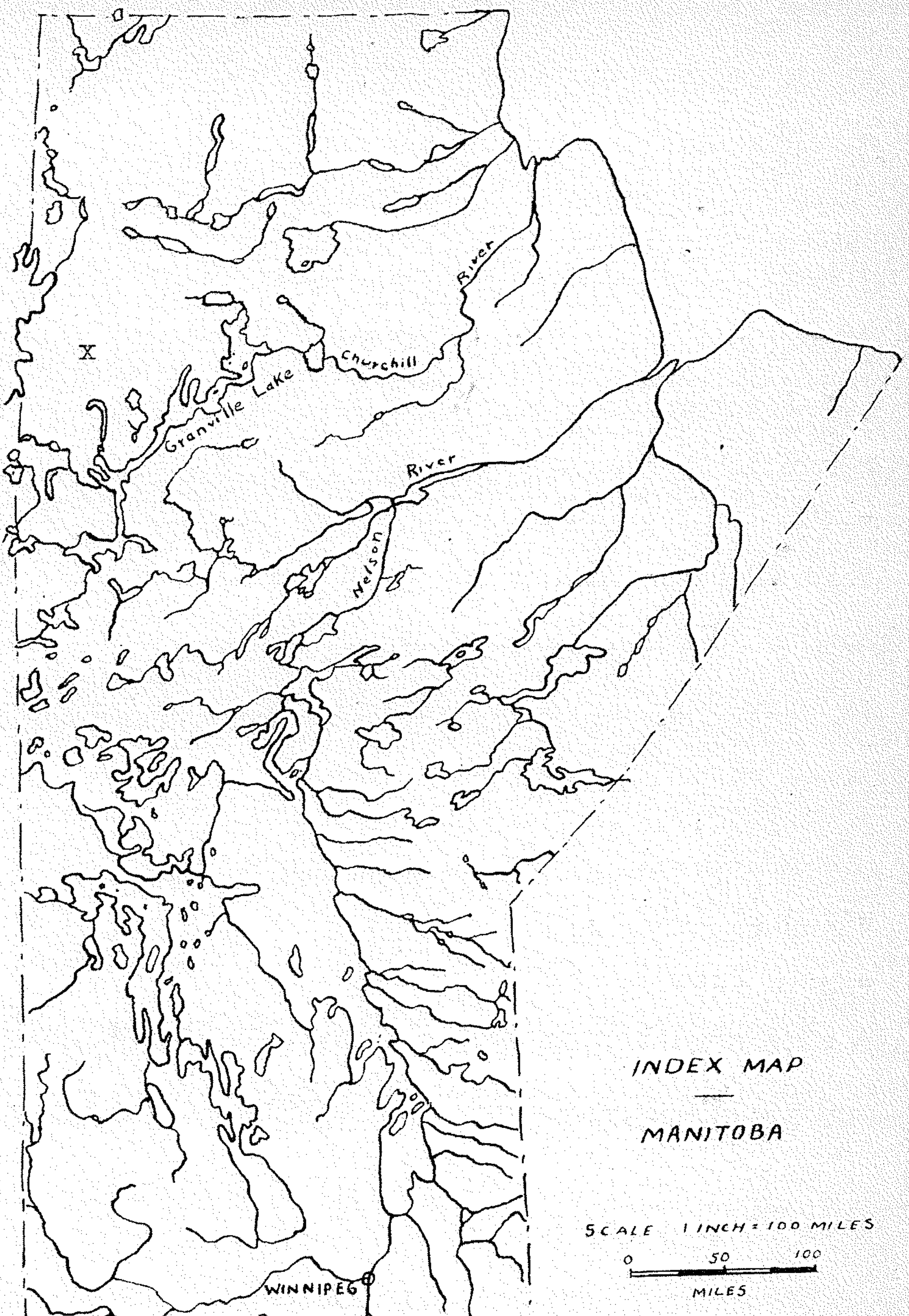
THE ORE BODIES

CHAPTER V

SUMMARY OF CONCLUSIONS

LIST OF PLATES AND ILLUSTRATIONS

LIST OF PLATES AND ILLUSTRATIONS



x - Approximate location of Map Area.

Figure 1.

from Sherridon during the winter months. A water route for canoe travel extends from Sherridon to Lynn Lake, but the route is long and numerous portages make it impractical.

Topography

The topography of the map area is typical of most of the Precambrian terrain of the region. Relief is low, but alternating ridges and low ground give the country a rugged appearance. Outcrops are few and the ridges are mainly of glacial drift, sand, and boulders. Few of the ridges rise more than 50 feet above the surrounding muskeg except several high ridges of sedimentary rocks in the eastern part. Within the area covered by the intrusive body, the ridges are more or less parallel, and trend generally from north 10 degrees east to north 30 degrees east.

Areas of low ground, swamp, and muskeg lie between the ridges and cover extensive parts of the east and south of the map area. The western part of the intrusive body is marked by low ground, and Lynn Lake lies in the southwest corner of this part.

Within the area of the intrusive body, outcrops are rare and are confined mainly to several large ridges. A few scattered outcrops occur on the smaller ridges and within the muskeg. Outcrops are more plentiful near the north contact, and the area of the bordering volcanic and sedimentary rocks.

History of the Area

In 1940 Austin McVeigh, prospecting for Sherritt Gordon Mines, Limited, found a small occurrence of sulphides on an isolated outcrop about 200 feet north of Lynn Lake. Assays made of the sulphides showed a fair nickel and low copper content.

The discovery was not publicized as it was not possible to secure men, materials, and transport facilities for development in war time. In 1945 claims were staked in the Ralph Lake-Lynn Lake area, and a diamond drill was flown in. A magnetic anomaly outlined by Austin McVeigh near Ralph Lake proved to be magnetite, and the drill was moved to Lynn Lake where a weak magnetic anomaly had been outlined near the original sulphide showing.

The first drill hole encountered low value sulphides and the second was abandoned owing to the difficulty of penetrating the overburden. The third hole intersected 100 feet of ore-grade sulphides. Extensive staking was started and continued over the freeze-up period. After freeze-up, men and materials were flown in, and construction was begun on a 160 mile tractor road from Sherridon. Heavy machinery and building materials, including prefabricated camp buildings, were transported over this route.

Exploration and development have been carried on since 1945. The sinking of a five compartment shaft on the 'A' ore body was begun on June 20th, 1948, and was completed to a depth of 1024 feet by July 3rd, 1949. To January 1950, a total of 205,000 feet of surface diamond drilling, and 27,100 feet of underground drilling had been done, and 3200 feet of underground workings had been completed. Five ore bodies have been outlined and to date more than 11,000,000 tons of ore have been blocked out.

Previous Geological Work

Prior to 1912, only rapid reconnaissance surveys of the Granville Lake district had been made near the main water routes. After this date more detailed reconnaissance work was done south of the Churchill River. In 1932 a detailed reconnaissance survey of the Granville Lake district was begun by J. F. Henderson and was continued in 1933 by G.W.H.Norman, and in 1935 by D.L.Downie.

The results of the surveys of Henderson, Norman and Downie, were included in the Geological Survey of Canada, Summary Report, 1933, Part 'C', and in Maps 343A and 344A, the west and east half of the Granville Lake Sheet respectively, issued by the Department of Mines, Ottawa, on a scale of 1 inch to 4 miles. The Lynn Lake area is included in the west half of the Granville Lake sheet.

A group of five map sheets, covering an area approximately 47 miles East-West and 17 miles North-South, including the Lynn Lake area and extending eastward, was mapped by the Manitoba Mines Branch during the summers of 1946-48 inclusive. The Lynn Lake area was mapped by J.D.

Allan in 1946 and the Report was published as Manitoba mines Branch Report 46-2, 1946.

Part of the southeast corner of Lynn Lake area lies within the McVeigh Lake area mapped by J. D. Bateman on a scale of 1 inch to 1500 feet in 1940. This map, with a detailed geological survey report was issued in 1945 as Geological Survey of Canada, Paper 45-14.

A study of the nickel-copper ores of Lynn Lake was carried out by J.D.Allen at the Massachusettes Institute of Technology during 1947-48. The results of this work are contained in an unpublished thesis entitled, "Geological Studies of the Lynn Lake Area, Northern Manitoba, Massachusettes Institute of Technology, 1948".

Present geological work.

The present report is based on information obtained during the summer of 1949 by the writer while employed by Sherritt Gordon Mines, Limited, on their property at Lynn Lake. Prior to this time, two summers were spent in the area as geological assistant with the Manitoba Mines Branch Geological Survey. The writer assisted in the mapping of the Hughes Lake and Cockeram Lake map areas which lie immediately east of the Lynn Lake area.

The north plug of the Lynn Lake intrusive body was mapped geologically on a scale of 1 inch to 250 feet. Traverses were made at intervals of 100 feet except where swamp made this impossible. The existing magnetometer grid, with lines cut every 100 feet, was used as a guide for the traverses. Outcrops were located by pacing along these lines from the nearest claim line or base line. It was not possible to use the pickets marking the grid, as these were for the most part missing or illegible. On the map, the size of many of the smaller outcrops was exaggerated, and the shapes of the outcrops were generalized. In areas of numerous small outcrops, the group of outcrops was mapped as a single unit.

Core from 26 diamond drill holes covering the area of the 'C' ore body was logged. In conjunction with company geologists, observations were made from the underground workings on the twelfth level at the 'A' ore body. Specimens of ore and the country rocks were obtained.

Petrographic study of the rock specimens collected was carried out at the University of Manitoba. Thin sections were obtained from representative surface, underground, and drill core specimens, and were studied by means of the petrographic microscope. The rock types encountered in the surface mapping were classified, and the information was recorded on the map on a scale of 1 inch to 250 feet. The master tracing was photostated to a scale of 1 inch to 500 feet for this report.

The minerals were identified by means of the petrographic microscope. The composition of the feldspar was determined in thin sections by the Statistical Method of Michel-Levy. (Rogers and Kerr, 1942, p.241). The composition of feldspar from hand specimens corresponding to these thin sections was checked by immersion in index oils. In all specimens examined, the composition as determined by index oils averaged 15 to 20 per cent more anorthite content than that indicated by the Statistical Method. The index oils were calibrated by the refractometer. As a third check, several thin sections were examined on the petrographic microscope by means of the universal stage, and the composition of the feldspar was determined by the Rittmann Zone Method of Plagioclase Study. (Emmons, 1943, p. 115). The composition determined by this method agreed closely with that determined by the Statistical Method. The composition of the feldspar as determined by the Statistical Method has been used for this report.

The rock types encountered in the drill core from the 'C' ore body and in underground specimens, were correlated with the classification established for the surface map. Five east-west sections of the 'C' ore body were drawn up on a scale of 1 inch to 50 feet. Section number 3 is included with this report. A three dimensional model of the drill holes was constructed on the same scale, using glass rods to represent drill holes. Some observations from this model are incorporated in this report.

General Geology of the Lynn Lake Area

The Lynn Lake area is situated in a belt of metamorphosed sedimentary and volcanic rocks which have been highly folded and intruded by igneous rocks ranging in composition from gabbro to granite. The volcanic and sedimentary rocks have been grouped into two series. The younger series, composed principally of conglomerate and quartzitic sediments, is called the Sickle Series. The older pre-Sickle Series is composed of interbedded volcanic, pyroclastic, and sedimentary material. Bateman (1945) proposed the term Wasekwan for the pre-Sickle rocks of the McVeigh Lake area. The terms Wasekwan and Sickle were used by Allan (1946-1947) to map the Lynn Lake and adjoining map areas.

The table of formations on page 10 summarizes the geology of the general area. The intrusive body mapped for this report lies entirely within the rocks of the Wasekwan Series which is designated as Archaen or early Precambrian in age. It is bordered on the south and east by a belt of sedimentary rocks that extends northeast from Francis Lake to beyond Lynn Lake. An older belt of volcanic flows, breccia, and tuff, and some interbedded sediments, lies to the west and north of the intrusive body.

The Lynn Lake body is intruded into the beds forming the east arm of an anticline with axis trending southwest from Berge Lake to the north tip of Evelyn Lake. The axis of the fold lies approximately two miles west of the map area. The volcanic and sedimentary beds trend generally northeast and dip vertically to steeply east.

Several other small basic intrusive bodies occur in the Lynn Lake area, and extensive areas of granite are found to the north of the Lynn Lake area around Berge Lake, and to the east in the vicinity of Eldon Lake. According to Allan (1949) the basic intrusive bodies are older than the granite

TABLE I

TABLE OF FORMATIONS LYNN LAKE AREA[1]

Precambrian	Later Intrusives	Basic dykes; pegmatite, aplite; porphyry and felsite; granite, syenite, granodiorite, tonalite, diorite; gneissic varieties of above.
		Diorite, quartz diorite, granodiorite; gabbro, amphibolite.
	Intrusive Contact	
	Sickle Series	Arkose, greywacke, conglomerate; derived schists
	Post-wasekwan Intrusives	Sheared granite gneiss, porphyry.
	Intrusive Contact	
	Wasekwan Series	Volcanics: Basic to acid lavas: breccia, tuff; derived hornblende schist and gneiss.
		Sediments: Quartzite, impure quartzite, greywacke, iron formation; derived mica schist and gneiss.

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[1] After Allan, (1948)

and may represent the first stages of an extensive period of intrusion that ended with the emplacement of the large granite masses.

LEGEND FOR GEOLOGICAL MAP OF THE LYNN LAKE BASIC INTRUSIVE BODY

🟧	(1)	Acid Intrusive Rocks. Granite and Feldspar Porphyry; Felsite and Pegmatite.
🟩	(2)	Basic Dykes. Fine-grained Gabbro Dykes.
🟦	(3)	Uralite Gabbro Phase 'C'. Labradorite (Ab_{45-50}) and bluish green actinolite.
🟦	(4)	Uralite Gabbro Phase 'B'. Labradorite (Ab_{40-45}) and less than 65 per cent pale-green actinolite.
🟪	(5)	Uralite Gabbro Phase 'A'. Labradorite (Ab_{40-45}) and 65 per cent or more pale-green actinolite.
🟫	(6)	Sedimentary Rocks. Quartz Biotite Gneiss derived from quartzose sedimentary rocks.
🟨	(7)	Altered Volcanic Rocks. Recrystallized and silicified volcanic flows and tuffs. Some interbedded sedimentary rocks.
🟩	(8)	Volcanic Rocks. Volcanic flows, breccia and tuffs.

CHAPTER II

PETROLOGY

Volcanic and Sedimentary Rocks

No attempt was made to map in detail the various units within the volcanic and sedimentary formations that make up the country rocks of the intrusive body. The gneisses and quartzitic sedimentary rocks that lie south and east of the intrusive body were grouped as sedimentary rocks (6), and the country rocks to the west and north were grouped as volcanic rocks (8). Detailed description of these formations are given by Allan (1948).

Altered Volcanic Rocks.

A group of outcrops extending from the northeast corner of lot 364 to the southwest corner of lot 387 have been mapped as altered volcanic rocks (7). These outcrops were formerly mapped as felsite by company geologists. The rocks form an irregular band along the northwest contact of the intrusive body, and grade in texture and mineralogical composition into normal volcanic rocks to the west and north.

In hand specimens, most of these rocks are medium to fine-grained, speckled green and grey, and have irregular, patchy grains of ferromagnesian minerals in a sugary groundmass of quartz and feldspar. Some outcrops have alternate bands of light and dark material ranging in width from two to six inches. To the southwest, the rocks become dioritic in appearance, and outcrop 365-3 shows marked gneissosity.

The mineral composition of different thin sections varies considerably, but the average composition is approximately quartz 30-40 per cent, feldspar (andesine) 20-30 per cent, bluish green amphibole 30-50 per cent, and minor biotite and epidote. The quartz and feldspar form an intergrowth of small, irregular, anhedral grains. Larger quartz grains lie in interlocking clusters and in some places as veinlets between the finer grained minerals. Some larger grains of feldspar have poikilitic inclusions of quartz and amphibole. The amphibole is in fibrous to needle-like grains and is bluish green in colour. Larger grains of amphibole have poikilitic inclusions of quartz and feldspar. Minor amounts of biotite and epidote are present in some sections.

Specimens from this area show general similarity to the volcanic rocks, and a gradation in texture and mineralogical composition can be traced from this area into the volcanics to the west and north. The irregular intergrowth of quartz and feldspar, and the poikilitic inclusions in ragged amphibole grains suggest recrystallization of the rock. The larger quartz grains lie in clusters and veinlets between the finer-grained minerals and appear to have been introduced during metamorphism. The writer concludes that the rocks are altered volcanic flows and tuffs that have been recrystallized and silicified during metamorphism.

It will be shown in a later section that small bodies of granite and feldspar porphyry intrude the rocks in this area, and may account for this alteration.

Sedimentary Rocks

The sedimentary rocks that form the east and south boundaries of the intrusive body are separated from the gabbro by extensive swamp areas except for outcrop 424-2. The rocks weather light-grey to light-brown and in some areas are reddish brown to brick red in colour. Streaks and lenses of biotite give the rock a gneissic appearance. The fresh surface is finely crystalline, grey to pinkish grey, and is composed principally of quartz, feldspar, and thin parallel lenses and streaks of biotite. Thin sections show an average of 70-75 per cent quartz, 10-15 per cent feldspar, 10-15 per cent biotite, 5-10 per cent muscovite, and minor amounts of andalusite and garnet. Feldspar is intergrown with fine-grained, anhedral quartz. Larger grains of quartz show strain shadows. Bands and lenses of biotite and muscovite lie between the fine-grained minerals, and small flakes of biotite and muscovite are scattered throughout the sections. Small shreds of andalusite and small garnets occur in some sections.

Outcrop 360-2 on the ridge north of the mine shaft, which was formerly included in the area mapped as felsite, has been mapped by the writer as sedimentary rock (X6). This rock is fine-grained, quartzitic, and is composed principally of quartz and feldspar. Biotite and muscovite flakes are scattered in a ground mass of quartz and feldspar, but do not occur in streaks and lenses. Rare grains of garnet and andalusite occur in some sections.

Nodules or eyes of quartz stand out above a dull white weathered surface on outcrop 380-1 which is located south of the bridge on the road to the 'El' ore body. The fresh surface is fine-grained, dull bluish grey in colour, and in some areas is streaked by fine, dark lines of indistinguishable mineral composition. Thin sections show small flakes of biotite and muscovite, up to 10 per cent andalusite, and numerous small garnets scattered throughout a groundmass of fine-grained quartz and feldspar. The nodules or eyes of quartz are made up of clusters of interlocking quartz grains. It has been suggested that this rock is possibly a porphyritic intrusive rock, but no evidence of intrusive relationship with the sedimentary rocks to the east was observed. The rock shows close similarity in mineral content and texture to the sedimentary rocks, although finer grained. Increased andalusite indicates a higher alumina content. The writer concludes that this rock was derived from silty, quartzose sediments, and is genetically related to the sedimentary rocks to the east.

Basic Intrusive Body

The rocks that constitute the main basic intrusive body have been mapped by the writer as three units. The units are designated as uralite gabbro phase 'C' (3), uralite gabbro phase 'B' (4), and uralite gabbro phase 'A'(5) respectively.

Areal Extent

The phase 'A' gabbro makes up the west part of the intrusive body, extending from the west contact to the ridge east of Lynn Lake. It extends slightly north of the 'C' ore body, and south to a position opposite the Lynn River. Two small groups of outcrops in this area have sufficient orthorhombic pyroxene to be classed as norite. Diamond-drill holes have indicated extensive occurrences of amphibolite and several small outcrops of amphibolite are exposed in the area. Bands of amphibolite and anorthosite occur in the normal gabbro.

The phase 'B' gabbro lies in a belt bordering the phase 'A' gabbro to the east, south, and possibly to the north. The phase 'B' gabbro extends to the south border of the intrusive body, and up the east side for an indeterminate distance. Lack of outcrop along the east side, and north of the 'C' ore body makes it impossible to define accurately the extent of the phase 'B' gabbro in those areas.

The remainder of the area, making up a wedged-shaped part on the northeast extremity of the intrusive body, is phase 'C' gabbro. The contact between the phase 'C' and phase 'B' gabbro is indefinite, as no outcrop is present in the contact area.

