A STUDY OF THE COPPER-NICKEL-ZINC DEPOSIT OF BIRD RIVER MINES CO. LTD., SOUTHEASTERN MANITOBA.

PAUL M. H. RITCHIE

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ABSTRACT

The "Ore Fault" copper-nickel deposit of Bird River Mines Ltd. contains an anomalous high amount of zinc mineralization. The small area containing the "Ore Fault" deposit is a faulted block containing metasedimentary and metavolcanic rocks of the Bird River Greenstone Belt and a sill-like body of ultramafic rock. The eastern part of the fault block is in sheared contact with a granite intrusion. The western part of the fault block is bounded by the 'ore fault' which also displaces the Bird River sill.

Copper-nickel ratios and copper-nickel-zinc values suggest a copper-zinc mineralization overlapped by a separate copper-nickel mineralization.

Copper-nickel ratios favour a magmatic origin for the copper-nickel mineralization. The host rocks appear to be ultramafic rocks which occur as small bodies in the deposit area. The copper-zinc plot does not correspond to a typical copper-zinc deposit which may be partly the result of mixing of the two proposed mineralization periods.

Sulphur isotope techniques were helpful in ascertaining a possible origin for the nickel and zinc mineralization. The sulphur isotope ratios obtained suggest that the nickel has a magmatic origin and the sphalerite does not have a sedimentary origin. The zinc mineralization could have originated from the mafic volcanic rock or the granite.

It is suggested that the products of two different mineralization periods were mixed by a later deformational or intrusive event.

FRONTISPIECE

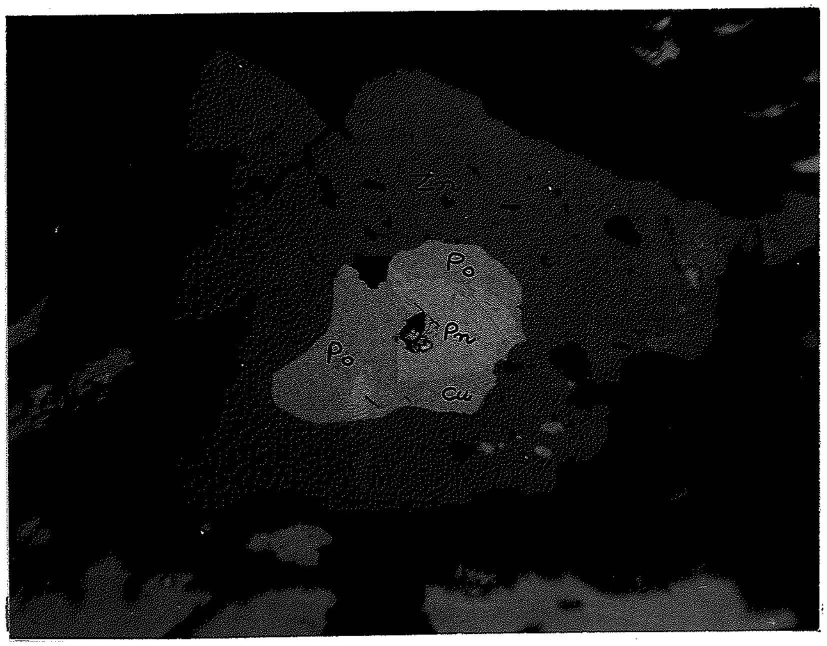

PLATE O: Copper, nickel, and zinc minerals occurring together in the "Ore Fault" deposit.
Po = pyrrhotite, Pn = pentlandite,
Cu = chalcopyrite, Zn = sphalerite.
X 100.8

This thesis is dedicated to my wife Jude.

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CHAPTER 1

INTRODUCTION

1.0 THE THESIS

The "Ore Fault" copper-nickel deposit contains an anomalous high amount of zinc mineralization. Copper-nickel-zinc deposits are uncommon and, e.g., are not included in the natural compositional groups of ore deposits (Wilson and Anderson, 1959).

The purpose of this thesis is to determine whether the zinc mineralization is originally associated with the copper-nickel mineralization or related to a separate event.

1.1 LOCATION AND ACCESSIBILITY

The "Ore Fault" Group of Bird River Mines is in southeastern Manitoba, 15.3 miles west of the Ontario-Manitoba Provincial border (lat. 50°28'40"N. and long. 95°30'W.).

