CANADA

MANITOBA

CANADA DEPARTMENT OF ENERGY, MINES AND RESOURCES
MANITOBA DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT

MINERAL RESOURCES DIVISION

OPEN FILE REPORT 77/1

NREP

NON-RENEWABLE RESOURCE EVALUATION PROGRAM

FIRST ANNUAL REPORT

1975/1976

1976

CANADA - MANITOBA

NON-RENEWABLE RESOURCE EVALUATION PROGRAM

(NREP)

1st ANNUAL REPORT

1975-76

PART A TECHNICAL REPORTS

Canada Department of Energy, Mines and Resources

Manitoba Department of Mines, Resources and Environmental Management

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

This report presents the results of the first year's work under the four-year (1975-1979) Canada-Manitoba Non-Renewable Resource Evaluation Program (NREP) which was begun April 1, 1975. The program was originally proposed by the Federal Department of Energy, Mines and Resources at the Western Economic Opportunities Conference held in Calgary in July of 1973, as a method for conducting joint federal-provincial resource appraisal studies.

The rationale for programs such as NREP is that there is a need to improve systematic documentation of Canada's mineral reserves and resources and to develop better methods for making forecasts of the existence and amounts of undiscovered resources. The necessity for this type of resource knowledge has been dramatized recently in the case of energy resources and Canada now has a variety of programs and research activities aimed at providing accurate data on the nation's energy resource base.

Definition and quantification of the resource base from which future mineral supplies will be derived is the basis for mineral resource appraisal and mineral based economic development. NREP objectives are the collection, synthesis and dissemination of metallogenic data on known mineral deposits and the estimation of probabilities of existence and amounts of undiscovered resources.

NREP-Manitoba will attempt to do five things:

1. Inventorize known reserves and resources, and document their geological environments,
2. Make estimates of additional or "extended" reserves in and near known deposits or camps,
3. Identify favourable geological environments for exploration,
4. Make estimates of resource potential of such environments,
5. Provide mineral resource data for regional economic planning.

NREP activities can be grouped into seven categories:

1. Mineral Inventory,
2. Computerization of mineral deposit data and assessment records,
3. Mineral deposit and metallogenic studies,
4. Exploration history review and evaluation,
5. Ore mineralogy studies,
6. Mineral economic studies,

8

7. Resource estimations: -
   (a) quantitative (probabilities of tonnages and grades)
   (b) geographic (probabilities of locations - metallogenic maps, mineral capability maps, etc.)

The major product of the program will be quantitative estimates of resources of Cu, Zn and Ni of Precambrian age, and the identification of most favourable areas for their locations. Interim products such as this report, will present the results from ongoing projects in a progress report format. These reports will be incorporated toward the end of the program (1979) in a series of final reports.

In the interests of making public the results of NREP work as quickly as possible, this report is released with a minimum of editing.

SUMMARY OF MANITOBA-NREP PROJECTS AND COSTS

The program contains 11 main projects funded at a total cost of about $1.6 million over the 1975-1979 period. Costs are shared equally between the Manitoba Department of Mines, Resources and Environmental Management and the Federal Department of Energy, Mines and Resources. Projects are carried out by permanent and contract personnel of the Mineral Evaluation and Administration Branch of the Manitoba Department. Each NREP project leader (Manitoba) has a federal counterpart (mainly personnel of the Economic Geology Subdivision, Geological Survey of Canada) whose function is to provide consultation and, where feasible, active participation in the program. Table I summarizes NREP projects, objectives and approximate four-year costs. Additional details are given in the individual project progress reports that follow. Table II provides a list of NREP personnel.

TABLE I

SUMMARY OF MANITOBA-NREP PROJECTS AND COSTS

Project No.	Title	Purpose	Estimated Costs 1975-1979 (thousands of 1975 dollars)
NM 7501	NREP Management	Direction and administration of the program.	188.9
NM 7502	Mineral Inventory	To prepare and publish a comprehensive mineral inventory file of all known mineral deposits and occurrences in Manitoba.	189.8
NM 7503	Data Management	To develop and implement a computerized mineral occurrence and mineral deposit file using input from Project NM 7502. To develop a parallel file for the storage and retrieval of provincial assessment records.	200.3
NM 7504	Evaluation of Nickel Environments	To investigate known and potential Manitoba nickel deposits and environments, including those of the Thompson and Lynn Lake belts; to develop deposit models to understand the genesis of known deposits; to apply cumulative knowledge to the evaluation of geologically favourable parts of the Province for undiscovered nickel potential.	184.5

(cont.)

TABLE I (cont.)

Project No.	Title	Purpose	Estimated Costs 1975-1979 (thousands of 1975 dollars)
NM 7505	Evaluation of Massive Sulphide environments	Investigation and evaluation of copper-zinc deposits and environments, as for nickel. Initial emphasis to be on the Flin Flon-Snow Lake and Lynn Lake belts; later in the program to include Superior Province greenstone belts.	234.8
NM 7506	Investigation of Disseminated Base Metal Environments	Investigation and evaluation of the base metal (mainly copper) potential of possible "bedded" environments such as the Sickle-Wasekwan contact zone and porphyry-type copper environments.	125.3
NM 7507	Vacant[1]		
NM 7508	Vacant		
NM 7509	Exploration Review and Evaluation	Evaluation of recorded geophysical, geological and geochemical exploration data to determine past exploration coverage as an input to resource appraisal and as a measure of residual exploration potential of such environments.	265.4

[1]Other projects may be added in later years of the program.

(cont.)

TABLE I (concluded)

Project No.	Title	Purpose	Estimated Costs 1975–1979 (thousands of 1975 dollars)
NM 7510	Ore Mineralogy	Investigation of ore mineralogy of known Manitoba deposits to determine further beneficiation possibilities and to provide a mineralogical basis for classification and correlation. Initial emphasis on Thompson Belt and Flin Flon–Snow Lake belt deposits. Laboratory work is being done at CANMET[1], Ottawa.	83.7
NM 7511	Mineral Economics	Three sub-projects: -1) Capital Expenditure analysis – investigation of capital expenditures required to bring a given mineral deposit into production in a particular region of the province -2) Mineral Production analysis – development of a "life-index" model to investigate viability of mining communities and required infrastructure -3) Economic Exploitability of Mineral Resources – development of a computer model to assess economic parameters of mineral exploitation	69.4
		Sub	1,542.1
		Contingencies	57.9
		Total	1,600.0

[1]Canada Centre for Mineral and Energy Technology (Department of Energy, Mines and Resources).

TABLE II

List of N.R.E.P. personnel

	Manitoba	Canada
Project NM 7501 - Program Management	F. J. Elbers	D. C. Findlay (G.S.C.)
NM 7502 - Mineral Inventory	J. Bamburak S. Haskins G. Josse D. Kowerchuk 1) R. Matthews 2)	K. Ewing (M.D.S.)
NM 7503 - Data Management and Computerization	H. Ambach M. Merson 3)	D. Picklyk (G.S.C.)
NM 7504 - Evaluation of Ni environments	P. Theyer R. Pinsent	O. R. Eckstrand (G.S.C.)
NM 7505 - Evaluation of massive sulphide environments	G. Gale J. Koo	D. F. Sangster (G.S.C.)
NM 7506 - Evaluation of disseminated base metal environments	D. Baldwin	R. V. Kirkham (G.S.C.)
NM 7509 - Exploration History Review	G. Burton 4) G. Southard L. Solkoski	
NM 7510 - Ore Mineralogy	J. Grice 5) D. Scott 6)	L. Cabri (CANMET)
NM 7511 - Mineral Economic Studies	R. Bagnall L. Skinner R. Cairns 7)	J. Zwartendyk (M.D.S.)

1) terminated Sept. '75
2) terminated April '76
3) from Sept.'75 to May '76
4) terminated April '76
5) terminated April '76
6) from July '76
7) terminated Sept. '75

14

SUMMARY OF 1975-76 WORK

During the first year of the Non-Renewable Evaluation Program projects were started on the evaluation of massive sulphide, nickel and disseminated base metal environments, complemented by mineral inventory and computerization of mineral deposit and assessment data projects. A review of exploration history was carried out in the Flin Flon - Snow Lake, Lynn Lake and Gods Lake areas. A mineralogical study was started on ores of present producers in Manitoba.

The evaluation of massive sulphide environments has been focussed on the mineral-producing Flin Flon - Snow Lake and Lynn Lake - Rusty Lake belts. Studies were directed towards the gathering of data which are necessary for deposit type modeling, such as lithologic and stratigraphic data, alteration patterns, mineralogy of sulphide deposits, and structure. It is hoped that a resource potential estimation can be carried out in the later years of the program on the basis of the formulated deposit type models. The collection of data will continue and extend into the Superior Province of Manitoba.

The evaluation of nickel environments had a belated start as a result of which no progress was made during the first year of the program. This project will focus on the nickel belt and the Lynn Lake belt.

The evaluation of disseminated base metal environments has been concentrated on disseminated copper mineralization in basal arkoses of the Sickle Group near Kadeniuk Lake. A geological environment has been outlined which has many characteristics of syngenetic copper mineralization.

The mineral inventory progressed with the systematic documentation of known mineral occurrences and deposits in Manitoba. Over half of the estimated total number of mineral occurrences were described by the end of the first year.

The computerization project progressed with the definition of file content of three different computer files. Coding of input document took place during the report year.

Review of exploration data was conducted in support of the massive sulphide project in the Flin Flon - Snow Lake, Lynn Lake and Gods Lake areas. This is a large task which will continue throughout the 4-year program. The data are compiled and plotted in a way that will be of assistance to the mining industry in their review of exploration history.

The mineralogy project started with a sampling program of producing Manitoba mines. During the winter season samples were analyzed and described. This project is addressing itself mainly to sulphide deposits.

Mineral economic studies were started on the analysis of past and projected mineral production data, and the formulation of a computer model to test economic viability of simulated mineral deposits in Manitoba.

In the second year of the program data collection will continue to be directed towards the formulation of deposit models which will form the basis of future resource potential estimations. It is anticipated that the mineral inventory and computerization projects will progress to a point where they can be of assistance in regional metallogenic analyses.

PROJECT REPORTS

NM 7501 PROGRAM MANAGEMENT - by F. J. Elbers and D. C. Findlay

Overall NREP Management is provided by a two-man committee composed of a provincial representative (F. J. Elbers, Mineral Evaluation and Administration Branch) and a federal representative (D. C. Findlay, Geological Survey). In addition, a federal advisory committee composed of representatives from the Geological Survey, Mineral Development Sector and CANMET (Canada Centre for Mineral and Energy Technology) provides technical advice. Figure 1 illustrates the NREP management structure.

Project 7504 (Nickel environments) did not commence until March 1976 because of delays in recruiting a project leader.

Project 7502 (Mineral inventory), 7509 (Exploration review) and 7511 (Mineral economics) were interrupted due to staff turnover (see Table II).

Work conducted during 1975-76 was aided significantly by cooperation extended by Sherritt Gordon Mines Limited. Discussions concerning cooperation and participation are continuing with Hudson Bay Mining and Smelting Ltd., Inco Limited and Falconbridge Nickel Mines Limited.

16

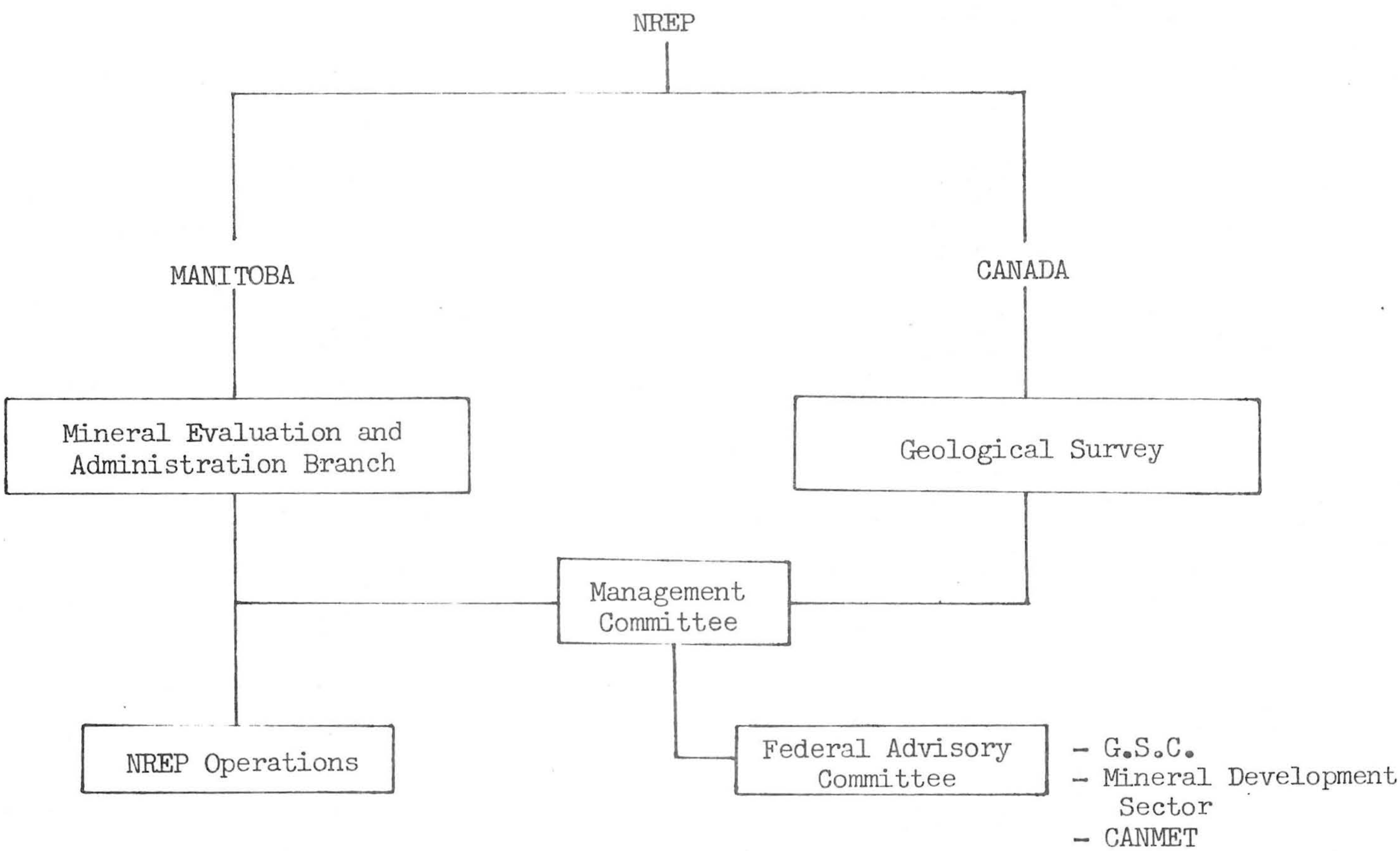


Figure 1 NREP Management Structure

NM 7502 MINERAL INVENTORY - by J. Bamburak

Introduction

The objective of the Manitoba Mineral Inventory Project is to provide a readily accessible file, in index card form, summarizing all available information on known mineral occurrences in the Province. Two types of index cards, illustrated in Figures 2 and 3, are used to record data on each occurrence. One card (Fig. 2) records the location and available references on each occurrence, plus a summary of its exploration, development and production history. The second card (Fig. 3) summarizes all geoscientific data for those occurrences on which sufficient information is available.

For retrieval convenience, the Mineral Inventory cards are filed by area, using the National Topographic System (N.T.S.), and by principal mineral commodities. Also, the cards are cross-referenced by property name, claim number and corporation name, if the latter was involved to a significant extent in the property history. The locations of all occurrences included in the file are plotted on 1:63 360 scale aeromagnetic maps.

During 1975/76, the Mineral Inventory Project attempted to complete the inventory of much of the Precambrian area lying south and west of the heavy black line in Figure 4. The predecessor* of the present project had completed a total of 378 Precambrian Mineral Inventory cards over an area north and east of line during its two years of operation.

Results of Work

A total of 251 cards were compiled between April 1, 1975 and March 31, 1976. Including the 378 cards previously compiled for the National Mineral Inventory, this comprises 63% of an estimated total of approximately 1000 cards.

During 1975-76, the Mineral Inventory received 83 requests for information. Of this total, 29 originated from within the Mineral Resources Division; 25 were from outside the Division, but within the Provincial Government; 20 came from industry; and 9 were from other sources.

Work Planned, 1976/77

The completion of the inventory of all known Precambrian mineral occurrences in the Province is expected between October 1, 1976 and April 1, 1977. An attempt will be made to update the previously completed Mineral Inventory cards in the former Winnipeg Mining District by April 1, 1977 and a start will be made on the inventory of known Phanerozoic mineral occurrences (industrial minerals, excluding sand and gravel) during the last half of the year.

Information from completed cards is being transferred onto MIND computer coding forms (see Project NM 7503, following). It is expected that all of the required information will be stored in the computer file by April 1,1977.

* In 1973 Manitoba began contributing Mineral Inventory cards to the National Mineral Inventory Section of the Department of Energy, Mines and Resources, Ottawa.

PRODUCT NICKEL	PROVINCE OR TERRITORY	Manitoba	N.T.S. AREA 63J/3 SE	REF. NI 1

NAME OF PROPERTY RESERVATION 34, AREA 1

OBJECT LOCATED Centre of Fred 16

UNCERTAINTY IN METERS 500 m Lat. 54°05.3' Long. 99° 11.2'

Mining Division (The Pas) District

County Township or Parish

Lot Concession or Range

Sec Tp. 59 R. 12 WPM

OWNER OR OPERATOR AND ADDRESS

1975 – Amax Potash Ltd.,
7 King Street, E.,
Toronto 1, Ontario.

DESCRIPTION OF DEPOSIT

See Card II

Associated minerals or products of value

HISTORY OF EXPLORATION AND DEVELOPMENT

The deposit is located midway between the Minago and William Rivers, about 14½ km northeast of William Lake and 30 km northwest of Limestone Bay on Lake Winnipeg. The deposit is also about 2½ km west of Provincial Hwy. No. 6.

In 1966, under Airborne Permit 66, Amax Exploration, Inc. conducted regional AFMAG and magnetometer surveys over an area south of the known Nickel Belt. Numerous AFMAG anomalies were detected. Sifting of the anomalies on the basis of anomaly character and amplitude revealed a number of long, semi-continuous features. On the basis of the AFMAG results, combined with the limited GSC aeromagnetic coverage and the broad-scale GSC gravity data available at that time, Exploration Reservations 33 and 34 were taken out in October, 1966 (Roth, 1975, p. 74).

Most of the early work was done on Reservation 33, but at the end of the 1968-69 winter program, attention turned to the western central portion of Reservation 34 (Area 1). The last drill hole (MXB-69-27) of the program intersected a wide serpentinized ultramafic carrying substantial sections of subeconomic nickel sulphide (Roth, 1975, p. 75 – 77).

In the spring of 1969, J. Crait staked C.B.469 over the deposit and immediately assigned it to Amax Exploration,Inc. During the 1969-70 program, DDH MXB-70-48 was drilled into the "nose" of a linear magnetic anomaly of moderate amplitude.

Intervals grading 0.73% Ni over 225 feet and 0.70% Ni over 336 feet were penetrated in this second hole. As an aid in assessing these intersections and as a guide in future drilling, detailed magnetometer and gravity surveys were carried out in the serpentinite zone (Roth, 1975, p. 77).

The claim block was converted into conventional mining claims in 1971. Fred 16 (P3548E) was staked in the vicinity of DDH MXB-70-48 by F. Beauchamp. This claim should cover a portion of the deposit. Shortly after, the claim was assigned to Amax Potash Ltd.

Subsequent drilling by Amax Potash Ltd. has outlined several mineralized zones within the "nose" of the serpentinite. Drill-indicated tonnage within these zones is about 7.3 million tons of 1.33% Ni (1% cutoff) to a depth of 1,200 feet.

(continued . . . reverse)

Mineral Resources Branch, Department of Energy, Mines and Resources, Ottawa.

HISTORY OF PRODUCTION

MAP REFERENCES

Map 63J/3, Gladish Lake (Topo.),1:50 000;Surveys & Mapping Br., Ottawa

*Map 2571G, 63J/3 (Aeromag.),1:63 360; Man. Mines Br. and Geol. Surv. Can.

Map (Figure 9),Detailed Magnetics:Area 1,1:48 000 – Accomp. Publ. by Roth (1975); CIM Bulletin

Map (Figure 14), Interpreted Regional Geology: Manitoba Nickel Belt-Accomp.Publ.by Roth (1975);CIM Bulletin

#Maps, SE3, 63J (Claim), 1:31 680; "Circa 1975" Claim Map Series, Mining Recording, Man. MRD.

REMARKS

Five kilometres southwest of Fred 16, Amax Potash Ltd. has applied for a second Explored Area Lease over the WAS Group of claims. This may indicate that another anomaly similar to those in Area 1 is present at this location.

Comp./Rev. By	JDB						
Date	9-75						

REFERENCES

Airborne Permit 66, Non-confidential Assessment File; Mineral Administration Section; Man. MRD.

Amax Exploration, Inc., SE13,63J; Corporation Files, Man. MRD.

Reservation 33, Non-confidential Assessment File; Mineral Administration Section; Man. MRD.

Roth, J., 1975: Exploration of the Southern Extension of the Manitoba Nickel Belt; CIM Bulletin, V. 68, no. 761, p. 73-80.

HISTORY OF EXPLORATION AND DEVELOPMENT – continued

The deposit is open at depth and the potential of the "limb" portion has not been fully assessed (Roth, 1975, p. 77).

In 1972, a 21-year lease (M-9434) was issued to Amax Potash Ltd. on Fred 16. In 1975, in order to conform to new mining regulations, Amax has applied for an Explored Area Lease over Fred 16 and other adjacent claims.

Figure 2 Mineral Inventory Card I

PRODUCT NICKEL | PROVINCE Manitoba | N.T.S. AREA 63J/3 SE | REF NI 1

NAME OF PROPERTY RESERVATION 34, AREA 1

STATUS Developed Prospect

TYPE OF DEPOSIT Stratiform

MINERALOGICAL COMPOSITION

Ore Minerals pentlandite and millerite

Gangue Minerals serpentinite

NATURE OF MINERALIZATION

Finely disseminated pentlandite and millerite with minor violarite and heazlewoodite. Pyrrhotite is essentially absent.

AGE OF MINERALIZATION early Hudsonian

HOST ROCKS

Rock Types olivine peridotite within volcanics and and sediments

Age Aphebian

Stratigraphic Unit

Wall Rock Alteration serpentinization

STRUCTURE OF DEPOSIT

Size
- Length 8000 feet
- Width 1000 feet
- Thickness 1000 feet

Attitude
- Strike
- Dip
- Plunge

Shape macro-boudins

STRUCTURAL FEATURES AND SETTING

Prominent faulting, paralleling the long axis of the Wabowden Subprovince, is generally accepted as the primary control for the emplacement of nickel sulphide mineralization and serpentinized ultramafics.

METAL/MINERAL CONTENT

RESERVES / RESOURCES

7.3 million tons of 1.33% Ni: (1% cutoff) to a depth of 1,200 feet.

GEOPHYSICAL EXPRESSION

1. Linear magnetic anomaly of moderate amplitude terminating at its south end with a suggestion of a fold or "nose".
2. Weak EM anomaly associated with magnetic anomaly.
3. IP surveys indicated anomaly was moderately conductive and weakly polarizable.

GEOCHEMICAL EXPRESSION

PHYSIOGRAPHIC SETTING

Under 60m of overburden and Paleozoic cover.

TECTONIC ENVIRONMENT

The Wabowden Subprovince is a prominent tectonic and chronologic boundary zone, between the Churchill and Superior provinces. The zone is characterized by major faulting sympathetic to the long axis of the belt, high regional metamorphism and Hudsonian radiometric ages.

The belt represents an accumulation of volcanics and sediments deposited in a restricted geosynclinal trough at the margins of the Superior craton (similar to and coeval with the Ungava geosyncline). The ultramafics were either a flow or shallow intrusive sheet within the geosynclinal pile.

ORE GENESIS

"The geosynclinal pile, now designated the Wabowden Subprovince, was subjected to considerable deformation and metamorphism during the early Hudsonian orogeny. The ultramafics, already perhaps partially serpentinized, were affected by this deformation and may have been squeezed upward along a strike fault, so that today they resemble macro-boudins. As at the Manibridge deposit (Coats, 1970), the sulphides in Area I are thought to be an original magmatic component, but have suffered deformation and/or remobilization during regional metamorphism along with the serpentinite. Intrusion of a granitic pluton (now metamorphosed to a granitic gneiss) further deformed the linear serpentinite at its southern and and may well have promoted recrystallization and/or remobilization of the nickel sulphide phase", (Roth, 1975).

REMARKS

Figure 3 Mineral Inventory Card II

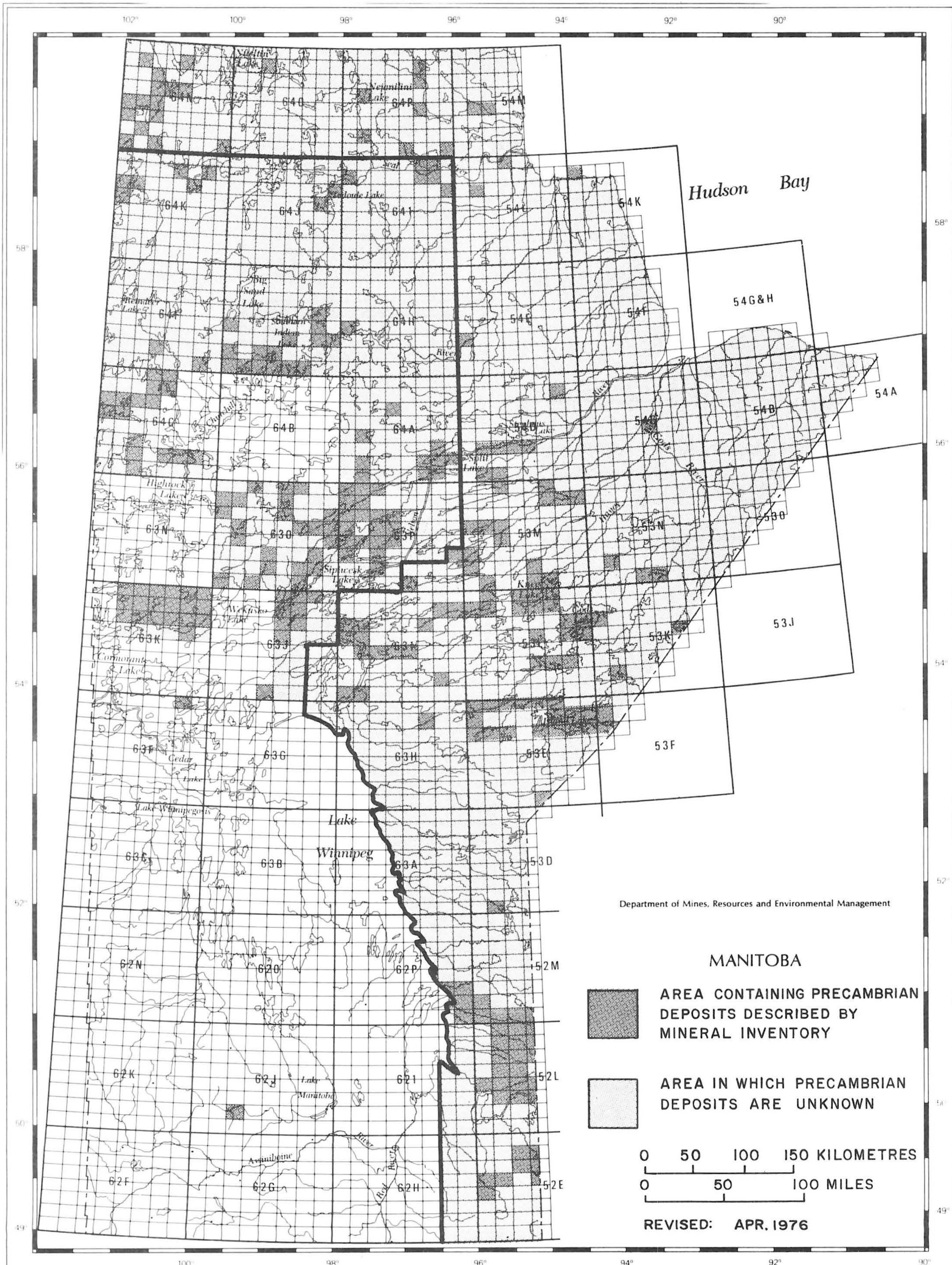


Figure 4 Progress map - Manitoba Mineral Inventory

The possibility of reproducing the completed cards in a reduced loose-leaf format or on microfiche for inclusion into binders is being investigated. A system of mineral occurrence maps is also being considered. Complete sets of cards and maps would then be available. A decision on these matters should be made by October 1, 1976.

The production of Mineral Deposit - Land Use Maps similar to those used in British Columbia will also be investigated.

Conclusions and Recommendations

The Manitoba Mineral Inventory Project moved significantly closer towards completion of its objective during 1975/76. The number of requests for information shows that there is a need for such a compilation of the Province's mineral resources. In addition, increased demand from planners, at various government levels, for regional mineral resource appraisals has made the need for mineral capability maps more urgent.

22

NM 7503 DATA MANAGEMENT AND COMPUTERIZATION - by H. Ambach

Introduction

Since the mid 1930's the Province of Manitoba has been responsible for administering its mineral resources. During this time several thousand reports of geological - geophysical exploration activity have been submitted to the Mining Recorder as evidence of work performed on mineral dispositions. Twenty per cent of these reports are presently confidential and are not available for public viewing. The remaining eighty per cent are "cancelled"; that is, the claims to which they refer have been dropped. This latter group of "assessment" reports forms the nucleus of our mineral resources inventory data base. Concomitant with these assessment reports are "mineral inventory cards" (see NM 7502, this report). These "cards" describe mineral occurrences in greater geological detail, at the expense of activity detail. A third group of records, associated with claims assessment reports, is drill logs. These logs are submitted by exploration companies as part of exploration and development reports. They generally contain a greater amount of geological detail, as compared to the mineral inventory and claims assessment reports.

To date these three sources of geological data have been combined into the Manitoba mineral inventory data base. Within the data base, three separate data files have been defined; CLASS, MIND and CORE, data for which is obtained from CLaims ASSessment reports, MINeral inventory cards, and drill CORE logs, respectively.

Data Files

A. CLASS

As previously noted, this file forms the nucleus of the Manitoba minerals data base. As a stand-alone file, it is an index to exploration activity. Combined with the MIND file, it presents a historical resumé of exploration activity.

The data comprising the CLASS file may be categorized into four main groups (Fig. 5):

1) Proprietary
2) Geophysical exploration
3) Surface exploration
4) Drilling exploration

1) Proprietary information (line 1, Fig. 5) includes current (at time of submission) holder of mineral disposition, identity of the disposition, the location (referenced to both the National Topographic System, and a prominent topographic feature), most recent year of activity, date of initial report submission, current total dollar value of exploration, major work type performed.

The method of locating the disposition (NTS claim map sheet plus topographic feature) is used primarily because of the diverse and irregular shapes of the dispositions. A point-location system would give no indication of orientation or configuration of the disposition.

Codes for geographic location and holder have been employed to eliminate confusion in the spelling of a name for retrieval purposes and also to reduce computer storage requirements. (These, and subsequent codes, are contained in an unpublished Guide to Indexing.)

2) Geophysical information (line 2, Fig. 5) includes survey type, contractor and an indication of the detail employed (line spacing, total distance). The presence, or absence, of any maps included in the report is indicated by the map scale.

3) A broad collection of exploration activities acceptable as claims assessment work is grouped under "Surface" work (line 3, Fig. 5). Generally, any activity, other than geophysics and drilling is included in this group. Again, codes have been employed to assist in data retrieval.

4) The last major data group is drilling (line 4, Fig. 5). The principal information included in this group is number of holes and total distance drilled, and the broad classes of mineralization present. Greater detail on the drilling is in the CORE file. The last three formatted lines are:

Assay (A) - if assays are contained in the report, this line is completed for each sample assayed.

Log (L) - completed for each drill hole which indicates base metal mineralization.

NTS (N) - cross reference to any other NTS area into which the mineral disposition extends.

The remaining five lines of the form are provided for repetition of any of the first seven lines.

B. <u>MIND</u>

Mineral Inventory "Cards" (see NM 7502, this report) are summarized onto a computer input document which consists of four separate forms (Figs. 6a-d).

Page 1 (Fig. 6a) contains proprietary information. Page 2 (Fig. 6b) contains the list of commodities, tonnages and grades, mineralogy and lithology. Page 3 (Fig. 6c) contains a historical resumé of ownership and references to the CLASS files, if any, which contain pertinent data. The last page (Fig. 6d) provides for remarks and published references.

Definitions of all data items conform to the definitions established for the National Mineral Inventory Reserves File maintained by the Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa.