Description

Uralite gabbro phase 'A'. The phase 'A' gabbro is medium-grained, dark-green to greyish green, and is composed mainly of feldspar and amphibole. The feldspar is weathered out of the exposed surface leaving a rough irregular mat of amphibole grains. Where visible, the feldspar on the weathered surface is greyish white. In many outcrops of this area the amphibole grains are arranged in roughly parallel rows. The fresh surface of the gabbro is medium-grained, dark yellowish greenm and appears to be composed entirely of amphibole, owing to the greenish white colour of the feldspar.

The mineral composition varies widely in specimens selected from small areas. Several Rosiwal analyses gave the average composition as feldspar 25-30 per cent, amphibole 65-70 per cent, antigorite 5-7 per cent, chlorite 3-5 per cent, minor sulphides, and small remnants of brownish green hornblende. The hypidiomorphic granular texture is usually masked by the high degree of alteration.

The feldspar composition ranges from Ab_{40} to Ab_{45}. The feldspar grains are fresh in appearance, and show only minor development of sericite and no kaolin. Some feldspar grains have well developed fractures that are filled with secondary amphibole and chlorite, and in a few grains there is displacement along these fractures. Fibres of amphibole penetrate the feldspar grains along fractures, and also penetrate unfractured feldspar grains. Small remnants of feldspar are completely surrounded by masses of amphibole and chlorite.

Pale-green, fibrous, slightly pleochroic amphibole constitutes over 90 per cent of the ferromagnesian minerals in the gabbro. The maximum extinction is 18 degrees, birefringence is moderate (0.020-0.025), elongation length

PLATE I

Figure 1. Fractured feldspar grain in uralite gabbro phase 'A'. The labradorite twins show the amount of displacement along the fracture. The fracture is filled with chlorite and actinolite.

Figure 2. Remnant of feldspar grain surrounded by a mat of fibres composed of chlorite and actinolite.

Figure 3. Remnant of enstatite (E) within grain composed mainly of talc and actinolite. Actinolite is fibrous and the talc forms a featureless mass.

PLATE I

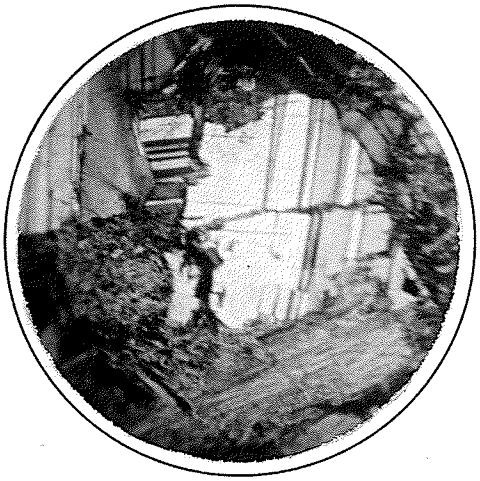


Figure 1.
Thin Section 359-2-3
x30
(crossed nicols)

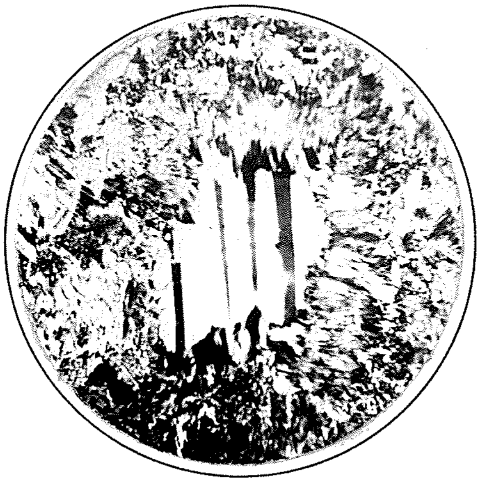


Figure 2.
Thin Section 358-1-4
x50
(crossed nicols)

Figure 3.
Thin Section 359-2-2.
x50
(crossed nicols)

slow (positive), optical sign is negative, and 2V is 70-80 degrees. This mineral is termed pale-green actinolite to distinguish it from the actinolite in the phase 'C' gabbro. The actinolite fibres range from minute fibres that are resolvable only under magnification greater than 20 diameters to blade-like fibres that are recognizable in hand specimens. In most grains the fibres are parallel to the long axis of the grain, but in rims about feldspar, and in some irregular grains, the fibres have random orientation. Under crossed nicols alternate groups of fibres show opposite optical orientation. Well defined actinolite grains are stubby, and appear to be pseudomorphic after pyroxene grains.

A small portion of the pale-green actinolite is somewhat more compact and has lower birefringence. Other optical properties are identical with the variety described above. Small remnants of compact brownish green amphibole show alteration to actinolite. This mineral occurs in larger grains in some fine-grained dykes, where it is identified as hornblende.

Chlorite, accompanied by secondary actinolite, fills fractures in feldspar grains, and forms rims about feldspar grains. Fibrous to platy antigorite flakes are pseudomorphic after actinolite, and grains of actinolite appear in all stages of alteration to antigorite.

Blebs and irregular patches of sulphides are present in all outcrops of phase 'A' gabbro, but only a few thin sections show sulphides. Description and discussion of sulphide-silicate relationship will be given in the section dealing with the ore bodies.

Outcrop 359-2 and the discovery outcrop near the mine shaft contain orthorhombic and monoclinic pyroxine. Within the same outcrops specimens also show secondary actinolite and no pyroxene. Table 2 lists the mineral content of five thin sections selected from outcrop 359-2.

The orthorhombic pyroxene is colorless to pale green, has parallel extinction, low birefringence (0.005-0.010), length slow elongation (positive), 2V is 80-90 degrees, and the mineral is optically positive. Some grains show very slight pleochrism. This mineral is enstatite with iron content approaching hypersthene.

The monoclinic pyroxene is colorless to pale green, has maximum extinction 41 degrees, moderate bifefringence (0.020-0.025), length fast elongation (negative), 2V is 65-70 degrees, and the mineral is optically positive. The mineral is augite.

Numerous fine fractures cut the pyroxene, and finely fibrous actinolite similar to that of the uralite gabbro fills the fractures, and forms rims about the grains. Within the fractures the fibres are parallel to the cleavage planes. More highly altered grains of orthorhombic pyroxene consist of a aggregation of actinolite and talc. In grains of mixed talc and actinolite the antinolite forms rims about the grains and lies in stringers of fibres across the grains, the stringers corresponding to fractures in the original pyroxene. The talc fills in the areas between the actinolite and unaltered pyroxene

TABLE II

MINERAL CONTENT OF FIVE SECTIONS FROM OUTCROP 359-2

Section Number	Enstatite	Augite	Actinolite	Talc	Feldspar	Chlorite and Antigorite
359-2-1	--	--	58%	5%	30%	7%
359-2-2	--	--	55%	3%	35%	7%
359-2-3	10%	3%	20%	38%	25%	4%
359-2-4a	30%	20%	15%	--	30%	5%
359-2-4b	--	--	45%	18%	30%	7%

(All specimens from an area with radius approximately 100 feet. Sections 359-2-4a and 359-2-4b were cut from the same hand specimen).

and replaces the pyroxene. There is no evidence that the talc replaces actinolite.

Feldspar, chlorite and antigorite have the same features and relationships to other materials as those in the uralite gabbro. Section 359-2-3 has minor amounts of sulphide interstitial with grains of altered pyroxene. The sulphide penetrates along cleavage planes and in one place forms a veinlet across a grain of secondary actinolite.

Amphibolite is exposed in several small outcrops and bands of amphibolite occur in the gabbro. The bands range in width from less than one inch to six inches, and are parallel to the lineation. A thin section of amphibolite from outcrop 359-1 shows 90 per cent actinolite and 10 per-cent labradorite. The rock is similar in all respects to the uralite gabbro except for the ratio of amphibole to feldspar.

Bands of anorthosite, ranging in width from less than one inch to six inches, are sometimes found associated with bands of amphibolite. A thin section from an anothosite band in outcrop 383-1 shows 90 per cent labradorite and 10 per cent amphibole. The feldspar shows a network of fine fractures and minor amounts of sericite along these fractures. The coarser fractures with secondary actinolite described in the uralite gabbro are also present. Pale green, fibrous actinolite lies in scattered grains between the feldspar.

Uralite gabbro phase 'B'. In the south part of the area the phase 'B' gabbro differs in appearance from the phase 'A' gabbro only in the amount of visible feldspar. Increased feldspar content results in an open net-like mat of greyish green amphibole grains standing out above greyish white feldspar. Lineation is prominent on the ridge south of Lynn Lake, but is lacking over most of the rest of the phase 'B' area. The fresh surface shows medium-grained, well-defined, greenish white feldspar and yellowish green amphibole in about equal proportions. North of lot 385 the gabbro becomes finer grained and has slightly higher feldspar content.

Rosiwal analyses indicate feldspar 40-45 percent, amphibole 45-50 percent, antigorite 7-10 percent, chlorite 3-5 percent, and minor amounts of sulphide. The texture is hypautomorphic granular and is more clearly defined than that of the phase 'A' gabbro as the alteration rims about feldspar grains are less strongly developed.

The feldspar is labradorite with average composition Ab_{45}. The grains visible in hand specimens are made up of groups of small grains in random orientation. The coarser-grained rocks to the south of the area have a few fractured feldspar grains, but this feature is lacking in the finer-grained rocks to the north. Alteration rims of chlorite and secondary amphibole around feldspar grains are less well developed than in the phase 'A' gabbro. The three types of amphibole described in the phase 'A' gabbro are present in the phase 'B' gabbro, and the remnants of compact brownish green hornblende are more plentiful. Chlorite and antigorite have the same relationship to other minerals as in the phase 'A' gabbro . Specimens of phase 'B' gabbro studied by the writer showed no pyroxene.

Two areas within the phase 'B' gabbro have rocks that are somewhat different than the normal gabbro. Speciment from outcrop 386-13 from the ridge south of Lynn Lake have bluish green, pleochroic amphibole that corresponds to the amphibole in phase 'C' gabbro, and feldspar corresponding to the phase 'B' gabbro. An area lying on each side of the claim line between lot 386 and lot 429 weathers blackish green in colour and is spotted with irregular patches of white feldspar. This section 429-1-5 from this area shows dark, bluish green amphibole in irregular flakes and fibres in a matrix of crushed feldspar. Larger grains of amphibole have poikilitic inclusions of untwinned feldspar. Feldspar grains have considerable development of sericite. Small irregular grains of quartz lie between the crushed feldspar fragments, and occur as poikilitic inclusions in the amphibole, Numerous minor shear zones extend through this area and trend generally from north 10 degrees east to north 30 degrees east.

Uralite gabbro phase 'C'. Phase 'C' gabbro is a medium to fine-grained rock, massive, of blackish green colour, and has resistant amphibole standing out above light-grey feldspar. In some areas the feldspar weathers a pinkish colour. The fresh surface of the gabbro is dark-green speckled with greyish white, and shows equal amounts of feldspar and blackish green amphibole. Some biotite occurs in specimens near the gabbro-volcanic contact.

Rosiwal analysis indicates feldspar 45 per cent, amphibole 45 per cent, chlorite 2 percent, antigorite 8 percent, and minor amounts of oxides and sulphides. Specimens near the contact have small amounts of biotite, epidote, and quartz. The texture is hypautomorphic granular.

The feldspar is labradorite, and the composition ranges from Ab_{45} in the main body to Ab_{50} near the contact. The feldspar is cloudy in thin section, and some grains show considerable alteration to sericite. Irregular grains of untwinned feldspar invade other grains of feldspar that have albite twinning. Amphibole fibres penetrate the feldspar grains, but alteration rims of chlorite and amphibole are lacking. A few feldspar grains have small fractures filled with chlorite, amphibole, and epidote.

The amphibole is somewhat less fibrous than that of the phase 'A' and 'B' gabbro, and shows marked pleochroism from bluish green to yellowish green. Some grains have darker,more strongly pleochroic rims about a lighter core. The maximum extinction of the amphibole is 20 degrees, and other optical properties are identical with the optical properties of the pale-green actinolite. The mineral is termed bluish green actinolite. Small, poikilitic inclusions of quartz and untwinned feldspar lie parallel to the cleavage planes in some grains. Larger fragments of feldspar, some of which show albite twinning, are spaced irregularly within the grains of amphibole. A few grains of amphibole have dark, dust-like inclusions (possibly magnetite dust) along cleavage planes and in veinlets that truncate the cleavage.

Specimens selected near the gabbro-volcanic contact show up to 15 percent of dark-brown, pleochroic biotite in flakes surrounding and replacing amphibole grains. In some places, the biotite forms rims about sulphides. The biotite appears to have formed by alteration from amphibole. Small grains of epidote lie between amphibole and feldspar grains, and sometimes within feldspar grains. A few scattered grains of carbonate replace small portions of feldspar grains. Small amounts of quartz lie interstitially with the silicates, and appear to have been an original constituent of the rock.

Discussion

The percentage and composition of the feldspar, the type of amphibole, and the grain size have been used as criteria for the subdivision of the rocks in the main intrusive body. Rocks within the phase 'A' gabbro area contain an average of 65 percent or more amphibole, although the proportion of amphibole to feldspar is not constant throughout the area, or within the individual outcrops. This arbitrary value was chosen as it resulted in the definition of a mappable unit within the intrusive body. The phase 'B' gabbro area includes rocks that contain an average of less than 65 percent amphibole. In the north portion of the phase 'B' area, the rocks are finer-grained. Phase 'C' gabbro is distinguished from phase 'A' and 'B' gabbro in hand specimens by the blackish green amphibole and the somewhat finer grain size. The feldspar is more acid in composition and the bluish green, pleochroic amphibole is easily distinguished in thin sections from the pale-green actinolite of phase 'A' and 'B' gabbro. The phase 'A' and 'B' gabbro are considered by the writer to be closely related genetically, and will be discussed under one heading.

Phase 'A' and 'B' gabbro. The main ferromagnesian minerals in these rocks are pale-green actinolite, brownish green hornblende, enstatite, and augite. The optical properties of the amphibole place the mineral in a class intermediate between hornblende and actinolite, closer to actinolite than to hornblende. More detailed mineralogical work is necessary to classify this mineral accurately. Allan (1948) reports a pargasite variety of amphibole having positive optical sign from the Lynn Lake intrusive body. No amphibole giving a positive optical sign was observed in the specimens studied by the writer. The determination of optical sign is uncertain owing to the fibrous character of the mineral.

The actinolite is a secondary mineral, and has formed by alteration of the original ferromagnesian minerals. Thin sectionsfrom outcrop 359-2 have shown that some actinolite has formed by alteration of enstatite and augite. Similarity between actinolite formed from these minerals and the actinolite from the remainder of the uralite gabbro suggests that a large portion of the actinolite may have formed from primary pyroxene. Some actinolite has also formed from compact brownish green hornblende. There is no evidence that the hornblende is a secondary mineral. Remnants of the hornblende are more plentiful in the phase 'B' gabbro, and it is possible that there was more primary hornblende in the felsi~~e~~c portion of the intrusive body.

As the large proportion of the ferromagnesian minerals in the gabbro is secondary actinolite, the rock is termed uralite gabbro. The writer believes that the phase 'A' gabbro and possibly the phase 'B', gabbro were originally norite.

The order of crystallization of the minerals is obscured by the high degree of alteration in the rock. Feldspar possibly crystallized later than the ferromagnesian minerals as shown by the clusters of small feldspar grains between larger amphibole grains.

The offset along some of the fractures in feldspar grains indicates that the rock was stressed sufficiently to cause movement at a time when the body was rigid enough to yield by fracture. This movement was not extensive enough to cause mylonitization. Fibres of actinolite penetrate these fractures, accompanied by chlorite. As the fibres extend into the feldspar grains from actinolite grains, the actinolite has evidently formed after the feldspar was fractured. This places the age of the fractures as later than the consolidation of the main silicates and younger than the alteration of the primary ferromagnesian minerals to actinolite. According to Dresser (1917), similar fractures in the feldspar from the Sudbury norite are related to movement at an intermediate stage in the consolidation of the magma, while the acid portion and sulphides were still fluid. Phemister (1924) concluded that the intrusive body at Lancaster Gap, Pennsylvania, was subjected to stress after consolidation of the silicates, and that this stress caused small cracks throughout the intrusive without resulting in large fractures.

Some feldspar has been replaced by actinolite, as shown by the fibres of actinolite that invade feldspar grains, and by rims of actinolite and chlorite around feldspar grains. Remnants of feldspar lie within fibrous actinolite grains, and may represent the remnants of larger grains that have been almost completely replaced by actinolite. It is possible that the replacement of feldspar by actinolite may account for the high percentage of mafic minerals in certain portions of the rock. The writer does not believe that this action accounted for the main concentrations of amphibolite that occur in the phase 'A' gabbro.

Actinolite present along cracks in otherwise fresh pyroxene, and as grains pseudomorphic after pyroxene suggests that some actinolite formed formed by direct alteration from pyroxene. Actinolite also has formed from hornblende, but there is no evidence that the hornblende represents an intermediate stage between pyroxene and actinolite.

Talc was observed only in specimens that have remnants of altered enstatite. Specimens that contain both enstatite and augite show enstatite but not augite, altered to talc. The relationship between talc and actinolite suggests that the talc formed later than the actinolite, from remnants of enstatite that had not been previously converted to actinolite. The agency that caused the development of talc did not affect the actinolite or augite, as there is no evidence that the talc replaces either augite or actinolite. The talc formation may post-date the actinolite considerably, or may have formed owing to a change in conditions at the end of the period of uralitization.

Chlorite is associated with actinolite in fractures in feldspar grains and in rims about feldspar grains. Chlorite does not replace actinolite, and appears to have formed directly from the feldspar, possibly at the same time as actinolite was developed. Grains of actinolite show stages of alteration to antigorite, and it appears that antigorite formed at a later stage than actinolite, possibly at the same time that enstatite altered to talc.

The following sequence of events is postulated from the above evidence.

(1) Ferromagnesian minerals, pyroxene and possibly some magmatic hornblende, crystallized first.

(2) Feldspar crystallized later than, or contemporaneously with, the ferromagnesian minerals.

(3) After consolidation of the main silicates, the intrusive body was stressed slightly, and fractures developed in the feldspar grains, and to a lesser extent in the pyroxene grains.

(4) The ferromagnesian minerals were uralitized,

and some feldspar was altered to chlorite.

(5) Some of the remaining enstatite was altered to talc, and at the same time some antigorite developed from actinolite.

Phase 'C' gabbro. Phase 'C' gabbro is characterized by feldspar more acid than that of phase 'A' and 'B' gabbro, and by strongly pleochroic, bluish green amphibole. The amphibole resembles the pale-green actinolite in all optical properties except the pleochrism and the ex tinction angle which is slightly greater. According to Wandke and Hoffman (1924), the bluish green amphibole from the Sudbury area is a form of actinolite. Colony (1923) reports the alteration of augite at the Creighton mine, Sudbury, to a complex of bluish hornblende, close to actinolite in composition. As the bluish green amphibole resembles the pale-green actinolite so closely, the writer has called the mineral actinolite.

The bluish green actinolite is fibrous,and appears to be secondary, but no remnants of pyroxene or hornblende are present to indicate the original mineral. Bluish green actinolite occurs in the phase 'B' gabbro south of Lynn Lake, and in sheared areas in outcrop 429-1. This suggests that some bluish green actinolite and also pale-green actinolite have formed from the same original minerals. Blue colour in amphibole minerals is normally associated with a high soda content. If the blue colour in the actinolite from the phase 'C' gabbro is due to a high soda content, the increased soda may have been an original constituent of this portion of the magma, or may have been introduced during metamorphism. The fact that both pale-green and bluish green actinolite have formed in some areas from the same primary minerals suggests that the blue colour may be due to the addition of some elements, possibly soda, during metamorphism. Colony (1923) attributes the blue colour of the amphibole at the Crieghton mine, Sudbury, to the addition of soda which was possibly derived from the soda-rich residuum at the final stage of crystallization.