The property is accessible by road from Lac du Bonnet, Manitoba. The road into the property joins the Cat Lake Road from the east 0.9 miles north of the Cat Lake Road and Bird Lake Road intersection.

1.2 HISTORY OF THE DEPOSIT

Copper-nickel mineralization in ultramafic rock was first discovered in 1953 when limited diamond drilling was undertaken on what was then called the Luckey Boy prospect. Mr. John Donner, who has been active in the area since 1930, staked this group in 1967 and contracted for a long wire Afmag Survey over the property. The survey defined a number of conductive zones, which were subsequently drilled. Each of the conductors drilled was found to be mineralized. Further surface stripping uncovered the north and south mineralized pits (see map in folder).

The area is included in Memoir 169, Canada, Department of Mines and Resources, Mines and Geology Branch, 1938; "Geology and Mineral Deposits of a Part of Southeastern Manitoba", by J.F. Wright. This report describes the regional geology of the area as well as the known mineral deposits.

The area is also included in the Province of Manitoba Mines Branch Publication 49-7 by G.D. Springer: "Mineral Deposits of The Cat Lake-Winnipeg River Area, 1950", which describes the regional geology of the area. This publication was written prior to the discovery and drilling of the Luckey Boy prospect (Ore Fault group).

The Province of Manitoba Mines Branch Publications 51-3 by J.F. Davies, "Geology of the Oiseau (Bird) River Area, 1952", is the first publication to specifically mention the Luckey Boy (Ore Fault) deposit. This paper refers to the original trenches found east of the existing surface exposures. Pyrrhotite, pyrite and chalcopyrite are the sulphide minerals noted in this report. The province of Manitoba Mines Branch Publication 54-1 by J.F. Davies, "Geology and Mineral Deposits of the Bird Lake Area, 1955", is similar to the previously mentioned Manitoba publication 51-3. The mapping for the report is at a scale of 1 inch = 1000 feet.

S. Karup-Möller and J.J. Brummer, (1971) reported on the area southeast of the "Ore Fault" deposit dealing with the copper-nickel deposit of Dumbarton Mines Limited.

The Manitoba Mines Branch is currently re-mapping the area including the Ore Fault property at a scale of 1 inch = ¼ mile.

1.3 FIELD WORK AND ACKNOWLEDGMENTS

In October, 1970 and June, 1971 the author spent several weeks mapping and sampling the Ore Fault property. Two maps with the following scales were compiled: 1 inch = 10 feet (in folder) and 1 inch = ¼ mile (P. 6).

The author wishes to acknowledge the assistance rendered to him by Dr. H.D.B. Wilson, who suggested the problem and gave guidance and criticism during the study. Thanks are also due to Dr. D.T. Anderson, who acted as my supervisor; Dr. A.C. Turnock, who helped with petrographic studies; and Mr. K. Ramlal, chemist of the Department of Earth Sciences, University of Manitoba, who provided the chemical analyses.

A very special vote of thanks is due to Mr. John Donner, the Property Manager of Bird River Mines Co. Ltd., who kindly allowed the author to map and sample the deposit, and examine the core and assay data.

The author also wishes to thank his colleagues at the University of Manitoba for many stimulating discussions and arguments which helped to clarify points of contention arising during this study. This appreciation is specifically extended to P.K. Seccombe who helped extensively with the sulphur isotope studies. Dr. R.H. Betts of the Chemistry Department (University of Manitoba) kindly made available the mass spectrometer for the sulphur isotope measurements.

CHAPTER 2

REGIONAL GEOLOGY

2.0 GENERAL STATEMENT

The regional geology of the area is described in J.F. Davies (1955). This report includes the deposit area, but does not refer to the area immediately to the west of the deposit (Figure 1).

The area to the west of the deposit is not adequately covered by previous reports. The author has therefore mapped the area which surrounds the deposit (Figure 2), at a scale of 1 inch = ¼ mile to tie in the geology with the work done by J.F. Davies and S. Karup-Möller and J.J. Brummer (1971).