EXPLORATION AND ASSESSMENT REPORT INDEX

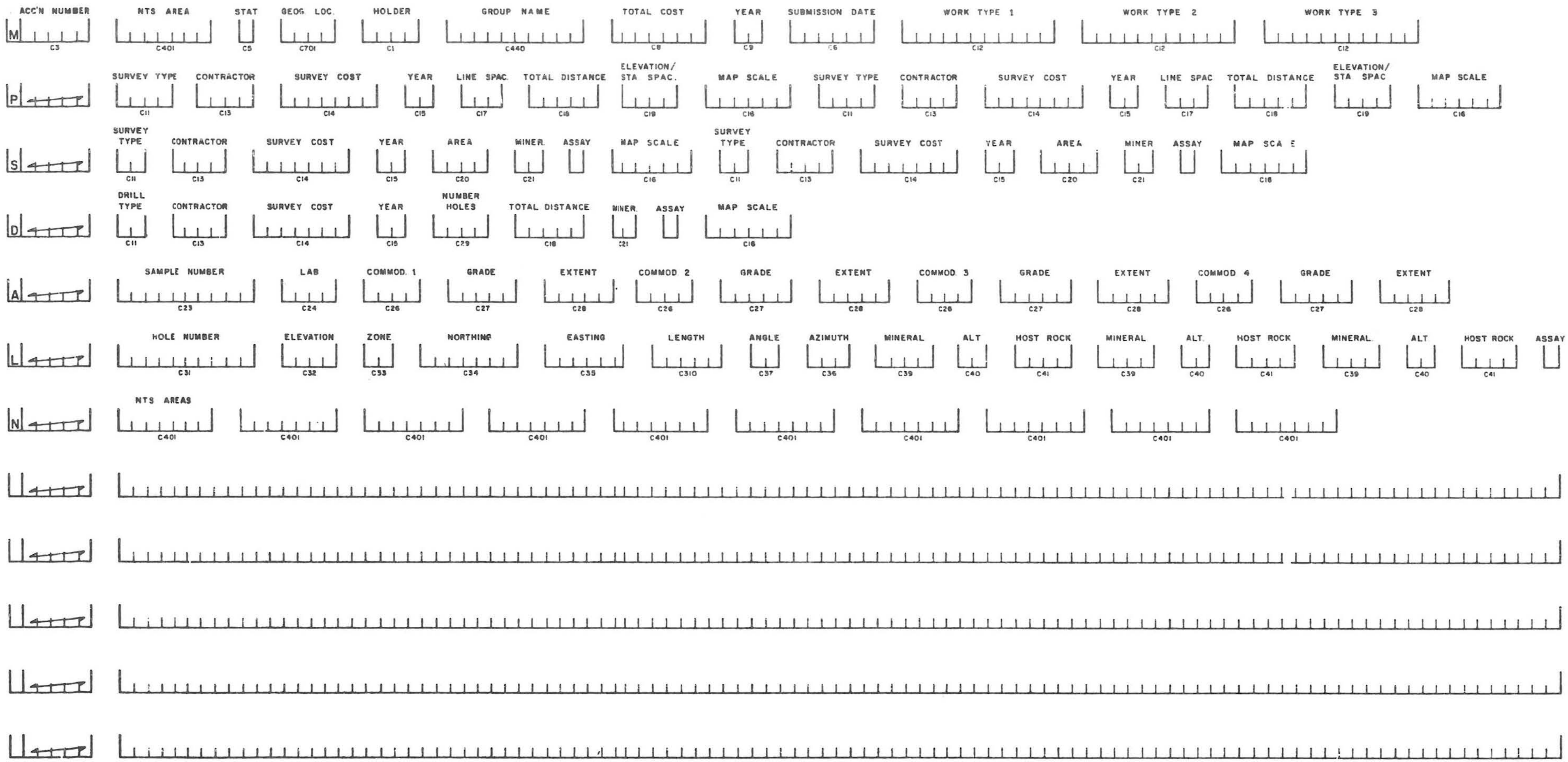


Figure 5 CLASS Index Document

NUMBER (________)
C202

PRIMARY COMMODITY (_____)
C1

DEPOSIT NUMBER (________)
C201

DEPOSIT NAME (________________________)
C401

YEAR (_____)
C402

STATUS (__)
C20

STATUS DATE (_____)
C21

CURRENT OWNER (________________________________)
C901

OWNER CODE (_____)
C903

YEAR (_____)
C902

POINT LOCATED (________________)
C17

UNCERTAINTY (_____)
C16

NTS AREA (________)
C301

LATITUDE (_______)
C11

LONGITUDE (________)
C12

UTM ZONE (__)
C13

NORTHING (________)
C14

EASTING (_______)
C15

GEOLOGICAL PROV. (___________)
C19

Figure 6a MIND Index Document, Proprietary Data

26

		PRODUCTION		RESERVES	
COMMODITY	STATUS	TONNAGE	GRADE	TONNAGE	GRADE
( ) C25	( ) C26	( ) C27	( ) C28	( ) C29	( ) C30
( )	( )	( )	( )	( )	( )
( )	( )	( )	( )	( )	( )
( )	( )	( )	( )	( )	( )
( )	( )	( )	( )	( )	( )

SOURCE EST. ( ) C23 NUMBER ORE ZONES ( ) C22

MINERALS

( ) C34	( )	( )	( )	( )
( )	( )	( )	( )	( )

ROCK TYPES

( ) C32	( )	( )	( )	( )
( )	( )	( )	( )	( )

Figure 6b MIND Index Document, Geologic Data

PREVIOUS

OWNER (____)
C901

OWNER CODE (______) C903   DATE (______) C902

OWNER (____)
C901

OWNER CODE (______) C903   DATE (______) C902

DEPOSIT NAME (____________________________) C401   DATE (______) C402

DEPOSIT NAME (____________________________) C401   DATE (______) C402

REFERENCE NUMBER (________) C420

REFERENCE NUMBER (________) C420

REFERENCE NUMBER (________) C420

Figure 6c MIND Index Document, Historical Data

REMARKS (____

____)
C41

REFERENCES

AUTHOR (____)
C36

TITLE (____)
C37

YEAR (____)
C38

AUTHOR (____)
C36

TITLE (____)
C37

YEAR (____)
C38

Figure 6d - MIND Index Document - Remarks and References

28

C. CORE

The largest and most complex data file, in terms of data items and hierarchical relationships, is the CORE file. The CORE file, based on diamond drill logs, uses a five-page document, shown in Figures 7a-e, for data collection. Proprietary data is contained on page 1 (Fig. 7a). Pages 2 through 5 successively refine the definition of a drilled interval, increasing in detail from hand-specimen identification of rock-type (Fig. 7b), mineralogy, form, texture and alteration (Fig. 7c), local structure (Fig. 7d), to composition obtained by analytical techniques (Fig. 7e). As is the case with CLASS and MIND, codes are used wherever possible.

This file is currently in the pilot-project stage. Following evaluation of test results, the structure, content and definitions may be changes to reflect - a) the uses of this data and -b) the availability of sound geological data. Following the final definition, all drill logs available in Manitoba's assessment files will be entered.

Data Collection

Input documents for each of the data files are completed by indexers. These documents are forwarded to an editor, whose responsibility is to ensure that required data is present, and that codes and data values conform to standards.

Following manual editing, the data is keyed off-line to an in-house terminal, a Sycor 340B Intelligent Communications Terminal. This terminal, equipped with 3 K bytes of programmable memory and twin tape cassette drives performs a second phase of editing. Data entered is type-verified (numeric, alphabetic or alphanumeric), range-verified (only a certain range is acceptable for some numeric fields, for example 0 to 100 percent for grade values), code-verified (a table lookup is performed to ensure a keyed code is acceptable), and occurrence-checked (for example, in the CLASS file, claim holder must be present), as it is keyed. Data records that pass verification are written automatically onto one of the tape cassettes. Incorrect entries are immediately flagged and an error message displayed on the terminal screen. The operator must correct the invalid field prior to keying the next field.

Periodically, the "clean" data are transmitted to a temporary file, which resides on a 3330 model 11 disk drive available on the IBM 370/168 computer, operating under OS-VS2 release 1.7 operating system, provided by Manitoba Data Services, a Government-operated Crown-Corporation. Transmission is accomplished by loading a communication program into the terminal and telephoning the main-frame computer. Access to the disk-bound files is through TSO (a time sharing option of the IBM System/370 Operating System). At present, data is transmitted one record at a time. However, in the near future, remote dial-up capabilities will be made available enabling us to transmit data in batch mode, thereby reducing processing costs.

After data is stored on the main-frame disk file, a batch COBOL program is run to update the master data file.

30

DRILL CORE LOG

Page ___ of ___

HOLE NUMBER ____________ YEAR ________ CLASS REFERENCE ________

OWNER ____

PROPERTY NAME ______________________ TOTAL LENGTH ______________

DRILLER ____

CORE SIZE __________ NTS-AREA ______________________

GRID NORTHING ______________________ GRID EASTING ______________

INDEX DATE ___/___/___ INDEXED BY ______________________

Figure 7a - CORE Index Document, Proprietary Data

LOG

Page ___ of ___

Hole Number __________

REF. FOOT.	ROCK TYPE	AZIMUTH	PLUNGE	MODIFIER	MODIFIER	MODIFIER
______	______	______	______	______	______	______

Figure 7b CORE Index Document, Hand Specimen Identification

PETROLOGY

Page ___ of ___

Hole Number __________

REF. SECT.	MINERAL	FORM	TEXTURE	ALTERATION
______	______	______	______	______

Figure 7c CORE Index Document, Petrology

SAMPLE DATA

Page ___ of ___

Hole Number __________

REF. FOOT.	SAMPLE LOCALE.	THIN SECT.	CORE ANGLE	FEATURE
______	______	______	______	______

Figure 7d CORE Index Document, Structure

DETERMINATION RESULTS

Page ___ of ___

Hole Number __________

REF. FOOT	LOCALE	TYPE	COMMOD.	ID	VALUE	MEMBER	MEM. VAL.
______	______	______	______	__	______	______	______

Figure 7e CORE Index Document, Analyses

32

File Processing

SYSTEM 2000, a general data base management system, is used for file maintenance and access. Two methods of access to the data files exist through SYSTEM 2000: (a) natural, and (b) procedural-language.

The chief advantage to using the natural language access method is that users, with very little command training, can perform retrievals and some restricted manipulations by themselves. The chief disadvantage lies in attempting massive updates to the data file, for which each data item and identifier must be specifically defined.

With the procedural language access method, characteristics are reversed; that is, massive updates are relatively simple to perform (once the procedural - language program is written), whereas individual retrievals necessitate writing a separate program for each new application.

Conclusions and Summary

The methods of data capture used in constructing the CLASS and MIND files have evolved over a period of 11 months, and are still continuing to evolve. As old procedures become familiar, they are evaluated and changes may be made. The CORE file, because it is relatively new, has as yet not received the same level of testing as the other two files. The chief handicap encountered to date has been the lack of reliable indexers. It has been found that the time required to become proficient in all aspects of the job is in the order of 3 to 4 weeks for a CLASS indexer. At present (June, 1976) two full time summer students are employed. Because the MIND indexers (personnel from the Mineral Inventory project) are already intimately familiar with the data, familiarization time is almost nil. It is still too early to fully assess the merits of the SYCOR terminal, but indications are that with additional memory, "cleaner" data can be entered into the data files, at a net reduction in cost.

Specific applications of the data base will evolve with use. However, several uses are self-evident. CLASS, for example may be used as an index to exploration reports. In the past, company and government geologists have spent considerable time searching the entire Cancelled Assessment Reports file for, in many cases, only one report. With CLASS, the number of reports to be examined will be reduced by careful phrasing of retrieval statements. Analysis of exploration activity, with regard to time, geographic area, or type of activity may be performed, with results presented in graphical, tabular or report form. Data in CORE, in addition to allowing for indexing capabilities, may be used in metallogenic studies, such as preparation of metallogenic maps. MIND may be used to monitor on-going development and production activities. Apart from these specific applications for each data file, the entire data-base will be an invaluable research tool, ultimately containing geological data and literature references to the geology of Manitoba.

NM 7504 EVALUATION OF NICKEL ENVIRONMENTS IN MANITOBA - by P. Theyer

Work on the project "Evaluation of Nickel Environments in Manitoba" was initiated with the hiring of an Economic Geologist as a project leader in March 1976. The following is a summary of planned activities.

Office Work

The initial phase of this program involves both inventory and recording of relevant geological data related to nickel-copper mineralization in the Province.

Main data sources at the moment are:

a) cancelled assessment files

b) confidential assessment files

c) mineral inventory files

d) various sources such as scientific papers, published maps, etc.

This data base will be supplemented during the summer field season by property visits and evaluations and some research.

The data will be presented on maps, generally at a scale 1:50 000. Larger scales will be used only in cases of complex geology or drilling patterns. These maps will display areas in which "work" in search of nickel-copper mineralization has been done. Recorded "work" can consist of geological, geophysical or geochemical surveys, diamond drilling, pitting, trenching, sampling, etc.

The results of this work, such as distribution and patterns of mineralization, rock distribution patterns, sulphide distribution patterns, etc. will also be recorded. Finished maps will display amount, type, location and results of any exploratory work done on any area in Manitoba.

Field Work

Field work in 1976 will center initially on locations along the Bird River Sill and in the Rice Lake region. These visits are intended for familiarization with various types of nickel-copper mineralization in southeast Manitoba.

Later in the program, a study of all accessible mines in the "Manitoba Nickel Belt" and their diverse mineralization patterns will be undertaken.

The main efforts of this field season will be directed towards an analysis of the copper-nickel deposits of Lynn Lake and the geology of surrounding gabbroic plugs. The objective is to find a deposit model for this type of mineralization and apply the acquired knowledge in the search of similar mineralization in similar geological environments.

The remainder of the year will then be spent on laboratory work and analysis of field data.

NM 7505 EVALUATION OF MASSIVE SULPHIDE ENVIRONMENTS - by G. Gale, J. Koo, L. Solkoski, and G. Southard

Abstract

Activities of the Massive Sulphide Project group were concentrated mainly on evaluating assessment work reports. Mining properties and mineral occurrences were investigated during a six week field season. Forty 1:50 000 map sheet (E & W halves) compilations for diamond drilling and mineral occurrences have been completed. Examples and preliminary results of the compilations, which will be made available to the public as open files, are presented.

Introduction

The overall objectives of this project are (a) to provide an estimate of known and potential Cu - Zn resources in Manitoba; and (b) to provide a picture of the metallogenesis of massive sulphide deposits in Manitoba in terms of deposit-type models. A comprehensive and integrated picture of the massive sulphide type mineralization in Manitoba may serve as a basis for sophisticated resource potential evaluation, as well as establishing a data base for efficient exploration.

The objectives for the year to April 1, 1976 were:

(a) to visit the producing Cu-Zn mines and study their geological setting and stratigraphic position,

(b) to review exploration history,

(c) to review deposit type models; and,

(d) to visit and evaluate the potential of known mineral occurrences.

The massive sulphide project (MSP) commenced on April 1, 1975 with the appointment of two assistant geologists to review and synthesize information contained in the Cancelled Assessment Files (CAF) of the Mineral Resources Division. Two economic geologists were engaged in the MSP in early July and spent 6 weeks each in the field before the end of the field season. As of April 1, 1976, a total of 39 man/months (3.25 man/yrs) have been expended on the MSP.

The initial efforts have been concentrated in the greenstone belts of Lynn Lake - Rusty Lake, Flin Flon - Snow Lake, and Oxford Lake - Knee Lake - Gods Lake; the first two belts contain producing Cu-Zn mines and the last is the largest non-producing greenstone belt in the province. Due to a late start (early August), field activities were limited mainly to visiting mining properties and becoming familiar with the general geological setting of the producing massive sulphide deposits and selected mineral occurrences in the Flin Flon - Snow Lake and Lynn Lake areas; no field activities were carried out in the Oxford Lake - Gods Lake area. Outside the field season, the main emphasis has been directed towards compiling information on mineral deposits and occurrences contained in the assessment files of the Department, and from published sources. In preparing this report only non-confidential information has been used. Additional information of a confidential nature has been gathered from exploration companies and will be useful in the appraisal of regional resource potential.

The areas for which assessment data compilations have been completed and are currently in progress are shown in Figure 8. Treatment of the data for individual map sheets varies from a plot of known diamond drilling locations to a plot of diamond drilling and geophysical anomalies plus a detailed summary of drill logs and a detailed geological description of individual occurrences; data availability and quality as well as the number of personnel employed in the study of each greenstone belt have differed considerably and the various segments of this report reflect these differences.

It should be noted that this report is not designed to present a complete picture of information obtained or conclusions drawn in the report year due to the confidentiality of much of the data base, incompleteness of data reduction in some areas and the large volume of data available. Consequently only typical examples of data syntheses and maps are presented here.

GENERAL GEOLOGY

The Flin Flon - Snow Lake "greenstone" belt in Manitoba is exposed in an elongated east-west belt approximately 150 x 50 km. Recent exploration has shown that volcanic rocks extend underneath Palaeozoic cover and that the actual width of the greenstone belt is probably in excess of 100 km. In the exposed portion of the greenstone belt approximately 50% of the area is underlain by volcanic and sedimentary rocks, the remainder is underlain by gabbroic and granodioritic intrusions. The oldest rocks in the area, known as the Amisk Group, consist mainly of subaqueous volcanic rocks and minor sediments; these are unconformably overlain by the arkoses and conglomerates of the Missi Group.

Massive sulphide deposits are associated with Amisk Group volcanic and sedimentary rocks. The volcanic rocks consist of basaltic, andesitic, dacitic and rhyolitic lava flows and variable but generally abundant volcanogenic clastics which contain considerable reworked material. Sedimentary rocks include greywacke, sandstone, argillite and conglomerate and are generally restricted to thin discontinuous units which locally can form important stratigraphic marker units (e.g. White Lake, Snow Lake).

Various lines of evidence suggest that the rocks of the Flin Flon - Snow Lake Amisk Group have formed in an island arc environment of Aphebian age (Bailes, 1971; Sangster, 1972a; Mukherjee et al, 1971; Stauffer et al, 1975; Bell et al, 1975). Available geochemical data indicates that the volcanic rocks are mainly of island arc tholeiite affinity and may be calc-alkaline in part (Stauffer, et al, 1975).

The Lynn Lake - Rusty Lake greenstone belt is an arcuate, approximately east-west trending belt 150 km in length and 10-50 km in width. Similar to the Amisk Group in the Flin Flon - Snow Lake belt is the Wasekwan Group, which consists of volcanic rocks, associated volcaniclastic material and minor sediment. Basic to intermediate volcanics and detritus derived from them are the dominant rock types; only minor acidic flows and volcaniclastics are present (Milligan, 1960; Roy and Haugh, 1971).

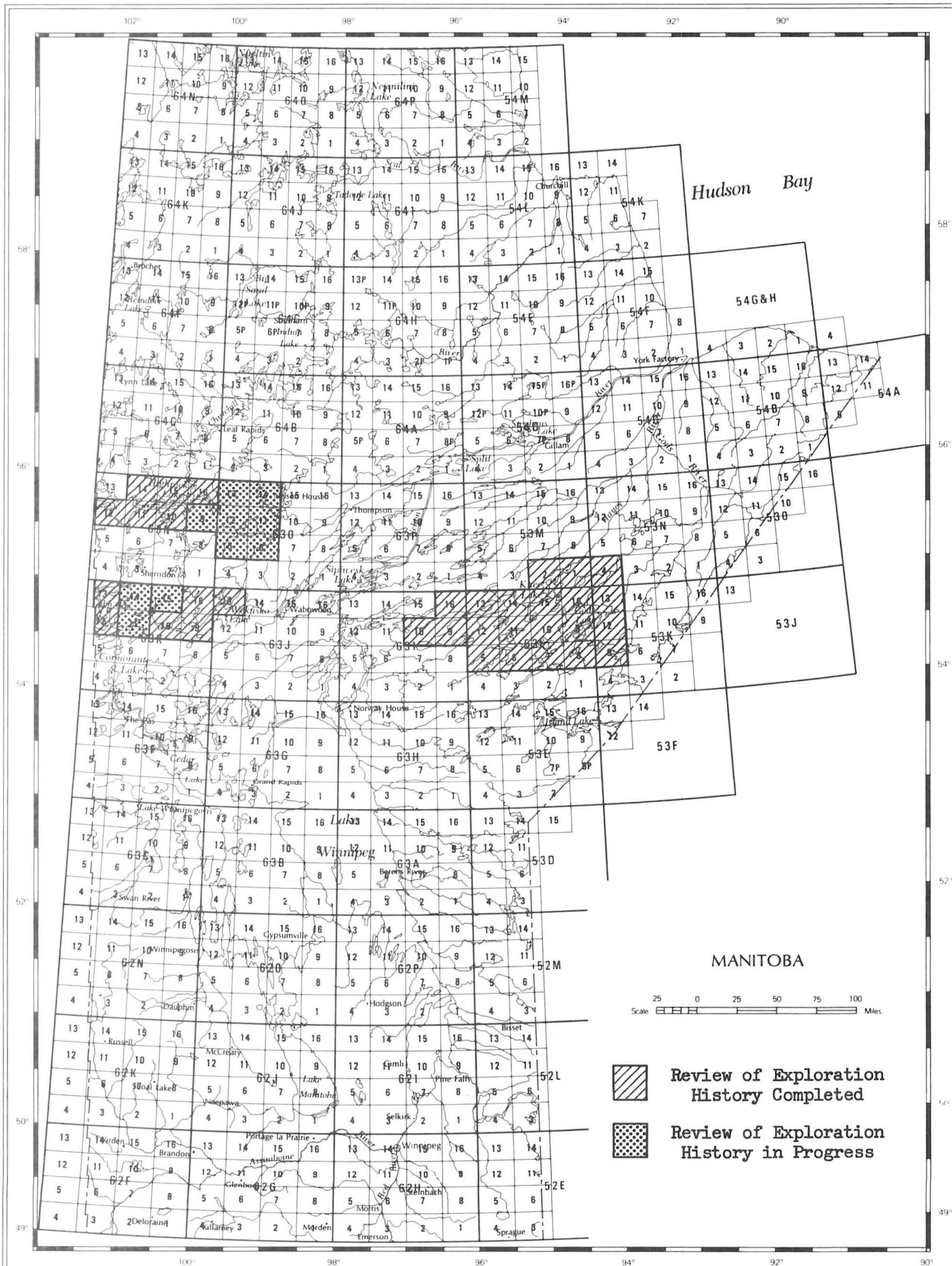


Figure 8 Progress of exploration history review

Zwanzig (1974) measured a stratigraphic section of Wasekwan Group rocks southwest of Barrington Lake at least 5,100 m thick; he also documented the volcanism as cyclical, in that basic to intermediate flows and pyroclastics are followed by acid flows and pyroclastic rocks. The volcanic cycles can sometimes be followed by argillite, calcareous phyllite and cherty iron formation laterally or vertically. The Wasekwan Group rocks are stratigraphically overlain by the Sickle Group arkoses and conglomerates at Lynn Lake (McRitchie, 1974). The Sickle Group is similar to the Missi Group in the Flin Flon - Snow Lake belt.

The Fox and Ruttan massive sulphide deposits are contained within the Wasekwan Group rocks. Geochemical data obtained from basaltic lavas of the Rusty Lake area have shown that they have stable-trace-element characteristics (J. A. Pearce per. comm.) of modern day island arc tholeiitic magmas. Radiometric dates available for the Lynn Lake - Rusty Lake greenstone belt suggest that Kenoran and Hudsonian orogenic events affected the area (Stockwell, 1964, Turek, 1967).

MASSIVE SULPHIDE ENVIRONMENTS

Due to the short field season in 1975 a detailed study of the geological setting of the known massive sulphide deposits was not possible. The following is a brief summary of results to date and will be augmented by further geological studies in the 1976 season.

Mineral Deposits

The distribution of massive sulphide deposits in the Flin Flon - Snow Lake area is shown in Figure 9. In the Flin Flon area the deposits are predominantly massive pyrite deposits containing chalcopyrite and sphalerite; pyrrhotite is abundant in the Pine Bay deposit. Pyrrhotite is also the dominant sulphide in the Dickstone, Stall Lake and Osborne deposits of the Snow Lake part of the belt. Although the Dickstone and Snow Lake area deposits are of higher metamorphic grade than those of the Flin Flon area, the dominance of pyrrhotite over pyrite cannot be attributed solely to the effects of metamorphism since both the pyrite-rich Anderson mine and Rod deposit are situated on either side of the pyrrhotite-rich Stall Lake mine and all three deposits occur in the same metamorphic zone.

The Chisel Lake and Ghost Lake mines differ from other deposits in the Flin Flon - Snow Lake area in that the dominant sulphide is sphalerite; galena is also present in addition to the "normal" pyrite and chalcopyrite.

It can be seen from Figure 9 that the major massive sulphide deposits of the Flin Flon area can be separated into 4 groups on the basis of their metal ratios: namely, Cu-, Cu>Zn, Zn≥Cu, Zn>>Cu deposits. These deposit types do not exhibit any regional distribution trends that can be correlated with metamorphic zones or tectonic environments as presently understood in this area (Bailes, 1971).

Other deposits of subeconomic massive sulphides are known to be present in the area; however, there are at present insufficient data available to us to establish their metal ratios.

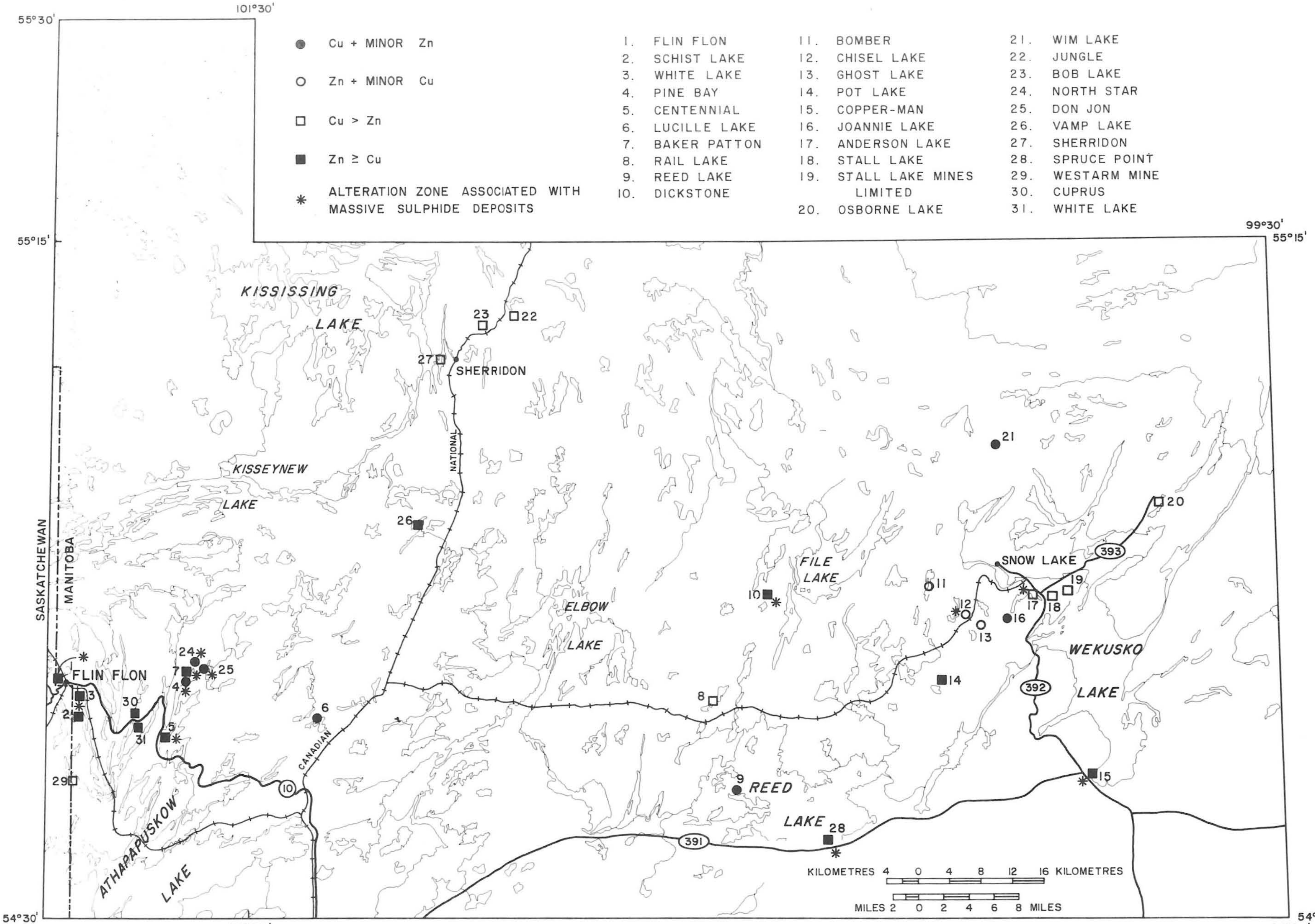


Figure 9 Distribution of massive sulphide deposits, Flin Flon - Snow Lake area

In the Lynn Lake area there are at least 48 known massive sulphide occurrences; only one of these, the Fox Mine, a Zn≥Cu deposit, is a producing mine (Fig. 10). In the absence of adequate analytical information to classify the Lynn Lake occurrences into deposit types such as recognized in the Flin Flon - Snow Lake area (Fig. 9), the available drill core analyses have been used to separate the occurrences into polymetallic (Cp-Sph-Py-Po) and Py-Po deposits. It can be seen from Figure 10 that both deposit types are distributed throughout the Lynn Lake area from Laurie Lake to Barrington Lake (compilations have not yet been completed for the eastern portion of the Lynn Lake - Rusty Lake greenstone belt). However, massive sulphide deposits containing Cu (≥ .5%) and/or Zn (≥ 1%) are clustered in three different segments of the Wasekwan belt centered near Fox Lake, Lynn Lake and Barrington Lake. The distance between these "centres" and between Barrington Lake and the Ruttan Lake deposit is approximately 50 km. It should also be noted here that the polymetallic deposits can be associated laterally and/or vertically with Py-Po deposits.

Stratigraphic control

After a long history of interpretation as "epigenetic" replacement deposits dating from the early days of the Mandy deposit (Bruce, 1916) to post 1957 (see "Structural Geology of Canadian Ore Deposits, 1957), the massive sulphide deposits of the Flin Flon - Snow Lake area are now generally recognized to exhibit features that are typical of volcanogenic massive sulphide deposits (Martin, 1966, Coats et al, 1970; Sangster, 1972a, 1972b; Koo and Mossman, 1975). The deposits are essentially conformable and stratabound, although in detail some deposits may exhibit minor crosscutting relationships due to mobilization (probably in a plastic state) relative to their surrounding host rocks during the late stage regional metamorphism (e.g. Stall Lake and Osborne Lake Mines).

Individual lenses of an ore deposit are known to occur at the same stratigraphic level, e.g. in the Flin Flon, Schist Lake, and Stall Lake deposits (Howkins and Martin, 1970; Martin, 1966). It has been suggested that the Flin Flon, Mandy and Schist Lake deposits occur at or near the same stratigraphic horizon (Howkins and Martin, 1970), however, in the absence of distinctive marker horizons this contention is difficult to verify. Observations in the Schist Lake mine indicate that the steeply eastward-dipping ore lenses at Schist Lake have Cu-rich footwalls and Zn-rich hanging walls. This same relationship has been noted by Howkins and Martin (1970) for the Schist Lake deposit, and by Bruce (1916) for the Mandy deposit. The deposits of the Flin Flon mine also exhibit a zoning in which the Zn-rich ores occur to the east of the Cu-rich ores. In the generalized model for volcanogenic massive sulphide deposits (e.g. Sangster, 1972a) the Zn-rich zone occurs stratigraphically above the Cu-rich basal zone. This would indicate that (1) both the Flin Flon and the Schist Lake - Mandy deposits are eastwards younging; (2) the Schist Lake - Mandy sulphide horizon does not occur on the east limb of the Burley Lake Syncline (Howkins and Martin, 1970) but on the east limb of an anticline with its axial plane to the west of the Schist Lake deposit; and

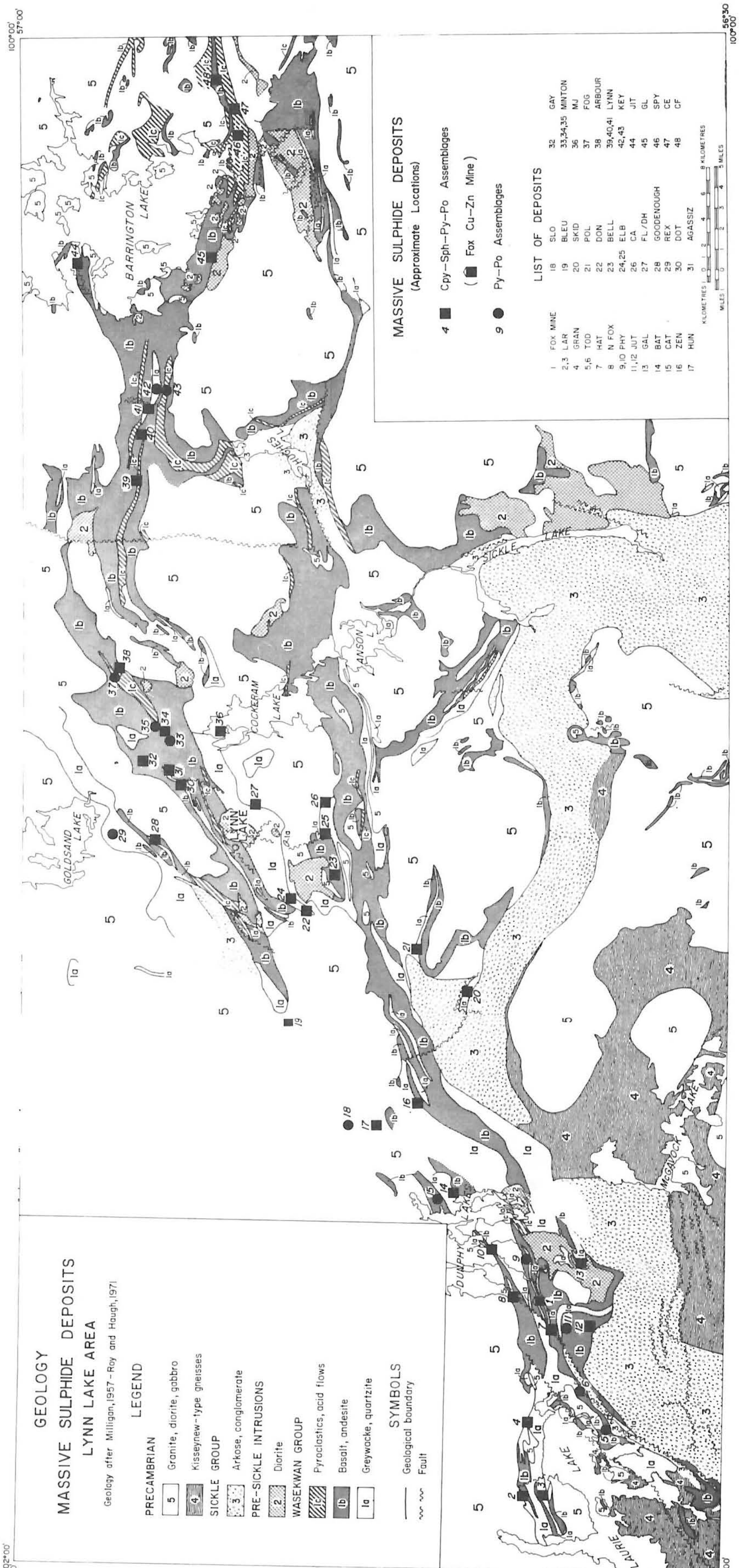


Figure 10 Geology and massive sulphide deposits in the Lynn Lake area

(3) the Flin Flon deposit and the Mandy - Schist Lake deposits are probably located at different stratigaphic horizons. A tentative interpretation is presented in Figure 11.