The blue colour may not be due to increased soda, as increase in soda content is normally followed by a decrease in the maximum extinction angle, whereas in the actinolite from phase 'C' gabbro, the extinction angle is slightly higher than that of the pale-green actinolite. Bluish green actinolite in sheared rocks that normally have pale-green actinolite suggests that additional metamorphism of pale-green actinolite results in the formation of bluish green actinolite. Bateman (1942) states that in general in the McVeigh Lake area, the greater the intensity of the metamorphism, the deeper the colour of the amphibole. The cause of the bluish colour in the actinolite from phase 'C' gabbro is not known, but the writer believes that the bluish green actinolite represents a higher degree of metamorphism than the pale-green actinolite.

General discussion. The development of fibrous, secondary amphibole in basic intrusive bodies is attributed by various authors to deuteric alteration, hydrothermal alteration, and thermal metamorphism. Colony (1923) attributes the uralitization of the Sudbury and Maskwa Lake norite bodies to deuteric alteration by the end products of crystallization. Dennen (1943) places the alteration of the ferromagnesian minerals at Dracut, Massachusettes, as deuteric or earlier. Kerr (1924) attributes the formation of tremolite-actinolite at Chicago Island, Alaska, to hydrothermal activity following magmatic changes. According to Cameron (1943) the most abundant hydrothermal alteration product at Mt. Prospect, Connecticut, is tremolite-actinolite pseudomorphic after hypersthene and monoclinic pyroxene. Schwartz (1939) states that uralitization is not necessarily confined to hydrothermal activity, and can take place during various stages of metamorphism. According to Harker (1932,p. 108) both rhombic and monoclinic pyroxene suffer uralitization under moderate-grade thermal metamorphism. Bateman (1942) states that actinolitic amphiboles associated with calcic plagioclase in the McVeigh Lake area represent low grade metamorphism.

All primary ferromagnesian minerals in the Lynn Lake intrusive body have been altered to fibrous actinolite, except for small amounts of pyroxene in the phase 'A' gabbro area, and remnants of hornblende in the phase 'A' and 'B' gabbro. Such extensive alteration by deuteric action would necessitate the presence of a considerable liquid portion of the magma at the time of alteration. It has been shown that uralitization followed the development of fractures in feldspar grains, and at this time the rock must have been fairly rigid and no appreciable portion could have been liquid. Uralitization by hydrothermal activity alone would require extensive action to bring about the amount of alteration present. Schwartz (1939) states that the most characteristic mineral change in hydrothermal alteration is the sericitization of feldspar. The feldspar from the gabbro at Lynn Lake is relatively free from sericite except in the phase 'C' gabbro near the gabbro-volcanic contact. Moreover, the feldspar is unusually clear and transparent. Harker (1932,p. 109) states that feldspars under thermal metamorphism often become pellucid owing to the absorption of minute inclusions. Considerable addition of water was necessary to alter the primary minerals to actinolite, and for the formation of chlorite. The writer believes that the uralitization of the intrusive body at Lynn Lake was caused by thermal metamorphism accompanied by hydrothermal activity.

The writer believes that talc formed later than actinolite in the intrusive body, possibly at a considerably later stage. Feldspar porphyry and granite intrude the body in the vicinity of the west contact, and may have caused this alteration. If the writer is correct in assuming that the talc is not related to the period of uralitization, and that the bluish-green actinolite represents a higher grade of metamorphism than the pale green actinolite, the intrusive body can be divided into three zones of progressive metamorphism. The zones are defined by unaltered pyroxene near the west contact, pale-green actinolite in the central part, and bluish green actinolite near the north and east contact. This suggests that the source of metamorphism lies to the north and east of the intrusive body. Extensive areas of granite lie to the north and east in the vicinity of Berge and Eldon Lakes. The granite bodies are believed to be younger than the gabbro (Allan, 1948) and may be the source of the alteration in the Lynn Lake gabbro.

Field mapping has shown three zones of increasing acidity in the intrusive body. These are represented by basic feldspar in phase 'A' and 'B' gabbro and by more acid feldspar in Phase 'C' gabbro. Phase 'A' gabbro represents a more basic portion than the phase 'B' gabbro, and possibly formed by gravitative crystal settling of the early crystallized ferromagnesian minerals. The phase 'A' gabbro also represents an inhomogeneous portion of the magma, in which the mafic mineral content was generally higher than the phase 'B' portion, but which contained local areas rich in felsic minerals.

Conclusions

(1) The Lynn Lake intrusive body is made up of three zones that increase in acidity from west to east across the body. The zones are represented by the phase 'A', 'B', and 'C' gabbro areas respectively.

(2) Differentiation of a body of basic magma resulted in the separation of an acid portion, phase 'C' gabbro, and

a more basic portion, phase 'A' and 'B' gabbro. The more basic portion was further differentiated, possibly by gravitational crystal settling, into a mafic rich portion, and a more felsic portion, phase 'B'.

(3) The primary ferromagnesian minerals were enstatite, augite, and hornblende. A part, and possibly all of the phase 'A' and 'B' gabbro was originally norite.

(4) Slight movement within the intrusive body after consolidation of the main silicates caused fractures in the feldspar grains, and to a lesser extent in the ferromagnesian mineral grains.

(5) Nearly all of the primary ferromagnesian minerals have been subsequently altered to fibrous actinolite. This uralitization post-dated the movement that caused the minor fractures, and was brought about by agencies not connected with the basic intrusive body.

(6) The uralitization was caused by thermal metamorphism accompanied by hydrothermal activity.

(7) The bluish green actinolite represents a higher degree of metamorphism than the pale-green actinolite.

(8) The sources of the heat and hydrothermal solutions that brought about the metamorphism of the gabbro body were granite intrusive bodies that lie to the north and wast of the gabbro body. This resulted in three zones of metamorphism increasing in degree from west to east across the basic intrusive body.

(9) Talc was developed from unaltered enstatite later

than actinolite, possibly after uralitization had ceased. The talc was possibly formed by the action of late acid intrusive bodies near the west contact of the gabbro body.

Basic Dykes

Description

Fine-grained dykes (2) of dark-grey to black rock cut through the basic intrusive body. The dykes are most numerous in the phase 'A' gabbro on the ridge east of Lynn Lake, particularly on lot 386. In some areas the dykes strike parallel to the lineation, but in most areas the strike is not uniform for more than a few feet. Some larger dykes branch into two or more smaller dykes. No chilled borders or flow structure were observed in the dykes.

The dyke rock is dark-grey to blackish green in colour, and is spotted with dust-like, greyish white feldspar on the weathered surface. Small cleavage flakes of amphibole sparkle on the fresh surface which is otherwise dark-grey to black in colour. The rock is dense and hard, and breaks with a subconchoidal fracture.

Thin sections show labradorite feldspar (Ab_{48}) and amphibole in approximately equal proportions, and minor amounts of chlorite, sulphides and oxides. The texture is hypautomorphic granular. The feldspar is in small, subhedral grains that show carlsbad and albite twins; some grains are zoned with slightly more acid borders. The amphibole is made up of compact, brownish green hornblende and smaller amounts of pale, greenish blue amphibole which resembles the pale-green actinolite in optical properties. The hornblende forms small, anhedral to subhedral grains and shows alteration to pale, greenish blue amphibole. A small amount of chlorite occurs around the border of the pale, greenish blue amphibole.

Two outcrops of fine-grained, blackish green rock are exposed east of the mine shaft. The north part of outcrop 363-2 is spotted with small irregular groups of whitish feldspar grains. Rocks from these outcrops are less dense than those of the fine-grained dykes, are somewhat coarser grained, and weather dark green to greenish black. In outcrop 359-3 bands or tongues of medium-grained gabbro appear to intrude the fine-grained rock. Two small areas of similar rock lie within the phase 'A' gabbro on the north end of outcrop 358-1. In this place the lineation of the gabbro tends to follow the outline of the fine-grained rock, and tongues of gabbro invade the fine-grained rock.

Thin sections from outcrops 359-3 and 363-2 show feldspar (Ab_{50}) and amphibole in equal proportions, and minor amounts of quartz, epidote, carbonate, and chlorite. The texture is allotriomorphic granular. Specimen 363-2-2 is glomeroporphyritic owing to clusters of small, anhedral feldspar grains. The amphibole forms small, irregular, fibrous to needle-like grains. Larger amphibole grains have poikilitic inclusions of quartz and feldspar, and are pleochroic from greenish blue to yellowish green. The amphibole resembles that of the altered volcanics. Quartz occurs as scattered, irregular grains between other silicate minerals. Flakes of epidote, small grains of carbonate, and rims of chlorite are associated with the amphibole.

Discussion

The narrow fine-grained dykes have gabbroic texture and composition, and may be termed fine-grained gabbro dykes. The dyke rock resembles the phase 'C' gabbro in feldspar composition and in the relative amounts of felsic and mafic minerals. Heavy mineral investigations by Dornian (1950) showed that the magnetite and ilmenite content of the phase 'C' gabbro is four to five times as great as that of phase 'A' and 'B' gabbro. He also showed that the magnetite and ilmenite content of the fine-grained dykes is of the same order of magnitude as that of the phase 'C' gabbro. Similarity between the dykes and the phase 'C' gabbro may indicate that the dykes are fine-grained equivalents of the phase 'C' gabbro, and represent a late stage in the differentiation of the intrusive body.

The outcrops of fine-grained rock east of the mine shaft have formerly been classed by company geologists with the fine-grained dykes. No contact relationships are exposed in these outcrops except for the possible intrusive character of the medium-grained gabbro in outcrop 359-3. Thin section study has shown considerable difference between the two rock types, and that these outcrops resemble somewhat the altered volcanic rocks to the north of the intrusive body. Dornian (1950) found that the content of magnetite and ilmenite in these rocks is less than one-fifth that of specimens of the fine-grained dykes. The writer believes that these outcrops represent inclusions of volcanic material in the gabbro.

Conclusions

(1) The narrow fine-grained dykes in the basic intrusive body are fine-grained gabbro dykes.

(2) The dykes are similar in composition to the phase 'C' gabbro, and represent a late stage in the differentiation of the basic intrusive body.

(3) Outcrops 359-3 and 363-2 east of the mine shaft are inclusions of volcanic material in the gabbro.

Acid Intrusive Rocks

Rocks of acid composition (1) intrude the altered volcanic rocks near the northwest border of the basic intrusive body. In outcrop 387-5, medium-grained, acid rock intrudes the altered volcanic rocks, and contains xenoliths of volcanic material. Some of the outcrops mapped as altered volcanic rocks, particularly outcrops 365-3 and 365-4 may be sheared equivalents of the acid intrusive rocks.

The acid intrusive rock is fine-grained, massive, bluish green and white in colour, and is composed of equal proportions of felsic minerals, quartz and feldspar, and mafic materials, amphibole and biotite. The feldspar is light grey to pale pink, and stands out with quartz in small knot-like grains on the weathered surface. Feldspar grains are slightly larger than other mineral grains, and the rock is somewhat porphyritic. A small body of similar rock intrudes the gabbro in outcrop 401-1 south of Lynn Lake.

Rosiwal analysis indicates quartz 40 percent, orthoclase 14 percent, oligoclase 2 percent, biotite 29 percent, amphibole 15 percent, and minor amounts of sulphides and oxides. According to Johannsen's classification, this rock is a quartz granite. The feldspar shows considerable alteration to sericite. Fibrous, dark bluish green amphibole has poikilitic inclusions of quartz and feldspar, and in some grains alteration rims of dark-brown, pleochroic biotite. Other grains of biotite may be primary.

Outcrop 364-3 on the ridge north of the mine shaft shows medium to coarse-grained phenocrysts of feldspar in a groundmass of fine-grained quartz and feldspar. Thin sections show the feldspar phenocrysts of orthoclase and oligoclase in a groundmass of fine-grained quartz, feldspar,and biotite. Rosiwal analysis indicates quartz 35 percent, orthoclase 35 percent, oligoclase 15 percent, and biotite 15 percent. The feldspar grains show considerable alteration to sericite, and the oligoclase phenocrysts are strongly zoned.

Diamond drill-holes at the 'C' ore body and underground workings at the 'A' ore body have intersected feldspar porphyry and granite similar to the rocks described above. It will be shown in the description of the ore bodies that these rocks intrude the gabbro. The distribution of these rocks suggests that a series of small granitic intrusive bodies, which may or may not be connected at depth, intrude the gabbro in the vicinity of the west contact and extend north into the area mapped as altered volcanic rocks.

It has been previously suggested in this report that the intrusion of these late acid rocks may have caused the formation of talc from remnants of enstatite which were unaltered during the period of uralitization. It is possible that the granitic bodies also caused the silification of the rocks mapped as altered volcanic rocks.

CHAPTER III

STRUCTURE

General Contact Relationships

The contact between the basic intrusive body and the country rocks is not accurately defined owing to lack of outcrop in the contact areas. Accordingly, the contact is mapped as an assumed contact. The contact is most accurately defined in lot 354, where a series of outcrops show mixed gabbroic and volcanic material. Outcrop 354-9 has volcanic rock on the north end, mixed gabbro and volcanic material in the central portion, and phase 'C' gabbro on the south end of the outcrop. In other areas, wide expanses of swamp or low ground lie between outcrops of gabbro and outcrops of the bordering volcanic and sedimentary rocks. The contact between altered volcanic rocks and volcanic rocks is gradational and is mapped as an approximate contact.

Diamond drill holes along the west border of the intrusive body indicate a nearly vertical contact,and some interfingering of the gabbro with the volcanic rocks. The few holes that intersect the contact, do so at a relatively shallow depth, and give no information as to the attitude of the contact below 100 feet.

Figure 2 shows the relationship of the intrusive body to the schistosity in the country rocks. The intrusive body is roughly concordant with the trend of schistosity

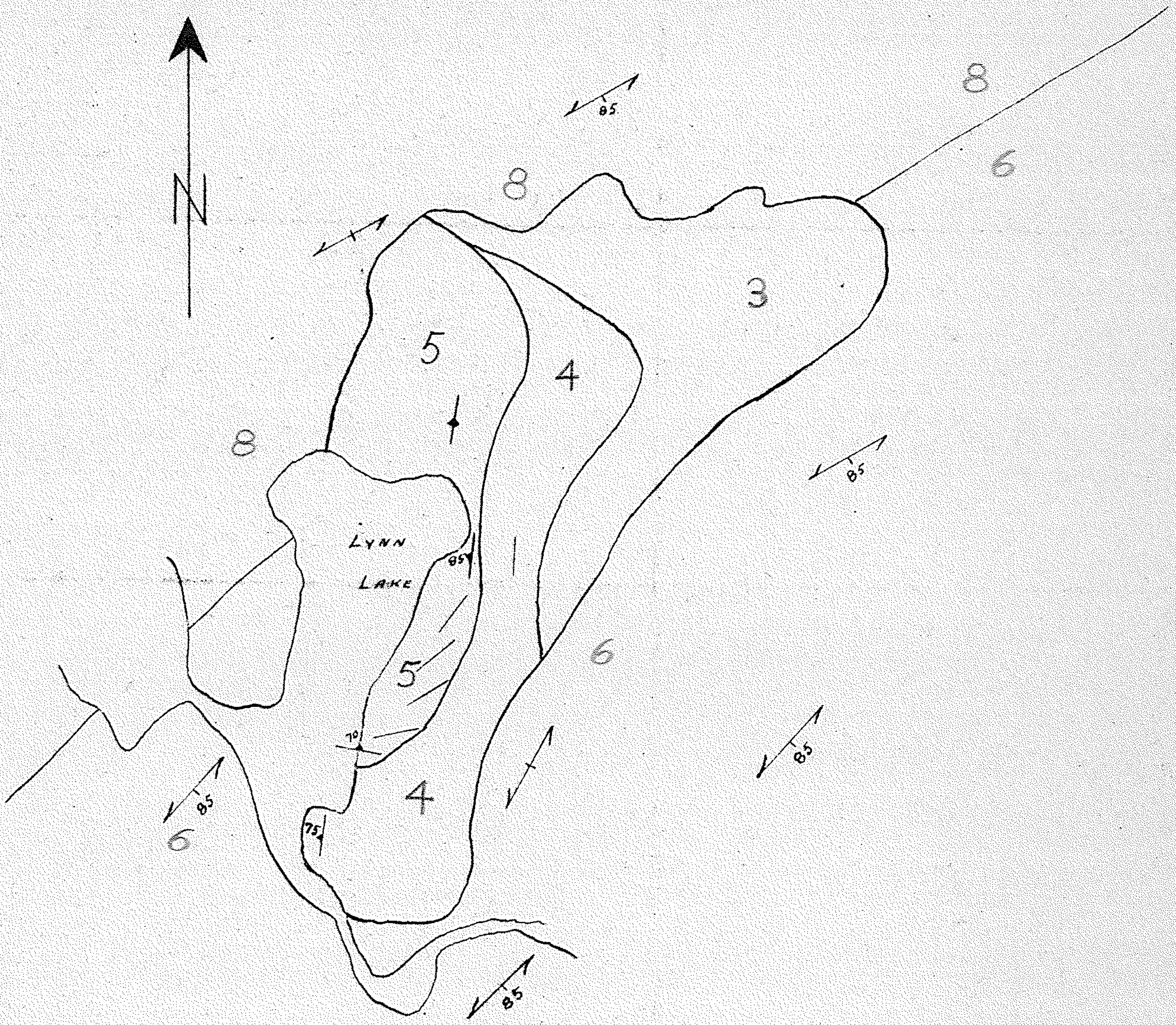


Figure 2

Lineation and Schistosity

LEGEND

3	Gabbro Phase 'C'
4	Gabbro Phase 'B'
5	Gabbro Phase 'A'
6	Sedimentary Rocks
8	Volcanic Rocks

⟷ Schistosity

— Lineation

Scale: 1" = 2500'

in the bordering rocks, and lies approximately along the contact between the volcanic and sedimentary formations.

Lineation

Description and discussion

The weathered surface of most of the phase 'A' gabbro and some of the phase 'B' gabbro has a more or less parallel arrangement of alternate, narrow bands of amphibole-rich and feldspar-rich material. The bands are usually less than one-eighth of an inch in width, but range up to two or three inches in width. The bands of anorthosite and amphibolite described in the phase 'A' gabbro appear to be a further developement of this feature.

The feldspar weathers out of the exposed surfaces, and ridges of amphibole stand out in relief. The ridges consist of aggregates of amphibole grains, some of which are tabular and have their long axes in the plane of the bands. Polished sections cut normal and parallel to the lineation show some amphibole grains to have their long axes in the plane of the bands, but with no preferred orientation in this plane. The compositional bands are made up of irregular lenses and streaks of feldspar-rich and amphibole-rich rock. There is more continuity in bands of amphibole than in those of feldspar. Thin sections show no structure, possibly because of the small size of the field visible under the microscope compared with the grain size of the rock. The feldspar-rich bands are made up of medium-grained feldspar with random orientations.

The lineation is the result of compositional differences in alternate bands, and the arrangement of some amphibole grains with their long axes in the plane of the bands. There is no evidence that post-solidification movement caused the alignment, and the lineation is considered by the writer to be primary.

Hall (1932) described the norite from the Bushveld Complex as faintly banded through a more or less parallel arrangement of the pyroxenes, which alternate with streaks and lenticules of highly feldspathic bands. The individual bands range from two inches to one-sixteenth of an inch in width. Daly (1928) concluded that the bands in the Bushveld norite were caused by the shearing of layer against layer in a plastic mass as the norite moved down the centripetal dip of the complex. Geikie and Teall (1894) attributed similar bands in tertiary gabbros from the Isle of Skye, to movement in a heterogeneous magma prior to crystallization. Grout (1918,1920) believed that the bands in the Duluth gabbro were caused by movement due to convection currents during cooling. Most writers agree that two agencies were active in the development of compositional bands similar to those in the Lynn Lake gabbro. The compositional difference in the bands is believed to be the result of heterogeneity in the magma, and the alignment of tabular crystals is believed to be the result of movement in the magma after crystallization had begun.