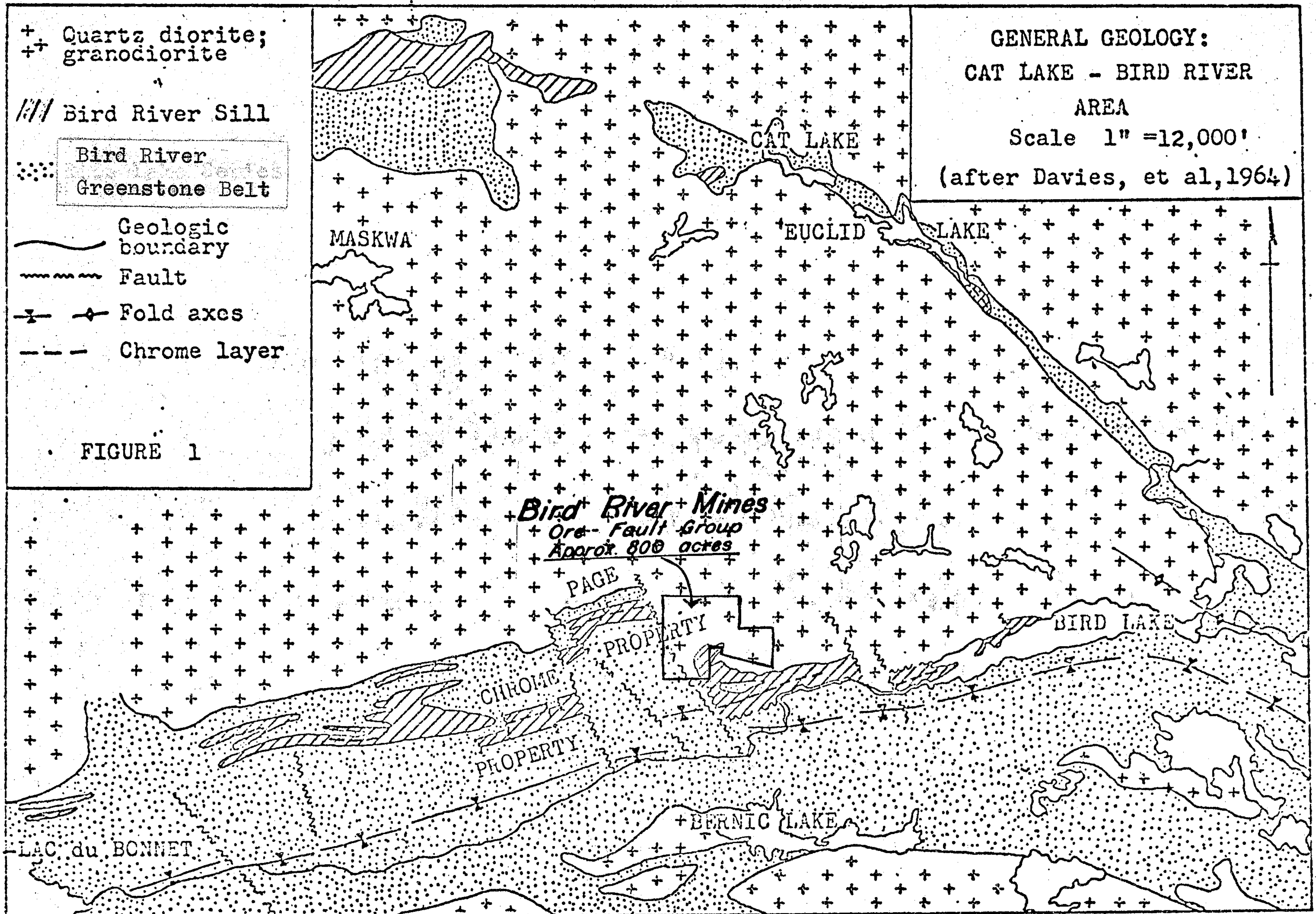
2.1 REGIONAL GEOLOGY

Intermediate to basic metavolcanic and metasedimentary rocks of the Bird River Greenstone Belt underlie the greater portion of the map area. These are intruded by the Bird River Sill which is composed of sill-like bodies of gabbro and ultramafic rocks. The Bird River Greenstone Belt and the basic intrusions have been invaded in turn by large bodies of granitic rock. The granitic rocks are intruded by younger diabase dykes.

The Bird River Greenstone Belt appears to have been folded into a syncline whose axis lies within the sedimentary rocks of the group. Consequently, the sedimentary rocks overlie the lavas. Some of the rocks of the Bird River Greenstone Belt have been intruded by granite and numerous dykes and sills of pegmatite intrude the Bird River Greenstone Belt in the southeastern part of the area.