The ruler-shaped White Lake and Cuprus deposits occur in similar lithologies; while detailed mapping and structural analysis of the area are needed before it can be established whether these two deposits occur on the same stratigraphic horizon, they can be considered as belonging to the same stratigraphic zone since they are adjacent to a well-defined clastic sedimentary unit which probably overlies the volcanic rocks.

Another zone of massive sulphide mineralization can be outlined in the Sourdough Bay area. On the basis of detailed mapping and geophysics it can be shown that the Centennial, Pine Bay, North Star, Don Jon, and several prospects in the area occur at a number of different stratigraphic horizons. This zone, outlined on Figure 12, contains a large volume of acidic volcanic rocks and appears from a preliminary investigation to contain at least several volcanic vents. Since this zone contains one of the larger areal exposures of acidic volcanism in the Flin Flon area, and has several base metal deposits (see Fig. 12), further studies will be made to delineate the different stratigraphic horizons on which there is known mineralization and to establish whether all or only some of the cycles of "basalt-andesite-rhyolite" have a base metal potential.

In the Snow Lake area five mines are located close to the contact of acidic and basic volcanic rocks but within the acidic rocks (Moore and Froese, 1973). Individual ore lenses at several of the mines (e.g. Chisel Lake - Martin 1966; Stall Lake - Howkins and Martin, 1970) occur at a single stratigraphic horizon. Although it has not yet been established whether all the ore deposits occur at the same horizon or not, the five producing mines and several other known deposits (e.g. Joannie and Rod Lake) appear to be contained within a single stratigraphic zone as can easily be deduced from published geological maps.

Although detailed mapping has been initiated in the File Lake area (Bailes, in prep.) and there are 4 known deposits in the Reed Lake - Dickstone area, the data base is insufficient to establish the stratigraphy in these areas.

A detailed survey of massive sulphide occurrences in the Lynn Lake area indicates that the deposits are commonly contained within acid volcanic pyroclastics and flows, and/or siliceous to argillitic sediments. These host rocks are generally stratigraphically underlain by basic to intermediate volcanic flows and breccias, particularly in the case of polymetallic massive sulphide deposits with "high Cu-Zn" grades (i.e. Cu>0.5%, Zn > 1%).

One aspect of the lithostratigraphic control is that the high Cu-Zn sulphide zones, including the Fox mine, are associated directly with acid volcanics (flows, dikes, tuffs) plus silicic volcanoclastics, and the "low Cu-Zn" (Cu < 0.5%, Zn < 1%) and barren sulphide zones are associated with siliceous to argillaceous sediments. These sulphide-bearing lithological

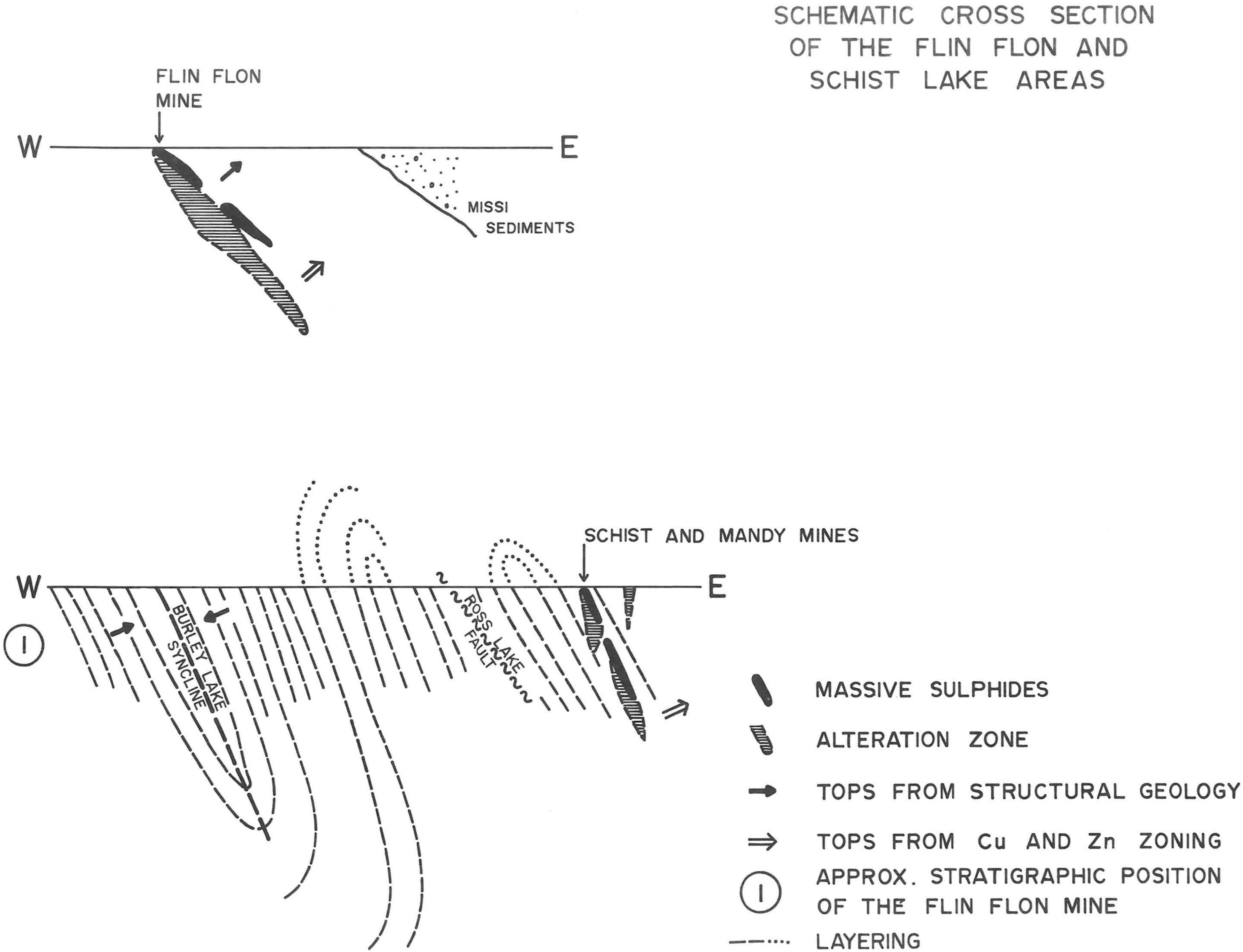


Figure 11 Schematic cross section of the Flin Flon and Schist Lake areas

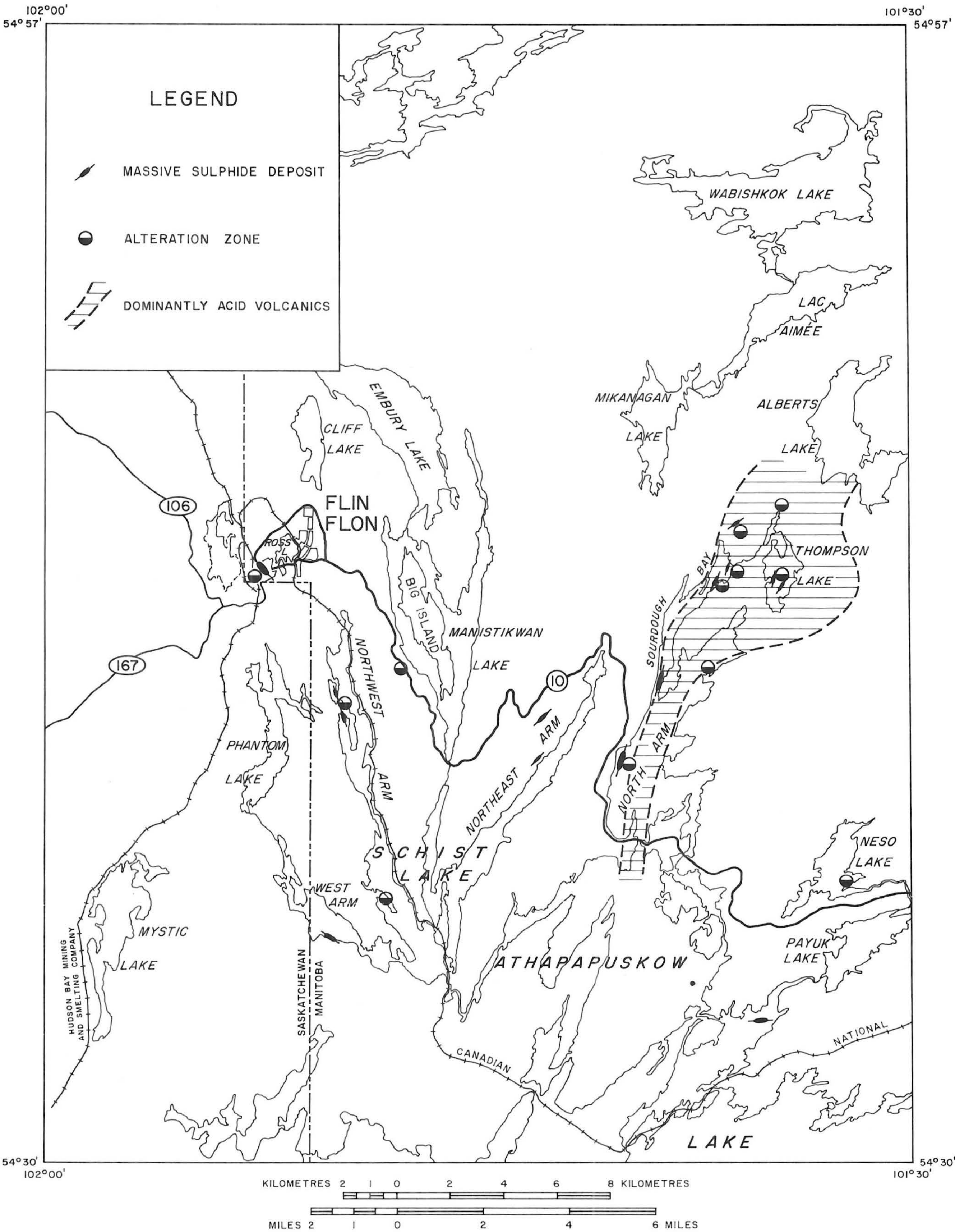


Figure 12 Massive sulphide deposits and alteration zones in the Flin Flon area

sequences are commonly overlain by greywackes, and/or by the Sickle arkose and conglomerate as reported for the Fox mine area (Stanton, 1949; Coats et al., 1972; Obinna, 1974). The high Cu-Zn sulphide - acid flow - tuff suites are, in many places, associated with barren sulphide - siliceous to argillitic suites laterally and/or vertically in the Wasekwan volcanic-sedimentary stratigraphy. It is also found that graphite occurs in a majority of the low Cu-Zn and barren massive sulphide zones in the area. Since graphite is commonly associated with the argillitic and/or impure siliceous sediments, it is suggested that the barren and/or low Cu-Zn massive sulphide deposits accumulated preferentially in the quartzite-argillite sequences. The high Cu-Zn massive sulphide deposits are virtually devoid of graphite.

Within the Wasekwan volcanic-sedimentary sequence southwest of Barrington Lake, barren sulphide zones are overlain by cherty Fe-oxide zones.

Alteration minerals reported are principally chlorite, sericite, quartz and/or carbonate. These principal types of alteration appear to be associated only with the polymetallic sulphide deposits.

The Cu-Zn massive sulphide deposits may be differentiated to some extent from the barren massive sulphide deposits on the basis of their detailed host rock stratigraphy at various localities. However, the two types of deposits are mutually transitional and closely associated with one another within narrow stratigraphic intervals. Therefore, the barren zones may still be important as path-finders in the exploration for new Cu-Zn deposits in their immediate vicinity. It is still a major question as to whether the basic to acidic volcanic sequences recognizable in the Fox, Lynn Lake and Barrington Lake segments are simply peripheral to or entirely different cycles of volçanism from a possible volcanic center localized further east of the Lynn Lake area as suggested by the regional distribution pattern (i.e. eastward thickening) of pyroclastic map units.

Detailed mapping and diamond drilling in the Oxford Lake - Gods Lake greenstone belt have revealed that at least some of the sulphide mineralization in that area is located at or near the boundaries of different volcanic cycles (see Appendix B this report).

Exploration History

Information on the exploration history of the various areas is being extracted from company exploration files and the Cancelled Assessment Files (CAF) of the Department.

Information contained in the CAF is being evaluated and synthesized. An Open File report on each NTS 1:50,000 map sheet is being prepared and will be made available to the public as completed.

The data obtained will be presented on 1:50,000 topographic and geological bases as: (1) a 1:50,000 index map showing areas for which detailed geological maps are available in the CAF plus a plot of known sulphide occurrences; (2) a 1:50,000 plot of known diamond drill hole locations; and (3) a short description of known sulphide occurrences, and a skeleton log of the rock types and mineralization in individual drill holes.

In addition to information on rock types and sulphide mineralization, encountered in drilling, the diamond drill records in some instances contain information on the type of wallrock alteration present or what can be interpreted as wallrock alteration (i.e. chloritization, silicification, carbonatization, pyritization). Because of the common association of volcanogenic massive sulphide lenses with a feeder zone or alteration pipe (Sangster, 1972a) attention has been directed towards the identification of alteration zones during the initial search of the files. The known sulphide deposits in the Flin Flon - Snow Lake area which have a zone of alteration (feeder) associated with them are shown in Figure 9 (most of the deposits shown without an alteration pipe are those for which little data are available).

The scarcity of analytical data in the CAF precludes any attempts at statistical treatment of the compositions of sulphide layers encountered in diamond drilling.

A synopsis of information extracted from the CAF for a portion of the Flin Flon - Snow Lake area is given in Appendix A of this report. Examples of the preliminary compilations are also presented. Appendix B contains a brief description of some of the mineral occurrences and CAF compilations for the Oxford Lake - Gods Lake area.

Massive Sulphide Deposit Production and Potential:

Since production began at the Mandy Mine in 1917, the Flin Flon - Snow Lake area has produced a total of 76.4 million tons of ore from massive sulphide deposits. Production figures are given in Table XIV accompanying project report NM 7511-2. During 1975 the Dickstone Mine ceased operations temporarily and the Schist Lake Mine was closed down. The Centennial and West Arm Mines are under development and will likely be in production in the near future.

Only two Cu-Zn deposits are presently being mined in the Lynn Lake - Rusty Lake greenstone belt; these are the Fox and Ruttan Mines of Sherritt Gordon Mines Ltd. Production figures for 1970-1975 are given in Table XIII of project report NM 7511-2.

Reserves

Proven reserves of Cu-Zn ore in the H.B.M. & S. mines at the end of 1975 totalled 17.45 million tons containing 2.77% Cu/ 2.8% Zn/ 0.033 oz Au/ 0.52 oz Ag. An additional 2.0 million tons of 4-5% Cu ore have been outlined at the Stall Lake Mine (Northern Miner - 76 03 18).

Known ore reserves of the H.B.M. & S. Co. have been maintained at approximately 18 million tons since 1930 when the Flin Flon mine began production. Although the reserve calculations are based on a number of economic factors, it is reasonable to assume that the known reserves will be maintained at the present level for a number of years due to the continuity of the ore zones below the deepest mine levels in 8 of the existing mines and known but unexploited satellite deposits in the area. Thus a 15-20 year life expectancy for the Flin Flon - Snow Lake mining camp is reasonably assured without the discovery of any additional new deposits.

Proven reserves of Cu-Zn ore in the Fox and Ruttan mines at the end of 1975 were 8.7 million tons (1.92% Cu / 2.08% Zn) and 43.6 million tons (1.45% Cu / 1.45% Zn) respectively. These reserves should provide a minimum life of 8 years for the Fox Mine and 13 years for the Ruttan Mine at the present mining rates and with favourable economic conditions.

Future activities

Future activities will be directed towards completing the evaluation of assessment files and presenting compilations of the CAF data as open file reports.

Field studies will be directed towards establishing the detailed stratigraphy in and around prospects, and past and present producing mines; detailed geological and geochemical studies will be carried out in selected stratigraphic zones to test the applicability of whole rock geochemistry as a local exploration tool and examine the feasibility of discriminating Py/Po layers associated with Cu-Zn mineralization from those that are not.

Appendix A

Compilation of Cancelled Assessment Work for N.T.S. 63K-10

The first geological mapping of the area was undertaken by J. B. Tyrrell in 1846, followed by Alcock 1917; J. F. Wright 1930; Stockwell 1934; Shepherd 1943; Stanton 1945; Harrison 1949; Hunt and Rousell 1965-66.

Prospecting started in the pre-1920's, carried on into the 1930's and 40's. The primary interest during these years was gold. Base metal exploration was being carried on during this time as well, but it wasn't until the 1950's and 1960's that any significant amount of exploration for base metals was carried out.

This report is a brief summary of information compiled from cancelled assessment files. Approximately 100 diamond drill holes were plotted on N.T.S. 1:50,000 topo 63K-10. Brief notes were made of the rock types, mineralization and alteration products encountered in each diamond drill hole. On the basis of these data, three major areas of high exploration intensity were identified in 63K-10 as Area A (Fig. 13), and areas B and C (Fig. 14). From an examination of Manitoba Mines Branch map 66-3 (N.T.S. area 63K-10E) by D. Rousell (1966), it can be seen that diamond drilling in Area A was conducted in both basic volcanics and intrusives; lithologic units mapped by Rousell comprise chlorite schists, hornblende schists, and gabbro. Thirty-eight of 49 holes drilled in Area A intersected mineralization. Of the 38 holes, 12 intersected graphite and/or pyrite. Some of the latter holes also contain pyrrhotite, chalcopyrite, sphalerite, and magnetite; 3 holes intersected only magnetite and pyrite; 1 hole intersected only magnetite; and 8 holes intersected only pyrite. The remaining 14 holes were apparently free of graphite and contained various combinations of pyrrhotite, pyrite, magnetite, chalcopyrite, sphalerite, bornite and millerite. Only 4 drill logs contain any assay values.

Siliceous andesite, tuff, graphitic and talcose schist, gabbro, dacite, rhyolite, trachyte, serpentinite, quartz feldspar porphyry, greywacke, argillite, and limestone are the main rock types noted in the drill logs. In only one diamond drill log is there any notation of brecciated rocks; this hole contained a one foot section of brecciated rhyolite which could have been produced by tectonic rather than volcanic processes.

The largest single unit of clastics (tuff, tuff breccia) mapped by Rousell lies outside Area A on an island some 1.5 miles west of the Reed Lake massive sulphide deposit of H.B.M. & S. (just north of Fourmile Island). Other smaller outcrops of clastic rocks occur within 1.25 to 1.75 miles of the Reed Lake deposit.

Most of Fourmile Island was mapped by Rousell as tonalite, "quartz-eye" tonalite, and plagioclase porphyry. Cancelled files do not contain any record of drilling here although numerous gold-bearing quartz veins have been trenched. This unit of massive silicic rock and the Reed Lake sulphide deposit occur within the centre of an apparent zone (Fig. 13) of volcaniclastic rocks (tuff, tuff breccia). In addition to the outcropping of "quartz-eye" tonalite, on Fourmile Island, diamond drilling some 3 miles to the north of the island (and the Reed Lake deposit) intersected

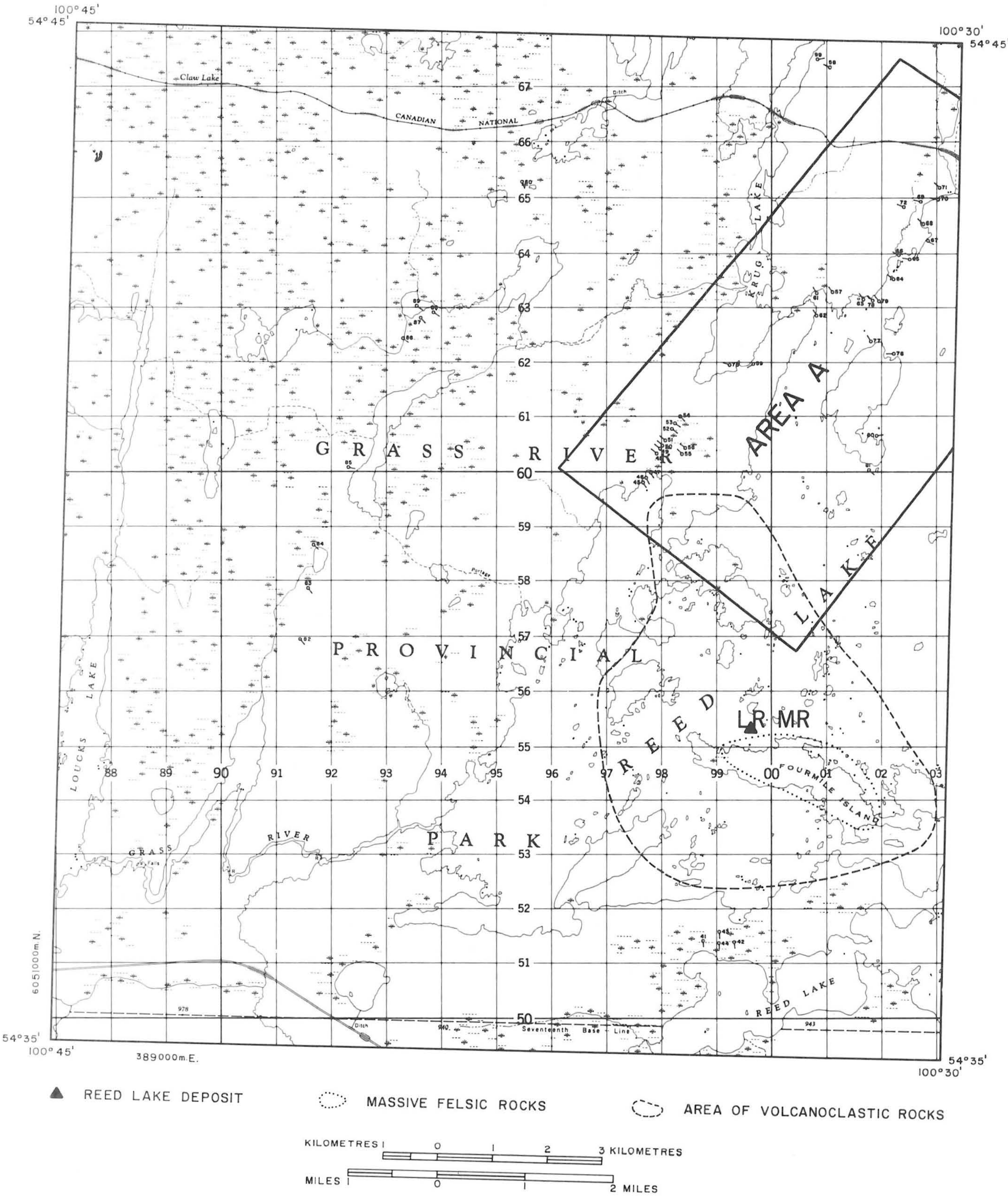


Figure 13 Plot of exploration DDH 63K-10, Area A

quartz feldspar porphyries stratigraphically underlain by basic volcanic flows. It is quite possible that the silicified tonalite on Fourmile Island may be a sub-volcanic equivalent of the same lithology and therefore should be investigated closely to see if it may represent a volcanic center. If the Fourmile Island does represent a center of volcanic activity and the Reed Lake deposit can be related to this activity, then it is possible that other massive sulphide deposits formed laterally from the vent area; establishing the nature of the volcanism in this area will enable a better estimation of the base metal potential to be made.

Area B (Fig. 14) was mapped by G. Hunt (1965) as ultramafic, serpentinitic, and meta-gabbroic intrusives, talc-chlorite schists, amphibolites and clastic rocks. The area is surrounded by tonalite, "quartz-eye" tonalite, leucogranodiorite, and adamellite. Two faults run through the area, intersecting at the centre of Barb Lake. Cancelled files contain the locations of 7 diamond drill holes; 4 holes intersected magnetite, 2 intersected graphite, and all 7 holes intersected sulphide mineralization in various combinations of pyrite, pyrrhotite, chalcopyrite and millerite. The sulphide mineralization occurs primarily in the serpentinite and talc-chlorite schists. Assay values were given for only 2 holes.

In Area C (Fig. 14), of 55 diamond drill holes, recorded logs for only 21 are available. The dominant rock types intersected in diamond drilling were andesite, schists (talc carbonate and talc chlorite); narrow intersections of rhyolite and feldspar porphyry are present. Various combinations of pyrite, chalcopyrite, pyrrhotite and magnetite were encountered in 18 holes. Of these, 8 intersected graphite and 7 intersected magnetite. One hole intersected "limestone", at a depth of 168' to 200', containing graphite, pyrite, "massive sulfides" and hematite. This "limestone" unit is overlain and underlain by talc-carbonate schists which grade into andesite with grains of magnetite. This 32' section of "limestone" alternates with layers of pyrite and graphite and is probably of Precambrian age.

Assays available for 6 of the 55 holes in area C indicated Au values from nil to 0.70 oz/ton; the mineralization occurred in andesites.

More than 15 of the 55 holes were drilled in a unit of clastic rocks mapped by G. Hunt as Iskwasum Lake pyroclastics. The remainder of the holes were drilled in andesites, serpentinites and amphibolites.

Recommendations

The geology of Fourmile Island and the surrounding area of clastic rocks should be examined in detail in order to establish whether Fourmile Island represents a volcanic center (acidic dome?).

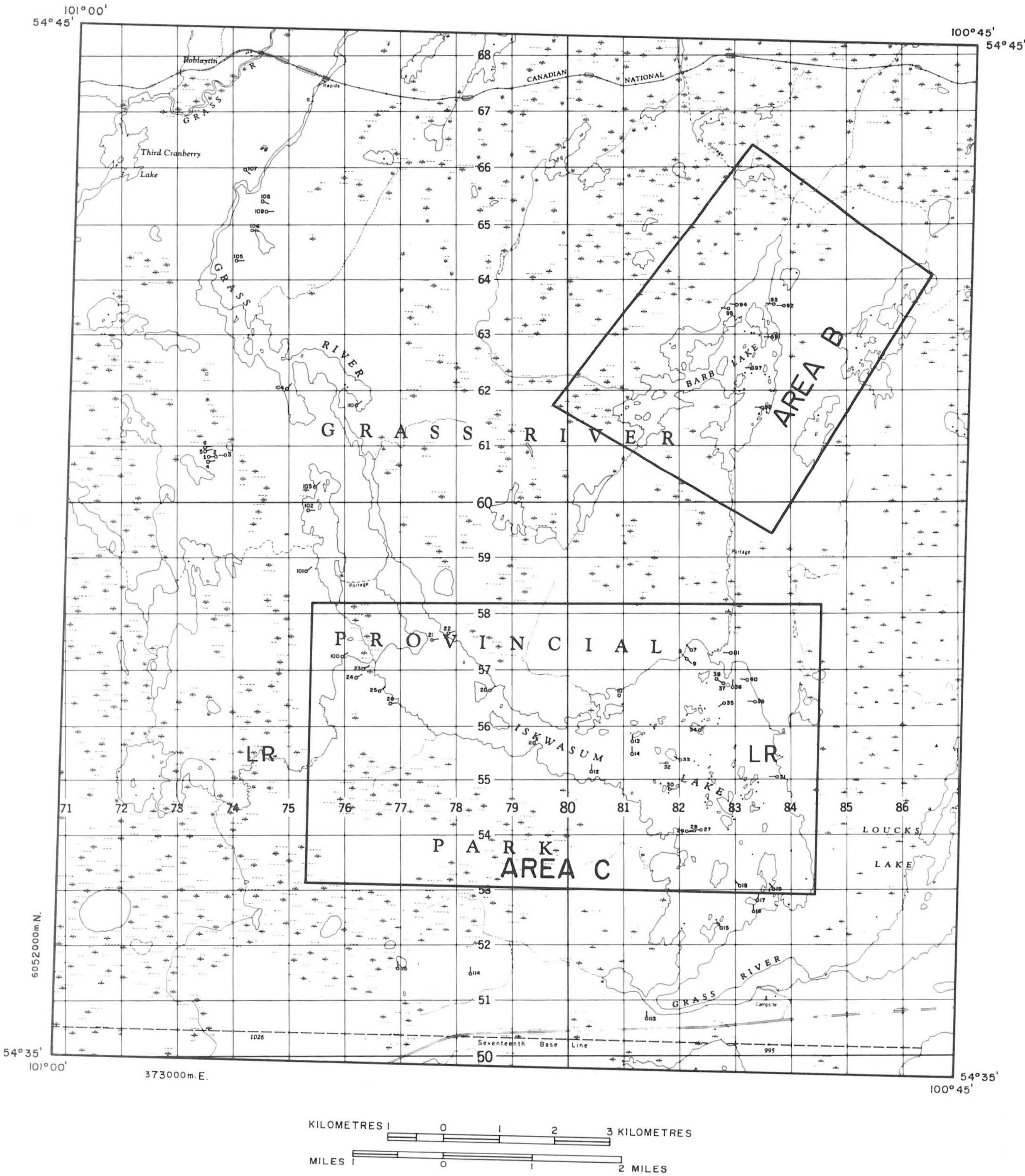


Figure 14 Plot of exploration DDH 63K-10, Areas B and C

Appendix B

Compilation of Cancelled Assessment Work for the Oxford Lake - Gods Lake Area

A compilation of the cancelled assessment data has been completed for the Oxford Lake - Gods Lake area as outlined in Figure 15. Diamond drill hole locations and significant surface showings were plotted at a scale of 1" = 1 mile (for eventual enlargement to 1 - 50,000). Where applicable, airborne electromagnetic and magnetic conductors were also plotted at the same scale (Fig. 16).

Since a separate open file report is being prepared for CAF data, only a few of the more interesting occurrences are presented here.

Most of the exploration activity has taken place in the Knee Lake - Cinder Lake volcanic belt, the Oxford Lake - Hyers Island area, and the volcanic belt exposed along the Carrot River. Volcanic rocks are present elsewhere in the project area but have not been as intensively explored due to either poor exposure and/or discouraging initial results.

Exploration work on the volcanic belts began in 1918 with the discovery of gold at Knee Lake. Gold provided the initial impetus for exploration work and it was not until several years later that base metal exploration began in earnest. Since the early 1950's base metal exploration programs have far outstripped those of gold exploration.

To date the best base metal mineralization found is a small copper deposit on the south-west tip of Hyers Island. The mineralization occurs in a pipe-like semi-massive sulphide body containing approximately 400,000 tons of 2.55% copper (Haskins & Stephenson, 1974).

Knee Lake Area

Detailed mapping has shown that a number of volcanic cycles are present in this area, which has subsequently been substantiated by geochemical analysis (Hubregtse, in prep.). Locally the cycle boundaries are marked by abundant sulphide mineralization. A number of electromagnetic anomalies situated along the cycle boundaries have been drilled and sulphide intersections of 10-20 m were encountered in several drill holes. The main sulphides are massive pyrite and pyrrhotite with occasional bands and stringers of sphalerite and/or chalcopyrite.

The sulphide mineralization is associated with a felsic volcanic unit containing porphyritic rhyolite and dacite. This unit is exposed in an area to the east of Cinder Lake and along the Pain Killer Bay area of southern Knee Lake (Fig. 17). As shown in Figure 18a a massive sulphide horizon occurs at the rhyolite ± rhyolite fragmental/andesite interface. Irregular chloritic bands are found in the rhyolite and locally the fragmentals are contained within a matrix of chlorite ± pyrite. This chloritization is interpreted as an alteration zone.