The alignment of tabular grains within the bands has been explained by some writers by gravitative settling of crystals. Grout (1920) suggests that the viscosity of the magma would prevent tabular crystals from attaining this alignment, and states that alignment of tabular crystals is due to movement in a partially crystallized magma. The writer believes that the anorthosite and amphibolite bands, and the more finely banded gabbro at Lynn Lake indicate seggregation of feldspar-rich and amphibole-rich areas in the magma, and that the alignment of amphibole grains indicates movement in the magma after at least a portion of the ferromagnesian minerals had crystallized.

The more highly felspathic phase 'B' and 'C' gabbro, particularly in the finer-grained rocks, do not show pronounced lineation. However, in the phase 'A' gabbro, lineation is most pronounced in outcrops that have a fairly high feldspar content. The writer believes that the more strongly lineated parts of the gabbro were intruded after a considerable portion of the ferromagnesian minerals had crystallized, whereas the parts lacking lineation were intruded in a more fluid state.

The presence of three zones of increasing acidity in the gabbro body suggests that differentiation took place at some stage in the development of the intrusive body. The zones are not aligned parallel to the contact, as would be expected if differentiation took place <u>in situ</u> in a sill-like body. The areal arrangement of the zones suggests that they were emplaced after differentiation.

Field mapping does not give any evidence of intrusive relationships between the zones, and no age relationships can be established in this way. Phase 'A' and 'B' gabbro are different only in the ratio of felsic to mafic minerals, and possibly represent contemporaneous stages in differentiation. If the phase 'A' gabbro became rich in mafic minerals by gravitative crystal settling, this would result in the mafic portion becoming viscous owing to the presence of crystals, whereas the felsic portion would be more fluid. Intrusion at this stage would result in the lineation of the mafic portion whereas the felsic portion would not be lineated.

Grout (1918) states that it would be expected that lineation produced by movement during crystallization would be more or less influenced by the boundaries of the intrusive body. According to Adams (1903) the vertical bands in the essexite from Mt. Johnson, Quebec, are the result of vertical flow of the magma through a pipe-like opening. The pattern of lineation in the Lynn Lake gabbro is shown in figure 2. The west contact of the intrusive body is not sufficiently well defined to show if a flexure in the contact is responsible for the change in trend of the lineation in the south part of the phase 'A' gabbro area.

The phase 'B' gabbro south of Lynn Lake is strongly lineated, and contains bands of amphibolite. This suggests a genetic relationship between this rock and the phase 'A' gabbro to the north. A minor degree of lineation concordant with that of the neighboring phase 'A' gabbro occurs in the phase 'B' gabbro east of the north end of Lynn Lake. The writer believes that the phase 'A' and 'B' gabbro were intruded contemporaneously after differentiation had resulted in the se~~g~~gregation of a more mafic and slightly heterogeneous portion of the magma. The steep dip of the lineation suggests that movement of the magma was nearly vertical, particularly in the north area.

The phase 'C' gabbro is believed to represent a more acid differentiate of the same magma that produced the phase 'A' and 'B' gabbro. Evidence will be given in Chapter IV to show that the phase 'C' gabbro possibly intrudes the phase 'A' gabbro near the 'C' ore body.

Conclusions

The writer postulates the following stages in the history of the Lynn Lake intrusive body. The paragenesis of the sulphite ores will be discussed in Chapter IV.

(1) A body of basic magma was differentiated in a magma chamber below the present location of the intrusive body. The differentiation resulted in three zones, represented by the phase 'A', 'B', and 'C' gabbro respectively.

(2) Phase 'C' gabbro represents the most acid differentiate.

(3) The phase 'B' gabbro represents an intermediate stage with more basic feldspar than phase 'C' and a lower ferromagnesian content than phase 'A'.

(4) The phase 'A' gabbro became the most basic portion owing to the settling of crystals, possibly pyroxene, and also became somewhat inhomogeneous as a result of segregation of portions rich in pyroxene and feldspar respectively.

(5) The phase 'A' and 'B' gabbro were emplaced contemporaneously. The phase 'A' gabbro became strongly lineated as it contained a considerable amount of pyroxene crystals, whereas the phase 'B' gabbro was only slightly lineated owing to its fluidity.

(6) The phase 'C' gabbro was intruded after the phase 'A' and 'B' gabbro, and possibly after these rocks had solidified.

(7) Dykes of fine-grained gabbro, possibly derived from the phase 'C' magma, intruded the basic body.

Shear Zones

No evidence of the presence of major faults was observed in mapping the intrusive body. Several steep ridges have faces that drop off abruptly to swamp or low ground, and minor shearing along these faces may indicate the location of faults, but confirmatory evidence is lacking. Several ridges with slightly sheared, steep edges are shown on the geological map by shear-zone symbols along the edge of the outcrops.

Numerous minor shear zones, ranging from two to six inches in width, occur in all parts of the intrusive body. Only a few of the more prominent of these zones have been mapped. The zones cannot be traced for more than a few feet along strike, and there is no indication of the direction or amount of relative movement. With a few exceptions, the shear zones trend from north 10 degrees east to north 30 degrees east, and dip steeply west.

The shear zones are most numerous on the ridge extending between lot 386 and lot 429. A part of this ridge lying on both sides of the claim line has been strongly sheared and contorted. Thin sections from this area show crushed minerals into which quartz has been introduced. The north end of outcrop 429-1 has been sheared and metamorphosed to chlorite-antigorite schist.

CHAPTER IV

THE ORE BODIES

Four ore bodies have been outlined in the map area, and are designated as the 'A', 'B', 'C', and 'E' ore bodies. They form a disconnected chain of pipe-like bodies that range from 400 feet to 800 feet east of the gabbro-volcanic contact. The ore bodies lie at various depths beneath the overburden, and the 'B' ore body is located beneath Lynn Lake. A group of small outcrops near the mine shaft consisting of norite, uralite gabbro, and volcanic inclusions constitutes the only outcrop in the vicinity of the ore bodies.

Classification of the Ore Types

Drill core specimens from the 'C' ore body, and specimens from the underground workings at the 'A' ore body show that the ore occurs as massive and disseminated sulphides. The ore minerals comprise pyrrhotite, chalcopyrite and pentlandite. Minor amounts of magnetite, ilmenite, pyrite, sphalerite, and picotite are associated with the ore minerals. A complete mineralogical description of the ores is given in reports by Allan (1948) and Dornian (1950), and only the main features will be discussed in this report.

Disseminated Sulphides

A large proportion of the ore at Lynn Lake is made

PLATE II

Figure 1. Interstitial Sulphides. Orthorhombic pyroxene (P), mainly enstatite, embedded in sulphide (black). Note the smooth borders of euhedral pyroxene crystals.

Figure 2. Interlaminated Sulphides. Sulphide (black) replacing actinolite (grey) along cleavage planes. The actinolite fibres are not displaced.

Figure 3. Partial Replacement. Sulphide (black) between grains of enstatite (grey). The large grain of enstatite (E) has an alteration rim of actinolite (A). Sulphide replaces actinolite along this rim.

Figure 4. Interstitial Sulphides. The sulphides (black) lie between grains of actinolite (grey) which is pseudomorphic after pyroxene. The sulphide has replaced portions of the actinolite.

PLATE II

Figure 1.
Thin Section U18-288
x30

Figure 2.
Thin Section U-14
x50

Figure 3.
Thin Section U18-288
x100

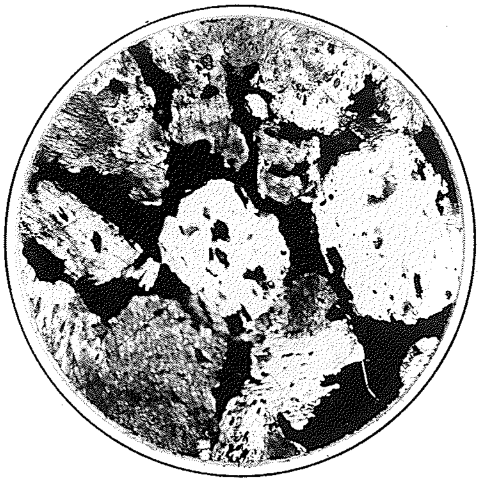


Figure 4.
Thin Section U-16
x50

up of sulphides disseminated in amphibolite and gabbro. Two classes of disseminated sulphides have been defined by the writer. Rocks in which sulphides lie between well defined silicate grains are termed interstitial sulphides, and those in which the sulphides are disseminated along cleavage planes in actinolite are termed interlaminated sulphides.

Interstitial Sulphides. Interstitial sulphides occur in rocks that have well defined and more or less compact silicate grains. Most specimens of this type contain pyroxene, or actinolite pseudomorphic after pyroxene. Pyrrhotite and chalcopyrite occur in about equal proportions and in a few specimens pentlandite can be recognized. The sulphide content ranges from scattered blebs and grains interstitial to the silicates, to a more or less continuous groundmass of sulphide in which grains of silicate minerals are embedded. Unaltered pyroxene grains have sharp boundaries with the sulphides. Some pyroxene grains have rims of actinolite, and in these grains the sulphides penetrate along the cleavage planes of the actinolite. The degree of penetration of sulphides along the cleavage planes appears to increase with increasing alteration of the pyroxene.

Interlaminated sulphides. As the name implies, sulphides in this class of ore lie in more or less parallel stringers between cleavage planes of actinolite. Hand specimens show fibrous actinolite and finely disseminated sulphides between the fibres. Thin sections show sulphides as more or less disconnected, elongated grains or stringers between fibres of actinolite. Larger grains of sulphide finger out into actinolite grains along cleavage planes, and veinlets of sulphide cut across and embay grains of actinolite. There is no distortion of the actinolite fibres, and the sulphite appears to replace the actinolite. Replacement has been mainly along cleavage planes . The writer believes that the interlaminated sulphides are a further development of the penetration of sulphides along cleavage planes in partially altered grains of pyroxene.

Massive Sulphides

Fine-grained massive sulphides. Fine-grained, equigranular, massive sulphides make up a large proportion of the massive ore in the Lynn Lake ore bodies. Bands and stringers of pentlandite,and minor amounts of chalcopyrite and pyrite, occur through a groundmass of fine-grained pyrrhotite. Traces of silicate minerals are present in all specimens, and in places the massive sulphides grade through an increase in silicate grains to disseminated sulphides. In other areas the fine-grained massive sulphides are in sharp contact with disseminated sulphides, and appear to intrude the disseminated sulphides.

Medium-grained massive sulphides.Bands and stringers of medium-grained massive sulphides that range in width from less than one inch to several feet cut through the fine-grained massive sulphides, the disseminated sulphides, and in some areas through barren host rock. On the twelfth level at the 'A' ore body, a narrow stringer of medium-grained massive sulphides cuts a pegmatite dyke. This type of massive sulphides fills fractures and brecciated zones in the gabbro. The minerals comprise pyrrhotite, pentlandite, and minor amounts of chalcopyrite and pyrite. Silicate grains are less common in the medium-grained massive sulphides than in the fine-grained massive sulphides.

Description of the Ore Bodies

The description of the 'A' ore body is based on observations made in the underground workings on the twelfth level at the 'A' ore body. The information about the 'C' ore body was obtained by logging core from 26 diamond drill holes that penetrate the 'C' ore body. The short descriptions of the 'B' and 'E' ore bodies are based on a paper prepared by the geological staff of Sherritt Gordon Mines, Limited, and presented to the Annual Western Meeting of the Canadian Institute of Mining and Metallurgy, October 15, 1948. Originals for the lateral sections of the 'A', 'B', and 'E' ore bodies were supplied by Sherritt Gordon Mines, Limited. The lateral section of the 'C' ore body is the writer's interpretation of information obtained from drill core logged by the writer and from company assay reports.

The 'A' Ore Body

The 'A' ore body is located 2500 feet north of Lynn Lake and 800 feet east of the gabbro-volcanic contact. It is a pipe-like body about 550 feet long by 250 feet wide, and extends more than 1200 feet down a steeply easterly dip.

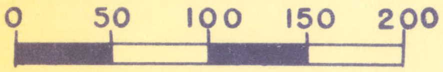
Rock types. The rock types observed in the underground workings at the 'A' ore body and in drill core from

LEGEND

■	HEAVILY DISSEMINATED TO MASSIVE SULPHIDES
⁙	FINE GRAINED GABBRO, DIKES, OR VOLCANIC INCLUSIONS
✓ ✓	GABBRO
× ×	AMPHIBOLITE

SYMBOLS

─·─	ORE OUTLINE TO INCLUDE ZONES OF LIGHTER DISSEMINATION OF SULPHIDES
∿	FAULT AND SHEAR ZONE
200	DIAMOND DRILL HOLE
- - -	GEOLOGICAL CONTACT



SHERRITT GORDON MINES LTD

LYNN LAKE PROPERTY

LATERAL SECTION OF
'A' ORE BODY
ALONG LAT **39650**
SCALE 1 IN.=100 FT.

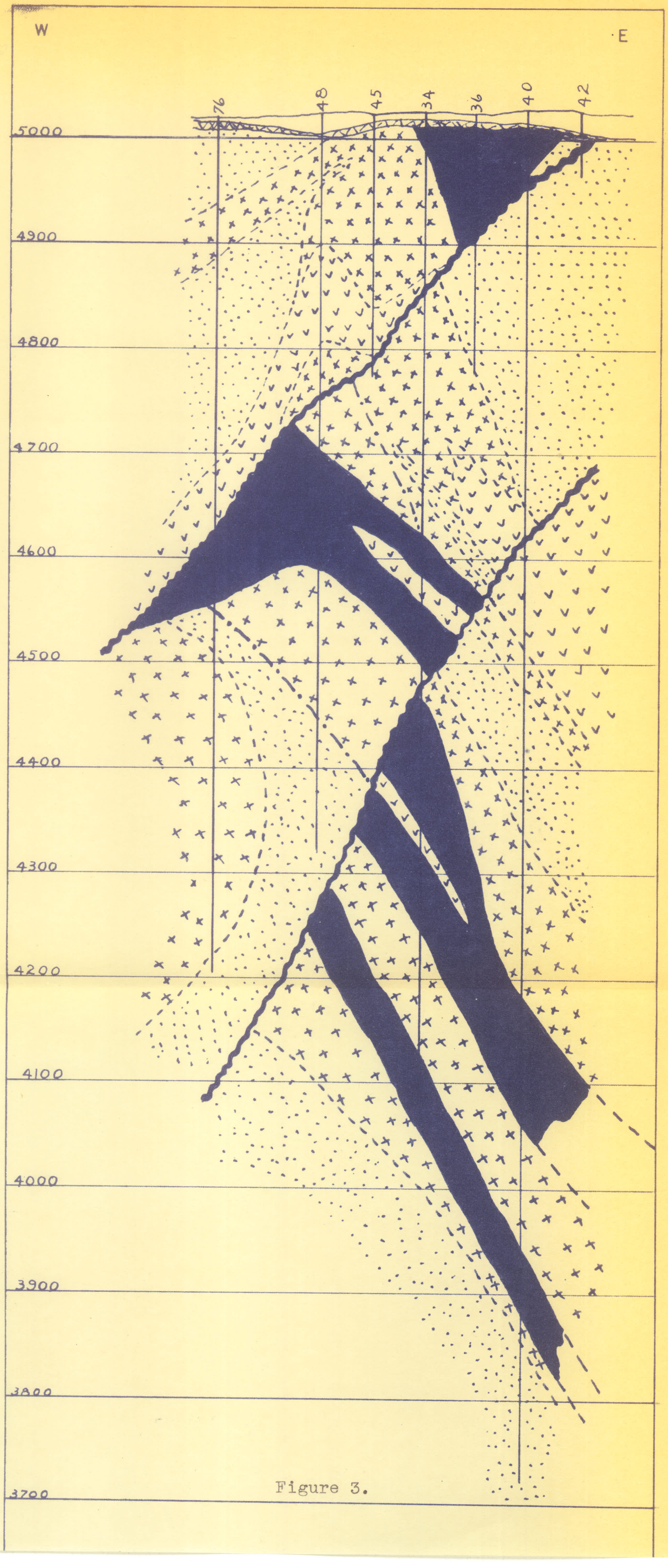

W
E
76
48
45
34
36
40
42
5000
4900
4800
4700
4600
4500
4400
4300
4200
4100
4000
3900
3800
3700

Figure 3.

underground exploration correspond to the classification established for the geological map, and comprise amphibolite, uralite gabbro, norite, gabbro dykes, possible volcanic inclusions, and acid intrusive rocks.

The amphibolite consists of fibrous, pale-green actinolite, in some places barren of sulphide and in others with sulphides disseminated along the cleavage planes of the actinolite. Most of the actinolite grains are made up of fine fibres similar to those described in Chapter II. Other grains are made up of coarser, blade-like actinolite, and in some places a core of finely-fibrous actinolite is surrounded by blade-like fibres in optical continuity with the finer fibres. The amphibolite grades to uralite gabbro through an increase in feldspar content. In most areas it is difficult to establish a line of demarkation between the two rock types. Near the shaft on the twelfth level, uralite gabbro intrudes amphibolite.

In dealing with a small area such as an ore body, the distinction between phase 'A' and 'B' gabbro is not practical, as the ratio of feldspar to amphibole varies over short distances. It has been previously stated that these divisions were based on average amphibole content over a considerable area. All uralite gabbro that contains pale-green actinolite and feldspar with composition from Ab_{40} to Ab_{45} may be considered phase 'A' gabbro. The phase 'A' gabbro from the 'A' ore body is similar in all respects to that described in Chapter II. No phase 'C' gabbro was

was observed in this area.

No norite was encountered in the underground workings, but drill hole U18 intersects 250 feet or norite on the fifth level. Amphibolite occurs on both sides of the norite, and the norite grades to amphibolite through increased alteration of pyroxene.

Thin section U18-288 shows labradorite feldspar (Ab_{40}) 15 percent, enstatite 35 percent, hypersthene 15 percent, augite 5 percite, actinolite 5 percent, sulphides 25 percent, and minor amounts of sericite. The feldspar lies in clusters of small grains, and in larger grains in which are embedded euhedral crystals of enstatite and hypersthene. The feldspar is clear and transparent, and in places has small areas of sericite. An unusual feature of this section is the presence of both enstatite and hypersthene. The enstatite has positive optical sign, and 2V is nearly 90 degrees indicating a high iron content. These minerals occur as subhedral to euhedral grains embedded in sulphide, and as smaller euhedral grains embedded in feldspar grains. A few subhedral grains of enstatite are enclosed in the larger grains of augite. Actinolite forms alteration rims about pyroxene grains, and extends along fractures in the pyroxene grains. The sulphide-silicate relationship will be discussed later in this chapter.

Fine-grained gabbro dykes intrude the amphibolite and gabbro. Some of the dykes have borders of biotite schist and others are almost entirely altered to biotite. It is possible that some of the larger occurrences of fine-grained basic material may be volcanic inclusions, but no specimens of such rock were secured.

Pegmatite and felsite dykes, ranging in width from two inches to several feet, intrude the amphibolite and gabbro. The dykes intrude both mineralized and barren amphibolite, and in one place, a pegmatite dyke contains an irregular inclusion of mineralized amphibolite. In the south drift a small pegmatite stringer intrudes a fine-grained gabbro dyke.

A large body of feldspar porphyry intrudes the gabbro in the south drift. The bordering gabbro has been altered to a mass of fine-grained talc and chlorite surrounding a few needle-like actinolite fibres. Small remnants of feldspar grains are surrounded by masses of chlorite. Considerable carbonate has been introduced as small anhedral grains that form veinlets across the thin sections. In some places, borders of biotite schist three or four inches in width lie against the porphyry. The zone of alteration is from 50 to 75 feet wide. The feldspar porphyry contains phenocrysts of orthoclase and oligoclase in a groundmass of fine-grained quartz and feldspar. The porphyry is mineralogically similar to that exposed on the ridge north of the mine shaft, and also to the porphyry encountered in the drill core from the 'C' ore body.

Ore occurrences. Disseminated sulphides constitute the main part of the 'A' ore body. The ore body is irregular in shape and is roughly circular. The boundary between ore-grade and non ore-grade rock is gradational on all sides of the ore body. To date no regular gradation in ore value has been observed in any direction through the ore body.