Faulting has affected all of the rocks of the region. Several easterly strike faults have been recognized, and probably others are present. Traverse faults, striking north-northwest, are abundant in the Bird Lake Belt.

Deposits of base metal sulphides are closely associated with


Quartz diorite; granodiorite
Bird River Sill
Bird River Greenstone Belt
Geologic boundary
Fault
Fold axes
Chrome layer
FIGURE 1
GENERAL GEOLOGY: CAT LAKE - BIRD RIVER AREA
Scale 1" =12,000'
(after Davies, et al,1964)
CAT LAKE
MASKWA
EUCLID LAKE
Bird River Mines
Ore- Fault Group
Approx. 800 acres
PAGE PROPERTY
CHROME PROPERTY
BIRD LAKE
BERNIC LAKE
LAC du BONNET

- 5 -

ultramafic, metavolcanic, and gabbroic rocks, and apparently occur along or near the contacts of these rocks with the granite. Chromite occurs near the top of the metaperidotite portion of the Bird River complex.

The accompanying table of formations (Table 1) indicates the classification of rocks within the area. In accordance with a previous interpretation for the area to the west (Davies, 1952, p. 6) all the rocks in the present area are considered Archaean in age.

2.1.1 BIRD RIVER GREENSTONE BELT

Rocks of the Bird River Greenstone Belt, occupying a belt three to four miles wide along Bird River, are flanked on both sides by granitic intrusions.

The lavas, andesite and basalt, and derived schists occur on the north and south sides of the belt; the central band consists of clastic sedimentary rocks - arkose, greywacke, tuff, and quartzose schists.

The volcanic and sedimentary rocks contain irregular bands of light - to dark-coloured, fine-grained siliceous rocks.

2.1.1.a Andesite

Narrow bands of massive andesite occur north of Bird River. In general, the lavas north of Bird River are less altered than those in the south part of the area.

The massive, fresh-looking, andesite, such as that occuring north of Bird River, is a fine - medium-grained, dark green to dark grey rock which is exposed in hummocky outcrops as much as 50 feet high. Some of the medium-grained varieties resemble fine-grained gabbro but flow features such as pillow structures and flow contacts, can be found in some places in the andesite.

2.1.1.b Greywacke, tuff, quartz-mica schist

The rocks of this unit constitute the lower members of the sedimentary portion of the Bird River Greenstone Belt. They are in contact with the southern volcanic belt but have not been observed in contact with the volcanic rocks north of the Bird River.

The different rock types in this unit are a fine-grained, dark brown, thinly laminated schistose greywacke, a fine grained,

TABLE 1

TABLE OF FORMATIONS

(after J.F. Davies, 1955)

Recent and Pleistocene		Glacial clay and sand
Great Unconformity		
A R C H A E A N	Intrusive Rocks	Trap, diabase Pegmatite dykes and sills Granite, granodiorite, quartz diorite
		—Intrusive Contact—
		Hornblende gabbro Peridotite, pyroxenite, hornblendite
		—Intrusive Contact—
	Bird River Greenstone Belt	Silicified rocks Arkose Greywacke, tuff, quartz-mica schist Andesite, basalt, derived schists

brown knotted cordierite schist, a fine to medium grained dark grey to black greywacke and schist, a dark green tuff and a fine to medium grained brown quartz mica schist.

2.1.1.c Arkose

Arkose occupies the central part of the sedimentary section of the Bird River Greenstone Belt and stratigraphically overlies the greywacke and related rocks. Thin beds of arkose are interbedded with some of the greywacke, and similarly, beds of greywacke commonly are interstratified with the unit mapped as arkose.

Two distinct textural types of arkose are readily distinguished; one is fine to medium grained, the other is coarse grained. Both types range from light to dark grey. The weathered surfaces of these rocks usually have a light brownish or orange cast.

2.1.1.d Silicified Zones

Cream, dark grey, or black, fine-grained siliceous chert-like rocks form several bands within the sedimentary portion of the Bird River Greenstone Belt. Two bands occur partly or wholly within the volcanic sequence. Some of the siliceous rocks exhibit thin delicate banding, others are entirely massive. Parts of some bands are coarser grained and have a sugary texture.