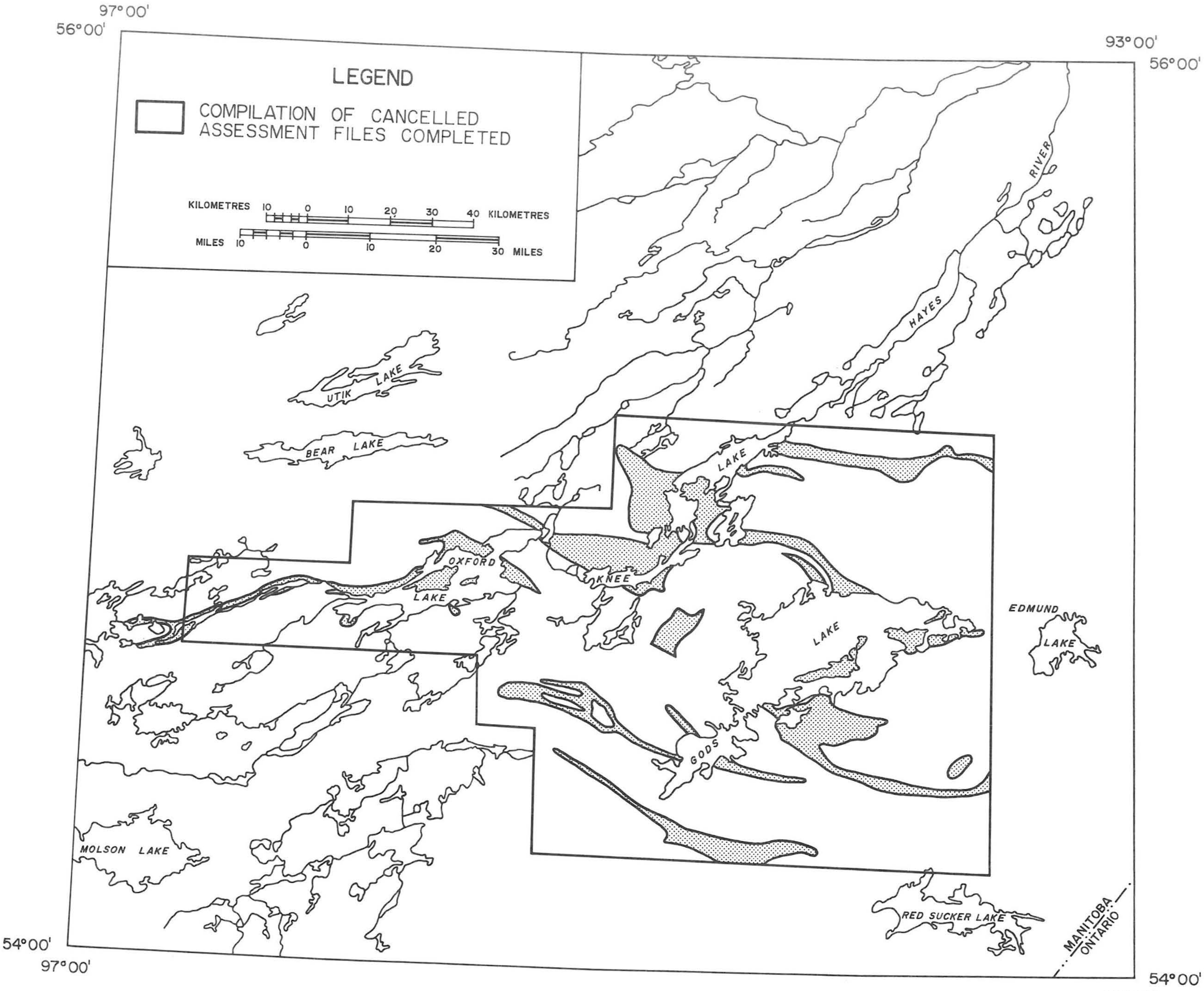


Figure 15 Distribution of the Greenstone belts in the Oxford Lake - Gods Lake area - Superior Province

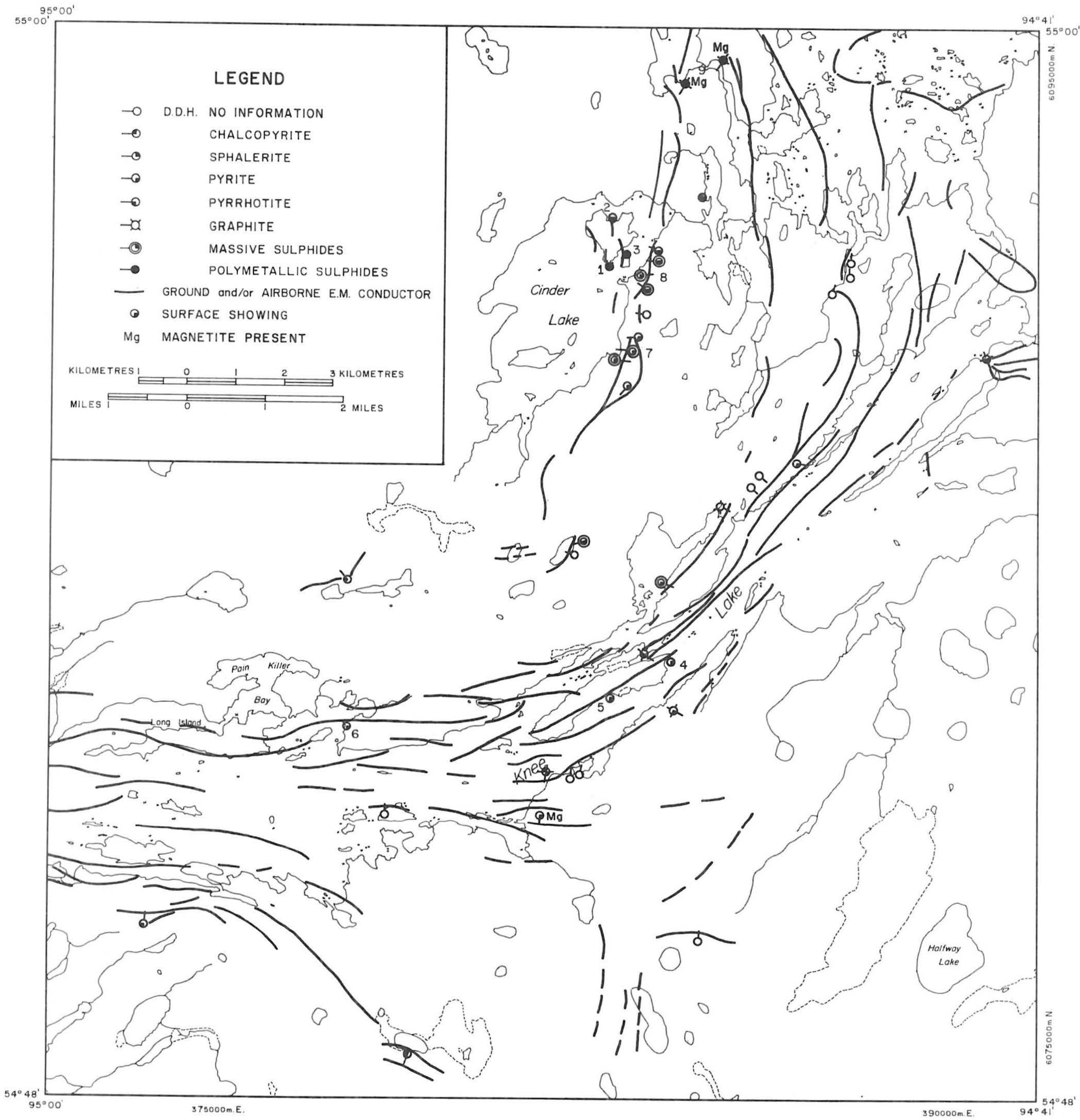


Figure 16 Drill hole location, mineralization, and EM conductors for a portion of 53L-15

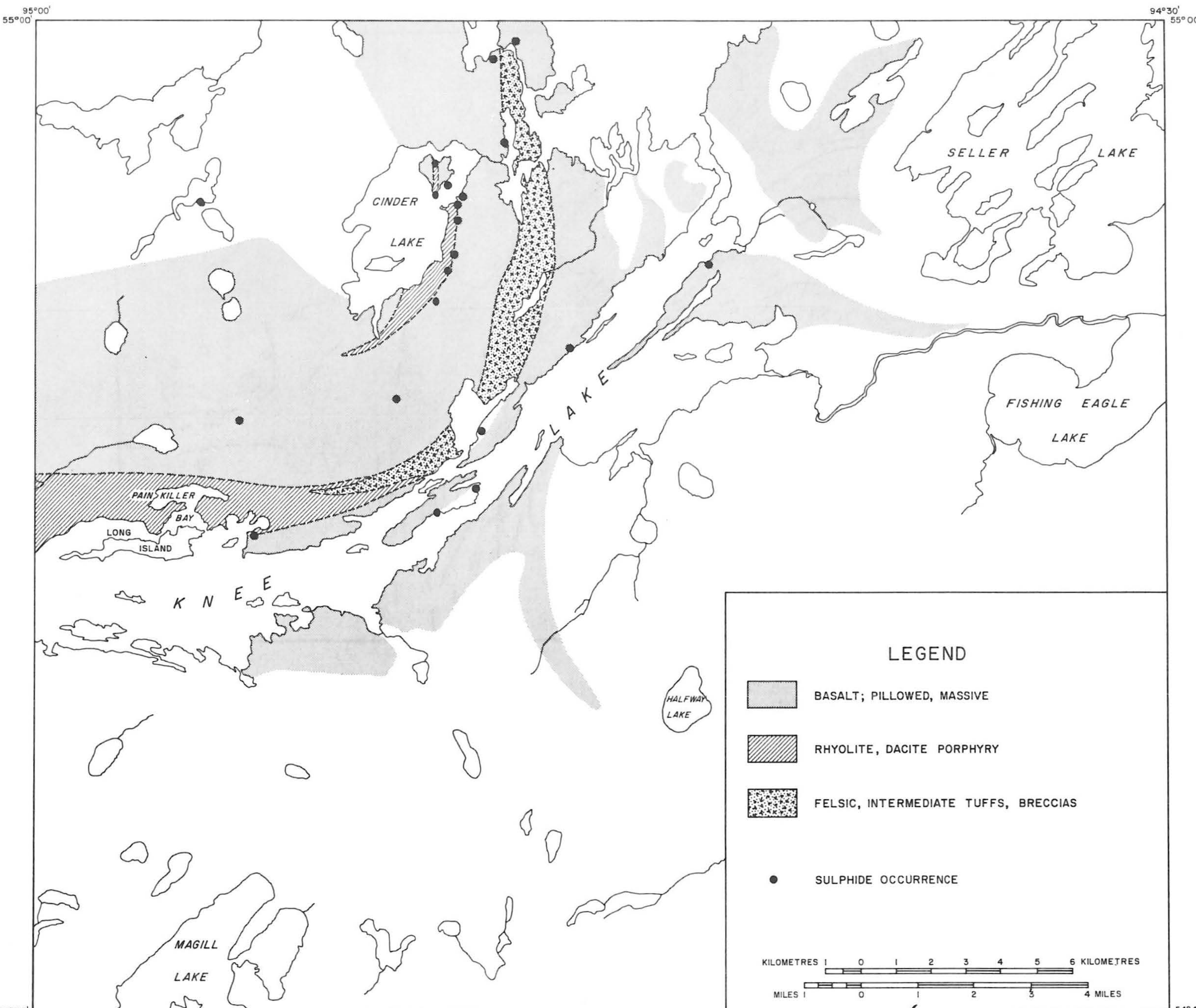
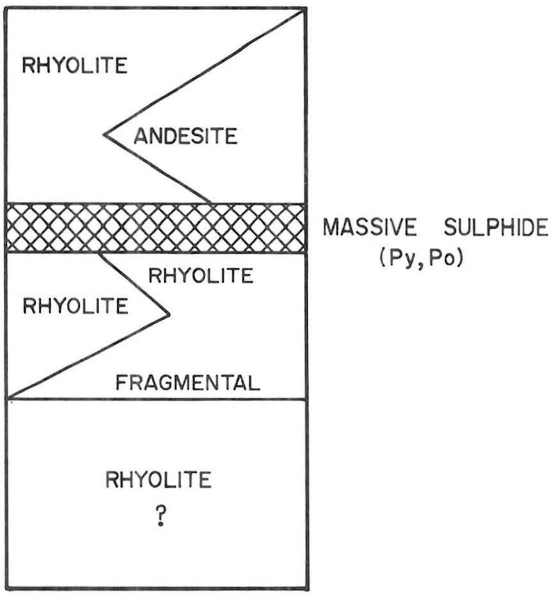
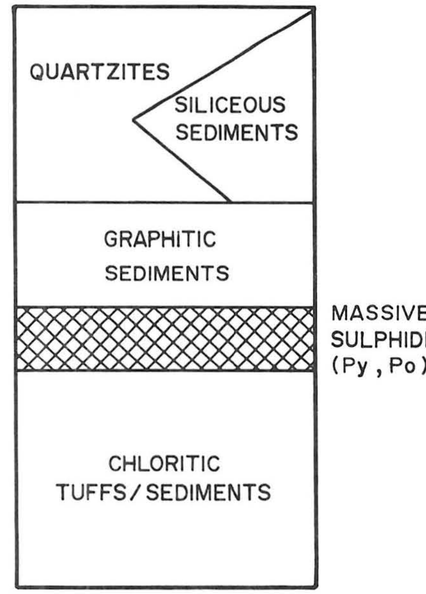


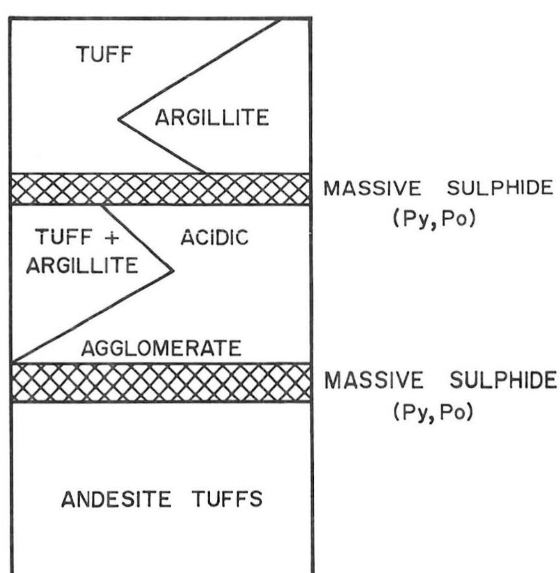
Figure 17 Geology of Cinder Lake and Knee Lake



18a



18b



18c

Figure 18a, b, c Sulphide-host rock relationships in the Knee Lake area

Figure 18b represents data from diamond drilling in an area 800 m to the south and west or stratigraphically below the units represented in Figure 18a. In this area a sequence of quartzites and siliceous sediments (possibly rhyolites, cherts?) overlie graphitic sediments. A 20 m layer of nearly solid sulphide (pyrite, pyrrhotite) occurs just below the graphitic sediments and above a locally chloritized tuff-sediments horizon.

Because these areas are contained within a single volcanic cycle it is tempting to assume that they also represent a single period of mineralization. However, the available data are insufficient to conform this assumption.

Another area of particular interest is a roughly crescent-shaped body of felsic to intermediate pyroclastic breccias and tuffs extending from just east of Pain Killer Bay to central Knee Lake (Figure 17). The eastern boundary of this unit is overlain by massive and pillowed basalts which young to the southeast. The contact zone between the pyroclastic and basalt unit coincides with a series of electromagnetic conductors, at least one of which appears to have a short strike length and magnetic correlation.

This contact zone has a strike length of ca 13 km, and from assessment work submitted appears to have been tested by only two diamond drill holes. In these holes, two seven-foot layers of massive pyrite were intersected at a tuff-argillite/acid agglomerate interface and at an acid agglomerate/tuff interface (Figure 18c). Sphalerite occurs as bands and narrow stringers within the andesite tuff and intermediate tuff units. Chalcopyrite is present as fine specks and blebs within the andesite tuff unit.

The association of massive sulphide mineralization with cycle boundary zones is not restricted to the isolated occurrences mentioned above but is a common feature of the area.

The same situation is evident approximately 21 km southeast of Cinder Lake in Map Sheet 53L/14. Diamond drilling of an electromagnetic and magnetic anomaly revealed a sequence of andesite:massive pyrite and pyrrhotite with rare chalcopyrite (50 cm thick) + feldspar porphyry (dyke) andesite:massive pyrite and pyrrhotite (15 cm thick):rhyolite, with pyrite and pyrrhotite:argillite. The thickest mineralized zone is found at the andesite/rhyolite interface.

Although most of the massive sulphide intersections are barren pyrite and pyrrhotite, polymetallic mineralization does occur within the area under discussion.

Diamond drilling approximately 11 km northeast of Cinder Lake indicated polymetallic mineralization in a sequence of dacite:andesite:acid-to intermediate tuff:rhyolite:argillite. The andesite locally contains a few grains of sphalerite and rare specks of chalcopyrite. Sphalerite and pyrrhotite occur in narrow stringers and bands along the contact between the acid to intermediate tuff units. Trace chalcopyrite and galena are also found in the tuffs. The rhyolite unit contains sphalerite bands (to 2.5 cm) and traces of chalcopyrite.

The number of areas in which massive sulphide mineralization can be correlated with cycle boundary zones, and the number of cycle boundary zones that have not been tested by diamond drilling, suggest that the residual exploration potential for massive sulphide deposits in the Knee Lake - Cinder Lake greenstone belt is high.

Carrot River Area

Sulphide mineralization is present in shear zones throughout the greenstone belt exposed along the Carrot River. The mineralized shear zones vary in width from a few centimetres to several metres and have lengths of several hundred metres. Pyrite and pyrrhotite are the most common sulphides. Chalcopyrite, sphalerite and galena are also present.

Significant base metal mineralization occurs in a northeast trending shear zone (?) on the south shore of the Carrot River. Barry (1960) reports a length of 50 m with a width varying from .07 to 1.7 m. The zone contains chlorite, tremolite, zoisite, quartz stringers and sulphides. Assay of a chip sample across a two foot interval shows: Au - nil, Ag - 3.5 oz/ton, Cu - 0.06%, Zn - 17.4%, Pb - 9.59%.

A sample from the occurrence shows a highly chloritized basalt (?) containing galena, sphalerite, chalcopyrite and pyrite. Further work is needed to determine if the chloritization is part of an alteration zone and related to a massive sulphide deposit.

Recommendations

Detailed mapping of all known occurrences is considered the next logical step in this project.

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NM 7506 THE EVALUATION OF DISSEMINATED BASE METAL ENVIRONMENTS - by D. Baldwin

Introduction (General Project)

This project is designed to evaluate the potential for conformable disseminated base metal and porphyry-type deposits in the Precambrian Shield area of Manitoba. The objective is to be attained by studying the geology of known mineralized localities in geological settings favourable for these deposit types. Favourable geological settings are determined from the study of published geological maps and reports.

Field work in the Churchill and Superior provinces of the Precambrian Shield will extend through a four year period - 1975-1979.

This report contains the results of field investigations carried out along the Sickle Group - Laurie River Group contact zone with emphasis on the Kadeniuk Lake copper occurrence. Field work was conducted during the months of June and July 1975.

Sickle Group - Laurie River Substudy

Introduction

Bateman (1945) named the "Wasekwan Series" for rocks in the McVeigh Lake area. In that work he made an eight-fold division in which five of the formations are predominantly of volcanic origin and the remainder sedimentary. Allan (1946) extended the series to include the rocks south and west of Lynn Lake, which are continuous with those described by Bateman. Milligan (1960) further extended the name to include volcanic and volcanic-derived sedimentary rocks from Laurie Lake east to Barrington Lake. Campbell (1969) proposed formal group status for the volcanic and volcanic-derived metasedimentary rocks in the Lynn and Granville Lakes area. In 1972 Manitoba Mines Branch geologists engaged in the "Southern Indian Lake Project" extended the group to include metasedimentary rocks that are similar in appearance to and possibly were derived from Bateman's Wasekwan Series .

The "Sickle Series" was named by Norman (1934) for the occurrence of meta-arkosic rocks at Sickle Lake. The name remained in the geological literature until Campbell (1969) proposed the name "Sickle Group" to include arkosic metasedimentary rocks in the Lynn and Granville Lakes area. The name "Sickle Group" has subsequently been extended to include all arkosic metasedimentary rocks in the Burntwood, Granville, Southern Indian and Lynn Lake region, the base of which is marked by conglomerates or amphibolite, and which appear to overlie Wasekwan Group rocks.

Baldwin (1974) proposed group status for a thick (up to 250m) succession of amphibolite rocks in the Kadeniuk Lake area. This "Amphibolite Group" of thinly interlayered amphibolite, calc-silicate rock, quartzite, marble and garnet amphibolite, conformably overlies the Laurie River Group and is conformably overlain by the Sickle Group. The Amphibolite Group has subsequently been recognized in the Kamuchawie Lake, McCallum Lake and McKnight Lake areas (Zwanzig, 1975; McRitchie, 1975; Lenton, 1975).

Controversy over the usage of the name Wasekwan Group flourished in the years 1969 - 1974. McRitchie (1974, p. 19) proposed the name "Wasekwan Group" for the predominantly metavolcanic terrain north of the Sickle Group and the name "Laurie River Group" for the predominantly metasedimentary rocks of greywacke composition south of the Sickle Group (Figure 19).

The use of the name Sickle Group in this report conforms to the proposal made by Campbell (1969). The use of the name Laurie River Group conforms to the proposal made by McRitchie (1974).

Contact relationships between rocks of the Sickle Group, Wasekwan Group and Laurie River Group have been a subject of much discussion since the work of Norman (1934), Bateman (1945) and Milligan (1960). McRitchie (1974) adequately summarizes the debate and it need not be repeated in this report.

During the 1975 field season the contact between rocks of the Sickle and Laurie River Groups was examined at Russell Lake, along the Laurie River and at Granville Lake, in addition to which a detailed study was made of a possible sedimentary type copper occurrence in the Kadeniuk Lake area.

The regional map coverage of the Granville Lake area (N.T.S. 64C) is extensive. McRitchie (1974) gives a complete account and review of the work prior to 1974.

Almost all exploration activity in the area is confined to the Lynn Lake Greenstone Belt. The metasedimentary rocks outcropping to the south of the greenstones have received little attention. Where work has been done in the metasediments, E.M. conductors associated with amphibolitic rocks of unknown origin have been the targets. Diamond drilling has shown the conductors to be caused by barren massive sulphide or graphite. The metasedimentary gneiss belt was therefore given low priority by the exploration companies.

Regional Geology

Regional geology and lithologies are summarized on the geological map (Fig. 19) and in the Table of Formations.

South and west of Granville Lake, the Amphibolite Group (Baldwin, 1974) occupies the stratigraphic position between the Sickle Group and Laurie River Group; it has not yet been described between the Sickle Group and Wasekwan Group from areas to the north and north-east of Granville Lake. The relationships between the Amphibolite Group and Sickle conglomerate are not clear and it may be that the two lithologies are stratigraphic equivalents. The Table of Formations is compiled from Milligan (1960), Barry (1965), Baldwin (1974), Campbell (1972), and Zwanzig (1975).

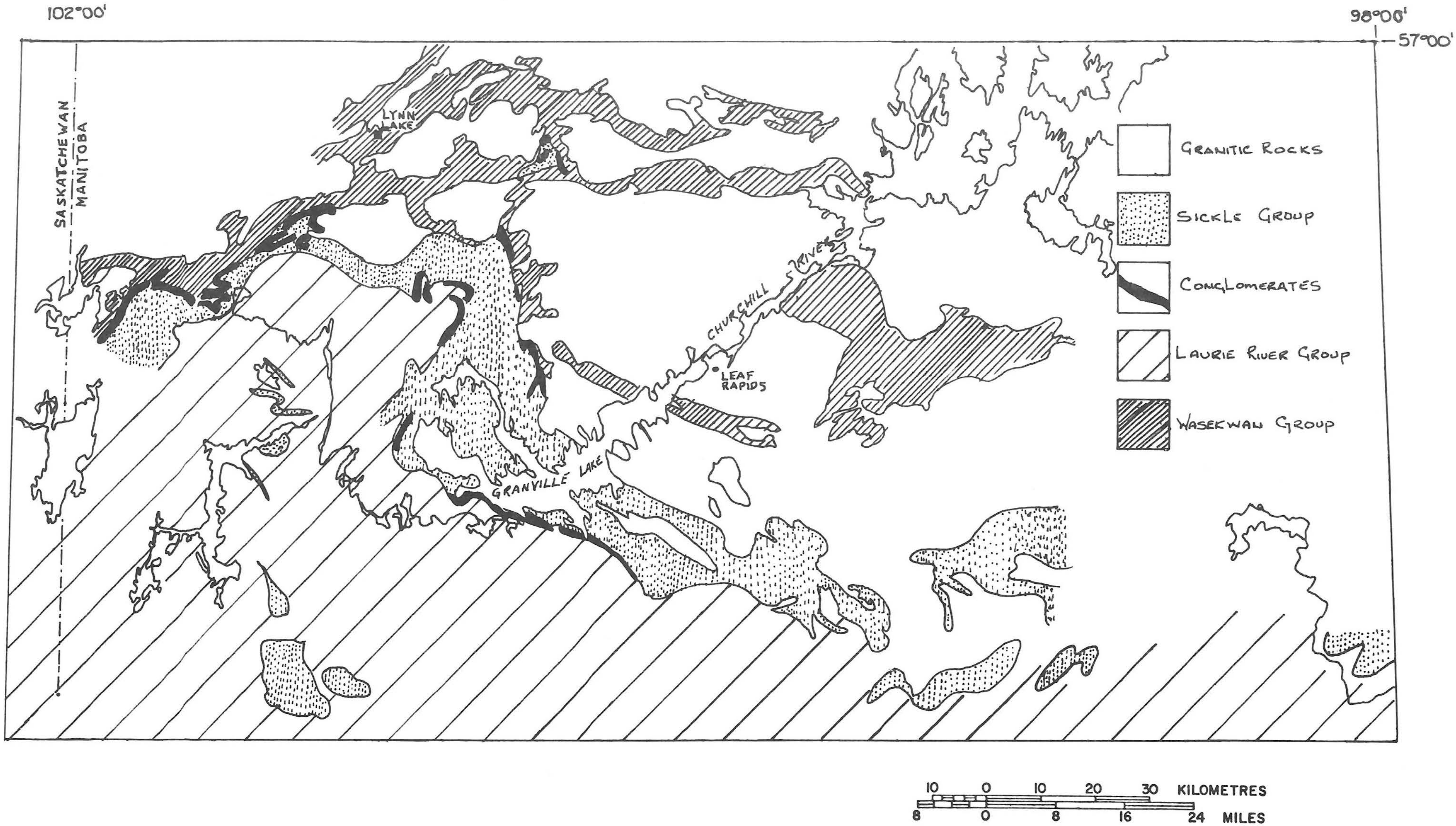


Figure 19 Distribution of the Sickle, Wasekwan and Laurie River Groups (after McRitchie, 1974).

GENERALIZED TABLE OF FORMATIONS

	For area north of the northern limit of the Laurie River Group (Figure 19).		For area south of the northern limit of the Laurie River Group (Figure 19).
PLEISTOCENE AND RECENT	Sand, gravel, till and boulder deposits, clays		Sand, gravel, till and boulder deposits, clays
	Great Unconformity		Great Unconformity
PRECAMBRIAN	Granitic rocks of uncertain age Post-Sickle Intrusive Group: Late lamprophyre dykes Quartz-feldspar porphyry; quartz porphyry Pegmatite, aplite; alaskite, pegmatitic and graphic granite (Some may be of pre-Sickle age) Microline granite; fine grained aplitic granite; some alaskite Gneissic and massive biotite-hornblende tonalite Black trout diorite		Plutonic rocks Tonalite, monzonite, quartz monzonite, granite and pegmatite
	Intrusive Contact		Intrusive Contact
	Sickle Group: Granitized and injected metasediments Coarse-grained porphyroblastic granitoid gneiss Granitized meta-arkose and feldspathic meta-greywacke Feldspathic meta-greywacke: meta-arkose: minor siltstone. Contains large quartz-muscovite-sillimanite porphyroblasts Feldspathic meta-greywacke with subordinate meta-arkose: minor siltstone and chert (?) Meta-arkose with subordinate feldspathic meta-greywacke: minor siltstone and chert (?) Fine-grained granite-pebble and quartz-pebble meta-conglomerate Feldspathic meta-greywacke, siltstone and minor pebble meta-conglomerate Coarse boulder meta-conglomerate		Sickle Group: Meta-arkose and meta-subarkose – biotite, biotite + magnetite, biotite + hornblende, hornblende + magnetite, quartz, feldspar gneisses (with or without quartz-sillimanite knots) Meta-arkose with minor interlayered meta-greywacke Meta-greywacke
	Angular and Erosional Unconformity ? ?		Conformable Contact
	Pre-Sickle Intrusive Group: Biotite granite, leuco-sodaclase granodiorite Hornblende-biotite tonalite (quartz diorite); minor amounts of diorite; porphyritic and massive phases Porphyritic leucotonalite Hornblende-biotite diorite; minor amounts of undifferentiated gabbro; small amounts of sodaclase tonalite (quartz diorite) Hornblende gabbro, norite, pyroxenite, peridotite; included volcanic rocks	← No correlation intended →	Amphibolite Group: Interlayered amphibolite, quartzite and marble Quartzite Garnet amphibolite Hornblende-bearing meta-greywacke
	Intrusive Contact		Conformable Contact
	Wasekwan Group: Banded iron formation and magnetite-bearing shales Tuff, agglomerate and flow breccia. Minor interbedded sediments and massive or porphyritic flows Siliceous and intermediate volcanic rocks Massive and pillowed basic volcanic rocks (probably andesite and basalt); some porphyritic and amygdaloidal flows. Minor interbedded sedimentary and pyroclastic rocks Impure quartzite (Some minor interbedded meta-conglomerate and fragmental flows southwest of Lynn Lake) Intimately interbedded sedimentary, volcanic and tuffaceous rocks; some flow breccia and agglomerate Meta-greywacke; minor quartzite; tuffs and interbedded flows Meta-conglomerate	← Probably time equivalents →	Laurie River Group: Blastic biotite schist Amphibolite — in part volcanic Impure quartzite Fine-grained, granoblastic, mica-poor quartzofeldspathic rocks At places very massive or coarsely layered Fine-grained, granoblastic micaceous regularly bedded metasediments and schists Greywacke, rhythmite, minor intraformational conglomerate (graded bedding commonly conspicuous)

66

Structure

Regional structural interpretations are based on the distribution of Sickle Group rocks. This is mainly because of the lack of structural marker horizons in the Wasekwan and Laurie River Group rocks. Detailed accounts of structural geology are given by Milligan (1960), Goddard (1966), Pollock (1966), Campbell (1972) and Schledewitz (1972).

The sequence of folding may be summarized as follows:

(i) East trending isoclinal folds.

(ii) Cross-folding on northeast trending axial planes deforming the rocks into a regional Z shaped structure.

Depositional Environment of Sickle Group Rocks

Sickle Group rocks are generally considered to have been deposited in a basin marginal to the Lynn Lake Greenstone belt. Arkose, sandstone, greywacke and conglomerate, plus sedimentary features such as crossbedding, scour-and-fill and possible ripple marks of the oscillation type imply shallow marine deposition.

Mineral Occurrences

In the Lynn, Granville and Southern Indian Lake areas numerous minor mineral showings occur near and along the contact of the major lithostratigraphic groups (the Sickle, Wasekwan and Laurie River Groups). Fifty kilometres south of Lynn Lake in the Kadeniuk Lake area forty-one occurrences of disseminated sulphides occur in two narrow zones associated with the Sickle Group and Laurie River Group. Thirty of these are disseminated pyrite or pyrrhotite but eleven contain chalcopyrite in Sickle Group metasedimentary rocks.

One of these showings, which was discovered by the author while mapping in the Kadeniuk Lake area (Fig. 20), locally assays 3% Cu in selected hand sample. The mineralization could be sedimentary in origin, a type not previously recorded in the Shield area of Manitoba.

Geologists of the Geological Survey Branch of the Manitoba Mineral Resources Division have confirmed that the Sickle Group - Laurie River Group contact in the Russell Lake region continues beyond the Kadeniuk Lake area and contains traces of chalcopyrite. In the Kamuchawie Lake area twenty-five new sulphide (Py + Po and Cu) occurrences have been found (Zwanzig, 1975). McRitchie (1975) reports six sulphide (Py ± Po) occurrences in the McCallum Lake area (Fig. 20). The majority of these occurrences are iron sulphide in Amphibolite Group rocks. Nevertheless, a few are from Sickle Group rocks indicating that the mineralizing processes were operative locally, within a large area.

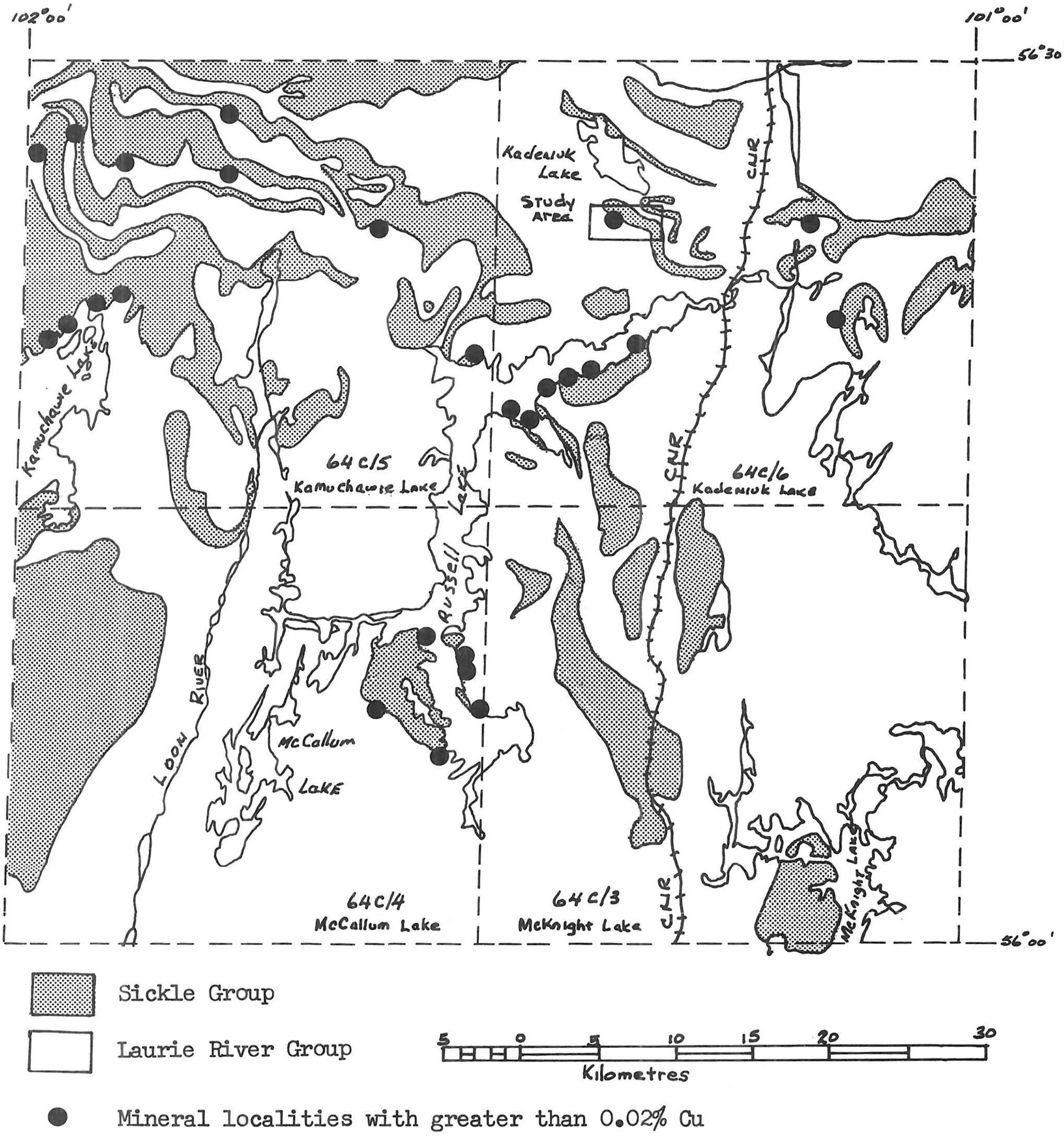


Figure 20 Map showing distribution of Sickle Group rocks and sulphide localities in the Russell Lake region

The Sickle Group - Laurie River Group contact extends from Saskatchewan eastwards to the Thompson Nickel Belt, a distance of some 250 km. Pyrite and traces of copper minerals are known to occur locally along the entire zone.

As part of the Federal-Provincial "Non-renewable Resources Evaluation Program", it was decided to investigate known mineral occurrences along the Sickle Group-Laurie River Group contact, with emphasis on environments of sulphide deposition and type and control of mineralization. The Kadeniuk Lake occurrence was chosen for detailed study to document the characteristics of the mineralized rocks and to form a base from which the potential for disseminated copper deposits along the contacts of the Sickle-Wasekwan and Sickle-Laurie River Groups could be assessed.

Kadeniuk Lake Copper Occurrence

Introduction

The study area of approximately 6.3 sq. km (Fig. 19) is situated in the central north-western portion of the Kadeniuk Lake area (N.T.S. 64C/6). The area is underlain by Precambrian (Aphebian) migmatites derived from greywacke and arkosic sedimentary rocks. The greywacke-derived migmatites of the Laurie River Group (McRitchie, 1974) are the most abundant of the supracrustal rocks in the Kadeniuk Lake area. Sickle Group migmatites, derived from arkoses and lithic arenites, lie in fold controlled outliers. Amphibolite Group rocks (Baldwin, 1974) occupy an apparently conformable position between the Laurie River and Sickle Groups. The geology of the area and copper showing are shown on the accompanying maps (Fig. 21 and 21(a)).