A large proportion of the disseminated sulphides is in amphibolite, where the sulphides are of the interlaminated type, and ~~is~~ are finely disseminated along cleavage planes in actinolite. Sulphides interstitial with the silicates occur in the norite from drill hole U18, and a specimen from the cross cut from the north drift shows sulphides interstitial with actinolite pseudomorphic after pyroxene.

Irregular bodies of fine-grained massive sulphides show no definite pattern, and are usually enclosed in mineralized amphibolite. In some areas the fine-grained massive sulphides grade into disseminated sulphides, and in other areas, the massive sulphides are in sharp contact with disseminated sulphides. Stringers and bands of medium-grained massive sulphides cut the fine-grained massive sulphides, the disseminated sulphides, and the barren host rock. In one place a one-inch stringer of medium-grained massive sulphides cuts a permatite dyke.

Sulphides composed chiefly of chalcopyrite and minor amounts of pyrrhotite, pentlandite and pyrite, fill minute fractures in pegmatite dykes and fine-grained gabbro dykes. Layers of sulphide up to one-quarter of an inch in width lie along slip planes in the gabbro at considerable dis-

LEGEND

■	HEAVILY DISSEMINATED TO MASSIVE SULPHIDES
⁘	FINE GRAINED GABBRO, DIKES, OR VOLCANIC INCLUSIONS
∨ ∨	GABBRO
× ×	AMPHIBOLITE

SYMBOLS

– • –	ORE OUTLINE TO INCLUDE ZONES OF LIGHTER DISSEMINATION OF SULPHIDES
〰	FAULT AND SHEAR ZONE
200	DIAMOND DRILL HOLE
- - -	GEOLOGICAL CONTACT

SHERRITT GORDON MINES LTD

LYNN LAKE PROPERTY

LATERAL SECTION OF
'B' ORE BODY
ALONG LAT 35800
SCALE 1 IN.=100 FT.

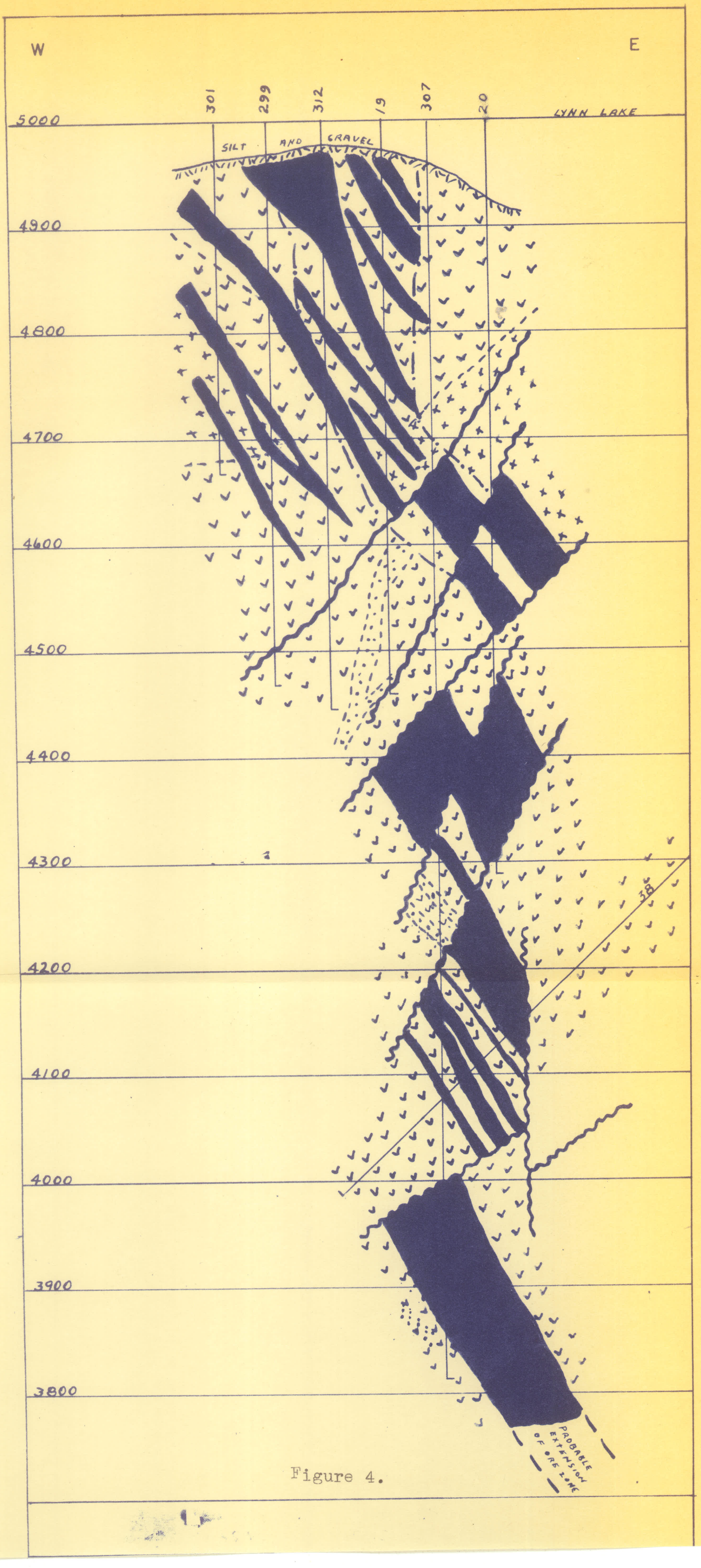

W
E
301
299
312
19
307
20
LYNN LAKE
SILT AND GRAVEL
5000
4900
4800
4700
4600
4500
4400
4300
4200
4100
4000
3900
3800
38
PROBABLE EXTENSION OF ORE ZONE

Figure 4.

stances from the ore body. The sulphide is mainly chalcopyrite and minor amounts of pyrrhotite, pentlandite, and pyrite. Some of these sulphide layers show slickensides.

The 'B' Ore Body

The 'B' ore body lies 3400 feet south of the 'A' ore body and about 400 feet east of the gabbro volcanic contact. The ore body is about 500 feet long and 150 feet wide, and extends down dip for more than 1200 feet. Above the 400 foot horizon the ore occurs in three parallel lenses of sulphides disseminated in amphibolite. Below this horizon the ore body becomes pipe-like and consists of more massive ore.

The 'C' Ore Body

The 'C' ore body lies 350 feet north of the 'A' ore body and about 500 feet east of the gabbro-volcanic contact. It lies about 250 feet south of the assumed contact between the phase 'A' and 'C' gabbro. The ore body is about 300 feet long, 100 feet wide, and extends down dip for more than 1000 feet.

Rock types. The 'C' ore body has a more complex assemblage of rock types than the 'A' ore body, possibly because of its location near the north contact of the intrusive body. Rock types encountered in drill core include medium and coarse-grained amphibolite, uralite gabbro phase 'A', uralite gabbro phase 'C', fine-grained gabbro dykes, volcanic inclusions, and acid intrusive rocks.

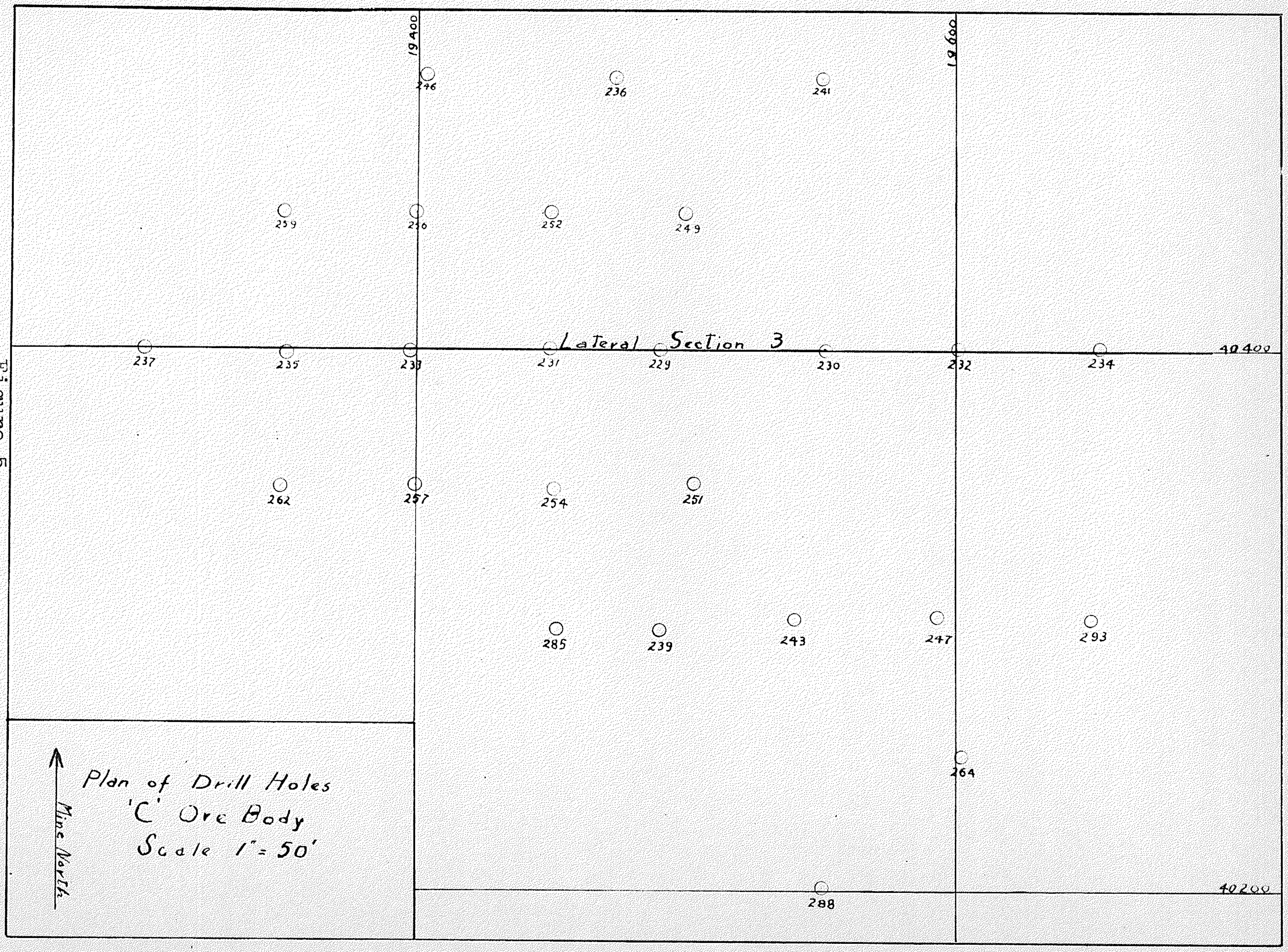

19400
19600
246
236
241
259
256
252
249
Lateral Section 3
237
235
233
231
229
230
232
234
40400
262
257
254
251
285
239
243
247
293
264
288
40200
Plan of Drill Holes
'C' Ore Body
Scale 1" = 50'
Mine North

Figure 5.

The medium-grained amphibolite is similar in mineral content and texture to that of the 'A' ore body. Fairly large areas of coarse-grained amphibolite containing amphibole grains up to one-half inch in length occur in sharp contact with the medium-grained amphibolite. Small knot-like clusters of coarse amphibole grains, and thin layers of coarse-grained amphibolite are interspersed throughout the medium-grained amphibolite. The two types of amphibolite differ only in grain size. Thin section study of the sharp contact show coarse and fine amphibole grains interlocking, and the contact does not appear to be intrusive.

The medium-grained amphibolite grades to phase 'A' gabbro through an increase in feldspar. As in the 'A' ore body it is somewhat difficult to define the point at which the change takes place. In other areas the contact is sharp, but no intrusive relationship was established. Small grains of apatite are present in most sections, and are usually closely associated with sulphide grains. In all other respects, the gabbro is similar to the phase 'A' gabbro described in Chapter II.

Drill holes along the east part of the 'C' ore body intersect phase 'C' gabbro. The phase 'C' gabbro is similar minerologically and texturally to that described in Chapter II. Most sections have up to 5 percent biotite in flakes surrounding amphibole and sulphide grains. Apatite is present in most sections, and rims of sphene surround some grains of sulphide.

The phase 'C' gabbro is limited to the east half of the 'C' ore body. Drill holes on the extreme east side intersect phase 'C' gabbro at the surface and at various depths to 1200 feet. The phase 'C' gabbro is not continuous, but interfingers with the other rock types. It extends west to drill hole 236, where only short areas were intersected at about 400, 500, and 800 feet. The contact between phase 'C' and phase 'A' gabbro is sharp, and there is a slight indication of chilled borders in the phase 'C' gabbro in some places. The interfingering of narrow bands of phase 'C' gabbro and the chilled borders suggest that the phase 'C' gabbro intrudes the phase 'A' gabbro.

Narrow fine-grained gabbro dykes intrude the gabbro and amphibolite. Thin sections from an extensive body of fine-grained basic rock outlined in drill sections, shows that this rock is similar to that exposed in outcrops 359-3 and 363-2 near the mind shaft. The writer believes that this is a large volcanic intrusion in the gabbro. An insufficient number of specimens were collected to classify all fine-grained basic rocks as either gabbro dykes or volcanic inclusions, as the distinction between the two rock types was not recognised at the time the drill core was logged.

Feldspar porphyry similar to that described previously forms an irregular tabular body that cuts the 'C' ore body. Felsite and pegmatite dykes occur as in the 'A' ore body. Two narrow sections of granite, similar in texture and mineral content to that of outcrop 387-5 were intersected in drill holes 238 and 237.

No norite was observed in the drill core from the 'C' ore body. Several thin sections of medium-grained amphibolite and phase 'A' gabbro show small remnants of enstatite surrounded by actinolite.

Ore occurrences. The 'C' ore body is made up principally of massive sulphides and smaller amounts of disseminated sulphides. Some of the disseminated sulphides are of the interlaminated type, finely disseminated in amphibolite, but a large proportion is in the form of individual grains and blebs ranging to one-half inch in diameter. Pyrrhotite, chalcopyrite, and pentlandite make up the grains and blebs, and thin sections show that the sulphide replaces actinolite as in the interlaminated sulphides. The grains and blebs of sulphide are most numerous in the medium-grained amphibolite and phase 'A' gabbro, and in places are sufficiently contentrated to constitute ore-grade rock. Extensive areas of coarse-grained amphibolite are barren except for a few scattered blebs of sulphide.

Medium-grained massive sulphides, occurring as bands and fracture fillings in brecciated parts of the gabbro and amphibolite, constitute the main source of ore at the 'C' ore body. The massive sulphides are sometimes associated with disseminated sulphides, but more often occur as breccia

LEGEND

■ HEAVILY DISSEMINATED TO MASSIVE SULPHIDES

⁘ FINE GRAINED GABBRO, DIKES, OR VOLCANIC INCLUSIONS

∨ GABBRO

× AMPHIBOLITE

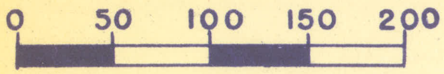
SYMBOLS

-·- ORE OUTLINE TO INCLUDE ZONES OF LIGHTER DISSEMINATION OF SULPHIDES

〰 FAULT AND SHEAR ZONE

200 DIAMOND DRILL HOLE

- - - GEOLOGICAL CONTACT



SHERRITT GORDON MINES LTD

LYNN LAKE PROPERTY

LATERAL SECTION OF
'E' ORE BODY
ALONG LAT **38850**
SCALE 1 IN.=100 FT.

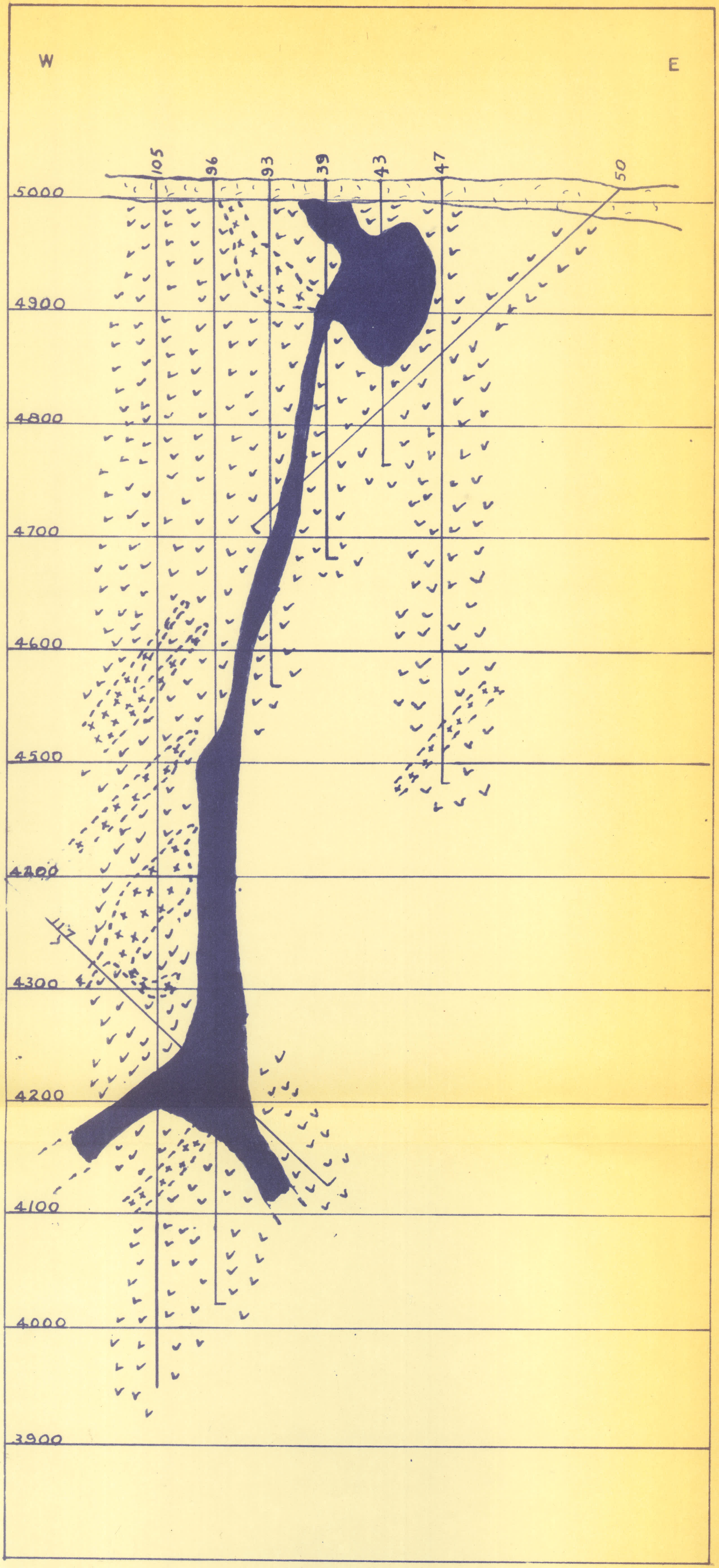

W
E
105
96
93
39
43
47
50
5000
4900
4800
4700
4600
4500
4400
4300
4200
4100
4000
3900

Figure 6.

fillings in barren host rock. Minor amounts of fine-grainäd massive sulphides are associated with disseminated sulphides. As in the 'A' ore body, fine fractures in pegmatite and gabbro dykes contain concentrations of chalcopyrite, pyrrhotite, and pentlandite.

The 'E' Ore Body

The 'E' ore body is located 350 feet south of the 'A' ore body and about 350 feet east of the gabbro-volcanic contact. The ore body is 350 feet long, 60 feet wide, and extends down dip for over 850 feet. The body is more or less tabular, and consists of numerous lenses of disseminated sulphides in amphibolite arranged on echelon.

Discussion

Rock Types.