Davies (1955) states that there is evidence in some places that these fine-grained siliceous rocks are actually silicified greywackes, arkoses and lavas. Both the texture and structure of the siliceous rocks can be directly related to the rocks with which they are associated.

2.1.2 INTRUSIVE ROCKS

2.1.2.a Bird River Sill

Ultramafic rocks commonly underlie the gabbro in the Bird River Sill. This is true of the ultramafic-gabbro sill west of the "Ore Fault" property. This relationship, however, is complicated in places. It is probable that, in addition to the normal ultramafic-gabbro complex, separate gabbro intrusions occurred, which may account for the irregularities found in parts of the sill.

The ultramafic rock is soft, medium-grained, dark green to black; in places massive, elsewhere schistose. The weathered surface is dark green or reddish brown. Schistose ultramafic rock is soft and friable on surface. The minerals are all secondary; no relicts of the original constituents were found. In the sections examined, fibrous serpentine and tremolite made up the bulk of the rock. These minerals form a felted aggregate with chlorite, carbonate, and magnetite.

The gabbro section of the sill is composed of various phases differing in grain size and proportions of amphibole and plagioclase.

The ultramafic-gabbro complex is of special interest because of the chromite and copper-nickel sulphide which it contains.

2.1.2.b Granitic Intrusive Rocks

The Bird River Greenstone Belt and the basic intrusions are bounded on the north by a large mass of granitic rock. Other granitic bodies invade the volcanic rocks south, southeast, and west of Bernic Lake (southeast of the "Ore Fault" property). The edges of the granitic intrusions trend parallel to the regional structure.

Davies (1955), describes two types of granitic rocks; an altered grey granodiorite and a pink granite with a fresh appearance. The granodiorite is composed essentially of plagioclase and quartz with 10 to 20 per cent ferromagnesian minerals, usually biotite, and in places, hornblende. The massive pink granite is composed mainly of quartz, microcline, and biotite; it may also contain small amounts of albite or oligoclase.

Other phases, which range in colour from grey to pink, and can be distinguished only under the microscope, contain varying proportions of microcline and albite or oligoclase. Such rocks have been classified as granodiorite and quartz monzonite.

2.1.2.c Pegmatite

Pegmatite intrusions are common in the southeastern part of the area. These bodies occur as pegmatite dykes, sills and irregular bodies.

The pegmatite is of two types, microcline pegmatite and albite pegmatite. No direct evidence was found indicating the derivation of the pegmatite from any particular granite body in the area.

These dykes and sills range from a foot or less up to several hundred feet wide, and from a few tens of feet to as much as a mile in length. Remnants of country rock, lavas or sediments, commonly occur within the pegmatite bodies.

The pegmatite intrudes both the volcanic and sedimentary rocks of the Bird River Greenstone Belt.

2.1.2.d Diabase - Trap

A number of dark green or black fine to medium grained diabase and trap dykes, striking in a northwest direction, cut the granite north of Bird River. In addition to those which exhibit intrusive relationships, there are irregular areas of andesitic and gabbroic rocks in the granite. These are shown as andesite and gabbro on the map but little evidence relates them to the gabbro and andesite of the main volcanic belt. One of these irregular areas contains the "Ore Fault" deposit.

The diabase consists of amphibole and andesine in varying amounts. Some sections contain about equal quantities of amphibole and andesine, in others amphibole may form 75 per cent of the rock. Diabasic texture occurs in some specimens.

2.1.3 STRUCTURAL GEOLOGY

2.1.3.a Folding

The volcanic rocks and the rocks of the Bird River sill, in the north part of the area, dip and face towards the south. The volcanic rocks in the south-central part of the area face north. The volcanic rocks therefore form a syncline, the center of which is occupied by the overlying sedimentary rocks. The location of the synclinal axis is not known precisely, but it lies within the sedimentary rocks.

The sedimentary rocks all dip steeply southward at angles of 75 to 85 degrees, indicating that the south limb of the syncline is overturned. Schistosity in the lavas and sediments is generally parallel to the bedding. There are also indications of some local minor tight folding.