Polyphase deformation, and metamorphism to upper amphibolite facies, have obscured primary features and resulted in a complex geological history that is extremely difficult to unravel. Intense polyphase deformation and high grade metamorphism have obscured stratigraphic detail. Nevertheless, from the examination of diamond drill core it appears that there is continuity of layers (beds) down dip toward the north and that the layers (beds) thicken in that direction.

Disseminated copper minerals occur in the basal part of the Sickle Group. The mineralization is conformable with the local layering and stratigraphic contacts. On surface the copper mineralization is traceable for 600 m along strike, and from a few centimetres to three metres across the strike. Chalcopyrite, bornite, native copper and chalcocite have all been observed but chalcopyrite predominates. Individual mineralized units are copper rich at the base, and Cu:Fe ratios decrease gradually upwards with decreasing copper and increasing iron in the sulphides.

The disseminated, conformable, stratabound and zoned distribution of the copper minerals in metasedimentary host rocks indicates a possible sedimentary or early diagenetic origin.

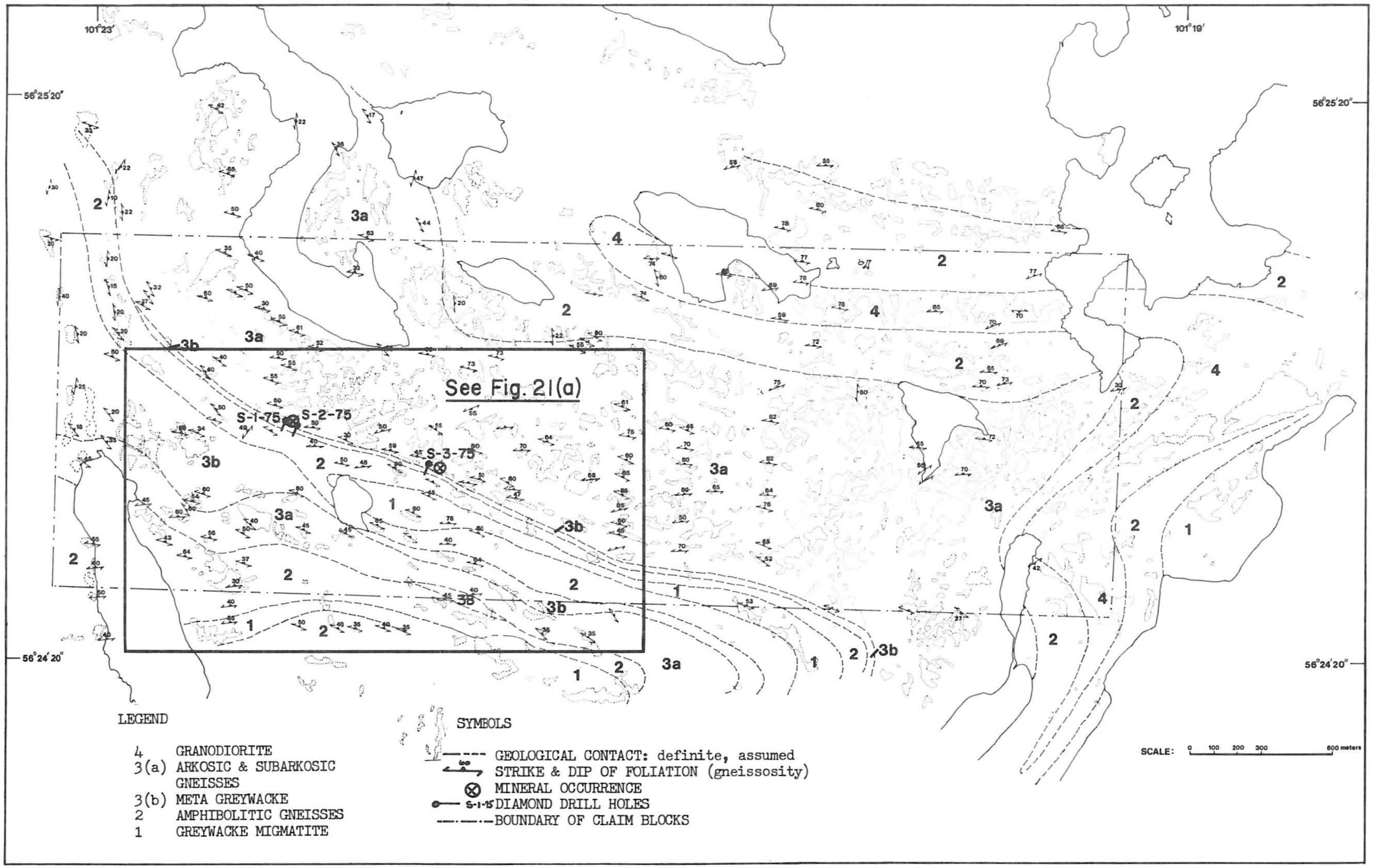


Figure 21 Geological map of study area

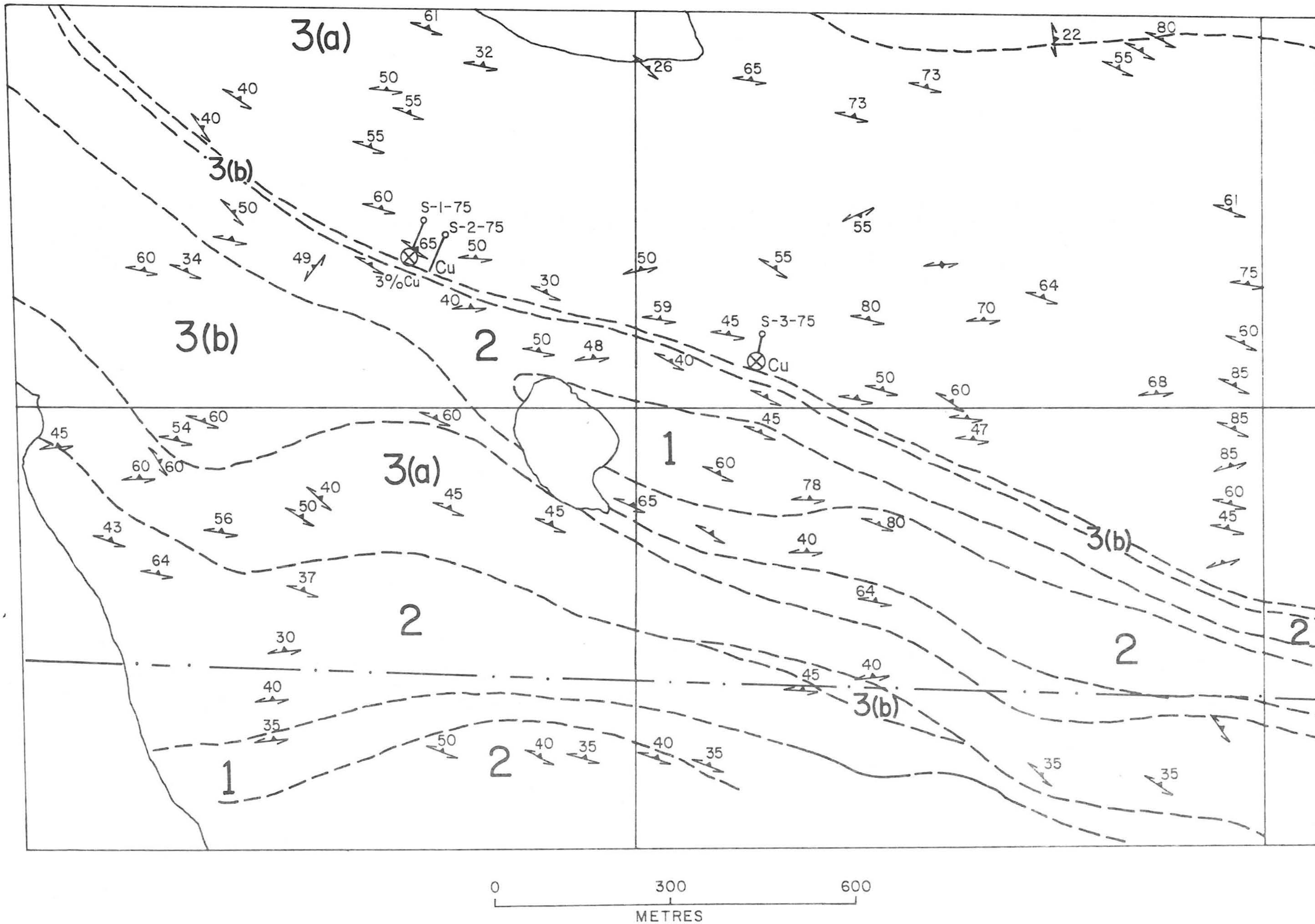


Figure 21(a) Geological map of area immediately around copper showings. Legend as per Figure 21

Preliminary observations were made during the summer of 1974. In the summer of 1975 scattered bedrock geochemical samples were taken over the area while mapping at a scale of 1 inch = 500 feet. Prospecting along the contact zone extended the strike length of the previously known mineralization. Three diamond drill holes totalling two hundred feet were put down to intersect the inclined layering at right angles. The drill core was logged (Appendix A, B and C), split, assayed, and samples were taken for thin sections. The data presented in this report are based on outcrop mapping and examination of the diamond drill core. The data that have been collected from the Kadeniuk Lake copper occurrence are at present insufficient to formulate a comprehensive deposit type model.

Although the occurrence of sedimentary type copper mineralization in Sickle Group rocks is interesting from a regional metallogenic viewpoint, the mineralization has been observed only locally and in minor concentrations, and is not in itself economically significant at present.

Stratigraphy and Lithology

Field mapping in the McKnight Lake area (Lenton, 1975), the Kamuchawie Lake area (Zwanzig, 1975), and the McCallum Lake area (McRitchie, 1975) has confirmed that the succession established in the Kadeniuk Lake area (Baldwin, 1974) continues beyond the Kadeniuk Lake area and contains traces of copper mineralization along the contact zone of the Sickle Group and Laurie River Group.

Table III summarizes the stratigraphy in the Kadeniuk-Kamuchawie Lake areas.

TABLE III

Stratigraphic Column of the Kadeniuk-Kamuchawie Lake Areas

Sickle Group	TOP	Ore Mineralogy
	top not exposed	
up to 300 m	knotted arkose (sillimanite faserkiesel)	
	gradational	
300 to 500 m	biotite-meta-arkose	
	gradational	
0 to 250 m	hornblende-meta-arkose, minor biotite-meta-arkose	Cp, Bn, Native Cu, chalcocite
	gradational	
0 to 350 m	meta-greywacke	
	conformable - sharp	
Amphibolite Group		
0 to 250 m	thinly interlayered amphibolite, quartzite, marble, and garnet amphibolite	Py, Po, minor Cp
	conformable - sharp	
Laurie River Group		
1000 + m	greywacke migmatite	minor Py, Po
	BASE	

72

Sickle Group Rocks

The Sickle Group rocks comprise meta-greywacke, hornblende meta-arkose, biotite meta-arkose and calc-silicate gneisses.

The meta-greywacke appears to mark the base of the Sickle Group. It is fine grained, equigranular, well foliated, grey, contains 1 mm garnets and is locally graphitic. Microscopically the rock has an equigranular granoblastic mosaic of quartz and plagioclase. Biotite is dark brown and nematoblastic. Garnet is subhedral porphyroblastic and some grains show poikiloblastic texture.

Hornblende meta-arkose varies in colour from pinkish grey, buff-pink to tan. The colour of the rock depends upon the hornblende plus biotite content. The rock is variably foliated. Textures show every gradation from hornblende clots set in an equigranular matrix of quartz and feldspar, to alignment of the hornblende giving a schistose texture to the rock. Quartz, plagioclase, potassium feldspar, hornblende, ± biotite, ± magnetite, ± ilmenite, and ± sphene have been identified.

The biotite meta-arkose is light grey to bright pink in colour depending upon the relative concentration of biotite and potassium feldspar. Grain size is slightly variable but is generally fine. The rock is very well foliated (schistose) except where biotite makes up less than five modal percent of the rock. Mineralogically the rock is composed of quartz, plagioclase, potassium feldspar and biotite ± magnetite ± ilmenite ± sphene.

Calc-silicate gneisses are interlayered with the hornblende meta-arkose and biotite meta-arkose throughout the Sickle Group at Kadeniuk Lake. The calc-silicate gneisses are generally slightly coarser grained than, and not as well foliated as the meta-arkosic rocks. A distinctive greenish grey or green-buff colour typifies the calc-silicate gneisses. Diopside is always euhedral and forms distinct individual grains 1.0 mm to 1.5 mm across. The mineralogy varies with calcium content. The most abundant calc-silicate rock is quartz, plagioclase, diopside, scapolite, calcite, sphene and sulphides. Quartz plus plagioclase make up less than 25 percent of the rock.

The mobilisate fraction (20%) of the migmatitic rocks is medium grained to pegmatitic sills of pink granite and quartz monzonite. Dykes of pink pegmatite which cross-cut the metamorphic layering are present but not abundant.

Amphibolite Group Rocks

A pronounced, thinly layered (2 cm to 4 cm) garnet-rich amphibolite appears to mark the base of the group. Garnet is abundant and occurs as deformed porphyroblasts and aggregates. Together with amphibole it is found in very garnet rich (90 - 95%) layers. In outctop the amphibolite is a striking contrast of dark green, pale green and brown-red. Mineralogically the rock is composed of quartz, plagioclase, hornblende, garnet and epidote.

A thinly layered amphibolitic gneiss devoid of garnet is very prominent in the area. The rock has 4 to 6 cm. layers of alternating hornblende rich and calc-silicate rich rock. The hornblende layers contain less than 15 percent quartz with about equal amounts of hornblende and plagioclase making up the remaining 85 percent of the rock. The calc-silicate layers are quartz, plagioclase and diopside. Diopside accounts for about 15 percent of the rock. Minor layers of quartzite and marble have been observed.

The Amphibolite Group rocks typically contain minor iron sulphides. Minor chalcopyrite has been noted locally. The rocks vary slightly in grain size from fine to medium grained. The origin of these rocks is questionable, but because of their thinly layered nature, the presence of minor quartzite and marble and since they occur within a sedimentary sequence they are tentatively considered as metasediments.

Laurie River Group

The oldest rocks in the area are meta-greywackes. They comprise psammitic, semi-pelitic and pelitic gneisses. Quartz, plagioclase, biotite ± hornblende ± garnet ± graphite are the mineralogical constituents of the rocks.

Semi-pelitic gneisses are the most abundant rocks with only minor inter-layered psammitic and pelitic gneisses.

The rocks are compositionally well layered. Layering is pronounced, and defined by changes in lithology (psammite, semi-pelite, pelite) and/or by thin biotite concentrations along layer boundaries.

Mobilisate in the metatexites is represented by sills of medium grained to pegmatitic, white to buff quartz monozonite - granodiorite.

A more detailed description of these rocks is given by McRitchie et. al. (in prep.).

Structural Analysis

Three phases of major folding have been recognized in the Kadeniuk Lake, Kamuchawie Lake and McKnight Lake areas (Fig. 22 and 23 a-c), (Baldwin, 1974; Zwanzig, 1975; Lenton, 1975).

The earliest recognizable folds (F_1) are large scale isoclines which apparently were initially recumbent structures (Zwanzig, pers. comm). Because of the intense polyphase deformation and metamorphism,nothing is known about the orientation of the first phase fold axis or vergence of these folds.

During the second fold event the presumably recumbent F_1 structures were refolded on west northwest trending, steeply dipping axial planes. Regionally the plunge on F_2 folds is variable but in the study area it appears to be plunging shallowly eastward. The F_2 event has resulted in very tight refolded first phase structures.

The youngest folds (F_3) have axial planes that trend northeast and are probably near vertical. The plunge is shallow to the northeast. Broad open warps have resulted from the interference of F_3 with the earlier formed folds.

The very tight structures produced by the superimposition of F_2 upon F_1 and the absence of top criteria make a detailed structural analysis difficult. Nevertheless two possible interpretations are presented. Both require that Sickle Group rocks occupied F_1 synclines (Fig. 23a) and that the axial plane of the F_2 fold passes through "X" Lake (Fig. 22). Regardless of whether the F_2 fold is a syncline or anticline the distribution of the rock types in the study area is the same (Fig. 23b and 23c). But, the choice of interpretation has important consequences regarding the positioning and distribution of the copper bearing unit.

If the F_2 fold is a synform (Fig. 23b) then the known mineralization occurs on the overturned limb of an F_1 fold. The copper bearing unit may therefore continue down dip for some distance. If the mineralization is continuous it may then outcrop south of "X" Lake (Fig. 24) - on the north side of the upright limb of the F_1 fold (Fig. 23b).

The alternative interpretation (i.e. F_2 is an antiform) places the known mineralized unit on the upright underlimb of the F_1 structure. The mineralization may continue down dip for a considerable distance. If the mineralization is continuous then it may outcrop south of "X" Lake (Fig. 24) - on the north side of the overturned limb of the F_1 fold (Fig. 23c).

In either of these interpretaions there exists a good possibility that the mineralization has been concentrated by mobilization into the hinges of the F_2 structure (Fig. 23b) or the F_1 structure (Fig. 23c).

If the mineralized unit was originally continuous over a vast area it may outcrop at points A (Fig. 23b and 23c). However, geological information indicates that stretching has occurred on these fold limbs. It is therefore considered unlikely that mineralization is preserved at points A (Fig. 23b and 23c).

Ore Mineralogy

Primary ore minerals are pyrite, pyrrhotite, chalcopyrite, bornite, native copper, molybdenite and magnetite. Malachite, chalcocite, native copper, marcasite and hematite are secondary ore minerals near surface and along fractures but are generally present in only minor amounts.

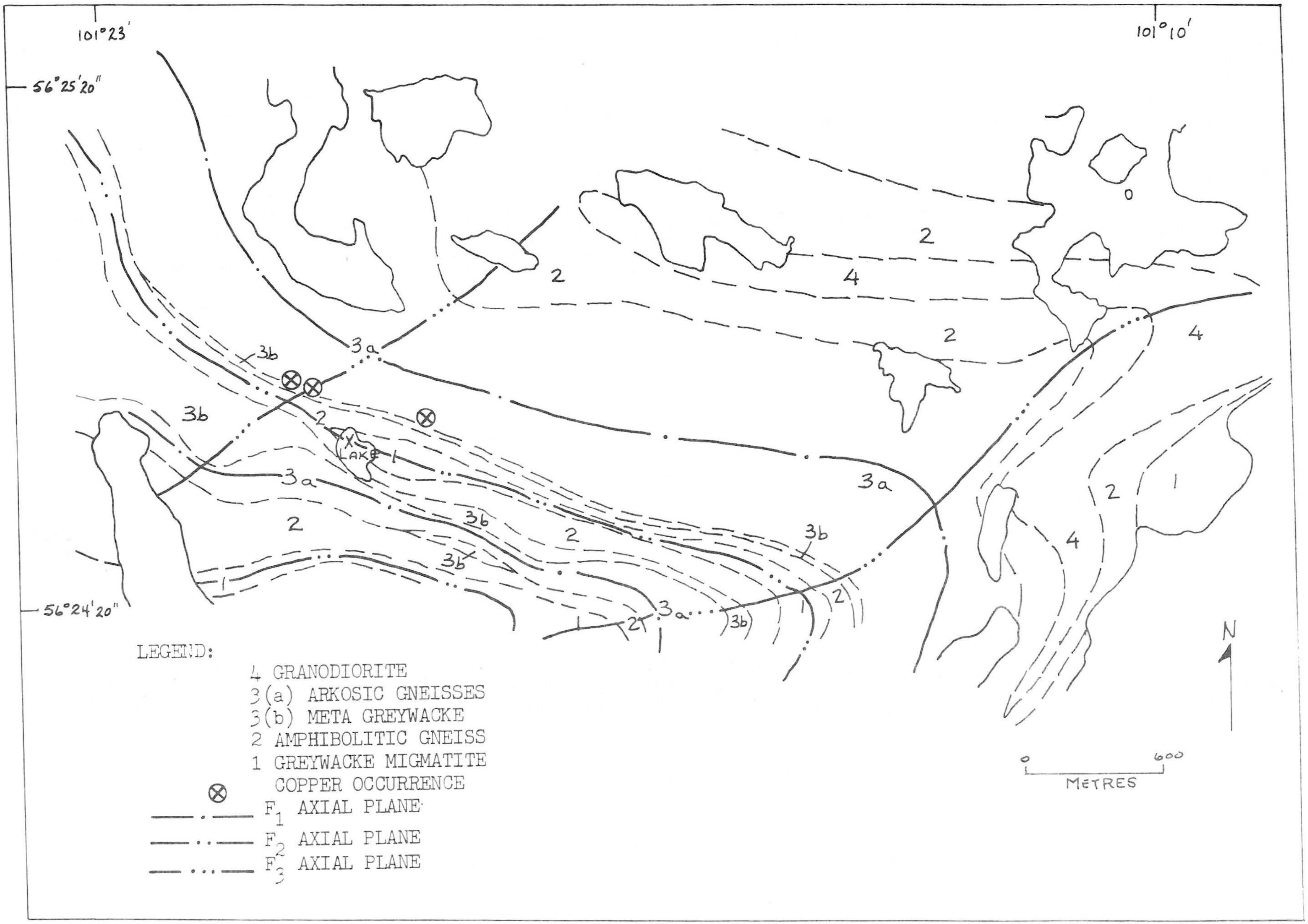


Figure 22 Simplified map showing interpreted fold traces

76

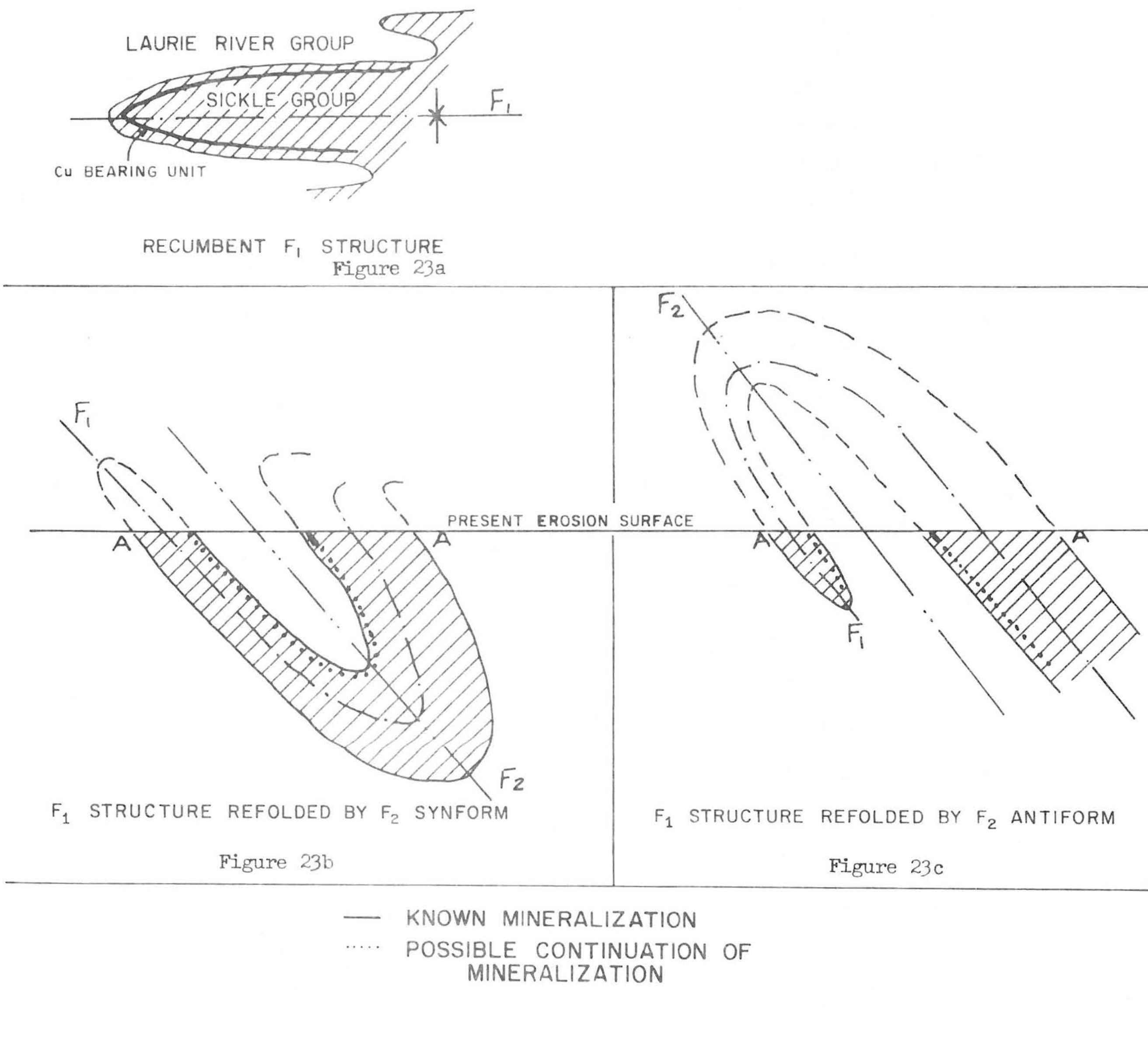


Figure 23a–c Diagram illustrating different possible structures (not to scale)

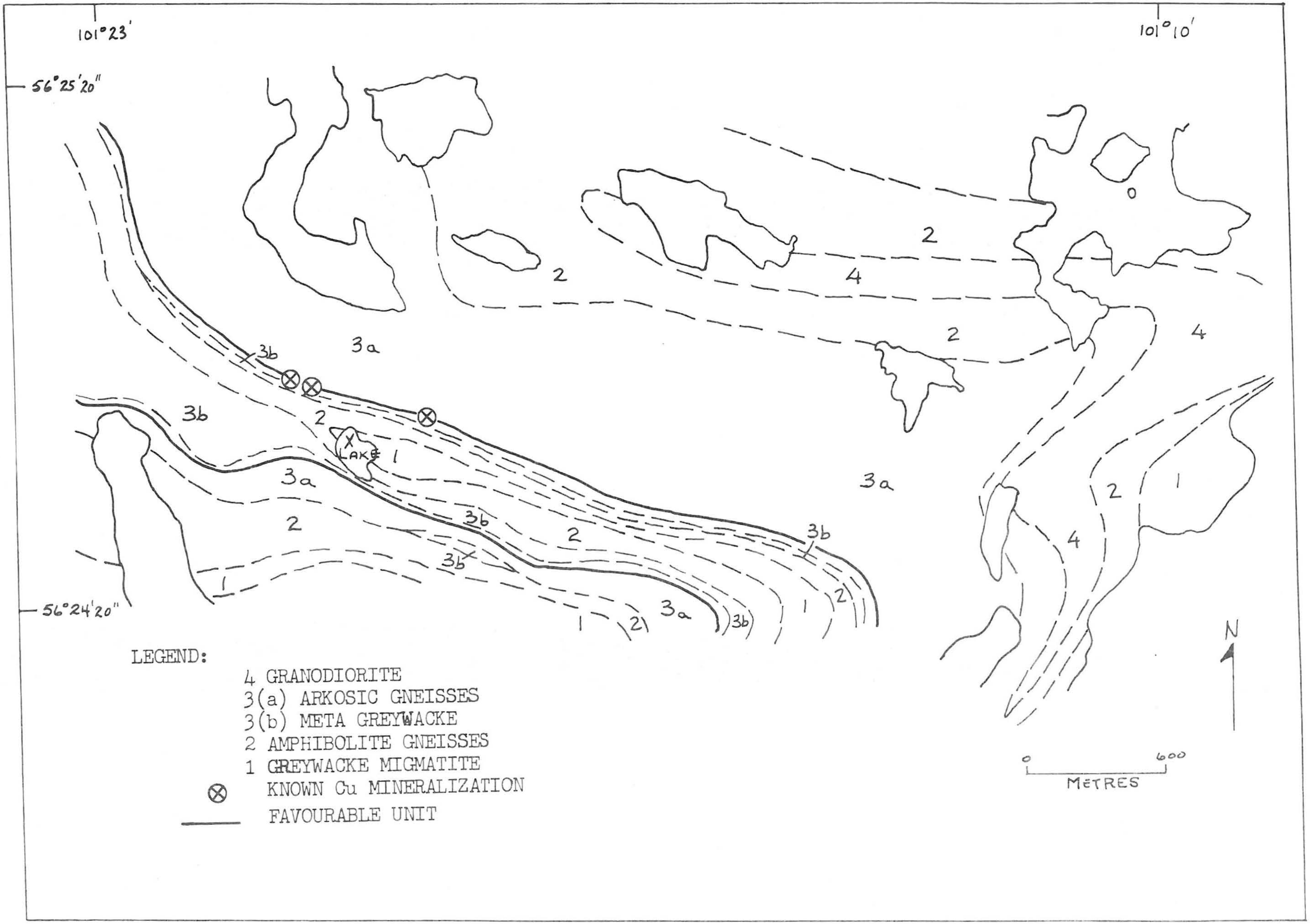


Figure 24 Simplified map showing location of known copper mineralization and favourable unit for prospecting

78

Except for molybdenite and native copper, the primary minerals occur as disseminated equidimensional grains uniformly distributed throughout the mineralized rocks, generally having the same size as the silicate crystals (grains). Iron sulphides are most abundant with lesser chalcopyrite and minor bornite in some localities. The copper and iron sulphides are zonally distributed. The zonation in the mineralized rocks is from a copper sulphide rich base passing stratigraphically upwards into more iron rich sulphide minerals.

Native copper occurs as thin foils which are interstitial coatings on and in quartz and feldspar grains. Fine native copper dust occurs included in feldspar grains giving them a copper red colour.

Molybdenite is concentrated in anatectically derived mobilisate within a few centimeters of the contact with the host (restite). It forms disseminated blebs which are unequally distributed in the mobilisate.

The secondary minerals form coatings on fractures and shear planes.

Malachite encrusts silicate grains and, rarely, occurs as pseudomorphs after native copper. Dendritic chalcocite and marcasite coat quartz and feldspar grains. Native copper also occurs as thin smears and foils on shear planes and in fractures. Hematite occurs as pseudomorphs after iron sulphides, particularly pyrite, and occasionally replaces magnetite.

Ore Mineral Relationships

Iron sulphides (pyrite, pyrrhotite) and magnetite occur in two modes by themselves, and with chalcopyrite.

Where chalcopyrite and iron sulphide co-exist, the chalcopyrite is either included within the iron sulphide or is interstitial between the iron sulphide and silicate minerals. In some zones chalcopyrite is present as the only ore mineral.

Bornite occurs with chalcopyrite and by itself. Where it is present with chalcopyrite it can be included in chalcopyrite, interstitial between chalcopyrite and silicate minerals or enclosing the chalcopyrite. Bornite has not been observed in association with the iron sulphides.

Where native copper is present it occurs as the only ore mineral in the rock.

Magnetite often occurs in association with iron sulphides but not in direct contact with them. Where magnetite and chalcopyrite co-exist, the latter is a very minor constituent; the two minerals have not been seen in contact. Bornite and magnetite have not been found in the same rock.

Host Rock - Ore Mineral Relationships

Iron sulphides and less so chalcopyrite have been found in all of the rocks present (Laurie River Group, Amphibolite Group, Sickle Group). Bornite, native copper, magnetite and ilmenite are confined to Sickle Group rocks. Iron sulphides (Po, Py) are dominant in the Laurie River Group rocks and the Amphibolite Group rocks. Chalcopyrite is very minor within these two groups. Iron sulphides, chalcopyrite and bornite occur in all rock types of the Sickle Group. Native copper observed in drill core and hand sample is confined to the biotite meta-arkose. Magnetite and ilmenite are more prevalent in the hornblende meta-arkose and though present in minor amounts in the biotite meta-arkose, are never seen in association with copper sulphides.

Mineral Zoning

Although the rocks are highly deformed and recrystallized, primary mineral zoning is preserved (Appendix D, E and F).

In diamond drill hole S-3-75 a fifteen foot intersection of sulphide mineralization is as follows:

23'0" - 25'8"	Fe sulphide
25'8" - 30'0"	Fe sulphide plus chalcopyrite
30'0" - 30'6"	Barren
30'6" - 32'0"	Chalcopyrite
32'0" - 35'4"	Barren
35'4" - 37'0"	Bornite plus chalcopyrite
37'0" - 38'0"	Native copper

Similar zoning is present in a twenty-five foot intersection from diamond drill hole S-2-75.

2'6" - 3'0"	Fe sulphide
3'0" - 4'6"	Barren
4'6" - 20'8"	Fe sulphide plus chalcopyrite with amount of chalcopyrite increasing with depth in hole
20'8" - 23'6"	Bornite plus chalcopyrite
24'6" - 25'8"	Barren
25'8" - 26'1"	Native copper
26'1" - 26'9"	Barren
26'9" - 27'6"	Bornite plus chalcopyrite

Zoning in diamond drill hole S-1-75 is not as well defined as in holes S-2-75 and S-3-75. But in general, intersections mineralized with sulphide show a copper-rich to iron-rich zonation (Appendix D,E and F).

80

Mineral zoning is not always facing in one direction. Vertical reversals seem to occur in D.D.H. S-1-75 (Appendix D), but these holes have not been drilled deep enough for positive documentation.

The zoning could be a primary feature, but may also have resulted from transposition of primary features.

Copper profiles from diamond drill core are shown in Appendix D, E and F. The analyses were done by atomic absorption with a detection limit of one ppm. Samples for analysis were split drill core. The assay interval is indicated on the profiles by the width over which that percentage of copper occurs.

Origin

The available geological data are insufficient to apply a deposit type model to this mineral occurrence.

The copper mineralization appears to be confined to the basal part of the Sickle Group rocks. Repeated zoning from copper rich to iron rich sulphides is present in layers within the mineralized strata. The nature of the mineralization suggests that sulphide deposition was pre-metamorphism and pre-consolidation. Rocks of the Amphibolite Group are rich in iron sulphide but are very poor in copper.