Diamond drill holes show that there is considerably more amphibolite in the west half of the phase 'A' gabbro area than in other parts of the intrusive body. It has been suggested in Chapter III that the alternating areas of gabbro and amphibolite were caused by differentiation which resulted in an inhomogeneous portion of the magma. The west part of the phase 'A' area is believed to represent the greatest degree of differentiation which resulted in the concentrations of amphibolite. Formation of amphibolite in this way would lead to gradational contacts between amphibolite and gabbro. Intrusion of amphibolite by gabbro, as observed in underground workings, may have resulted from emplacement of the intrusive body after the mafic-rich portions had been concentrated. The mafic portions would be highly viscous as they consisted mainly of crystallized pyroxene, and the more felsic portions would be fluid as they consisted of uncrystallized magma. Emplacement at this time might cause the fluid magma to intrude the viscous mafic portions locally.

To date no definite pattern has been recognized in the amphibolite. A three dimensional model of drill holes from the 'C' ore body suggests a more or less tabular body of amphibolite striking north 30 degrees east and dipping steeply east. The picture is obscured by the complex fault pattern, and the irregular gradational contact between gabbro and amphibolite.

Phase 'C' gabbro occurs in the 'C' ore body where it appears to intrude the phase 'A' gabbro and amphibolite along the east side of the area. This indicates that the phase 'C' gabbro is younger than the phase 'A' and 'B' gabbro as was suggested in Chapter III. To date no phase 'C' gabbro has been recognised in the other ore bodies. The areal distribution of the phase 'C' gabbro as outlined on the geological map would suggest that phase 'C' gabbro might be expected to appear in the 'C' ore body but not in the other ore bodies.

In specimens of norite from drill hole U18 all the primary ferromagnesian minerals are pyroxene. In some specimens the pyroxene makes up 90 per cent or more of the silicate minerals and the rock may be classed as a pyroxenite. The norite grades to uralite gabbro through alteration of the pyroxene to actinolite, and similarly the pyroxenite grades to amphibolite. Much of the amphibolite was probably originally pyroxenite.

At the time the information was secured for this report, no distinction was made between the fine-grained gabbro dykes and volcanic inclusions. As a result it is not possible to define the extent of each rock type. Specimens from the 'C' ore body show that a large body of fine-grained basic rock outlined in drill sections is similar mineralogically and texturally to the fine-grained outcrops near the mine shaft which the writer has mapped as volcanic inclusions. It may be of some importance to outline the volcanic inclusions accurately, as they may have had some influence on the emplacement of the ore. The inclusions may have directed the flow of magma locally, or may have formed a base against which the sulphides collected. Bjørlykke (1947) attributes the ore concentration at the Flat mine, Norway, to segregation against 'flakes' of gneiss included in the original norite body.

Pegmatite and felsite dykes are evidently later than the gabbro, amphibolite, and fine-grained gabbro dykes as they intrude these rocks. Pegmatite dykes intrude the mineralized amphibolite, and one such dyke includes an irregular fragment of mineralized amphibolite. It appears that the pegmatite post-dates the mineralization, but the sulphides are of the interlaminated replacement type and could have been introduced after emplacement of the pegmatite.

The extensive alteration in the gabbro bordering the large body of feldspar porphyry in the south drift indicates that the porphyry intrudes the gabbro. The porphyry from the 'A' and 'C' ore bodies is similar mineralogically and texturally to that exposed in outcrop 364-3 north of the basic intrusive body. Small granite bands in the 'C' ore body are similar to the granite exposed in outcrop 387-5. The writer believes that the porphyry and granite are part of a series of acid intrusive bodies that intrude the basic body near the west contact. It does not seem likely that such an extensive series of acid intrusive bodies has been derived by differentiation of the relatively small basic body, and it is possible that they are related to the younger granite bodies of the area.

No relation was established between the granitic bodies and the felsite and pegmatite dykes. The dykes may be part of the intrusion of porphyry and granite, or may be acid differentiates of the basic body.

Sulphide-silicate Relationships

The writer has divided the disseminated ore from Lynn Lake into two classes, interstitial sulphides and interlaminated sulphides, in which the sulphide-silicate relationship is different. Interstitial sulphides occur in fresh norite and pyroxenite, and the sulphides fill interstices between the grains of pyroxene or form a ground mass in which pyroxene grains are embedded. Contacts between sulphide and pyroxene grains are sharp and there is no evidence that sulphides replace pyroxene. Interlaminated sulphides occur in fibrous amphibolite and uralite gabbro. The sulphides lie mainly within grains of actinolite, and replace actinolite along cleavage planes.

Intermediate between the two extreme classes, the sulphide tends to lie between silicate grains and to penetrate the silicate along cleavage planes. Where fresh pyroxene grains, and pyroxene grains that have alteration rims of actinolite occur in the same section, the sulphides are in sharp smooth contact with pyroxene, but extend into the rims of actinolite along cleavage planes. Gradation can be traced from interstitial sulphides with no replacement to interlaminated sulphides where the relationship is entirely one of replacement. The w riter believes that the interlaminated sulphides were developed by redistribution of interstitial sulphides and that the redistribution took place practically in situ. The redistribution was accomplished by the replacement of actinolite by the sulphides.

Although the sulphides replace actinolite, it is not possible to state definitely whether the replacement tookplace during or after the formation of actinolite. If the sulphides had been redistributed by some agency after the pyroxene had altered to actinolite, some replacement of pyroxene by sulphide might be expected. The evident relationship between actinolite and the occurrence of replacement suggests that the agency that altered the pyroxene to actinolite also resulted in the redistribution of the sulphide. The writer has suggested previously that thermal and hydrothermal action caused the alteration of pyroxene to actinolite. It is possible that the hydrothermal solutions redistributed the sulphides at this time.

The writer believes that sulphides already present in the rock as interstitial sulphides were redistributed by the thermal and hydrothermal activity that caused the uralitization of the pyroxene, and that the redistribution caused only minor migration of the sulphides. As the sulphides were already present in the rock, and the migration of sulphides was for short distances only, the redistribution played no part in the concentration of the sulphides or in the emplacement of the ore bodies in their present location.

General Sulphide Relationships

Scattered sulphides occur in all parts of the intrusive body. Investigations by Dornian (1950) showed no pentlandite in specimens from the phase 'C' gabbro or the fine-grained gabbro dykes except where sulphides filled fractures in the gabbro dykes. Specimens of phase 'C' gabbro and fine-grained gabbro dykes were crushed and the sulphides separated and tested with dimethylglyoxeme. No positive tests for nickel were obtained in these specimens. Specimens assayed from magnetic anomalies in the phase

'C' area and from the country rocks surrounding the intrusive body showed no nickel content.

Specimens from phase 'A' and 'B' gabbro treated in the same manner as those of the phase 'C' gabbro gave positive nickel tests. Specimens assayed from magnetic anomalies in the phase 'B' gabbro area showed nickel-copper content but in quantities insufficient to constitute ore bodies. All of the known ore bodies lie in the west part of the phase 'A' gabbro area where diamond-drill holes have shown a high proportion of amphibolite. It appears that the nickel bearing sulphides are confined to the phase 'A' and 'B' gabbro, and that ore grade sulphides are further limited to areas with a high proportion of amphibolite.

Within the ore bodies an increase of feldspar in the rock is normally accompanied by a decrease in sulphide content. Few ore-grade sections are present in gabbro except in the 'C' ore body where in some places sufficient blebs of sulphide are concentrated to constitute ore-grade rock. The largest part of the sulphides is concentrated with amphibolite. The writer believes that the sulphides were concentrated by the same agencies that resulted in concentrations of amphibolite.

The interstitial sulphides appear to constitute an original mineral in the rock. If the interstitial sulphides are primary minerals in the rock, then their concentration with amphibolite can be explained by segregation at the same time as that of the mafic minerals. Howe (1915), Coleman

(1912), Calkins (1916), Kemp (1894), and Baker (1917) have advanced the idea that sulphides in basic bodies segregate as a melt at an early stage in crystallization.

The writer has suggested that the amphibolite represents pyroxenite which formed by the gravitative settling of early crystallized pyroxene grains. The high specific gravity of the sulphides would cause them to settle towards the base of the intrusive body, and collect along with concentrations of pyroxene in pools near the base of the magma chamber. The lighter pyroxene grains would tend to float in the sulphide melt, and nearly pure liquid sulphide would grade upward through increasing pyroxene content to disseminated sulphides and finally to barren rock in which only a few scattered drops of sulphide were present. If the rock solidified at this stage, massive sulphides would show gradational contacts with disseminated sulphides.

It has been stated that fine-grained massive sulphides grade into disseminated sulphides and also appear to intrude disseminated sulphides. The disseminated sulphides which contained considerable amounts of pyroxene grains would be more viscous than the liquid sulphide melt, and if movement took place in the magma at this stage, some of the less viscous liquid sulphides might intrude the disseminated sulphides and result in the intrusive contacts noted.

The medium-grained massive sulphides in the Lynn Lake ore bodies appear to intrude the disseminated sulphides, fine-grained massive sulphides, and barren rock, and appear to have been emplaced after consolidation of these rock types. The medium-grained massive sulphides may represent a portion of the sulphide melt that remained liquid after consolidation of the other rocks, possibly owing to the presence of mineralizers, and which was intruded when the rock mass was fractured. The presence of increased amounts of mineralizers in this portion might also account for the larger grain size.

Sulphides comprising chalcopyrite, pyrrhotite, pentlandite and pyrite fill minute fractures in the gabbro dykes and pegmatite dykes both within the ore bodies and at considerable distances from the ore bodies. Concentrations of the same minerals lie in layers up to one-quarter of an inch thick along slip planes in the gabbro in the vicinity of the ore bodies. It is not possible to determine from mineralogical evidence whether the sulphides were introduced in liquid form or by hydrothermal solutions. An extremely tenuous sulphide melt would be necessary to penetrate the minute fractures and to extend beyond the borders of the ore bodies. It is possible that the hydrothermal solutions that redistributed the disseminated sulphides may have carried these minerals into the fractures in the bordering rocks. The stringer of medium-grained sulphides that cuts a pegmatite dyke may also have been emplaced in this manner.

Conclusions

(1) The interstitial sulphides constitute an original rock forming mineral in the Lynn Lake intrusive body.

(2) The interlaminated sulphides, in which the sulphides replace actinolite, were formed from interstitial sulphides by hydrothermal action. The sulphides were redistributed by the hydrothermal solutions that caused the uralization of the pyroxene, and the redistribution was possibly contemporaneous with the alteration of pyroxene to actinolite.

(3) The redistribution caused only minor migration of the sulphides and interlaminated sulphides formed in this way are in the same location as the interstitial sulphides from which they were developed.

(4) The hydrothermal solutions were not responsible for the concentration or emplacement of the ore bodies in their present location.

(5) The sulphides were concentrated as a melt by segregation at an early stage in the crystallization of the magma, and collected with concentrations of pyroxene near the base of the magma chamber.

(6) The fine-grained massive sulphides represent heavy concentrations of sulphides that collected in this manner.

(7) The medium-grained massive sulphides represent portions of the sulphide melt that remained liquid until the main body had solidified, and were intruded into fractures and brecciated zones by subsequent movement in the intrusive body.

(8) The fine fracture fillings of sulphides in the late dykes were emplaced by hydrothermal solutions after consolidation of the rock, probably at the same time and by the same solutions that redistributed the disseminated sulphides.

CHAPTER V

SUMMARY OF CONCLUSIONS

Hypothesis of Origin

An hypothesis of origin for the Lynn Lake ore bodies must account for the concentration of the sulphides, and the emplacement of the ore bodies in their present location. The hypothesis must also explain the pipe-like character of the ore bodies, the features exhibited by the various types of massive and disseminated sulphides, and the stringers of nickel-copper bearing sulphides that cut the late basic and acid dykes.

Much of the literature that has been written about the various nickel-copper deposits of the world is concerned with the question of origin. Writers differ greatly in their views concerning the mechanics of sulphide concentration and ore emplacement for nickel-copper ore bodies. The classic example of nickel-copper deposits is the norite body at Sudbury, Ontario. The ore deposits at Sudbury are the largest of their kind in the world and have been studied more extensively than any other similar deposit. It might be expected that detailed study by geologists over an extended period of time should lead to agreement as to class of ore deposit and the origin of the ore bodies. However, there is still a wide divergence of opinion concerning the Sudbury deposits.

Phemister (1925) in his report on the Sudbury ore deposits includes a short historical review of the hypotheses advanced to account for the origin of the ore bodies. He classes these under four headings which can be briefly summarized as follows:

(1) The sulphides were injected in a molten condition after consolidation of the silicates. The separation of the sulphides from silicates took place in a magma chamber not far from the present norite-pegmatite sill.

(2) The sulphides crystallized from ore magmas which formed independent members in a series of magmatic injections.

(3) The sulphides were introduced by hydrothermal replacement of the country rocks, the solutions being derived from the norite or from the same deep seated reservoir which was the source of the post-Sudburian igneous rocks of the district.

(4) The ores formed by settling of an immiscible sulphide melt from the norite.

A fifth hypothesis to account for the origin of nickel-copper deposits is given by Tolman and Rogers (1916). They class nickel-copper deposits as magmatic deposits and define magmatic deposits as segregations of ore minerals that take place under the influence of, or closely associated with, the molten stage of the parent rock. They state that magmatic ores have been introduced at a late stage as a result of mineralizers, and that ore minerals replace the silicates. This hypothesis differs from the pneumatolytic and hydrothermal hypotheses in that quartz and secondary silicates are not formed as the ore is desposited.

The five hypotheses listed above have been used to explain the origin of most of the nickel-copper ore bodies of the world. The evidence obtained during the present study of the Lynn Lake basic intrusive body will be examined in view of these hypotheses.

The injection of sulphides in a molten condition after consolidation of the silicates was suggested by Howe (1914), and Bateman (1917) to account for certain features in the Sudbury ore deposite. The sulphides were presumed to have originated by differentiation from the norite in a magma chamber below the present location of the ore bodies. Spurr (1924) advocated a similar theory of liquid injection from an ore magma that was independent of the norite. Hoffman (1931) concluded from his observations of the Vlakfontein nickel deposits of the Rustenburg area, Transvaal, that the ore bodies were introduced after consolidation of the rock and were formed from agencies that came from below. He did not decide whether the sulphides were introduced as a melt or by hydrothermal solutions. Howe (1915) studied the sulphide bearing rocks of Litchfield, Connecticut, and attributed the concentration of the ore to differentiation before intrusion, the sulphides and associated silicates being the last to be drawn from the magma chamber. He postulated a composite intrusion in which the sulphide rich rocks occur as small intrusive bodies in a rock previously solidified.

The intrusion of sulphides in a molten condition after the consolidation of the main gabbro body would explain the pipe-like character of the Lynn Lake ore bodies, and would also explain the massive ore that fills fractures in brecciated gabbro. This hypothesis does not account for either the interstitial sulphides that form an original constituent of the rock, or the gradational contact between ore-grade and non ore-grade rock, unless the intrusion included disseminated sulphides and barren host rock as well as molten sulphides. Diamond drill holes in the vicinity of the ore bodies and underground workings at the 'A' ore body show no evidence that the rocks associated with the ore are in any way different from the main gabbro, and also show no evidence of intrusion of sulphide bearing rocks into formerly solidified host rock. The sulphide injection hypothesis would have to be modified considerably to be applicable to the Lynn Lake ore deposits.

The hypothesis of a hydrothermal origin for the Sudbury ore bodies was advocated by Dickson (1904), Gregory (1908) and Knight (1917) who noted that in some areas the sulphides obviously replace the silicates. Wandke and Hoffman (1924) supported the hydrothermal hypothesis for the Sudbury deposits. Uglow (1911) attributed the interstitial sulphides from the Alexo mine, Ontario, to selective hydrothermal replacement. Phemister (1924) studied the nickel deposits at Lancaster Gap, Pennsylvania, and concluded that the ore was introduced by hydrothermal solutions that penetrated the intrusive body along the contact.

Allan (1948) studied specimens of the sulphide ores from Lynn Lake and concluded that the sulphides were deposited mainly by hydrothermal replacement of the silicates after consolidation of the gabbro host rock. He concluded that the development of secondary actinolite and the emplacement of basic and acid dykes took place before ore deposition. He cited the association of actinolite with the disseminated sulphides to show that hydrothermal activity was closely associated with ore deposition and to show that the temperature of deposition was sufficiently high that actinolite was stable, but not talc, sericite, or chlorite. He maintained that the temperature of deposition was not sufficiently high to result in the formation of pyroxene in contact with the sulphides. He concluded that the ore bodies are in the class of high temperature hydrothermal deposits.

The specimens studied by Allan were secured at an early stage in the exploration and at that time no interstitial sulphides in unaltered norite had been encountered. The specimens of disseminated ore which he studied were of the replacement type described in this report as interlaminated sulphides. The writer agrees with the relationships established by Allan in his study of this type of sulphide ore. The sulphides replace actinolite, and the replacement took place after consolidation of the host rock.

Further exploration has revealed fresh norite in the ore bodies. The writer has concluded from studies of the interstitial sulphides that the sulphides occur as an original component of the rock. Grains of pyroxene lie embedded in sulphide and emplacement of the sulphide by hydrothermal solutions would necessitate a temperature sufficiently high to render pyroxene stable. The interstitial character of the sulphides that show no replacement of fresh pyroxene grains would necessitate a high degree of selective replacement of feldspar, and no evidence for this action was observed. The writer has shown that in some places interlaminated sulphides have developed by redistribution of interstitial sulphides, and has suggested that all the interlaminated sulphides developed in this way.

The writer agrees that the intrusive body has undergone extensive hydrothermal alteration, and has suggested that the alteration post-dated the concentration and emplacement of the ore. The hydrothermal solutions are believed to have resulted in the uralitization of the pyroxene and at the same time to have caused minor redistribution of sulphides already present in the rock. The redistribution caused the formation of interlaminated sulphides from interstitial sulphides, and introduced nickel-copper bearing sulphides into minute fractures in the late acid and basic dykes. The writer believes that the sulphides in the Lynn Lake intrusive body were concentrated and emplaced in their present location by agencies other than hydrothermal solutions.

The late magmatic hypothesis of Tolman and Rogers (1916) cannot be applied to the Lynn Lake ore deposits for the same reasons that obviate a hydrothermal origin. The evidence suggests that the sulphides were present prior to consolidation of the rock and were not introduced by replacement as postulated in this hypothesis.

Most writers agree that the nickel-copper deposits are genetically related to the basic intrusive bodies in which they occur. Bell (1891) was the first geologist to suggest this relationship between the ore bodies at Sudbury and the norite sill. Adams (1893) postulated that the Sudbury ores were ultrabasic differentiates of the norite. This hypothesis was accepted and further developed by Coleman (1912). Baker (1917) described the ore deposits at the Alexo mine, Ontario, as massive sulphides against pillow lavas and in sharp contact with disseminated sulphides in serpentine(altered peridotite). The disseminated ore in turn graded into barren peridotite away from the contact. He refuted Uglow's (1911) hypothesis of hydrothermal replacement and cited the sharp contact between massive and disseminated ore to modify Coleman's (1910) views of simple magmatic segregation. He suggested three stages in the emplacement of the ore. (1) the collection of sulphides by settling to the base of the intrusive body. (2) Shrinkage of the intrusive body owing to cooling. (3) Injection of sulphides from a lower source between the footwall and disseminated ore. Kemp (1894) explained the ore deposits at Lancaster Gap, Pennsylvania, by segregation <u>in situ</u> according to the

Soret principle. Calkins (1916) described the ore deposit at the Friday mine in San Diego County, California, as a steeply inclined chimney-like body poorly defined except where it is faulted. He attributed the ore concentration to magmatic segregation from the gabbro. The writer has concluded from evidence presented in this report that the sulphides at Lynn Lake were concentrated by magmatic segregation, and suggests the following history of the formation of the ore bodies.