2.1.3.b Faulting

A major northwest trending fault is located near the "Ore

Fault" deposit. This fault has caused the Bird River sill, which trends east-west to be displaced a considerable distance (Davies, 1952). One section is located north and west of the "Ore Fault" deposit. The gabbro-peridotite intrusion located southeast of the "Ore Fault" deposit is the other part of the Bird River sill which has been faulted southward. However, the major northwest fault which caused the displacement does not come in contact with this peridotite and gabbro intrusion because of pre-fault intrusion of granite and east-west post-granite faulting (Figures 1 & 2).

The post-granite nature of faulting is well illustrated by the faults west and north of Bird Lake. A large number of north-northwest faults cut the granite. Most are visible as distinct lineaments on aerial photographs, and generally can be seen on outcrops of the granite. Some of these faults dip steeply eastwards, others are essentially vertical.

The large fault which displaces the Bird River sill is located approximately 165 feet west of the "Ore Fault" deposit (south pit). It is not exposed on surface, however. The author believes that the deposit area is related to this fault or perhaps to another fault just east of the main fault and trending in the same direction.

CHAPTER 3

DETAILED GEOLOGY

3.0 GENERAL STATEMENT

The table of Formations (Table 1) in Chapter 2 is valid for this discussion on detailed geology. A volcanic conglomerate unit should be added to the Bird River Greenstone Belt. The area immediately surrounding the "Ore Fault" deposit has been mapped at a scale of one inch equals ¼ mile (Figure 2). The area including the surface exposures of the "Ore Fault" deposit has been mapped at a scale of one inch equals 10 feet (large map located in the back folder).

3.1 DETAILED GEOLOGY

Fine grained black to dark green metavolcanic rocks occur in the deposit area. Metasedimentary rocks are observed in two varieties: volcanic conglomerate, and epiclastic metasedimentary rocks.

The small area containing the "Ore Fault" deposit is a faulted block containing metasedimentary and metavolcanic rocks of the Bird River Greenstone Belt and a sill-like body of ultramafic rock. The fault block is bounded on the southeast, east, and north by a granite intrusion. The western part of the fault block is bounded by the 'ore fault' which also displaces the Bird River sill. The deformation in the surface exposures of the "Ore Fault" deposit can possibly be explained by the proximity to the acid intrusion and also to the 'ore fault'.

The sulphide mineralization in the "Ore Fault" deposit is contained in a series of shears on the surface (large map in folder) and at depth. The massive nickel mineralization appears to be related to the amphibole rich metavolcanic rock in the deposit area. The amphibole rich rock could possibly be an actinolitic hornblendite ultramafic rock.

3.1.1 Bird River Greenstone Belt

3.1.1.a Metavolcanic Rocks

Metavolcanic Rocks are observed in many varieties: fine grained massive, pillow lava, chlorite schist, and massive coarse grained amphibole rich sections which may be ultramafic rocks. In addition, a fine grained massive variety occurs along the Cat Lake Road northwest of the deposit area (Figure 2).

All four varieties of metavolcanic rocks occur also in the surface exposures of the "Ore Fault" deposit. The north pit contains two varieties: a fine grained massive slightly mineralized variety which is located in a small area in the northern portion of the pit and a medium grained highly mineralized amphibole rich rock which is observed in the rest of the north pit. Thin section analysis indicates that this latter rock is composed of 99% blue green actinolitic amphibole which exhibits a non-oriented texture. This rock is either a highly altered metavolcanic rock or possibly an ultramafic rock (an actinolitic hornblendite - chemical analysis 804) which has intruded the pre-existing volcanic and sedimentary rocks. This amphibole rich rock in the north pit becomes less mineralized and less coarse grained toward the east. A granite intrusion is observed in contact with this amphibole rich rock a few hundred feet east of the north pit (Figure 2).

The south pit contains all four varieties of metavolcanic rocks. The chlorite schist appears to be an extension of the mineralized shears into the nonmineralized metavolcanic rock. The pillow basalts are located in the northern part of the pit (Plate A & chemical analysis 500). The small area of amphibole rich rock in the south central portion of the pit is similar to the amphibole rich rock in the north pit. This fine to medium grained amphibole rich rock could either be an extremely altered volcanic rock, as it is shown on the map, or an actinolitic hornblendite ultramafic rock which has intruded the pre-existing volcanic rock (chemical analysis 506). Plate B shows the amphibole rich rock, left, in sheared contact with a metasedimentary rock, right. Fine grained massive