Mechanisms involving the circulation of copper-enriched ground waters have been invoked by some authors to explain the zoning in syn-sedimentary sulphide deposits. In a reducing environment where such waters pass through rocks rich in iron sulphide, the copper in solution is postulated to replace the iron sulphide, resulting in primary ore minerals such as chalcocite, bornite and chalcopyrite. If this mechanism was operating during the formation of the Kadeniuk Lake deposit the ground water did not pass through the amphibolite, otherwise the iron sulphide presumably would have been replaced by copper sulphide.

Recommendations

(1) Evaluation of Exploration Techniques

(i) Geochemistry

In the 1975 field season approximately 150 samples of bedrock from the study area were analyzed for Cu, Pb, Zn, Ni, Co, Ag and Au. The data were plotted on sample location maps. The distribution of Pb, Zn, Ni, Co, Ag and Au is so erratic that attempts to contour the data were unsuccessful.

It appears that none of these elements behave as an indicator for copper mineralization in the study area.

Nowhere in the area have copper values that are above background been recorded without there being visible sulphide or native copper in the sample.

Consequently, it appears that the copper mineralization does not show secondary dispersion and that the contact relationship of mineralized and non-mineralized rock is extremely sharp.

It is therefore considered that rock geochemistry is of very limited value as an exploration tool for this type of copper deposit in Sickle Group rocks.

(ii) Geophysics

Considering that the mineralization in the study area is disseminated, the choice of geophysical methods is limited and expensive.

In comparing existing geological maps and aeromagnetic maps in the Kisseynew Belt, Sickle Group rocks have a high magnetic signature ($>$ 2300 gammas). This is due to their magnetite content. It has been observed during this study that copper bearing Sickle Group rocks are devoid of, or contain very little magnetite.

A study should be made across the zone of known mineralization with a ground magnetometer to see if the copper bearing zone is expressed as a magnetic low within rocks that are regional magnetic highs. If this method proves successful, then it may be used in the early stages of exploration to delineate target areas within Sickle Group rocks.

(iii) Prospecting

Because quartz and feldspar comprise the bulk of their modal composition, Sickle Group rocks are generally hard and resistive. Where these rocks outcrop they form ridges of fairly continuous exposure that generally parallel the strike of the layering (bedding).

Except for native copper the mineralization is in the form of sulphides which are visible upon careful examination. The native copper forms thin foils interstitial to rock grains. Its identification in hand sample is very difficult and except to the well trained eye may be easily overlooked.

Copper staining on the surface of outcrops is absent, but within a few millimetres of the weathered surface the rock may be heavily stained with malachite and/or azurite.

Therefore, prospecting for disseminated copper occurrences in Sickle Group rocks requires extensive rock breaking and careful examination. Nevertheless, because of the good exposures and the nature of the mineralization it is probably the best exploration method to employ in the initial exploration stage.

(iv) Diamond Drilling

In 1975 three holes were drilled in the study area. None of these was deep enough to intersect Amphibolite Group rocks. The stratigraphic

82

thickness of the mineralization is therefore still unknown. Consequently, it is of utmost importance that drill holes intersect Amphibolite Group rocks and ensure that the entire mineralized zone is penetrated to gain insight into the stratigraphy below surface.

(2) Potential Exploration Areas:

The Sickle Group - Laurie River (Wasekwan) Group contact zone extends from the Thompson Nickel Belt westward into Saskatchewan over a distance of some 250 km. East of Mynarski Lake and Notigi Lake the contact is not well defined. Post 1969 mapping by the Geological Services Branch of Manitoba Mineral Resources Division has defined the contact from Mynarski and Notigi Lakes west to the Manitoba-Saskatchewan border.

The geology along the contact is similar to that described in this report, for the Kadeniuk Lake Area.

Disseminated chalcopyrite occurs in the base of the Sickle Group rocks which outcrop on the west shore of Notigi Lake (B. Esposito, pers. comm.). The nature and extent of mineralization at this locality has not yet been investigated.

Mineralization has not been documented in the Sickle Group rocks outcropping south of the northeast arm of Russell Lake. The proximity and similar geology of these rocks to the Kadeniuk Lake occurrence suggest that this area should be further investigated.

In the Kamuchawie Lake area twenty-five very minor copper showings have been discovered (Zwanzig, 1975). Copper values of grab samples range from trace to 0.2 percent copper. Chalcopyrite, malachite and azurite were noted during the course of mapping. More recently, microscopic inspection of hand samples has revealed the presence of minor bornite, native copper and possibly chalcocite.

In summary, areas along the Sickle Group - Laurie River Group contact, worthy of further investigation, are Kamuchawie and Kadeniuk Lake areas N.T.S. 64C/5 and 64C/6), despite the fact that most of the known occurrences appear to be quite minor. The occurrence at Notigi Lake is now under water as a result of the construction of the Notigi Lake water control structure.

Conclusions

From the limited geological data available from the Kadeniuk Lake copper occurrence the following tentative conclusions can be made:

1) Copper mineralization in the metasedimentary supracrustal rocks of the region is concentrated in the basal Sickle Group rocks.

2) The mineralization appears to be syn-sedimentary.

3) The mineralized unit contains more than one mineralized layer.

4) The mineralized zones are themselves zoned with respect to the copper sulphides.

5) Native copper is the only ore mineral that is restricted in occurrence to a specific rock type (biotite meta-arkose).

6) Layering appears to thicken down dip.

Metamorphism and polyphase deformation have obliterated primary sedimentary features and make interpretation of sedimentary processes and the environment of ore deposition most difficult.

Much more data are required to gain insight into the source of the copper, the mechanism of copper deposition, and the shape and grade of the occurrence at Kadeniuk Lake. (Since this report was prepared, more data has become available. The analysis of this data may result in a further understanding of the mineral occurrence).

Future Activities (entire project)

In the 1976 field season areas with potential for porphyry environments will be investigated in Flin-Flon - Snow Lake belt.

Further field investigations along the Sickle Group - Laurie River Group contact will be made in the Kamuchawie, Russell, Lasthope and Notigi Lake areas.

Trenching is presently (June, 1976) underway at Kadeniuk Lake. Upon completion of this work the area will be re-visited to gather additional information on the geology of the mineral occurrence.

APPENDIX "A"

DIAMOND DRILL LOGS D.D.H. S-1-75

FOOTAGE	ROCK TYPE	MINERALIZATION	ASSAY	SPECIFIC NOTES
0'0" to 4'11"	Hornblende meta arkose	Minor Py		Minor diopside, sphene -
4'11" to 21'11"	Calc-silicate gneiss			Diopside, sphene, carbon-ate
		4'11" to 11'0" Cp	10'5" to 11'3" 0.11% Cu 13'0" to 13'6" 0.01% Cu	
		11'0" to 14'6" Cp & Bn		
		14'6" to 15'10" Cp		
		15'10" to 16'3" Cp & Bn		
		16'3" to 18'3" Cp	0.02% Cu	
		18'3" to 19'9" Cp & Py		
21'11" to 32'2"	Biotite meta arkose	24'1" to 26'0" Py, Po, very minor Mt		
		27'2" to 28'1" Bn	0.009% Cu	
		29'7" to 32'2" Py & Cp		
32'2" to 40'6"	Calc Silicate	32'2" to 38'0" Py		Diopside, sphene
40'6" to 42'6"	Biotite meta arkose	40'6" to 41'5" Cp		
42'6" to 42'10"	Calc Silicate gneiss		42'9" to 53'0"	
42'10" to 43'2"	Pegmatite		0.005% Cu	
43'2" to 46'9"	Calc Silicate gneiss	Py, Po		
46'9" to 48'8"	Biotite meta arkose			
48'8" to 49'1"	Hornblende meta arkose			
49'1" to 49'11"	Biotite meta arkose			
49'11" to 50'7"	Calc Silicate gneiss			Scapolite
50'7" to 51'7"	Core missing			
51'7" to 53'7"	Biotite meta arkose	Py & Cp		
53'7" to 57'3"	Biotite schist with layers of Quartz, plag., scapolite rock.			Sheared, Scapolite
57'3" to 72'0"	Interlayered hornblende and biotite meta arkose	57'3" to 60'6" Native Cu, Secondary Cc in fractures		Fractures coated with minor malachite
		60'6" to 60'11" Cp & Bn		
		61'4" to 63'8" Cp & Py		
		63'11" to 65'0" Native Cu		Minor malachite
		68'4" to 69'0" Py & Cp	0.081% Cu	
		69'0" to 69'3" Cp		
		69'3" to 70'0" Native Cu secondary marcasite		
		71'0" to 72'0" Py		
72'0" to 94'4"	Biotite meta arkose	72'5" to 72'6" Native Cu	0.018% Cu	

		72'6" to 73'1" Cp		
		73'2" to 80'3" Native Cu	0.04%	
		secondary Cc in fractures		
		Malachite		
		80'3" to 83'8" Py & Cp		
		83'8" to 84'3" Native Cu		
			1 ft @ 0.2% Cu	
		84'3" to 92'0" Cp	3 ft @ 0.06% Cu	
			4 ft @ 0.02% Cu	
94'4" to 96'6"	Pegmatite	92'0" to 99'2" Py & Cp		
	Calc Silicate		0.05% Cu	
99'3" to 121'0"	Qtz. plag. Biotite gneiss (possible meta greywacke)	99'3" to 99'8" Molybdenite in mobilizate	0.017 % Mo	
		99'8" to 107'0" Py & Cp	0.05% Cu	Identification confirmed by X-ray.
		107'0" to 121'0" Py		

End of hole

APPENDIX B

DIAMOND DRILL LOGS D.D.H. S-2-75

FOOTAGE	ROCK TYPE	MINERALIZATION	ASSAY	SPECIFIC NOTES
0'0" to 12'0"	Calc-Silicate gneiss	2'7" to 2'10" Py		
		4'6" to 4'7" secondary Cc in fractures	0.014% Cu	
		4'7" to 5'8" Py & Cp		0.5% sulphides
		6'0" to 6'1" secondary Cc in fractures	0.09% Cu	
		6'1" to 8'10" Py & Cp		
12'0" to 15'5"	Hornblende meta-arkose			
15'5" to 24'0"	Calc-Silicate gneiss	15'5" to 20'8" Py & Cp		1% sulphides
		20'8" to 24'3" Cp & Bn	1.76% Cu	4% sulphides
24'0" to 25'10"	Biotite meta-arkose	25'8" to 25'10" Native Cu	0.2% Cu	
25'10" to 26'0"	Calc-Silicate gneiss			
26'0" to 27'4"	Pegmatite	26'8" to 27'2" Cp & Bn		1% sulphides
27'4" to 27'9"	Biotite meta-arkose	Trace malachite in fractures	0.12% Cu	
27'9" to 28'8"	Calc-Silicate gneiss	Py & Cp		Less than 1% sulphides
28'8" to 29'3"	Biotite meta-arkose	28'8" to 28'10" Native Cu		
29'3" to 29'7"	Calc-Silicate gneiss	Cp		Less than 1% sulphides
29'7" to 30'0"	Biotite meta-arkose	Trace malachite stain on feldspar		
30'0" to 30'6"	Calc-Silicate gneiss	Malachite stain on feldspar		
30'6" to 38'0"	Horneblend meta-arkose	37'0" to 38'0" Py & Cp	0.02% Cu	1% sulphides
38'0" to 40'2"	Biotite meta-arkose			

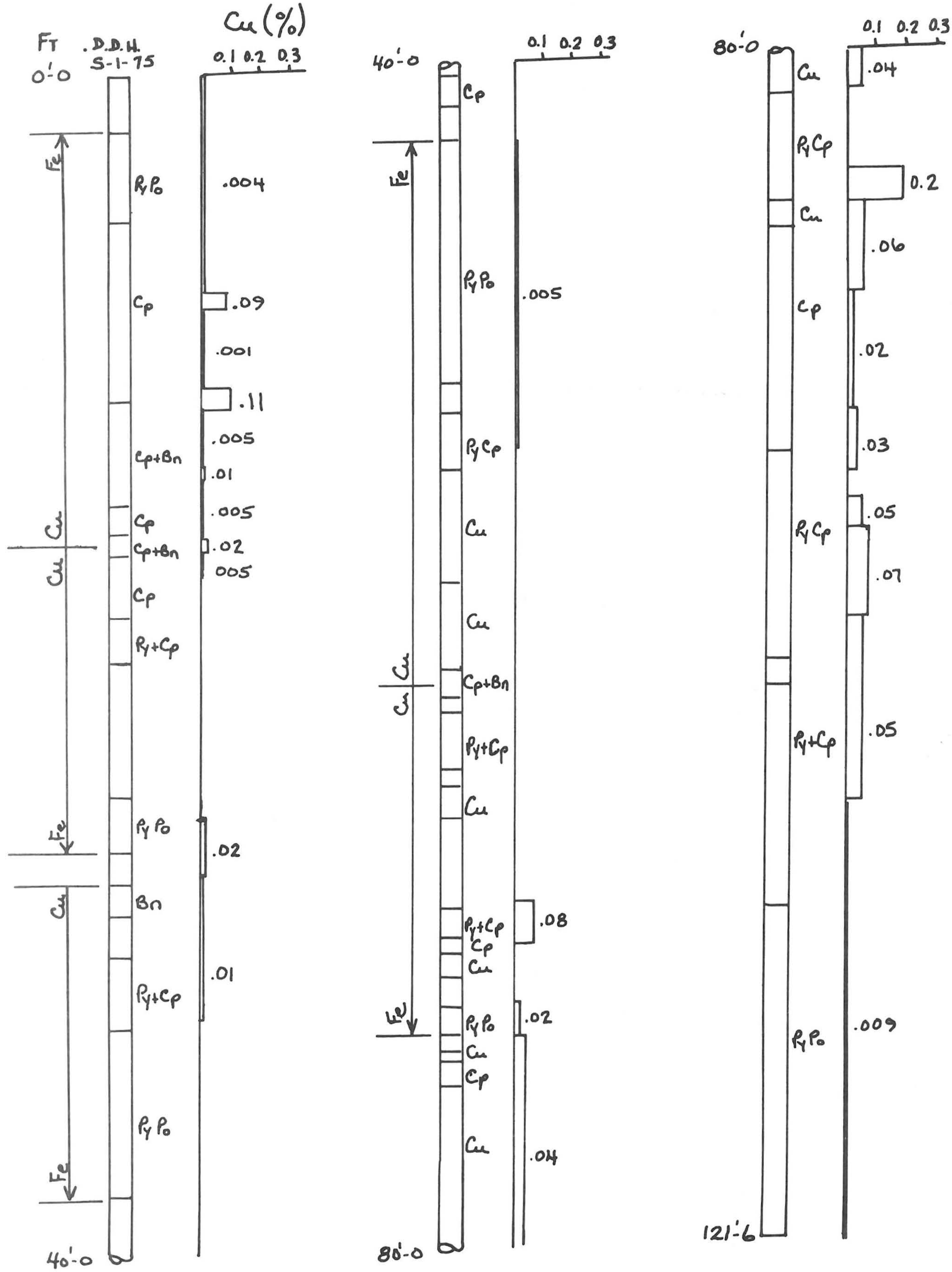
End of hole

APPENDIX C

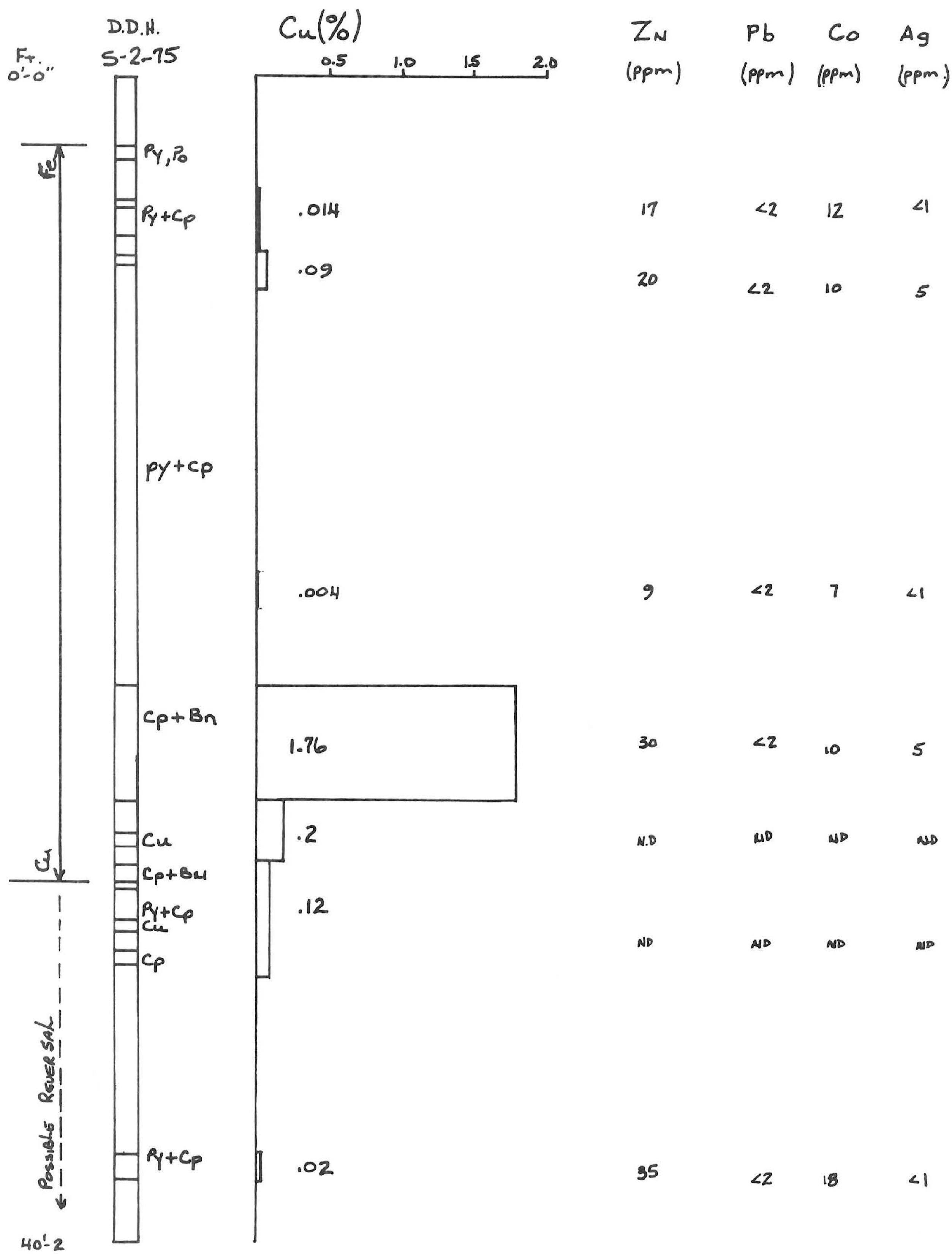
DIAMOND DRILL LOGS D.D.H. S-3-75

FOOTAGE	ROCK TYPE	MINERALIZATION	ASSAY	SPECIFIC NOTES
00'-0" to 36'-8"	Hornblende meta-arkose	23'-0" to 25'-9" Py		0.5% sulphides
		25'-9" to 29'-11" Py+Cp		1% sulphides
		30'-4" to 32'-7" Cp		0.5% sulphides
		35'-6" to 36'-8" Cp+Bn	1.3% Cu	6% sulphides
36'-8" to 38'0"	Biotite meta-arkose	36'-8" to 37'-10" Native Cu	0.027% Cu	less than 1% sulphide
		37'-10" to 38'-0" Cp + Native Cu in fractures		
38'-0" to 38'-4"	Calc-Silicate gneiss			
38'-4" to 43'-0"	Hornblende meta-arkose	38'-4" to 40'-5" Cp + Secondary Cc in fractures	0.031% Cu	1% sulphides
43'-0" to 43'-8"	Calc-Silicate gneiss	Cp minor Py		1% sulphides
43'-8" to 46'-3"	Hornblende meta-arkose	Secondary Cc in fractures		
46'-3" to 51'-6"	Biotite meta-arkose			
51'-6" to 55'-6"	Hornblende meta-arkose			

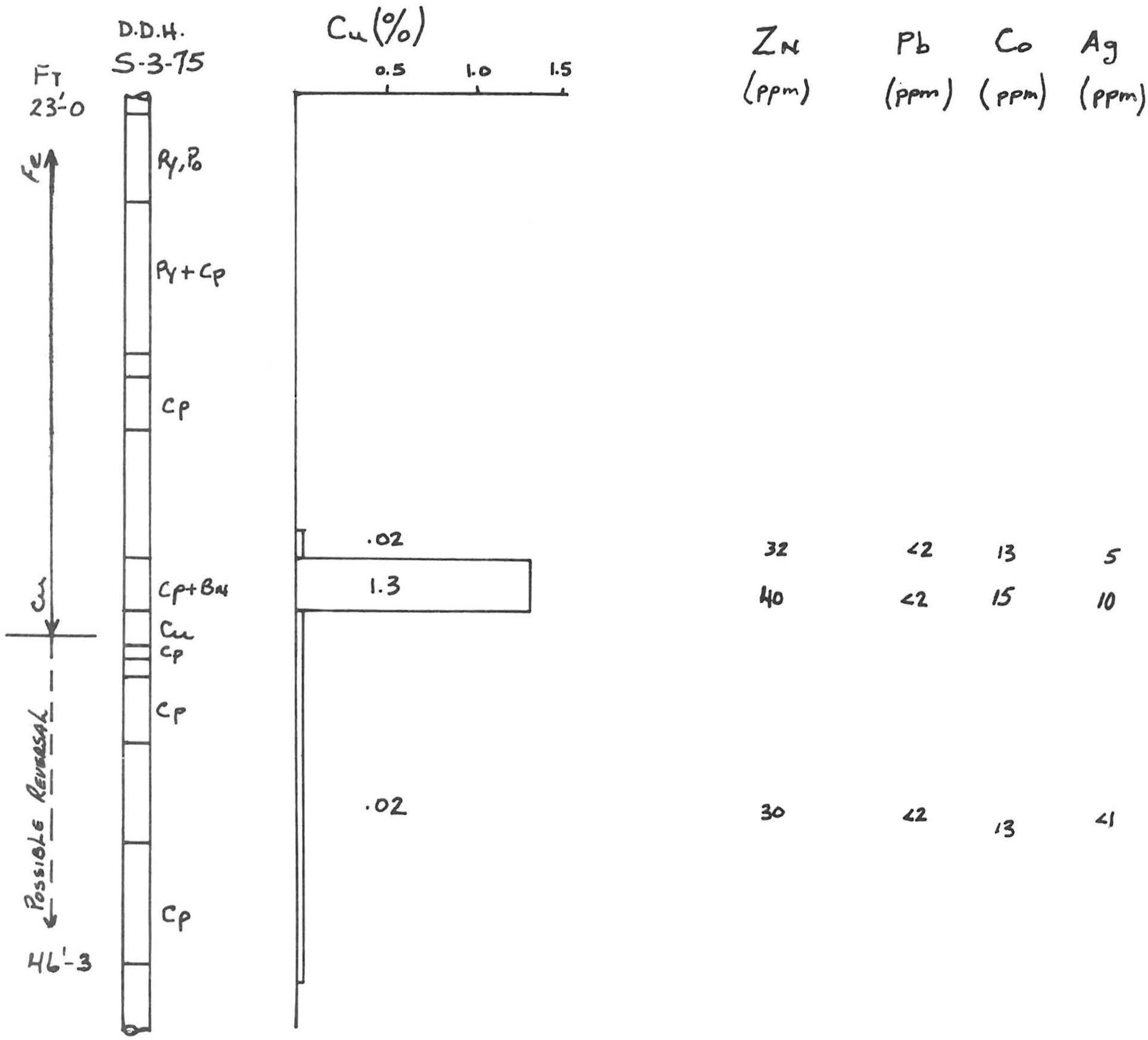
End of hole



Appendix D Distribution of sulphide minerals, native copper (Cu) and copper profile in D.D.H. S-1-75. Scale 1" = 5.0 feet



Appendix E Distribution of sulphide minerals, native copper (Cu) and copper profile in D.D.H. S-2-75. Scale 1" = 5.0 feet



Appendix F Distribution of sulphide minerals, native copper (Cu) and copper profile in D.D.H. S-3-75. Scale 1" = 5.0 feet

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92

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NM 7509 EXPLORATION HISTORY REVIEW OF AIRBORNE GEOPHYSICAL SURVEYS CONDUCTED IN THE FLIN FLON - SNOW LAKE BELT - by G. Burton

Editors Note

This paper is an attempt to provide an objective evaluation of the effectiveness of various airborne electromagnetic survey systems used in the Flin Flon - Snow Lake region. The conclusions are based on analysis of data in the open assessment files of the Mineral Resources Division. It is recognized that such analyses may contain elements of value judgement; however, it is considered that these and similar analyses may be of use to exploration companies, and they are essential in resource appraisal studies.

Introduction

This is a summary of preliminary investigations made to date into the evaluation of airborne geophysical surveys conducted in the Flin Flon - Snow Lake Mineral Belt. The scope of this initial report is necessarily limited since it does not go into details regarding the airborne systems nor into any discussions of their individual results. It will serve only to illustrate the work that has been accomplished to date, plus indicating the AEM Systems used and a brief assessment of their qualities, as well as setting out plans for future investigations.

Only airborne geophysical surveys, primarily airborne electromagnetics (EM), have been investigated. Ground coverage will be evaluated at a later date. An index of all the airborne work in the project area has been plotted on a scale of 1 inch to 2 miles (using A. Bailes' geological compilation map of the area as a base). Lists of all the airborne geophysical data available on the area, both open and confidential, have been prepared. A list for the airborne EM data available, and areas for which airborne permits have been issued but for which data have not been submitted, are presented in Tables IV and V respectively. These lists are incomplete and will be updated in the final report.

General Information

The first airborne geophysical surveying began in 1948. This consisted of aeromagnetic investigations. Airborne EM investigations were initiated in 1955. Surveying continued regularly until 1971. Hudson Bay Exploration and Development (HBED) carried out the bulk of the work during this period. Other prominent companies involved were Inco, Newmont, Selco, and Cerro Mining. A tremendous increase in airborne surveying occurred after 1971. More airborne surveys were carried out in the area during the period 1972-75 than were conducted in the previous 16 years (18 areas as compared to 14 areas previously). Companies involved in performing these surveys were Manitoba Mineral Resources (MMR), Noranda, Geosearch, NorAcme Gold Mines, Granges, Falconbridge, HBED and recently Sherritt Gordon. Many other surveys were conducted further south over the Paleozoic-covered zones, notably from Goose Lake through Cormorant and Moose Lakes down to the north end of Lake Winnipeg, as well as areas in the Nickel Belt and Nickel Belt Extension from Setting Lake and Wabowden to Lake Winnipeg. However, they were not included in the present study and surveys pertaining to them have been omitted from this report.

A large part of the airborne surveying under discussion has been conducted over the Paleozoic cover just south of its contact with the rocks of the Precambrian shield extending from Lake Athapapuskow to Wekusko Lake. Other areas of concentration of the surveys are in the Reed Lake and Wekusko - Snow Lake regions. For the Flin Flon, Athapapuskow, Cranberry Lakes areas and regions to the north a number of airborne permits have been filed to carry out aerial surveys. The surveying was probably done during 1972 through 1975 on these permits; however, results will not be available until 1976 and 1977 (refer to Table V). It appears that a large portion (if not all) of the most favourable areas for base metal mineralization have been covered by airborne geophusical (EM) surveys in the Flin Flon - Snow Lake Mineral Belt.

Airborne Systems Employed

Most surveys have been electromagnetic in conjunction with either magnetic or radiometric coverage. The radiometric surveys, which have been carried out mainly by HBED, have been generally of poor quality and have not been helpful in defining any radioactive source or delineating geology. Therefore, they are not discussed further. Aeromagnetic surveying has been largely confined to the Paleozoic cover. One large region was flown by Inco in 1948-51 in the Snow Lake area. The results of this survey have been incorporated in the government published 1"= 1 mile aeromagnetic maps.

The airborne EM systems used are illustrated in Table VI. Both fixed-wing and helicopter EM methods have been utilized. Systems measuring only the quadrature (phase) responses were employed initially. The Hunting helicopter EM method, measuring in-phase and out-of-phase components, was used often in the sixties by HBED. With the advent of newer and more sophisticated airborne equipment, usage of airborne EM surveying accelerated in the early 1970's. By far, the most popular method was Barringer's INPUT System which was used on about 60% of the properties surveyed during the last four years.

Discussions on the Quality of the various Airborne EM Systems

The quality of each airborne EM System employed has been studied in a "first look" assessment of the available data. This general assessment is discussed under the following headings:

A. Data Recovery An evaluation of the reduction and recovery of the airborne data with respect to flight path, picking of anomalies and analysis of flight records.

B. Record Quality Discussion of the noise level of the system and its sensitivity.

C. Data Presentation An assessment of the method of presentation of airborne results and the type of information supplied.

D. Rating A categorization of the overall effectiveness of the airborne systems.

TABLE IV

Airborne EM Data Available for Flin Flon - Snow Lake Mineral Belt

AREA	COMPANY	DATE	SYSTEM	DATA ON FILE
OPEN				
Res. 2-6. Athapap - Cranberry - Reed L.	Parmlee	March/57	Quadrature single freq. (Aerophysics)	Reports, EM anomaly map, (scale 1" = ½ mi.), mag. contour map, composite map (1" = 1 mile), ground surveys, D.D. In Open Reservation file. (No Airborne flight records)
Airborne Permit 10. File - Reed Lake.	HBED	May 1955	Quadrature Two Freq. (Hunting)	Report, EM anomaly map (scale 1" = 200 ft. In open airborne Permits File (No flight records)
Airborne Permit 19. Snow Lake - Wekusko Lake area.	INCO	May 1957	Quadrature Two Freq.	EM anomaly maps only. In open stacor files. (No flight records)
Airborne Permit 26. Reed Lake - south of Farewell Lake.	INCO	May 1959	Quadrature Two Freq.	EM anomaly maps only. In open stacor files. (No flight records)
Res. 121 (122). Goose Lake - Rock Lake Area plus area to south.	HBED	Aug. 1973 July 1974	In phase - out of phase.	Report, EM Anomaly map (scale 1" = ½ mi., ground EM and DD. No flight tapes submitted, but available from HBED upon request. In confidential reservations file. Partly open.
Airborne Permit 49. Goose Lake (T)	Selco	Oct. 1963	INPUT MK. III	Report, EM anomaly map showing mag. correlation. File under open airborne permits. Original flight tapes on file. Ground geophysical data & DD.
Cer 1 cl., RMR 35 & CB's. Athapap Beach. (T)	Cerro	July 1971	INPUT MK V	Report, EM Anomaly map and Mag. contour map on microfilm. EM Anomaly map & mag contour map (scale 1" = ¼ mile) in stacor file. Original flight tapes on file. Original file in storage file.

AREA	COMPANY	DATE	SYSTEM	DATA ON FILE
Res. 109. East of Simonhouse Lake. (T)	MMR	Jan. 1972	INPUT MK V	Report, EM maps (2) with magnetic indication scale 1" = ½ mi., ground surveys and DD. Tapes on microfilm.
Res. 107 & 108. Black Duck Lake. Paleozoics south of Reed L.	Geosearch	Jan/June 1972	INPUT MK V	Report, EM maps with magnetic indication on scale 1" = ½ mi. In open reservation file. Original tapes on file.
Res. 110 & 113. McClarty Lake, In paleozoics south of Res. 107 & 108. (T)	MMR	Jan/June 1972	INPUT MK V	Report, EM maps with magnetic indications scale 1" = ½ mi. In open reservation file. Flight records on microfilm.
Pot and Pan claims. East of Wekusko L. (T)	Newmont	Aug. 1960	Helicopter 1P/OP Newmont/Aero	Mag. contour map with EM anomalies, scale 1" = ¼ mi. and flight records on microfilm in open assessment files. (NE12-63J)
OZ claims. Kisseynew Lake (T)	HBED	Aug. 1960	Helicopter 1P/OP (Hunting)	Report, EM anomaly maps (scale 1"= ¼ mi.) and flight records on microfilm in assessment files (NE13-63K)
Wim claims - performed under A.P. - large area. Squall L. to Wimapedi L. (T)	HBED	Aug. 1961	Helicopter 1P/OP (Hunting)	Report, EM anomaly maps (scale 1" = ½ mi.) filed under confidential assessment file (35W-630). Most of the area open some ground still confidential. Tapes in storage at Century.
Law claims - Iskwasum Lake (T)	HBED	July 1964	Helicopter 1P/OP (Lockwood)	Report and EM anomaly map (scale 1" = ½ mi.) located in Confidential Assessment Files (NW10-63K). Only small part is still confidential. Flight tapes on file separately.
Airborne Permit 54. Tramping-Wekusko Lakes area.	HBED	May/June Nov/Dec 1965	Helicopter 1P/OP (Lockwood)	Report and EM anomaly map (scale 1" = ½ mi.) In Open Airborne Permit File. Flight records submitted but not located yet.

AREA	COMPANY	DATE	SYSTEM	DATA ON FILE
Airborne Permit 67. Reed Lake (T)	HBED	June 1967 Apr/May 1968	Helicopter 1P/OP (Lockwood)	Report and EM anomaly map (scale 1" = ½ mi.) in Open Airborne Permit File. Flight records filed separately.
LUS and Creek claims. Barb L. (T)	HBED	July 1970	Helicopter 1P/OP (Lockwood)	Report and EM anomaly map (scale 1" = ½ mi.) on microfilm in Assessment File (NW10-63K). Flight records in original final in storage.
Bart cl. and CB's. Herblet Lake (T)	Fosco	May 1971	LHEM 200 1N/OP Can. Aero.	Reports, EM anomaly map. Mag. contour map, and interpretation map (scale 1" = ¼ mi.) ground geophysics, geology, and DD. Flight records. All information in Confidential Assessment Files (NW13-63J)
Res. 116. South of Athapap Lake (T)	Nor-Acme	Feb 1973	Helicopter 1P/OP Aerodat	Report, EM anomaly maps, Mag. contour and mag filtered maps (scale 1" = ¼ mi) in Confidential Reservation File. Flight records on file
CONFIDENTIAL				
Airborne Permit 102 Morton - File Lakes (T)	Noranda	Mar 1972	INPUT	Report, EM anomaly map (scale 1" = ½ mi.) copies of Flight records in Confidential Airborne Permit File.
Res 111 & 112. East of Farewell Lake. (T)	MMR	Jan/Feb 1972	INPUT MK VI (Res. 111) MK V (Res 112)	Report, EM anomaly maps (scale 1" = ½ mi). Ground data. In Reservation File. Flight tapes on microfilm.
Claim Blocks. East of Wekusko Lake (T part)	Geosearch	Oct 1972	INPUT MK VI	Reports, EM anomaly map (scale 1" = ½ mi) & ground data. In Confidential Assessment Files (NW12-63J). Flight tapes for lines 1-22 only on file.
Claim Blocks. Trampin Lake & east. (T)	MMR	Sept 1973	INPUT VI	Reports & EM map (scale 1" = ½ mi) in Confidential Assessment File (SE-63K). Flight records on microfilm on file. Drawer 6.