The sulphides settled as an immiscible melt together with early crystallized pyroxene, and collected in pools at or near the base of the magma chamber. The concentrations graded from nearly pure liquid sulphides through disseminated sulphides to barren host rock. The phase 'A' and 'B' gabbro and the concentrations of sulphides were intruded contemporaneously to the present location of the intrusive body. Lineation suggests that the movement of the viscous magma was nearly vertical. The sulphide concentrations were carried along by the movement of the viscous silicates in the form of roughly circular, elongated bodies surrounded on all sides by silicates that contained only scattered blebs of sulphide. During the emplacement of the magma the less viscous sulphide melt intruded the more viscous disseminated sulphides in some areas, and resulted in intrusive contacts as opposed to gradational contacts in other areas. A similar action resulted in gradational and intrusive contacts between viscous pyroxenite and more fluid norite. The massive sulphides originally lay below the disseminated sulphides but as they were more mobile than the disseminated sulphides, the massive sulphides tended to force their way upwards through the viscous pyroxene-rich rock and formed irregular disconnected areas enclosed by disseminated sulphides. The flow of magma was restricted near the gabbro-volcanic contact and the sulphide concentrations were directed away from the contact.

The main body of silicates, the disseminated sulphides and most of the massive sulphides, solidified at this stage. A portion of the massive sulphides remained liquid owing to the presence of mineralizers. Extensive movement in the intrusive body caused brecciation of the norite and the remaining liquid sulphides were injected into the fractures. The sulphides solidified as medium-grained massive sulphides, the increased grain size possibly being caused by the mineralizers.

After complete solidification of the silicates and sulphides, the intrusive body was subjected to thermal and hydrothermal alteration by the heat and solutions from the younger granite bodies in the area. The metamorphism altered pyroxene to actinolite and the hydrothermal solutions redistributed a large part of the interstitial sulphides by replacement of actinolite along cleavage planes. This redistribution caused only minor migration of the sulphides. The same solutions carried sulphides including chalcopyrite, pyrrhotite, pentlandite, and pyrite into minute fractures in the acid and basic dykes and along slip planes in the gabbro.

The writer has suggested that movement took place after consolidation of the silicates and all but small portions of the sulphides, and that this movement squeezed the still liquid sulphides into fractures and breccia zones in the norite body. Information from drill core sections and underground maps shows a complex fault system, and suggests that more than one period of post-solidifidation movement has occurred. As the sulphides are believed to have been present in the original rock, all post-solidification movements should affect the ore bodies.

The writer postulates that the contentration of sulphides at Lynn Lake was by magmatic segregation, and that the concentration was followed by intrusion of the still liquid sulphides together with the semi-fluid norite into its present vertical position. Subsequent redistribution of some of the sulphides was caused at a much later time when metamorphism of the norite body was brought about by intrusion of the younger granite bodies in the area. The redistribution of the sulphides is of minor importance as far as the location of ore bodies is concerned as only minor migration of the sulphides was caused.

Geological History of the Lynn Lake Intrusive Body

The writer suggests the following sequence of events in the geological history of the Lynn Lake intrusive body.

(1) A body of basic magma in a magma chamber below the present location of the intrusive body underwent differentiation into an acid portion (phase 'C' gabbro) and a more

basic portion (phase 'A' and 'B' gabbro).

(2) The more basic portion was further differentiated by gravitative crystal settling into an inhomogeneous mafic-rich portion (phase 'A' gabbro), and a more felsic, homogeneous portion (phase 'B' gabbro).

(3) The early crystallizing minerals that collected by gravitative crystal settling were enstatite, hypersthene, and augite. Some primary hornblende formed at this stage, mainly in the phase 'B' gabbro portion. It is possible that the primary ferromagnesian minerals in the phase 'C' gabbro magma were mainly hornblende and some pyroxene.

(4) The sulphides were concentrated with the early crystallized pyroxene and collected in pools at or near the base of the magma chamber.

(5) The phase 'A' and 'B' gabbro and the concentrated sulphides were intruded more or less concordantly along the contact between Wasekwan volcanic and sedimentary rocks. Irregular inclusions of volcanic material and possibly some sedimentary material were trapped in the gabbro. At the time of intrusion the sulphides and felsic portions of the magma were fluid, but the pyroxene-rich portions were highly viscous owing to the high proportion of crystals. The more viscous phase 'A' gabbro became strongly lineated whereas the more fluid phase 'B' gabbro was only slightly lineated. The lineation suggests that the flow of magma was nearly vertical.

(6) After emplacement of the phase 'A' and 'B' gabbro and solidification of the main silicates a slight movement in

the intrusive body caused small fractures in the feldspar and to a lesser extent in the ferromagnesian minerals.

(7) The silicates and all but small portions of the massive sulphides solidified at this stage.

(8) Considerable movement within the intrusive body squeezed the still liquid portions of the sulphides into fractures and brecciated zones in the norite. The age of this sulphide injection is not definitely established and may have occurred after emplacement of the basic and acid dykes.

(9) The phase 'C' gabbro was intruded concordantly between the Wasekwan volcanic and sedimentary rocks immediately to the east of the phase 'B' gabbro. In places the phase 'C' gabbro intruded the phase 'A' and 'B' gabbro. Dykes of gabbro, possibly derived at a late stage from the phase 'C' magma intruded the phase 'A' and 'B' gabbro.

(10) Dykes of pegmatite and felsite, possibly derived as an acid differentiate of the basic body, intruded the basic body after emplacement of the phase 'C' gabbro.

(11) A period of intensive movement in the intrusive body resulted in the formation of a complex fault system that offset the ore bodies and produced numerous shear zones. This may represent the same period of movement listed in (8).

(12) At a considerable time after consolidation of the sulphides and silicates the intrusive body was subjected to thermal and hydrothermal alteration from the younger granite bodies to the east and north of the area. A large proportion of the ferromagnesian minerals were altered to actinolite, and some feldspar was altered to chlorite. The hydrothermal

solutions redistributed a portion of the disseminated sulphides by replacement of actinolite, and also deposited sulphides in fine fractures in the late acid and basic dykes.

(13) Small bodies of granite and feldspar porphyry intruded the basic body in the vicinity of the west contact and the volcanic and sedimentary rocks to the north of the basic body. This intrusion post-dated the uralitization of the pyroxene and resulted in the alteration of some remaining orthorhombic pyroxene to talc.

(14) The area was eroded and glaciated to its present form.

Problems for further Study

(1) A problem of major economic importance is the solution of the complex fault system that offsets the ore bodies. The study should consider information from all drill holes and underground workings in the vicinity of the ore bodies. The problem might be simplified by the compilation of a composite plan of the area including the ore bodies on which the information from drill holes and underground workings could be incorporated.

(2) The volcanic inclusions in the vicinity of the ore bodies should be accurately outlined and the possibility investigated that these inclusions may have influenced the location of the ore bodies. The inclusions may have influenced the flow of magma and in this way affected the location of ore bodies, or may have formed bases against which some of the sulphide segregated.

(3) The study of the Lynn Lake intrusive body has

failed to clarify the age and possible genetic relationships of the intrusive bodies of granite and feldspar pophyry and the dykes of felsite and pegmatite. An investigation of this relationship might be extended to include an attempted correlation of the granite and porphyry with the granite bodies near Berge and Eldon Lakes.

(4) The writer has classified the fibrous secondary amphibole as actinolite. More detailed mineralogical study is needed for the accurate classification of this mineral, and the investigation of the possibility that a pargasite variety of amphibole occurs in the Lynn Lake gabbro as suggested by Allam (1948). This study might also include an investigation into the cause of the blue colour of the amphibole in the phase 'C' gabbro.

(5) The discrepancy between the feldspar composition determined by immersion in index oils and that determined by the Statistical Method and the Rittman Zone Method has not been explained. Further minerological study of the feldspar, including possibly a chemical analysis for sodium, calcium, and trace elements might discover the reason for this discrepancy.

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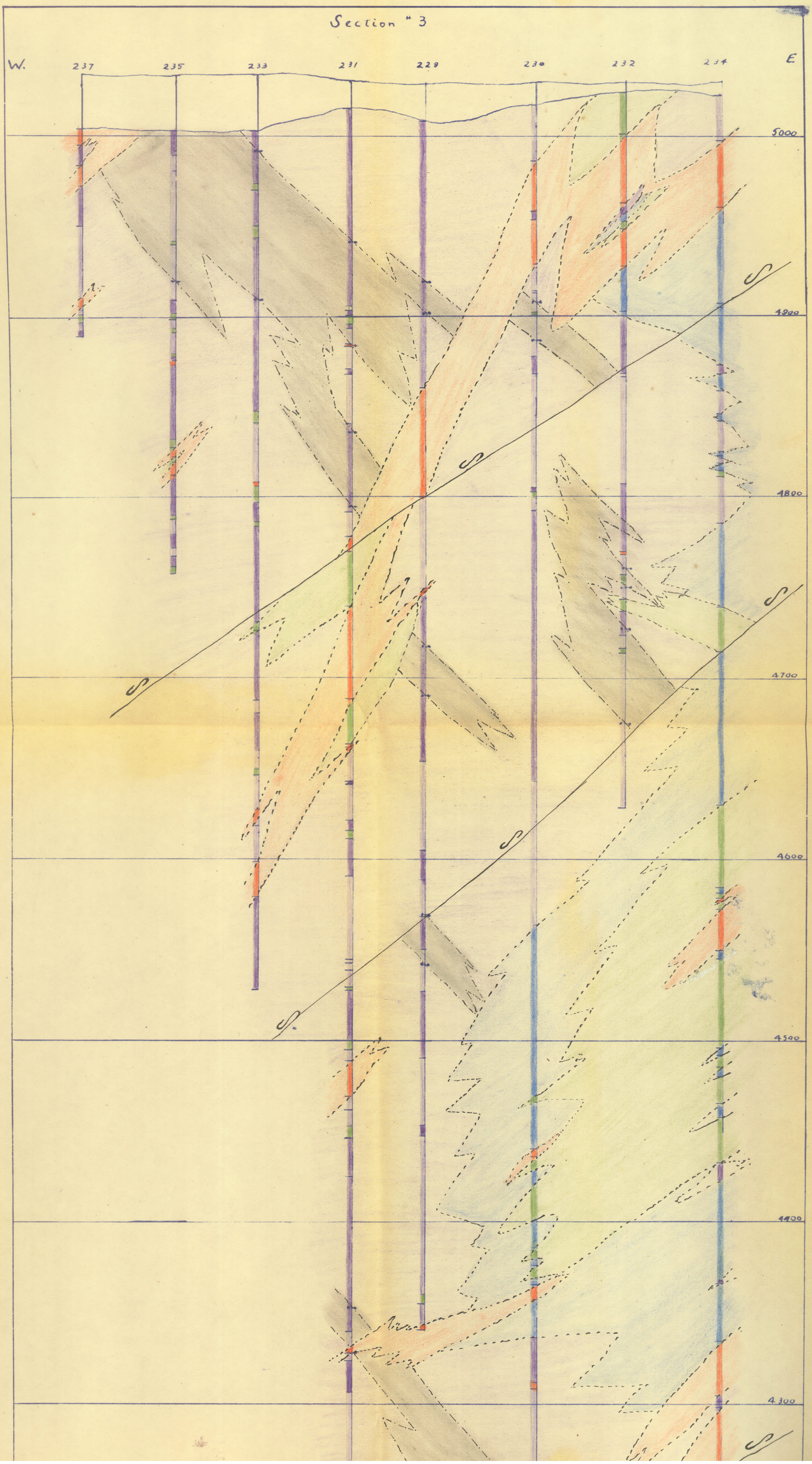
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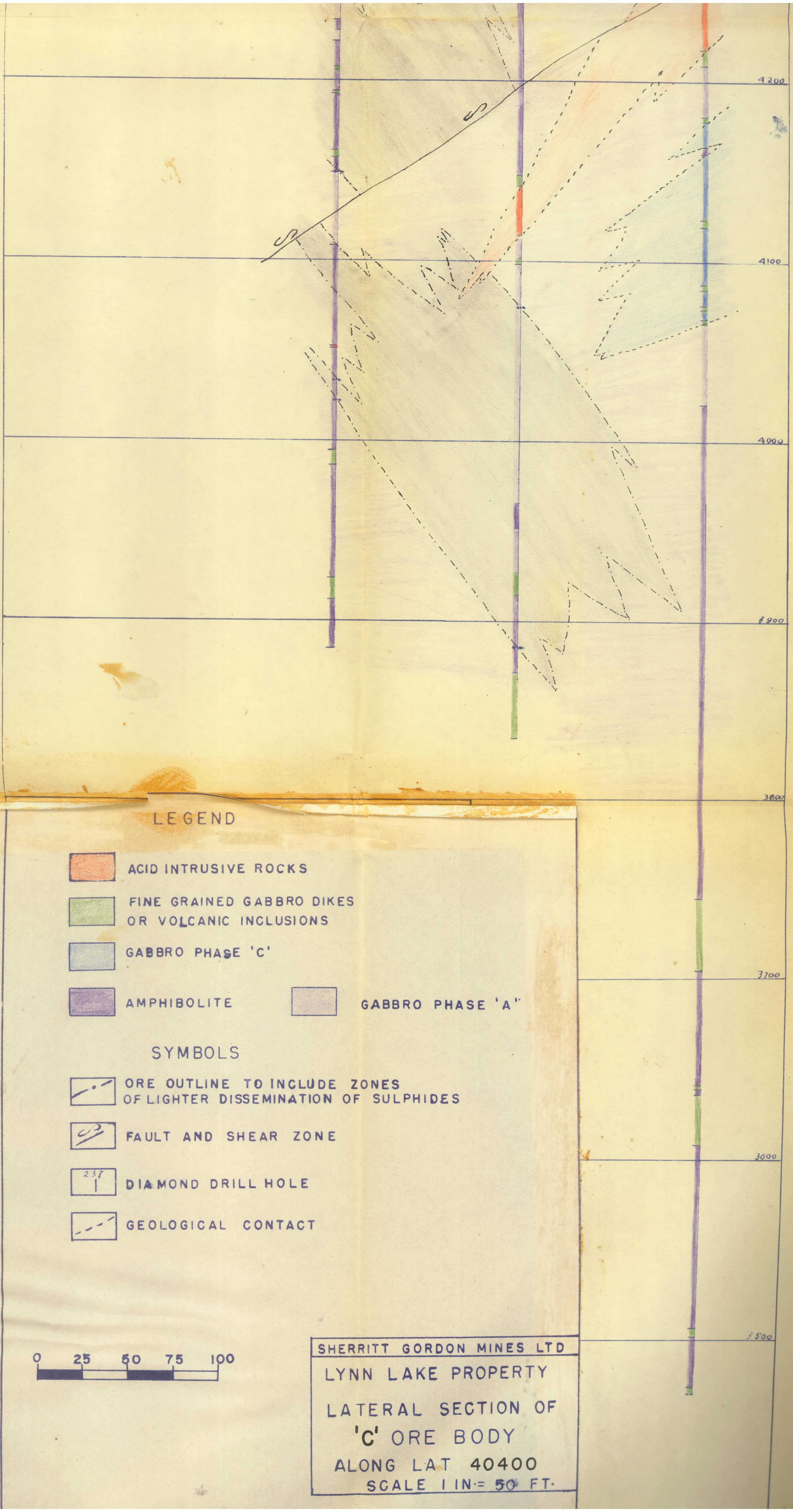


LEGEND

🟥 ACID INTRUSIVE ROCKS

🟩 FINE GRAINED GABBRO DIKES OR VOLCANIC INCLUSIONS

🟦 GABBRO PHASE 'C'

🟪 AMPHIBOLITE

▨ GABBRO PHASE 'A'