AREA	COMPANY	DATE	SYSTEM	DATA ON FILE
CB's & Res. 123 South of Wekusko (T)	MMR	Sept 1973	INPUT MK VI	Report & EM map in Confidential Reservations File. Flight records on microfilm on file. Drawer 6.
CB 1048. South of Morgan Lake (T)	Granges	Oct 1973	INPUT MK VI	Report, EM anomaly map (scale 1" = $\frac{1}{2}$ mi) and mag contour map (scale 1" = $\frac{1}{4}$ mi) & Flight records in Confidential Assessment File (NE9-63K). Drawer 7.
CB's. Krug L. (T)	Granges	Feb 1974	INPUT MK VI	Report, EM anomaly map and Mag contour map (scale 1" = $\frac{1}{4}$ mi) & flight records in Confidential Assessment File (SE15-63K). Drawer 7.
EF claims & CB's Chisel-Morgan-Squall Lakes (T comp.)	Falconbridge	Nov 1973	Helicopter 1P/OP Aerodat.	Report, computerized EM profiles, anomalies & filtered Mag map & EM Anomaly map & Mag contour map (scale 1" = $\frac{1}{4}$ mi) in Confidential Assessment File (SE16-63K).

TABLE V

Airborne Permits for which data is not available.

A.P.	Company	File	Issue Date	Data Due Date	Area	System
104	Sherritt Gordon	69984	Mar.14/72	Mar./76	Sherridon	Newmont type IP/OP?
109	HBED	70710	Jan.22/73	Jan./77	Flin Flon - Cranberry North to Kisseynew	HBED Geonics IP/OP.?
112	Granges	71067	July 27/73	July/77	Tramping-Reed-Woosey-Chisel-Wekusko.	INPUT
113	Man. Mineral Resources	71149	Aug.15/73	Aug./77	Moose L. - File L. to Kiski Lake	INPUT
114	Sherritt Gordon	71169	Sept.11/73	Sept./77	Flin Flon to Snow Lake	Newmont type IP/OP?
116	Falconbridge	71170	Sept.27/73	Sept./77	4 Areas. 1A, 1B-Athapap-Wabishkok east of Reed L.	Aerodat?
					[1c Chisel-Woosey L. already flown and data submitted]	Aerodat
					1D Wekusko-Watts R.	Aerodat?
120	Granges	71388	June 18/74 (extended to July 31/75)	June/78	Flin Flon-Wabishkok-Noosap	INPUT?

100

TABLE VI

Airborne EM Systems Used in Flin Flon - Snow Lake Belt

SYSTEM	TRANSMITTER FREQUENCY	COIL CONFIGURATION	COIL SEPARATION	FLYING HEIGHT	RECEIVER HEIGHT	LINE SPACING	LINE DIRECTION	LINE MILE
1. Quadrature single frequency (Aerophysics)	140 Hz	vertical co-planar		400 ft	150 ft	¼ mile	NW-SE	5438
2. Quadrature Two Frequency (Hunting)	400 Hz 2300 Hz		250 ft	400 ft	150'-200'	1/8 mi	E-W	
Quadrature Two Frequency (INCO)	between 100 Hz & 2500 Hz	co-axial & co-planar	400 ft (horizontal)	500 ft	275 ft	¼ mile	NW-SE	
3. Inphase-out of phase (Geonic HBED?)	1185 Hz	3 coils vertical, maximum coupled & horizontal		400 ft	150 ft	1/8 mi	E-W	
4. INPUT MK III.	285 Hz	Tx. horizontal.. Rx. vertical	on 500 ft cable	380 ft	150 ft	¼ mi	E-W	
INPUT MK V & VI.	285 Hz	Tx. Horizontal. Rx. Vertical	on 500 ft cable.	380 ft	150 ft	1/8 mi	NW-SE, E-W, N-S, NE-SW,	
5. HEM(1) - Inphase out of phase (Newmont/Aero)	390 Hz	vertical co-axial.	50 ft	200 ft	100 ft	1/8 mi	E-W	
HEM-Inphase - out of Phase. (Hunting)	4000 Hz	vertical co-axial.	20 ft	200 ft.	100 ft.	1/8 mi	NW-SE E-W N-S	
HEM - Inphase out of phase LHEM-200	4000 Hz	vertical co-axial	30 ft	200 ft	100 ft	1/8 mi	N-S	183
6. HEM - Inphase out of phase Aerodat	918 Hz	vertical co-a ial & min. coupled?	22' or 30'	200 ft	100 ft	1/8 mi	E-W NW-SE	708 315

Note: (1) Helicopter-borne EM System

A. Data Recovery

A proper assessment of reduction and record qualities of the Quadrature Systems which were utilized during the initial period has not been carried out since the flight records were not submitted for these areas. An analysis of the features concerning airborne surveying on HBED's Airborne Permit #54 in the Tramping - Wekusko Lakes area has not been made. Although flight tapes were submitted for this survey, they have not as yet been located. Also HBED's recent survey in Res. 121 and 122 in Goose Lake area was not analyzed since they were not required to submit the flight records.

An insight into the functions of, and the efficiency and effectiveness of the remaining systems was properly achieved by reference to the flight records. These were submitted with the reports on the airborne surveys and are available in the files.

Data recovery of the systems which did not have any accompanying flight tapes can be described in a very general way. The Single Frequency Quadrature system seems to have been recovered quite well. Recovery of HBED's Hunting survey was fair. Inco's data recovery and presentation is very poor. HBED's recovery of their new fixed-wing in-phase/out-of-phase system appears to be fair.

Of the airborne systems for which flight tapes are available, the Aerodat helicopter system showed the best data recovery. This is likely due to the fact that the data has been reduced by computer. Selco's recovery of the results from the INPUT Mark III survey was fair. Later INPUT surveys by Questor showed an improvement in the data recovery. Data reduction on the Newmont/Aero system was fair as was that for Lockwood's helicopter EM. HBED's recovery of data from their helicopter EM surveys was poor to very poor. A number of legitimate conductors have been omitted from some of the EM anomaly maps, particularly in those areas flown by Questor.

B. Record Quality

There is normally a wide difference in the quality of the flight records from fixed-wing survey systems as compared to helicopter-mounted rigid-boom systems. Coupling between transmitter and receiver coils is affected more in the helicopter rigid-boom systems than in coil configurations used for the fixed-wing systems. This contributes to the high noise level. Airframe noise is also a factor. In the INPUT system, noise levels are generally very low because of the nature of the transmitting signal.

Again, because of the lack of flight tapes for the earlier system, adequate assessment of the flight records was not possible. However, reports on the noise levels given in previous publications can be used as a general indication.

For the Single Frequency Quadrature System of Aerophysics the noise level has been reported to be high for the total response. The noise level of the phase response has been reported as fair at 1000 ppm. The geological noise for this system is reported as quite low. However, its sensitivity is also low.

102

The instrument noise for Hunting's Dual Frequency Quadrature System has been reported as fair. However, geological noise is very high. Sensitivity is low to moderate. Inco's Quadrature System has been reported to have a fair to poor noise level at less than 1500 ppm. The system is susceptible to high noise due to turbulence and aircraft maneuvering. Sensitivity is fair. HBED's newly operational fixed-wing in-phase/out-of-phase system is reported to have a good signal to noise ratio. Levels are reported to be less than 300 ppm. Sensitivity appears to be fair to good.

A wide range of signal to noise ratios is evident in the various INPUT surveys conducted in the project area. The noise levels range from very low to very high. On the whole the noise levels for the majority of the flight records have been quite good. Very noisy readings have been encountered when the sensitivity gains have been set too high. Good noise levels range between 5 to 10 ppm and up to 20 ppm. The sensitivity of the earlier system is fair. Later models show an increase in sensitivity. However, when increased noise has been affecting the system, gains have been low and sensitiveness has subsequently decreased. There seems to have been a noise problem with the introduction of the MK VI model in early 1972. In later surveys this problem seems to have been much reduced.

The Newmont/Aero helicopter EM systems have a fair to good noise level (approximately 1 div.). This is likely due to choice of frequencies and proper selection of flying times to eliminate air turbulance. Sensitivities are fair. The in-phase/out-of-phase helicopter system employed by HBED has a very high noise level and sensitivity is low to very low. A later model of the Lockwood system shows an improved signal to noise ratio, however, it still retains a fairly high noise level. In-phase responses are noisier than quadrature readings. Sensitivity is very low. These high frequency systems are more susceptible to geological noise.

Aerodat's in-phase/out-of-phase helicopter system has introduced a greatly improved signal to noise ratio by eliminating the rigid boom concept of the earlier helicopter systems. A patented "floating" transmitter-receiver mechanism has been responsible for improving the coupling between transmitter and receiver. This has eliminated much of the noise inherent in the "rigid" systems. Sensitivities are fair for the system.

C. Data Presentation

Generally, presentation of airborne geophysical data has improved greatly over the years. Early presentations were poor. Anomalies and conductivities were not properly identified. Recently there has been greater precision in plotting and better identification of geophysical parameters measured. In the last several years, computerization has added its improvements to map presentation.

Presentation of the data by Aerophysics for the airborne EM survey over the large tract of ground over the Paleozoic limestone has been good. Proper identification of the various types of conductors has been made. Map identifications are good. Information on Aeromagnetic's survey flown for HBED in the File Lake - Reed Lake area was poorly presented. Anomaly identification and conductivity indications are very poor. Inco's anomaly maps of their geophysical surveying in the Reed Lake and Snow Lake areas are extremely poor. There is no proper anomaly definition nor any proper indication of anomaly conductivities or magnetic correlation. HBED's presentation of their helicopter EM data has been poor. However, presentation has improved in more recent reports. Presentation of early INPUT data was fair to poor. However, the information from later surveys has been presented very well. Proper identification of anomalies, conductivity and topographic features using mosaics has provided a great improvement.

Early presentation of helicopter EM data was poor. HBED's maps are very simple and do not provide adequate information. Presentation of airborne data on the latest surveys by Aerodat has proven to be the best so far. Maps are excellent and provide very accurate data.

D. Rating

An overall comparison of the individual characteristics of the airborne EM systems employed in the Flin Flon - Snow Lake belt, has led to a general categorization of their effectiveness. Earlier systems necessarily have lower ratings than the later, more advanced systems. These two groups are therefore listed separately. The systems are listed in decreasing order of effectiveness.

Early Systems (1955-60)

Inco Dual Frequency Quadrature System
Newmont/Aero HEM System
Aerophysics Single Frequency Quadrature System
Lockwood HEM System
Hunting HEM System
Hunting Dual Frequency Quadrature System

Later Systems (1961-75)

INPUT MK V and MK VI
INPUT MK III
Aerodat HEM

HBED Fixed-Wing In-Phase/Out-Of-Phase
Hunting/Lockwood HEM

INPUT has proven to have the greatest penetration depth of all the systems used in the area. The earlier systems lack this depth sensitivity. Better resolutions are afforded by the INPUT and Aerodat HEM system. Also, the later model Lockwood systems show better resolution than the previous models. These characteristics were not assessable for the new HBED fixed-wing IP/OP system because no tapes were submitted.

Frequencies and coil configurations employed during airborne surveying of any areas influence the effective responsiveness of the system. These factors have to be taken into account when assessing the various airborne systems.

Some Results and Comparisons

The capabilities of several airborne systems could be compared in some instances in which they were flown over the same areas and the same mineralization.

The Freeport Sulphur deposit located on Spruce Point on Reed Lake was covered by Inco system in 1955, by Aerophysic's Single Frequency Quadrature system in 1957,

104

and more recently by INPUT and HBED's Hunting helicopter EM systems. The first two systems (Aerophysics and Inco) did not show any response over the deposit. Since the flight tapes are not available for these surveys, it is not known whether the systems did not actually pick up the response or if any response was considered too weak to plot. The INPUT system showed a good response over the deposit. The HBED helicopter survey in 1967 did not pick up the deposit itself. This is possibly due to the angle of approach to the strike of the deposit. However, a weak response was indicated on one line which crossed the north end of the deposit. The aeromagnetic survey flown in 1956 showed a weak, single line magnetic response over the deposit.

The geological features enveloping HBED's Rail deposit, Copper-Man's deposit and HBED's Wim deposit appear to have been picked up by all the airborne systems that were flown over them. The systems involved are as follows:

HBED Rail Lake Deposit:

a) HBED's fixed-wing Hunting type IP/OP system in 1955
b) Inco's Quadrature System in 1959
c) INPUT
d) HBED's Hunting type Helicopter System

Copper-Man's Deposit, Wekusko Lake:

a) Inco's Quadrature System
b) HBED's Hunting Helicopter System

Wim Deposit:

a) Inco's Quadrature System
b) HBED's Hunting Helicopter System

The Dickstone deposit was not indicated in Inco's survey over the area. HBED's survey in 1955 may have picked up the mineralization. However, this was only on one line and positioning is questionable. Although INPUT was flown over the deposit, proper identification of any response over the mineralization was hampered by extremely high interference in the area due to power lines and mine buildings.

The Inco system did not show any response over HBED's Reed Lake deposit, nor any of the mineralization and mineral deposits in Snow Lake-Chisel Lake-Cook Lake area. HBED's airborne EM response over their Reed Lake deposit was very good but limited in strike length.

The Aerodat helicopter system responded to the formational feature related to the Pot Lake deposit southwest of Snow Lake. However, the same survey did not respond to the Bomber deposit on Cook Lake. Exact information on the nature of these deposits is not known, so the success of the Aerodat system cannot be determined properly.

Plans for Future Investigations

Immediate plans are to produce index maps that will indicate the coverage for both EM and magnetic airborne surveys in the project area on a scale of 4 miles to the inch. Five maps will serve as overlays to the Geologic Compilation Map of the Mineral belt.

The government files will be rechecked to ensure that all available geophysical data has been compiled. Thereafter, the ground geophysical data will be organized.

After the results of the airborne surveys have been studied in more detail, a compilation of all the data will be made. Reinterpretation of airborne survey results in more selected areas will follow.

106

NM 7510 ORE MINERALOGY - by J. Grice

This report describes mineralogical investigation of the base metal deposits in the Thompson, Snow Lake, Flin Flon, and Lynn Lake areas.

I. The Thompson, Birchtree, Pipe, and Manibridge Nickel deposits.

Introduction

The Thompson-Wabowden belt is a well known nickel producing area which extends 170 km from Moak Lake in the northeast to Kiski Lake in the southwest. To date all known nickel deposits of this belt lie within the Wabowden subprovince.

In July 1975 the author collected located samples in the four operating mines Thompson, Birchtree, Pipe and Manibridge within this belt. A list of samples per mine and methods of investigation are given in the Appendices.

The author would like to thank the Inco and Falconbridge companies for their cooperation in this investigation.

Mineralogical Descriptions - Thompson Mine Mineralogy

The main ore minerals in this deposit are pyrrhotite, pentlandite and pyrite with minor to trace amounts of magnetite, graphite, chalcopyrite, sphalerite, and gersdorffite. In general the sulfides are coarse grained massive (0.5 - 3 mm) on major and minor fold noses and fine grained disseminated or network (0.05 - 0.5 mm) on the limbs of the fold.

Pyrrhotite is the main sulfide constituent within the Thompson Mine ore. The pyrrhotite coexisting with pentlandite is usually the ferromagnetic monoclinic polytype; the only exceptions to this observation were in areas of faulting or shearing where the pyrrhotite is two phase with irregular hexagonal cores surrounded by the monoclinic form (Figure 25). Two areas of pyrrhotite barren of coexisting pentlandite were examined. One area on the 2800' level, 890 stope formed a spike approximately 3 m wide by 30 m in length extending from the end of the major fold nose in the ore zone. This spike consists of massive, coarse grained, hexagonal pyrrhotite (non-ferromagnetic). Note in Figure 26 the decrease in Ni content with distance from the spike end with .36 wt % Ni to the ore/barren sulfide contact with .13 wt % Ni. The four probe analyses for samples G75-T15, T16, T17 and T18 are given in Table VII. The other barren pyrrhotite zone studied runs parallel to the fold limb ore zone, 30 m to the east. Inco kindly provided a series of drill core samples along the zone. It consists of two phase pyrrhotite (hexagonal and monoclinic) plus pyrite and minor magnetite. The pyrrhotite in G75-T27 (Table VII) from this zone is very low in Ni. In this sample as in other two phase pyrrhotite samples there is always more Ni in the hexagonal phase than in the coexisting monoclinic phase; this was also noted by Harris and Nickel (1972). Probe analyses of the Ni-bearing pyrrhotites are given in Table VII.

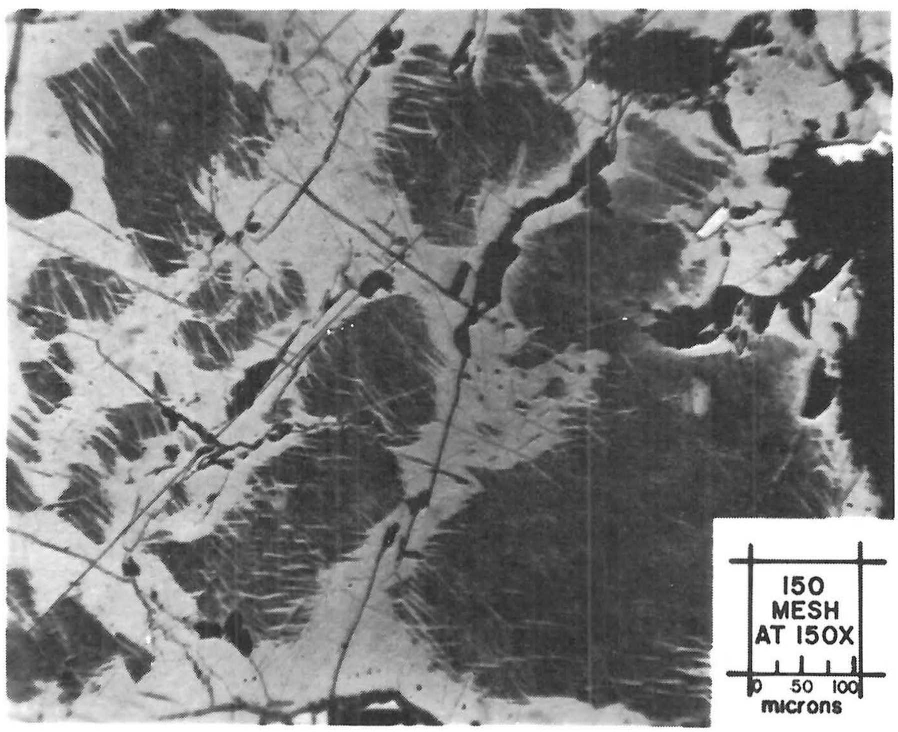

Figure 25 Photomicrograph showing the textural relationships of hexagonal pyrrhotite (dark grey) to monoclinic pyrrhotite (light grey) in the coarse grained Thompson Mine ore. Black inclusions are gangue. Sample is etched with HI.

108

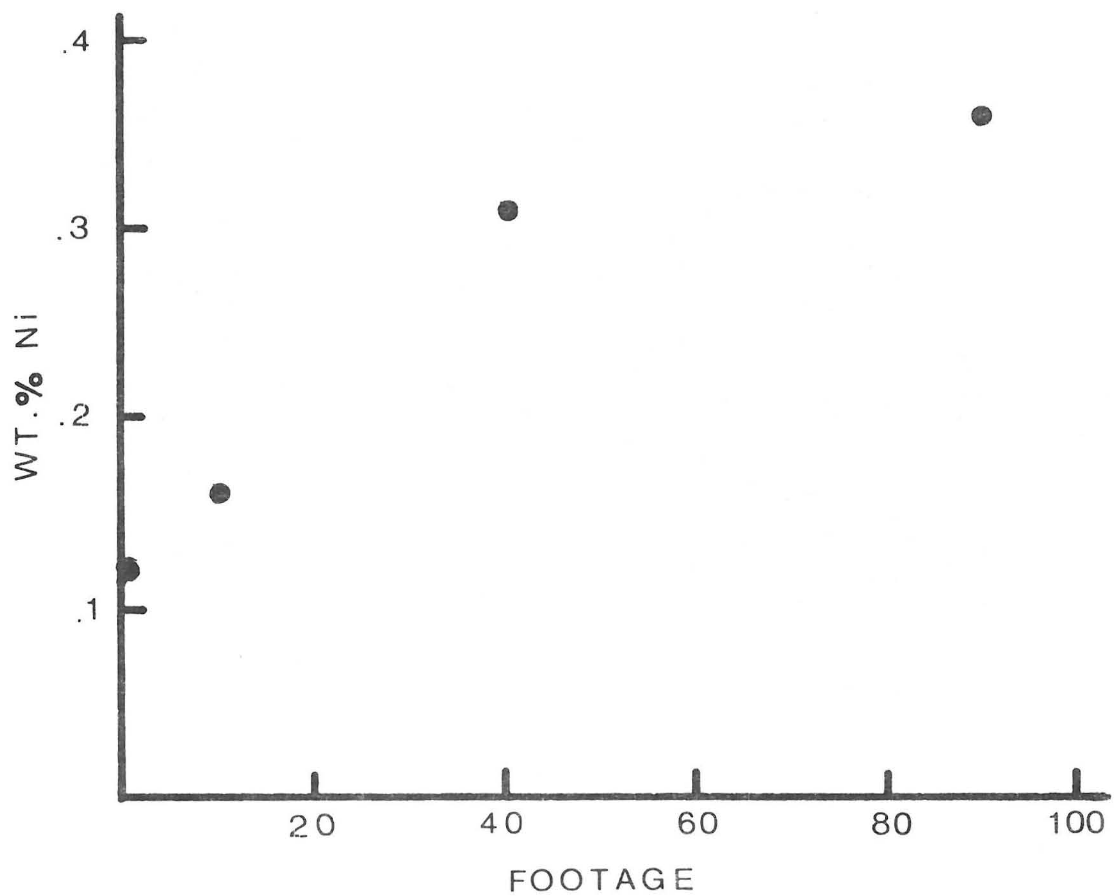

Figure 26 Diagram showing the Ni contents of hexagonal pyrrhotite in the Thompson Mine "barren spike". Zero footage is at the ore zone contact.

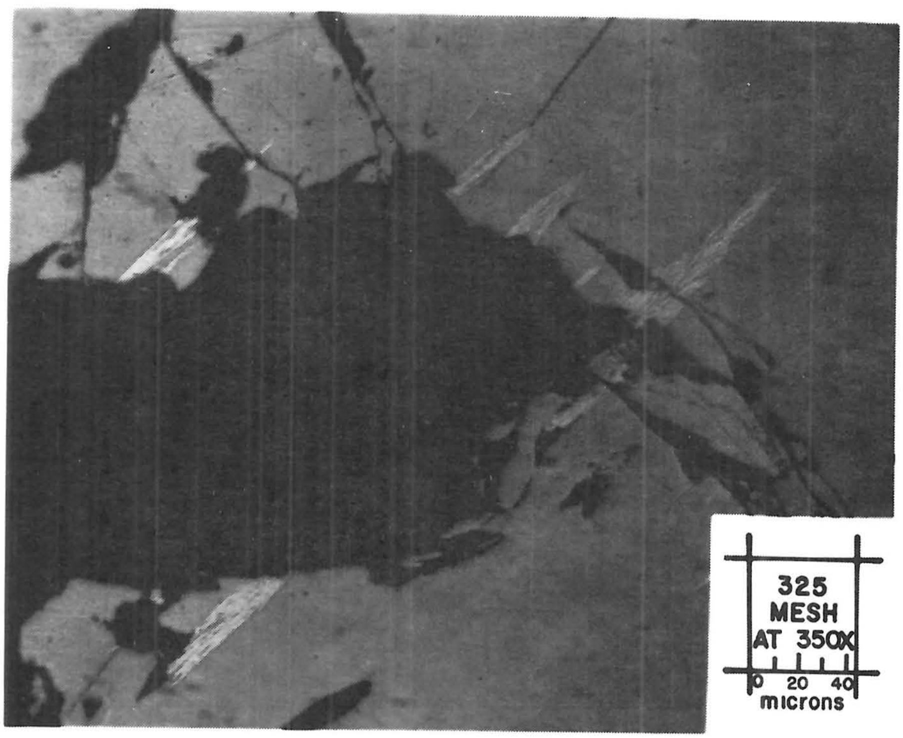

Figure 27 Photomicrograph of a Thompson Mine sample showing pentlandite flames in monoclinic pyrrhotite (grey) adjacent to silicates (black).

110

TABLE VII ELECTRON MICROPROBE ANALYSES OF THOMPSON MINE SAMPLES

Pyrrhotites

Sample	Phase	Fe	Ni	S	Total
G75-T1	M	60.3	.7	39.7	100.7
		(46.3)	(.6)	(53.1)	
G75-T4	M	60.3	.6	39.5	100.4
		(46.5)	(.4)	(53.1)	
G75-T8	M	60.7	.3	39.7	100.7
		(46.7)	(.2)	(53.1)	
	H	61.0	.4	39.6	101.0
		(46.8)	(.3)	(52.9)	
G75-T9	M	60.1	.5	40.2	100.8
		(46.0)	(.4)	(53.6)	
G75-T10	M	60.0	.9	39.9	100.8
		(46.0)	(.7)	(53.3)	
G75-T12	M	60.4	.4	39.9	100.7
		(46.4)	(.2)	(53.4)	
G75-T15	H	61.3	.4	38.9	100.6
		(47.4)	(.2)	(52.4)	
G75-T16	H	61.4	.3	39.3	101.0
		(47.2)	(.2)	(52.6)	
G75-T17	H	61.6	.2	39.4	101.2
		(47.3)	(.1)	(52.6)	
G75-T18	H	61.3	.1	39.4	100.8
		(47.1)	(.1)	(52.8)	
G75-T20	M	59.8	1.1	40.1	101.0
		(45.8)	(.8)	(53.4)	
G75-T22	M	59.5	1.3	40.2	101.0
		(45.4)	(1.0)	(53.6)	
G75-T25	M	60.8	.2	39.6	100.6
		(46.7)	(.2)	(53.1)	
	H	61.2	.4	38.7	100.3
		(47.5)	(.3)	(52.2)	
G75-T27	M	61.0	.1	40.3	101.4
		(46.5)	-	(53.5)	
	H	61.8	.1	39.1	101.0
		(47.6	-	(52.4)	

Cont'd

TABLE VII (cont'd – Thompson Mine)

G75-T37B Coarse	M	60.6 (46.5)	.4 (.3)	39.8 (53.2)	100.8
	H	60.7 (46.9)	.7 (.5)	39.1 (52.6)	100.5
Fine	M	60.4 (46.5)	.4 (.3)	39.7 (53.2)	100.5
Average	M	60.3 (46.3)	.6 (.4)	39.9 (53.3)	100.8
Average	H	61.3 (47.2)	.3 (.2)	39.2 (52.6)	100.8

Pentlandites

Sample	Ni	Fe	Co	S	Total
G75-T1	37.5 (29.1)	29.7 (24.2)	.1 –	32.9 (46.7)	100.2
G75-T4	35.6 (27.2)	31.1 (25.1)	1.0 (.7)	33.5 (47.0)	101.2
G75-T8	34.5 (26.3)	32.2 (25.8)	1.4 (1.1)	33.5 (46.8)	101.6
G75-T9	37.2 (28.6)	29.7 (23.9)	.6 (.5)	33.5 (47.0)	101.0
G75-T10	36.9 (28.3)	29.9 (24.0)	.5 (.4)	33.7 (47.3)	101.0
G75-T12	35.8 (27.6)	30.5 (24.8)	.6 (.5)	33.4 (47.1)	100.3
G75-T20	36.0 (27.7)	30.3 (24.6)	.7 (.5)	33.5 (47.2)	100.5
G75-T22	36.7 (28.3)	29.6 (24.0)	.8 (.6)	33.4 (47.1)	100.5
G75-T25	34.7 (26.6)	31.7 (25.6)	.1 (.1)	34.0 (47.7)	100.5
G75-T37B					
Coarse	33.9 (26.1)	31.6 (25.6)	.5 (.3)	34.1 (48.0)	100.1
Border	35.7 (27.6)	31.1 (25.2)	.5 (.4)	33.1 (46.8)	100.4
Fine	35.0 (27.3)	31.0 (25.3)	.5 (.4)	33.0 (47.0)	99.5

Cont'd

TABLE VII (Cont'd - Thompson Mine)

Average + mpo	36.6 (28.1)	30.1 (24.4)	.6 (.5)	33.4 (47.0)	100.7
Average +mpo+hpo	34.4 (26.3)	31.8 (25.7)	.7 (.5)	33.9 (47.5)	100.8

Pyrites

Sample	Fe	Co	Ni	S	Total
G75-T5	45.6 (32.3)	1.1 (.7)	n.d.	54.1 (67.0)	100.8
G75-T9	44.2 (31.3)	2.9 (1.9)	n.d.	54.1 (66.8)	101.2

	Sphalerite G75-T1
Zn	61.7
Fe	4.9
Cd	n.d.
Mn	n.d.
S	33.0
Total	99.6

	Gersdorffite G75-T23
Ni	22.3
Fe	5.9
Co	7.2
As	46.0
Sb	.4
S	18.0
Total	99.8

Notes

1) Microprobe Operator: Mr. P. Carriere
2) Phase: M ——→ monoclinic, H ——→ he agonal
3) Atomic per cent in brackets
4) Co not detected in pyrrhotites
5) Pyrites non homogeneous re metals

Pentlandite is the major ore mineral. It is generally subhedral to anhedral with the (111) cleavage and shrinkage cracks commonly visible. Pentlandite also occurs as flame-like segregations in the coarse grained monoclinic pyrrhotites, particularly along silicate grain boundaries as seen in Figure 27. Table VII gives microprobe analyses for pentlandites and their coexisting pyrrhotites. Note that pentlandites coexisting with two phase pyrrhotites are Ni-poor relative to those coexisting with only monoclinic pyrrhotite.

Pyrite is less abundant than pyrrhotite or pentlandite but it is found throughout the ore body in varying amounts. On the limb of the fold where it is one of the major sulfide minerals it tends to have euhedral grains ($\sim$ .1 mm) being only in part replaced by pyrrhotite and chalcopyrite along fractures within pyrite grains. In coarse grained material (fold nose) there is only remnant euhedral pyrite grains, almost entirely replaced by monoclinic pyrrhotite. Two pyrite analyses are given in Table VII, in G75-T5 pyrite is a major constituent and in G75-T9 a minor constituent. Ni was not detected in either but Co was present in zones.

Magnetite is ubiquitous but is more predominent in the coarse grained, massive sulfides where it occurs as euhedral crystals. It is also seen as disseminated grains and stringers within serpentine.

Chalcopyrite and closely associated sphalerite are late-forming minerals. Chalcopyrite is fracture-filling within silicates and pyrite and it also occurs as anhedral grains adjacent to or within pentlandite. One analysis of the Zn-rich sphalerite is given in Table VII.

Gersdorffite occurs as small blebs primarily in the massive sulfides of the fold nose. In addition to the analyses given in Table VII an effort was made on several grains to detect the precious metals Pt, Pd and Rh by electron microprobe. As this proved unsuccessful several bulk samples were sent for atomic absorption analyses but the results are not yet available.

– Birchtree Mine Mineralogy

The main ore minerals in this deposit are pyrrhotite, pyrite and pentlandite. The accessory minerals are magnetite, chromite, ilmenite, galena, marcasite, sphalerite, gersdorffite, nickeline, maucherite and wehrlite. Most of the samples examined were medium to coarse grained massive sulfides but finer grained stringer and breccia ore are also present.

Most of the pyrrhotite at Birchtree is monoclinic. In only one sample of breccia sulfide was hexagonal plus monoclinic pyrrhotite observed. Much of the pyrrhotite shows a zebra-like texture due to differing crystallographic orientations probably caused by pressure twinning. Pyrrhotite probe analyses are given in Table VIII and it appears there is generally $\sim$ .3 wt. % Ni in solid solution.

Pyrite has two forms at the Birchtree Mine and an analysis of each from the one polished section G75-B2 is given in Table VIII. The anhedral pyrite in massive sulfides, being replaced by pyrrhotite and chalcopyrite or in some samples marcasite, is presumably early-formed while the euhedral pyrite in silicates is probably later. Both types of pyrite are non-homogeneous with respect to Co and Ni. The Co content seems significantly higher in the earlier-formed pyrite.

Pentlandite at Birchtree occurs as fine to coarse grains and there is a large amount of flame-like exsolved pentlandite in monoclinic pyrrhotite. The wide variation in grain size might give rise to milling problems. The majority of pentlandite analyses given in Table VIII are for pentlandites coexisting with monoclinic pyrrhotite and pyrite. The average Ni and Co contents for these pentlandites are 35.7% and .8% respectively. Sample G75-B5 is from a fold limb on the 700' level and it is of special interest. The assemblage in this area is pentlandite-pyrite (notably no pyrrhotite). The significance of this assemblage is the sharp increase in Ni contents to 39.4 wt. %. This increase in Ni occurring within this assemblage was also noted by Harris and Nickel (1972) for the Texmont and Marbridge No. 4 Mines.

Magnetite is a common accessory mineral in this ore. It occurs as subhedral grains, fracture-fillings in sulfides and as an asbestiform replacement in silicates. Commonly magnetite forms as overgrowths on earlier-formed chromite. This chromite is Zn-bearing and in some instances it is replaced by minor amounts of ilmenite.

Sulfarsenides and arsenides are common constituents in the massive coarse grained sulfides while none were observed in the interstitial or network sulfides. Gersdorffite is much more common than the associated minerals maucherite and nickeline. These minerals are probably formed late within the sulfide crystallization sequence. Within the group itself nickeline forms first and is sometimes replaced by maucherite. Gersdorffite is the last to crystallize and may contain blebs of nickeline with or without maucherite. Analyses of these minerals are given in Table VIII; maucherite and nickeline are homogeneous while gersdorffite is non-homogeneous with respect to metals. Attempts at detecting precious metals in these minerals by electron microprobe were not very successful. Only two spots within one of two grains gave any significant detection; Pd .05 and .09 wt. %; Rh .18 and .35 wt. %; Pt not detected. Bulk samples have been submitted to the G.S.C. for trace element analysis.