SYMBOLS

-·- ORE OUTLINE TO INCLUDE ZONES OF LIGHTER DISSEMINATION OF SULPHIDES

∽ FAULT AND SHEAR ZONE

237 | DIAMOND DRILL HOLE

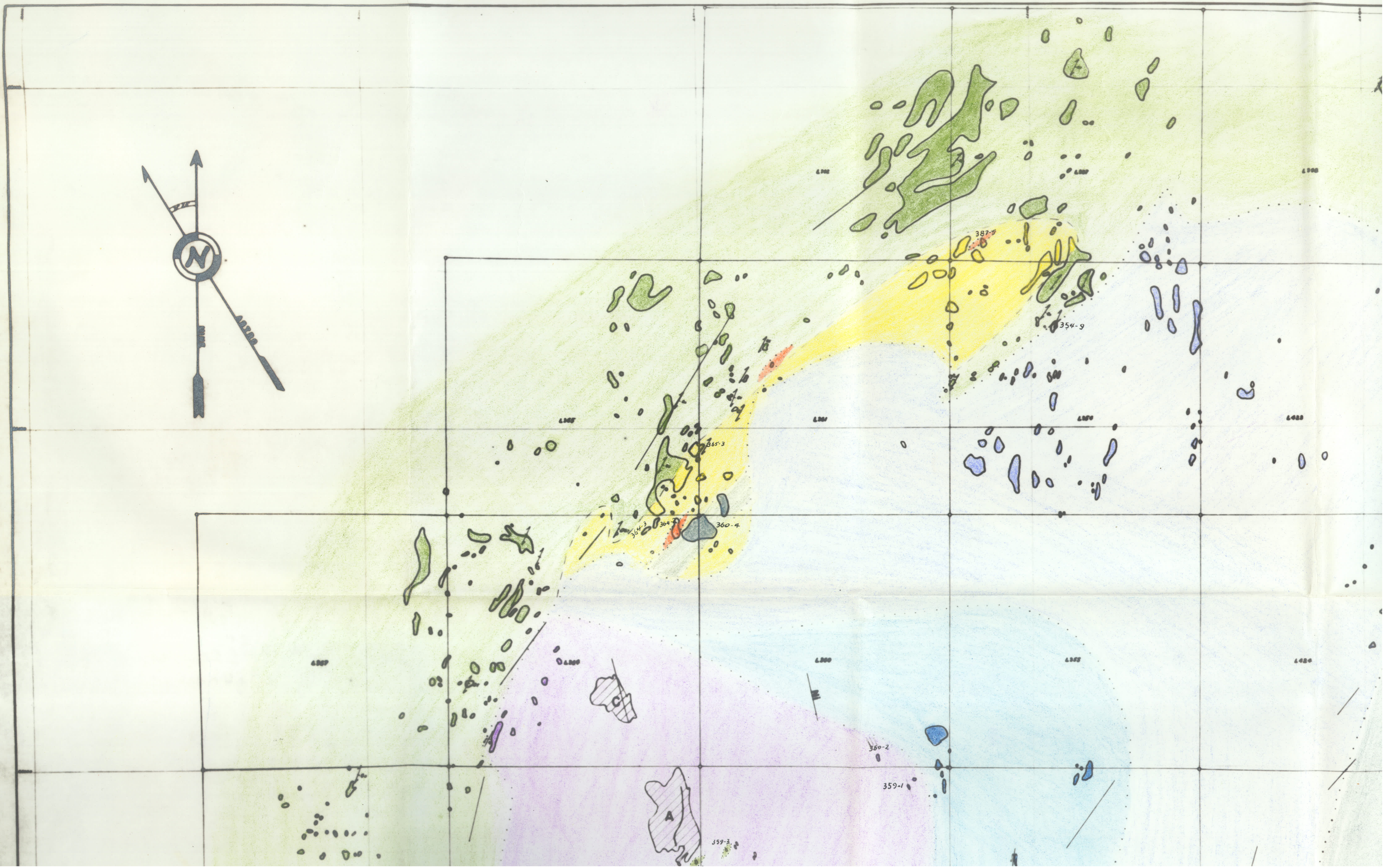
- - - GEOLOGICAL CONTACT

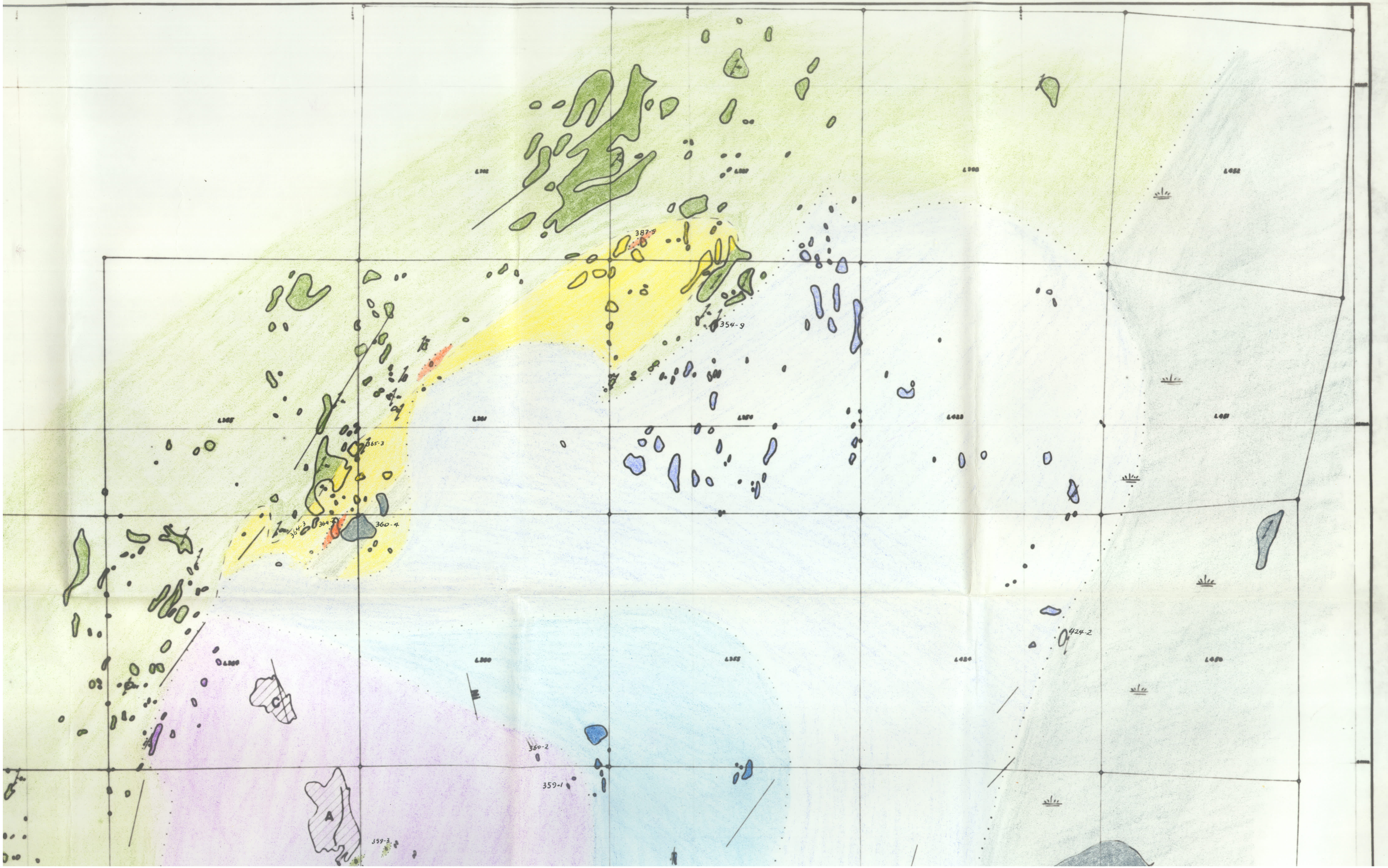
0 25 50 75 100

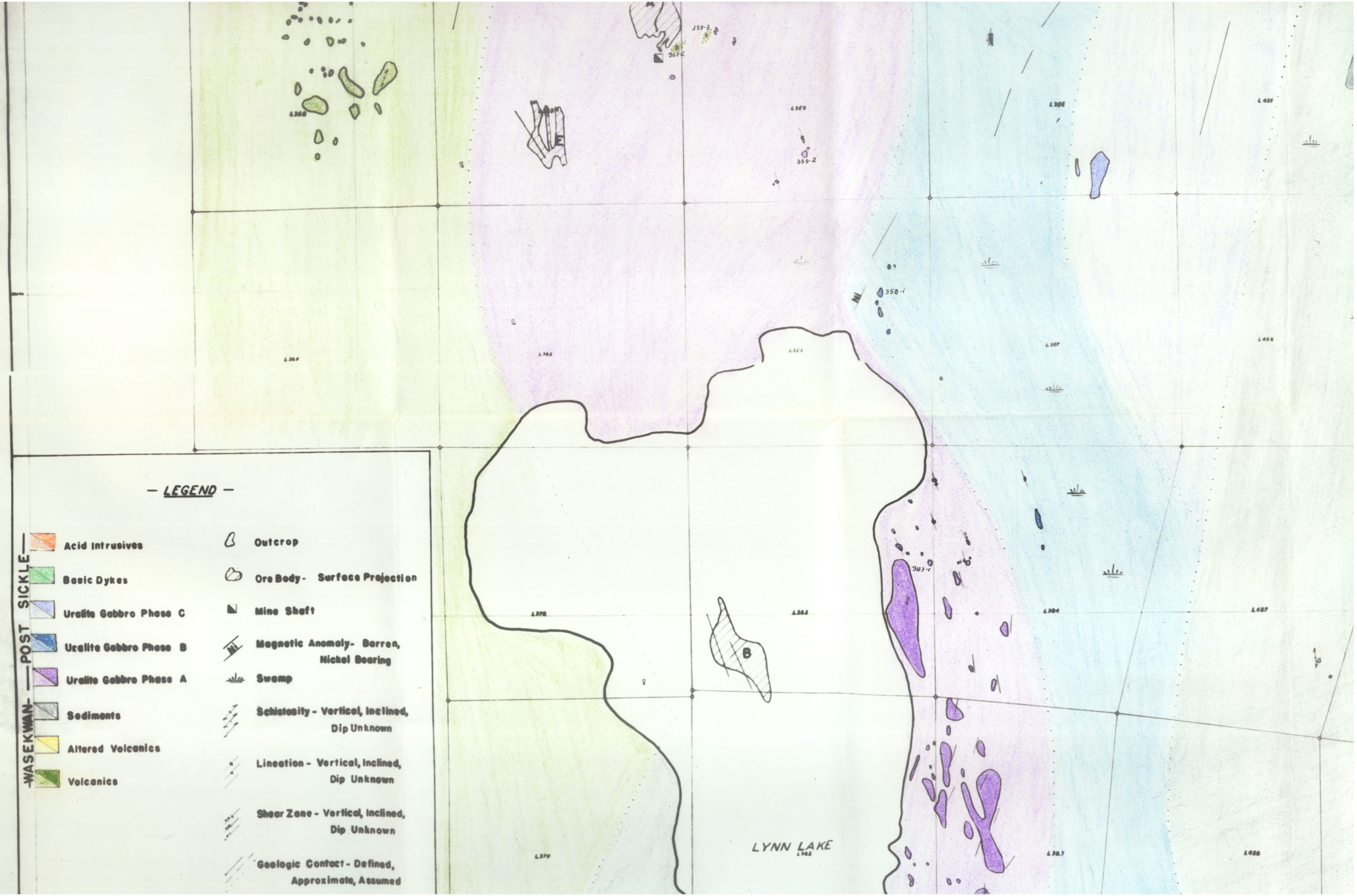
SHERRITT GORDON MINES LTD

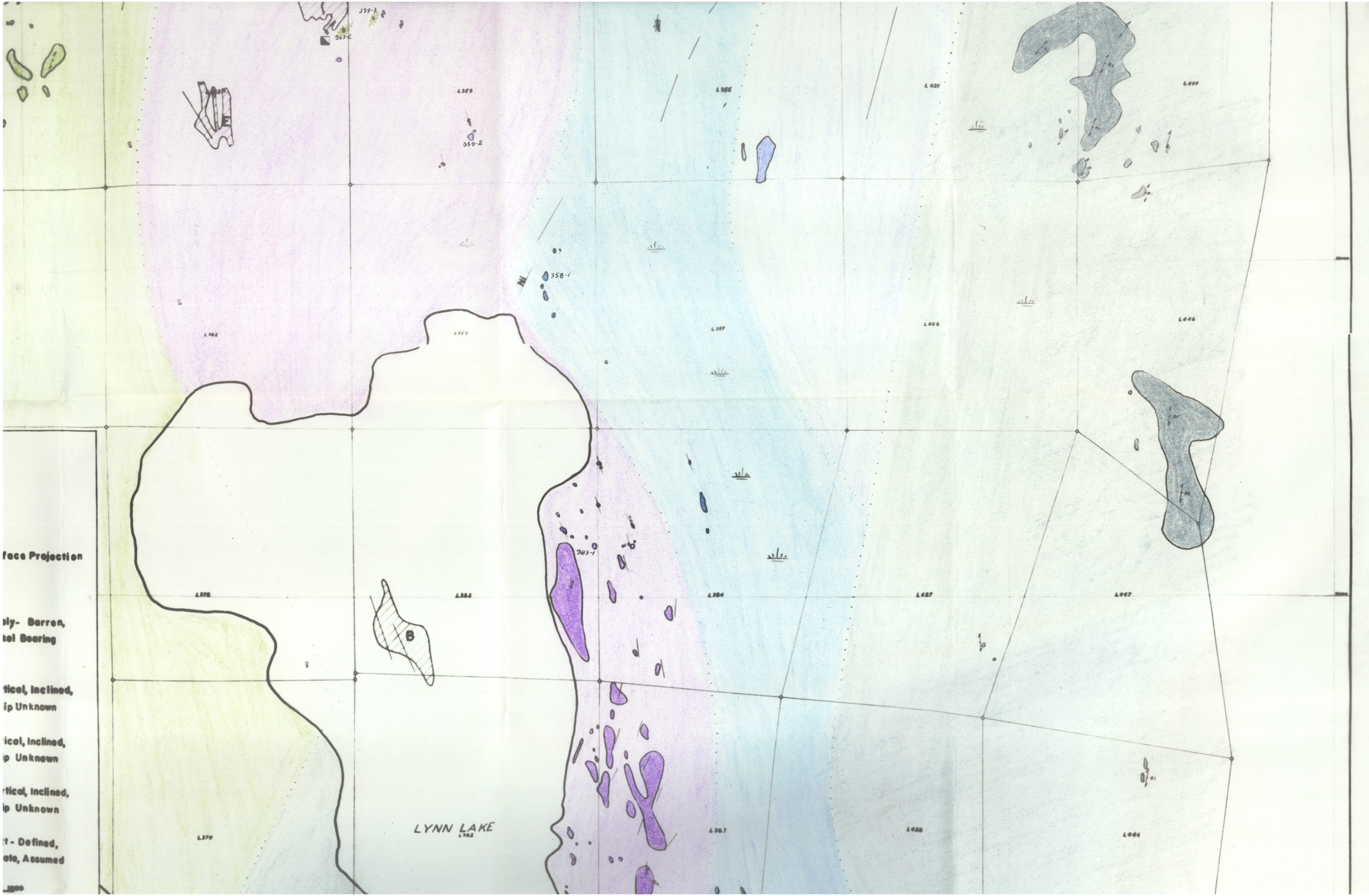
LYNN LAKE PROPERTY

LATERAL SECTION OF
'C' ORE BODY
ALONG LAT 40400
SCALE 1 IN = 50 FT.


N
387-5
354-9
365-3
364-3
364-2
360-4
C
360-2
359-1
A
359-3


387-5
354-9
365-3
364-3
364-2
360-4
424-2
C
350-2
359-1
A
359-3


- LEGEND -
WASEKWAN
POST SICKLE
Acid Intrusives
Basic Dykes
Uralite Gabbro Phase C
Uralite Gabbro Phase B
Uralite Gabbro Phase A
Sediments
Altered Volcanics
Volcanics
Outcrop
Ore Body - Surface Projection
Mine Shaft
Magnetic Anomaly - Barren, Nickel Bearing
Swamp
Schistosity - Vertical, Inclined, Dip Unknown
Lineation - Vertical, Inclined, Dip Unknown
Shear Zone - Vertical, Inclined, Dip Unknown
Geologic Contact - Defined, Approximate, Assumed
A
E
B
359-3
363-2
359-2
358-1
383-1
L360
L362
L359
L358
L356
L357
L425
L426
L370
L364
L427
L379
L428
LYNN LAKE



face Projection
aly- Barren,
kel Bearing
rtical, Inclined,
ip Unknown
tical, Inclined,
ip Unknown
rtical, Inclined,
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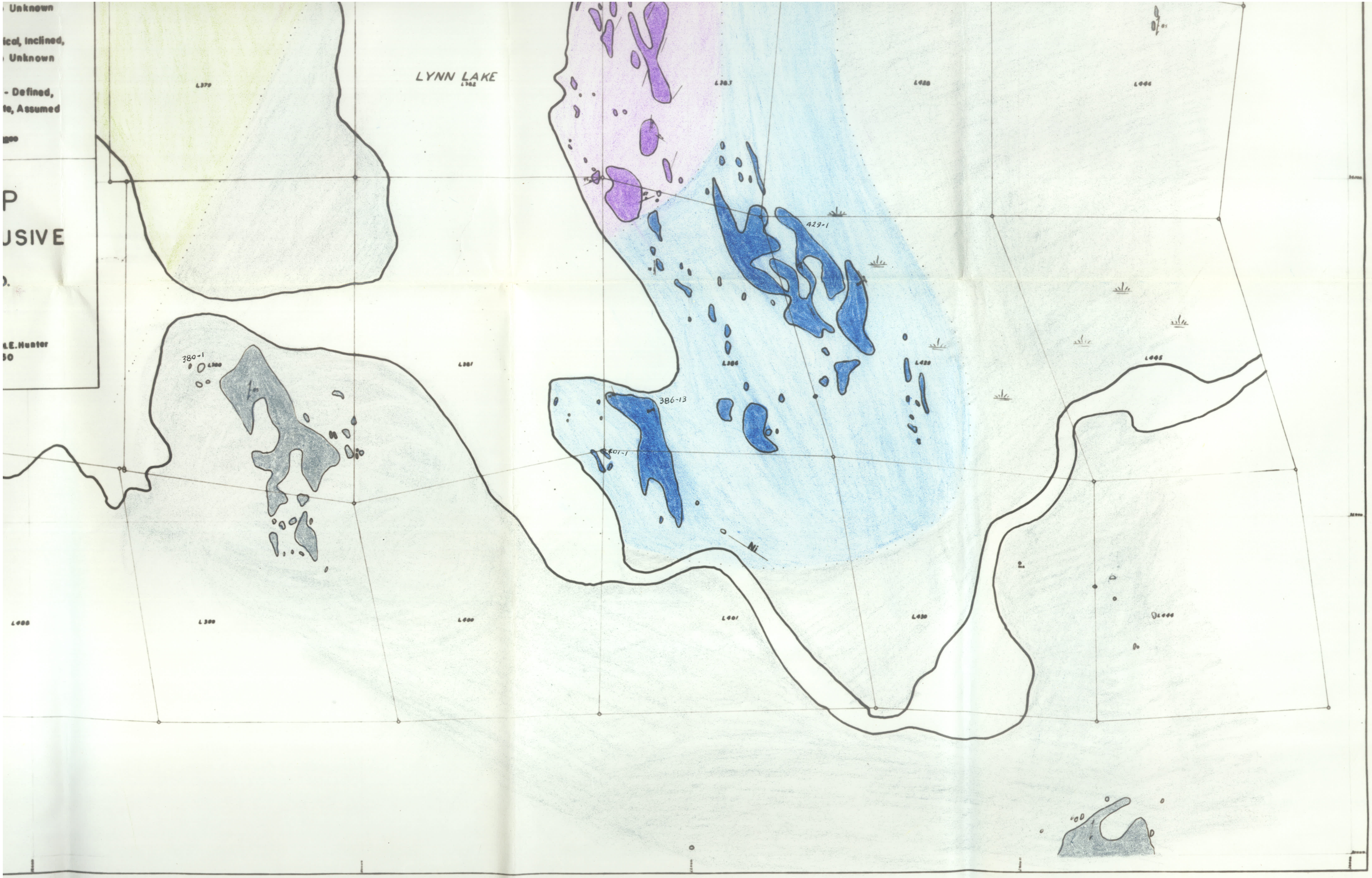
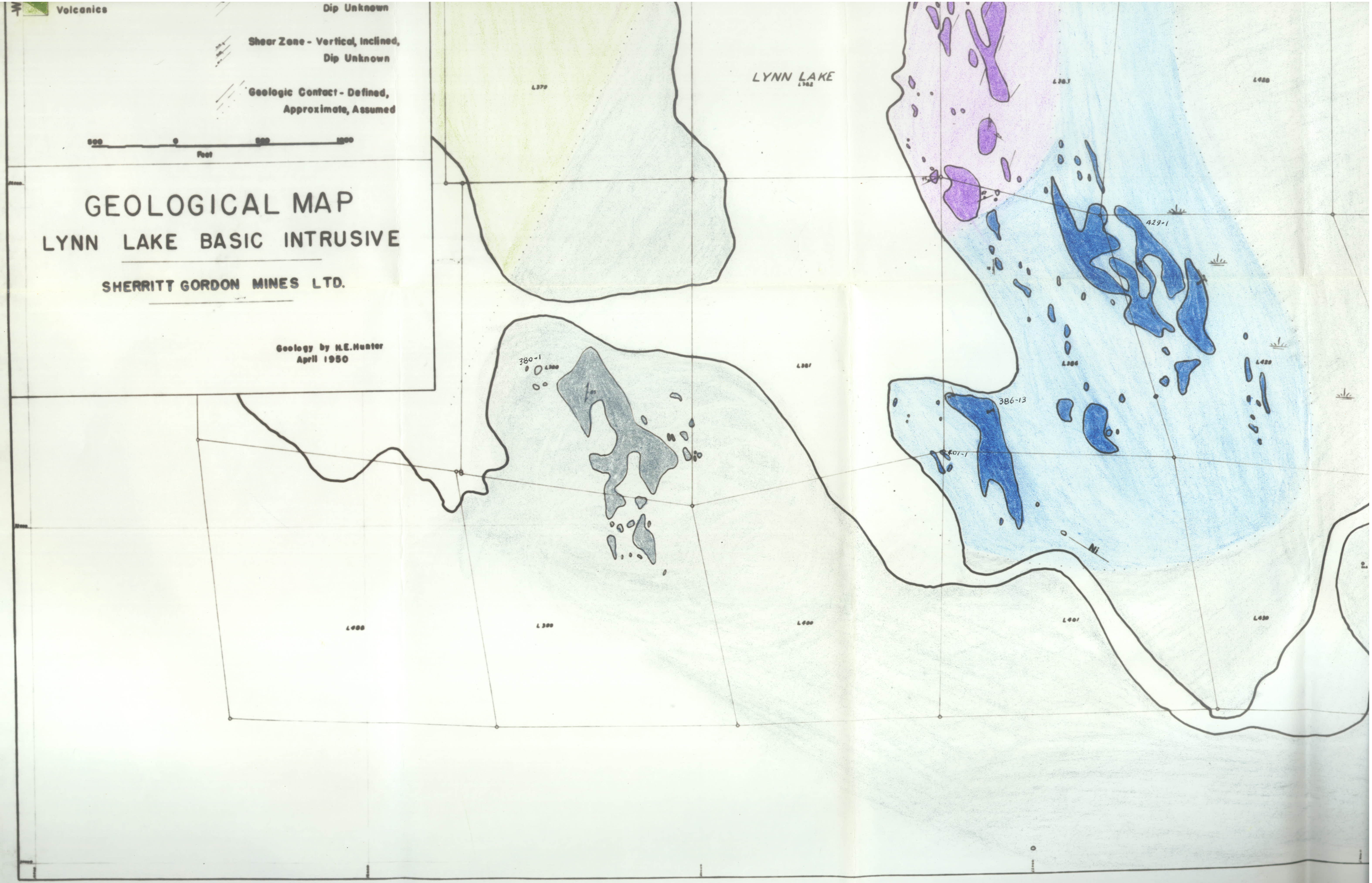
t - Defined,
ate, Assumed
359-3
363-2
359-2
E
358-1
383-1
B
LYNN LAKE


Unknown
tical, Inclined,
Unknown
- Defined,
te, Assumed
gee
P
USIVE
D.
H.E. Hunter
50
LYNN LAKE
L379
L382
L383
L428
L444
429-1
380-1
L380
L381
L386
L429
L445
386-13
401-1
Ni
L400
L380
L400
L401
L430
L444



GEOLOGICAL MAP
LYNN LAKE BASIC INTRUSIVE

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Geology by H.E. Hunter
April 1950