Galena and wehrlite are rare at the Birchtree Mine. They appear to have crystallized late, at about the same time as the arsenides with which they are associated. A wehrlite analysis is given in Table VIII.

- Pipe Mine Mineralogy

The major opaque minerals in the open pit at Pipe Mine are pyrrhotite and pentlandite. The common accessory minerals are magnetite, chromite, mackinawite, violarite, cubanite and chalcopyrite. There are also minor to trace amounts of gersdorffite, nickeline, maucherite, sphalerite, goethite, rutile and graphite. The ore occurs as fine grained disseminations and medium to coarse grained massive stringers in sheared areas.

TABLE VIII ELECTRON MICROPROBE ANALYSES OF BIRCHTREE MINE SAMPLES

Pyrrhotites

Sample	Phase	Fe	Ni	S	Total
G75-B1	M	60.2 (46.4)	.6 (.5)	39.7 (53.1)	100.5
G75-B2	M	60.3 (46.6)	.3 (.2)	39.5 (53.2)	100.1
G75-B8	M	60.4 (46.0)	.9 (.6)	40.2 (53.4)	101.5
G75-B15	M	60.4 (46.5)	.4 (.3)	40.0 (53.2)	100.8
Average	M	60.3 (46.3)	.6 (.4)	39.9 (53.3)	100.8

Pentlandites

Sample	Ni	Fe	Co	S	Total
G75-B1A	36.2 (27.4)	29.1 (24.6)	.7 (.5)	34.2 (47.5)	100.2
G75-B2	33.6 (25.6)	32.1 (25.7)	1.0 (.7)	34.4 (48.0)	101.1
G75-B5	39.4 (30.5)	26.7 (21.7)	.5 (.4)	33.4 (47.4)	100.0
G75-B8	38.8 (28.4)	29.8 (24.1)	.4 (.2)	33.5 (47.3)	100.5
G75-B15	36.1 (27.8)	30.0 (24.3)	1.2 (.9)	33.3 (47.0)	100.6
Average + mpo	35.7 (27.3)	30.3 (24.7)	.8 (.6)	33.8 (47.4)	100.6
Average + py	39.4 (30.5)	26.7 (21.7)	.5 (.4)	33.4 (47.4)	100.0

Pyrites

Sample	Fe	Co	Ni	S	Total
G75-B2 Anhedral	44.5 (32.1)	1.0 (.7)	.5 (.3)	53.1 (66.9)	99.1

Cont'd

116

TABLE VIII (Cont'd - Birchtree Mine)

Euhedral	45.9 (33.0)	.4 (.2)	.6 (.4)	53.2 (66.4)	100.1
G75-B5	45.5 (32.6)	.7 (.5)	.4 (.3)	53.3 (66.6)	99.9

	Gersdorffite G75-B5	Nickeline G75-B5	Maucherite G75-B5		Wehrlite G75-B8
Ni	18.1	43.3	51.2	Bi	61.6
Co	13.3	.3	.1	Pb	3.3
Fe	5.3	.2	.0	Te	33.9
As	48.4	55.4	48.1	Sb	.4
S	16.9	.1	.1	S	.1
Sb	.0	.5	.2	AS	n.d.
Total	102.0	99.8	99.7	Total	99.3

Notes

1) Microprobe Operator: Mr. P. Carrière
2) Phase: M ----→ monoclinic
3) Atomic per cent in brackets
4) Co not detected in pyrrhotites
5) Cu in G75-B2 anhedral pyrite is .05%
6) Pyrites non-homogeneous re metals

Much of the pyrrhotite at Pipe comprises both the hexagonal and monoclinic types. The two-phase pyrrhotite in the disseminated ore is like that shown in Figure 25 for the disseminated Thompson ore. From samples across the massive sulfide ore zone on the 350' and 510' benches it appears that the outer portions of the ore body adjacent to the wall rocks contain predominantly monoclinic pyrrhotite with very minor amounts or no hexagonal pyrrhotite, whereas the central portions of the ore zone contain much larger amounts of hexagonal pyrrhotite. Figure 28 shows the two phases coexisting and it can be seen that the monoclinic phase borders silicate-filled fractures and contains pentlandite flames. In samples where both types are present, the hexagonal pyrrhotite contains more Ni (.26% average) than the monoclinic (.16% average).

Pentlandite at the Pipe Mine is either medium to coarse, fractured grains, or flames. Generally the shallower pentlandites are considerably altered along fractures to mackinawite (20-100 μ in size) and very fine violarite (< 20 μ). These fine inclusions might affect milling. The mackinawite contains $\sim$8 wt. % Ni (Table IX) but the violarite was too fine to analyze. Table IX gives a number of pentlandite analyses; note that pentlandite in coexistance with two-phase pyrrhotite averages 34.1 % Ni while pentlandite coexisting with just-monoclinic pyrrhotite has a higher average of 35.8% Ni.

Gersdorffite, often found with inclusions of nickeline and maucherite, is found as small euhedral grains in pyrrhotite. These minerals are concentrated in the massive sulfides and the associated veins.

Cubanite appears to be more abundant than chalcopyrite. Both minerals occur as anhedral grains up to a few hundred microns in size and generally in pyrrhotite, but also sometimes in pentlandite fractures.

Chromite generally occurs as cores within large euhedral overgrowths of magnetite. These grains which are up to a few millimeters in diameter are probably primary. There is also secondary magnetite which occurs as fine anhedral grains or as an asbestiform replacement. In one section goethite was replacing magnetite.

- Manibridge Mine Mineralogy

The major ore minerals in this deposit are pyrrhotite, smythite, pentlandite and pyrite with accessory phases of magnetite, violarite, chalcopyrite, marcasite, ilmenite and goethite. Most of the ore occurs as fine grained (< .5 mm) intercumulus blebs disseminated in altered peridotite. In a few places massive, coarse grained (1-3 mm) remobilized ore was observed.

Pentlandite is the primary ore mineral. It has two characteristic occurrences; as larger grains ($\sim$ .5 mm) which are often extensively altered to violarite along partings and as fine ($\sim$ 20 μ) flame-like "recrystallizations" within smythite either along fractures or at the surrounding silicate boundary (Fig. 29). It should be noted that these pentlandite recrystallizations do not have the same characteristics as the "flame-like exsolutions" often seen

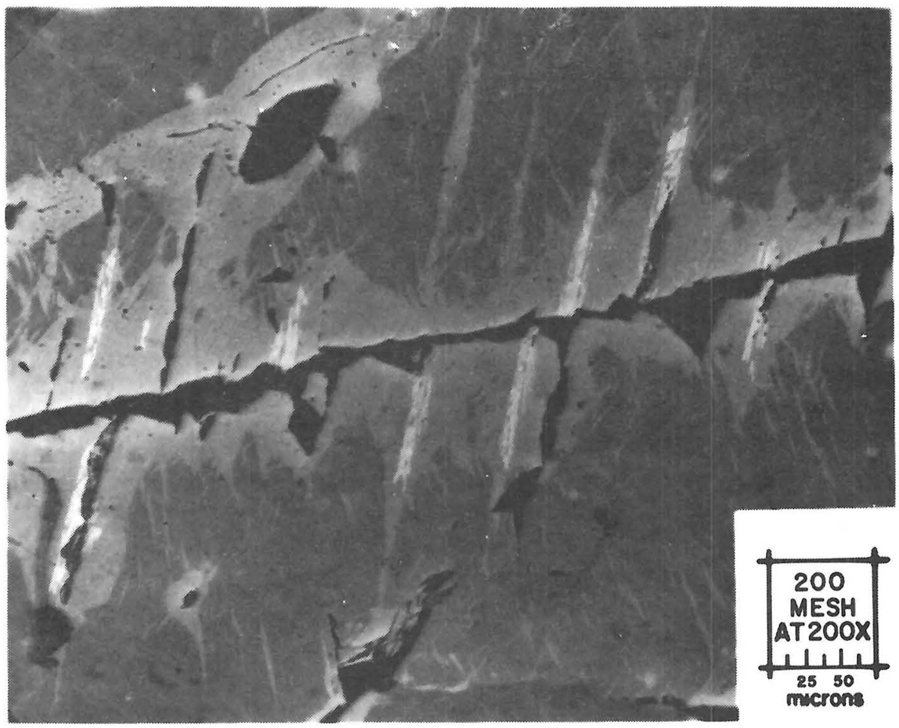

Figure 28 Photomicrograph of a Pipe Mine sample showing pentlandite flames enveloped in monoclinic pyrrhotite (light grey) adjacent to fractures (black). The monoclinic pyrrhotite is in hexagonal pyrrhotite which has a darker etch.

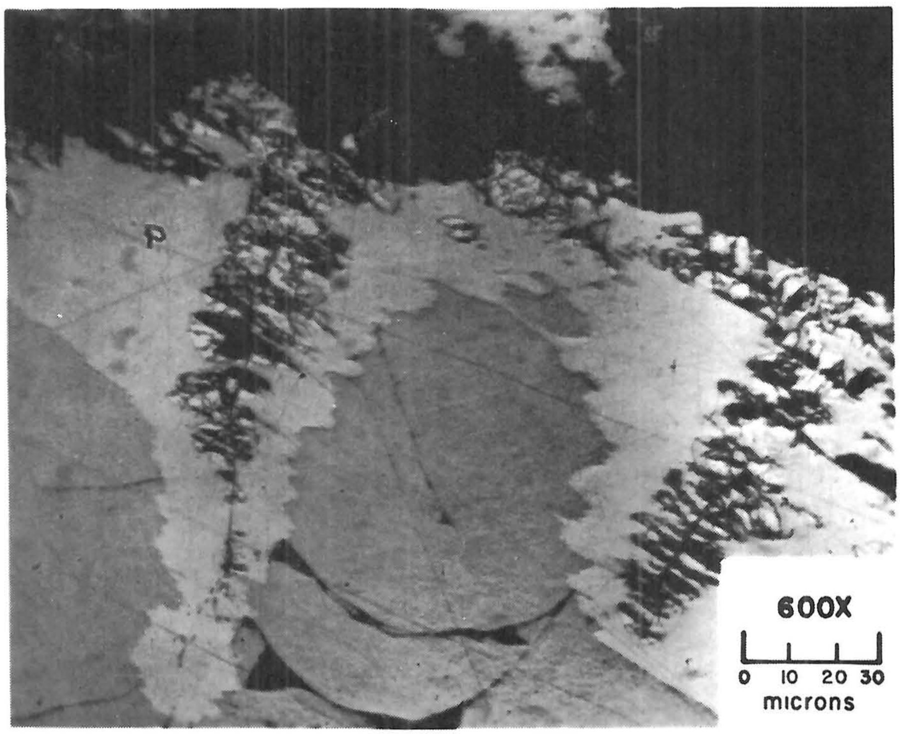

Figure 29 Photomicrograph of a Manibridge Mine sample showing smythite (light grey) replacing monoclinic pyrrhotite (dark grey). There are fine grained recrystallizations of pentlandite along fractures in the smythite. Sample is etched with HI.

120

TABLE IX ELECTRON MICROPROBE ANALYSES OF PIPE MINE SAMPLES

Pyrrhotites

Sample	Phase	Fe	Ni	S	Total
G75-P7	M	60.3 (46.6)	.1 (.1)	39.7 (53.3)	100.1
	H	61.6 (47.4)	.2 (.2)	39.1 (52.4)	100.9
G75-P8	M	61.2 (46.9)	.2 (.1)	39.8 (53.0)	101.2
	H	61.2 (47.2)	.3 (.2)	39.1 (52.6)	100.6
G75-P10	M	60.9 (46.5)	.3 (.2)	40.01 (53.3)	101.2
G75-P15	M	60.5 (46.8)	.3 (.2)	39.3 (53.0)	100.1
	H	60.2 (47.1)	.5 (.4)	38.5 (52.5)	99.2
Average	M	60.7 (46.7)	.2 (.2)	39.7 (53.1)	100.6
Average	H	61.0 (47.2)	.3 (.3)	38.9 (52.5)	100.2

Pentlandites

Sample	Ni	Fe	Co	S	Total
G75-P7	34.2 (26.3)	30.6 (24.7)	1.7 (1.3)	33.9 (47.7)	100.4
G75-P8	34.3 (26.3)	31.0 (24.9)	1.8 (1.4)	33.8 (47.4)	100.9
G75-P10	35.8 (27.5)	28.7 (23.2)	1.9 (1.4)	34.1 (47.9)	100.4
G75-P15	34.0 (26.0)	31.6 (25.4)	1.7 (1.3)	33.8 (47.3)	101.1
Average +mpo	35.8 (27.5)	28.7 (23.2)	1.9 (1.4)	34.1 (47.9)	100.5
Average +hpo+mpo	34.1 (26.2)	31.1 (25.0)	1.7 (1.3)	33.9 (47.5)	100.8

Cont'd

TABLE IX (cont'd - Pipe Mine)

Mackinawite

Sample	Fe	Ni	Co	S	Total
G75-P7	55.9 (43.9)	8.0 (5.9)	1.1 (.9)	36.2 (49.3)	101.2

Notes

1) Microprobe Operator: Mr. P. Carrière
2) Phase: M ⟶ monoclinic, H ⟶ hexagonal
3) Atomic per cent in brackets
4) Co not detected in pyrrhotites
5) Mackinawite has .02 wt % Cu

122

in monoclinic pyrrhotite. These recrystallizations are a continuous phase across the form and show partings or crystal boundaries, whereas the exsolutions are discontinuous and feather-like (Fig. 27). An analysis of an interstitial or network pentlandite and its associated phases is given in Table X. It coexists with monoclinic pyrrhotite and smythite and is Ni-rich as noted by Harris and Nickel (1972).

Pyrrhotite appears as remnants within the central portions of smythite grains and as a replacement of pyrite. The probe analyses (Table X) revealed that this is the monoclinic form and that it contains .9% Ni and no Co.

Smythite occurs as a flame-like replacement of pyrrhotite extending inward from the silicate sulfide boundary (Fig. 29). It is Ni rich (~ 2.2%) compared to the coexisting pyrrhotite.

Pyrite in the disseminated sulfides appears early-formed, the rounded anhedral grains being replaced by pyrrhotite and smythite. It is characteristically non-homogeneous in chemical composition, Co varying from 1.61 to .39 wt. % and Ni varying from .26 to .03 wt. %. In one sample of remobilized ore pyrite was slightly altered to marcasite.

Violarite occurs extensively as a secondary phase along the octahedral partings of pentlandite. Within the violarite are many fine inclusions of pyrrhotite. Great care was taken to find an area sufficiently large for a good probe analysis (Table X). It is iron rich, as noted for some violarites by Misra and Fleet (1974). The metal:sulfur ratio of 3.08:4 indicated the sample is free of pyrrhotite and pentlandite impurities.

Magnetite is ubiquitous and common. It is anhedral to asbestiform, and is probably a product of serpentinization. In some cases magnetite has been altered to goethite to a very minor extent.

Discussion and Conclusions

The major ore-bearing sulfide assemblages encountered at the Thompson, Birchtree, Pipe and Manibridge deposits are plotted on the Fe-Ni-S diagram in Figure 30. The composition of the pentlandite (averages from Tables VII to X) and its coexisting iron sulfide(s) is joined by tie lines. The assemblages with pentlandite are; (a) hexagonal pyrrhotite + monoclinic pyrrhotite ± minor pyrite, (b) monoclinic pyrrhotite ± pyrite, (c) monoclinic pyrrhotite ∓ smythite + pyrite, and (d) pyrite. Note the increasing Ni content of the pentlandite as the coexisting assemblage becomes more sulfur rich (i.e. as one proceeds from assemblage (a) to assemblage (d)). The phases violarite and mackinawite are surpergene alterations of pentlandite.

TABLE X ELECTRON MICROPROBE ANALYSES OF MANIBRIDGE MINE SAMPLES

Mineral	Fe	Ni	Co	S	Total
Pyrite	45.5 (32.6)	.1 (.1)	1.1 (.7)	53.5 (66.6)	100.2
Pentlandite	28.3 (23.0)	37.5 (28.9)	.3 (.2)	33.9 (47.9)	100.0
Violarite	30.00 (22.6)	28.4 (20.4)	.7 (.5)	43.0 (56.5)	102.1
Pyrrhotite	60.0 (46.3)	.9 (.7)	n.d. (.00)	39.5 (53.0)	100.4
Smythite	57.2 (43.7)	2.2 (1.6)	n.d. (.00)	41.1 (54.7)	100.5

Notes

1) Microprobe Operator: Mr. P. Carrière
2) Atomic per cent in brackets
3) Pyrite non-homogeneous re metals
4) Pyrrhotite is monoclinic type

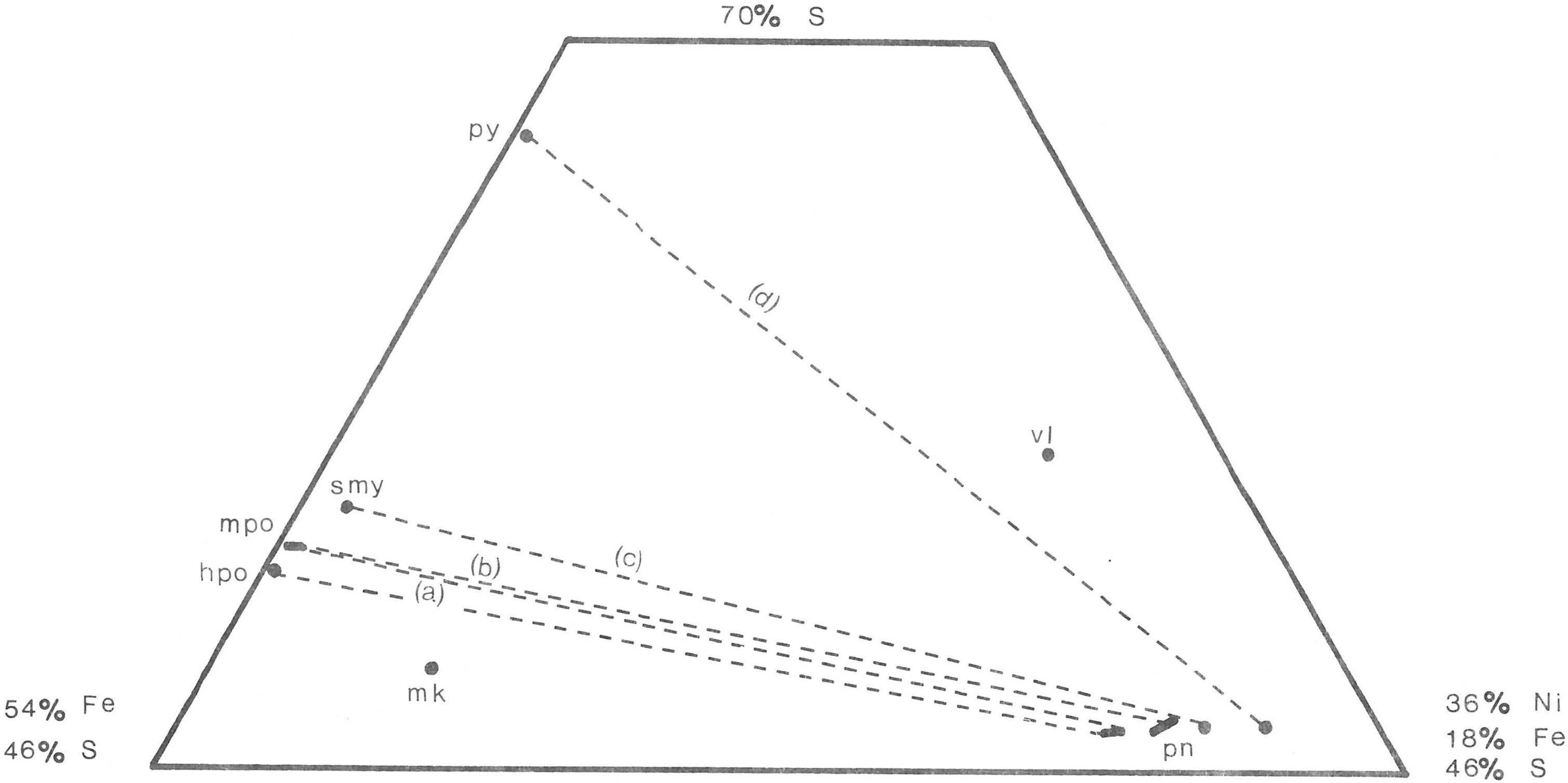

Figure 30 A portion of the Fe-Ni-S diagram showing pentlandite compositions (plotted as atomic per cent) in relation to the associated sulphide phases. Abbreviations: hpo → hexagonal pyrrhotite, mpo → monoclinic pyrrhotite, mk → mackinawite, pn → pentlandite, py → pyrite, smy → smythite.

Thompson Mine

At the Thompson Mine the major assemblage is (b) with pyrite predominant on the fold limbs and pyrrhotite predominant on fold noses. Assemblage (a) is evident in sheared zones. The assemblage hexagonal pyrrhotite + magnetite is barren of pentlandite. This series of assemblages represents continuous desulfurization from fold limb to fold nose to shear zones, possibly due to an increasing pressure gradient; i.e. as pressure increases pyrite → pyrrhotite (Toulmin and Barton, 1964) and S contents decrease with pyrrhotites (Morimoto et al., 1975).

One sample of particular interest from the Thompson Mine is G75-T37 which was kindly forwarded by Inco. This sample labelled "breccia sulfide" is shown in Figure 31. The breccia fragments are 1 to 5 cm in size, subangular to rounded and approximately equi-dimensional. In general the surface of one fragment parallels that of its neighbour and is separated by 1 - 3 mm of interbreccia material. The breccia fragments are fine grained (50-100 μ) with monoclinic pyrrhotite and pentlandite ($\sim$ 20%) as major phases and chalcopyrite, graphite and silicates as minor phases. Bordering the breccia fragments is a band .2 to 1 mm wide consisting primarily of fine grained (100-200 μ) pentlandite ($\sim$ 70%) with concentrations of graphite and some silicates. The interbreccia material is coarse grained ($\sim$ 1 mm) consisting mainly of hexagonal and monoclinic pyrrhotite and pentlandite. There are grains of pentlandite as well as exsolved flames in the coarse monoclinic pyrrhotite. Like the breccia fragments, there are blebs of chalcopyrite, and the graphite is well crystallized in the silicates. Chemical analyses are presented in Table VII and a photomicrograph in Figure 32.

The breccia sulfide sample described above might represent a hand specimen of a major geological event undergone in the Thompson deposit. On the basis of textural relations of adjacent breccia fragments I would discount a hypothesis of two phases or ore deposition in this locale. The initial fine grained sulfide assemblage, monoclinic pyrrhotite $\pm$ (pyrite) $\pm$ pentlandite, was possibly derived from a basic intrusion which is in limited evidence at the location of this sample and in other parts of the mine. The ore could have been hydrothermally emplaced along a permeable sedimentary formation now represented by the biotite schist. The graphite observed in the ore samples would be formed by crystallizing the carbon derived from the sediments. Later the deposit underwent regional metamorphism, the effects of which have been to remobilize the sulfides, resulting in a coarse grained assemblage as seen in the interbreccia zone of the sample described, and in fold noses. Where the two-phase pyrrhotite persists the Ni content in the pentlandite is lower, the excess Ni is absorbed by hexagonal pyrrhotite, keeping a constant bulk composition.

Birchtree Mine

The Birchtree Mine has a mineralogy similar to that of the Thompson Mine. The major assemblage is (b) in Figure 30 with one observed area of assemblage (d) on a fold limb. The finer grained assemblage (d), pyrite + pentlandite, may represent the primary phases. Upon regional metamorphism resulting in

Figure 31 Photograph of Thompson Mine "breccia sulphide". Sample size 18 x 12 cm.

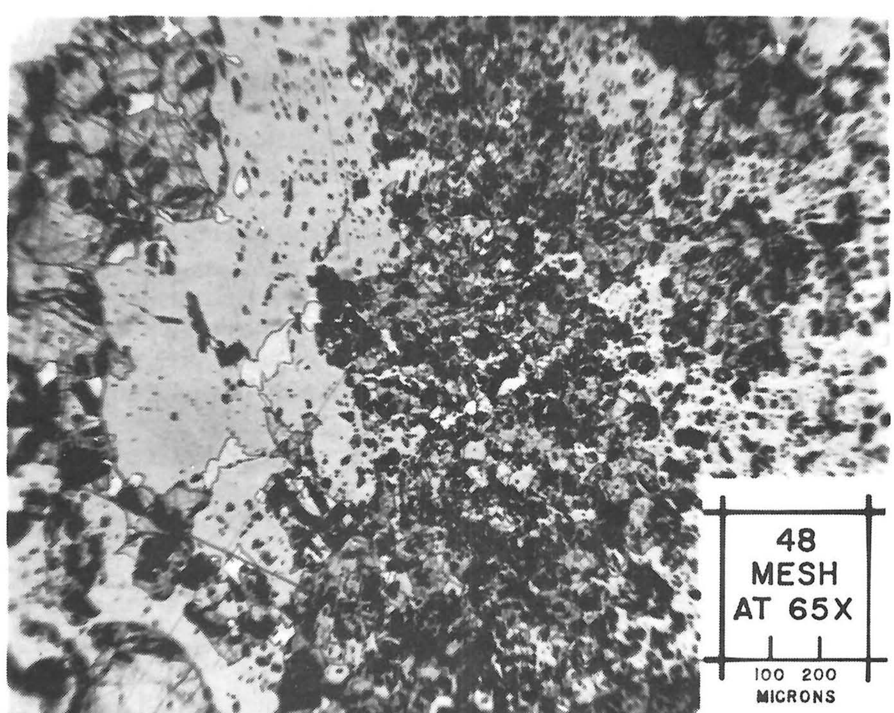

Figure 32 Photomicrograph of Thompson Mine "breccia sulphide" sample. Fine grained breccia material to the right, pentlandite border zone center and coarse, interbreccia pyrrhotite and pentlandite to the left.

remobilized sulfides and desulfurization, as described for the Thompson deposits, the monoclinic pyrrhotite + pyrite + pentlandite assemblage (b) stablizes. Extensive flame structure pentlandite might be evidence of a retrograde transition of hexagonal pyrrhotite to monoclinic pyrrhotite exsolving excess Ni as pentlandite flames. The secondary pyrite, in silicates, (described previously) may have formed from the excess sulfur derived from the desulfurization reaction.

Pipe Mine

The major ore assemblage at the Pipe Mine is (a) in Figure 30, hexagonal pyrrhotite + monoclinic pyrrhotite + pentlandite. The distribution of the pyrrhotite phases, described earlier, points to an oxidation reaction. Taylor (1971) showed that at lower temperatures ($T=250^{\circ}C$) hexagonal pyrrhotite could be converted to the monoclinic type by oxidation. As the distribution of monoclinic pyrrhotite is controlled by the fracture system in the massive ore zone, it could be a result of oxidation by a hydrous fluid. The conversion of Ni-rich hexagonal pyrrhotite to monoclinic results in exsolved pentlandite flames. Further evidence of hydrothermal action is the alteration of pentlandite to mackinawite plus minor violarite and minor alteration of magnetite to goethite.

Manibridge Mine

The primary sulfide assemblage at the Manibridge Mine appears to have been pentlandite + pyrite + monoclinic pyrrhotite, assemblage (b) in Figure 30. The secondary assemblage (c) consists of smythite + pyrite + monoclinic pyrrhotite + pentlandite + violarite. It is probable that this secondary assemblage is a result of oxidation by an aqueous solution giving rise to the reactions: monoclinic pyrrhotite → smythite and pentlandite → violarite + pyrrhotite. This solution might also have provided a transport medium for Ni ions released during serpentinization of Ni-bearing olivine and/or released during the formation of violarite. The secondary flame-like pentlandite, on smythite grains (Fig. 29), could represent the recrystallization of freed Ni ions.

Recommendations

In continuing the investigation of the Ni deposits it would be of interest to study the following:

(1) Compositions of coexisting oxides.
(2) Coexisting silicate phases.
(3) Microscopic investigation of heavy mineral concentrates to look for precious metal phases.
(4) Trace element geochemistry of ore-associated and barren pyrrhotites.

128

II. The Flin Flon - Snow Lake - Lynn Lake Area.

Introduction

In the Flin Flon, Snow Lake and Lynn Lake Areas eleven massive copper-zinc deposits plus one nickel-copper deposit (Lynn Lake) were visited in August, 1975. In Appendix I the mines visited and the numbers of located samples collected are listed.

The following report contains brief descriptions of the ore mineralogy for each mine, and the results are summarized in Table XI. The methods of investigation are described in Appendix II.

Mineralogical Investigation

Flin Flon Mine Mineralogy

The major ore minerals in the Flin Flon Mine are pyrite, chalcopyrite and sphalerite, with minor amounts of arsenopyrite, galena, altaite, marcasite, ilmenite, and magnetite. The sulfides are generally fine grained (.1-.2 mm), massive to network, but some coarser grained (.1 to .4 mm) massive ore is also present.

Pyrite is the most abundant sulfide. It is euhedral in silicates and sphalerite and rounded, subhedral in chalcopyrite. In the coarser grained samples pyrite aggregates are evident.

Chalcopyrite and sphalerite are interstitial and massive amongst pyrite grains. Chalcopyrite is also seen as blebs (20 μ) in sphalerite and as blebs, often with pyrrhotite, in pyrite. In general chalcopyrite is concentrated toward the footwall and sphalerite toward the hanging wall.

Pyrrhotite is of minor importance and is usually only seen as larger grains in the coarser grained massive material where it is two-phase (hexagonal + monoclinic). Where it occurs as blebs in pyrite, or fine grained disseminations, it is monoclinic.

Arsenopyrite has two forms: (a) anhedral fine grained replacement of pyrite, (b) coarse grained euhedral crystals coexisting with coarse altaite and galena. Form (a) is more usual but an analysis of form (b) is given in Table XII with its associated altaite analysis. The altaite is Se-bearing (Table XII), containing more Se than the Se-bearing altaite from Sudbury (Cabri and Laflamme, 1976).

Centennial Mine Mineralogy

From the one cross-section sampled in the Centennial Mine, it appears that pyrite, chalcopyrite and sphalerite are the main sulfides, with minor amounts of magnetite and arsenopyrite. The ore minerals in general are fine grained (.05 - .2 mm) and banded.

TABLE XI FLIN FLON - SNOW LAKE - LYNN LAKE AREA MINES

Mine	Major Ore Minerals	Minor Ore Minerals	Major Host Rock
Flin Flon	pyrite, chalcopyrite, sphalerite	pyrrhotite, arsenopyrite, galena, altaite, marcasite, magnetite, ilmenite	chlorite-sericite schist
Centennial	pyrite, chalcopyrite, sphalerite	magnetite, arsenopyrite	chlorite-sericite schist
Schist Lake	pyrite, chalcopyrite, sphalerite	arsenopyrite, galena	chlorite schist
White Lake	pyrite, pyrrhotite, chalcopyrite, sphalerite	galena, arsenopyrite	chlorite-sericite schist
Dickstone	pyrrhotite, chalcopyrite, magnetite	pyrite, sphalerite, wehrlite	
Stall Lake	pyrrhotite, pyrite, chalcopyrite, sphalerite	magnetite, ilmenite	hornblende gneiss
Anderson Lake	pyrite, chalcopyrite, pyrrhotite	sphalerite, magnetite	staurolite-garnet-cordierite gneiss
Osborne Lake	pyrrhotite, pyrite, chalcopyrite	sphalerite, arsenopyrite, galena, marcasite, rutile	hornblende-biotite gneiss
Chisel Lake	pyrite, sphalerite, chalcopyrite, pyrrhotite	galena, arsenopyrite, rutile, tetrahedrite, marcasite	staurolite-garnet gneiss
Fox	pyrrhotite, pyrite sphalerite, chalcopyrite	ilmenite, magnetite arsenopyrite	hornblende-biotite gneiss

TABLE XI (cont'd - Flin Flon - Snow Lake - Lynn Lake Area Mines)

Ruttan Lake	pyrite, chalcopyrite, sphalerite	ilmenite, pyrrhotite, arsenopyrite, galena, rutile, magnetite	amphibolite
Lynn Lake	pyrrhotite, pentlandite, chalcopyrite	magnetite, pyrite, marcasite, ilmenite	peridotite

Notes:

(1) Minerals are listed in decreasing order of abundance as viewed in polished sections.

(2) Lynn Lake Mine is not classified as a massive copper-zinc deposit.

130

TABLE XII ELECTRON MICROPROBE ANALYSES OF FLIN FLON, DICKSTONE AND OSBORNE LAKE MINE SAMPLES

Pyrrhotites

Sample	Phase	Fe	S	Total
G75-D3	M	60.9	39.9	100.8
		(46.7)	(53.3)	
	H	61.3	39.1	100.4
		(47.4)	(52.6)	
G75-D7	M	60.6	40.0	100.6
		(46.5)	(53.5)	
		61.6	39.2	100.8
		(47.4)	(52.6)	
G75-OS3	M	61.1	40.0	101.1
		(46.8)	(53.2)	
		61.5	39.3	100.8
		(47.3)	(52.7)	
G75-OS8	M	61.0	39.7	100.7
		(46.9)	(53.1)	
		61.7	39.0	100.7
		(47.5)	(52.5)	
G75-OS14	M	60.9	40.5	101.4
		(46.3)	(53.7)	
		61.2	39.0	100.2
		(47.4)	(52.6)	
Average	M	60.9	40.0	100.9
		(46.6)	(53.4)	
Average	H	61.5	39.1	100.6
		(47.4)	(52.6)	

Arsenopyrites

	G75-FF24	G75-S15
Fe	33.8	34.5
Co	1.5	.0
As	43.9	45.5
S	20.9	20.1
Total	100.1	100.1

Altaite

	G75-FF24
Pb	63.4
Bi	n.d.
Te	32.7
Se	2.4
Total	98.5

Dickstone "Burned Ore" G75-D10

	Troilite (av. 5 analyses)		Yellow (av. 5 analyses)		Orange	
Fe	63.4	(49.6)	37.2	(30.8)	20.3	(17.7)
Cu	1.0	(.7)	28.6	(20.9)	49.2	(37.8)
Zn	----	----	1.0	(.7)	----	----
S	36.5	(49.8)	32.9	(47.6)	29.2	(44.5)
Total	100.9		99.7		98.7	

132

TABLE XII (cont'd - Flin Flon, Dickstone and Osborne Lake Mines).

Notes:

(1) Microprobe Operator: Mr. P. Carrière

(2) Atomic percent in brackets

(3) Pyrrhotites: Cu, Co, Ni not detected

(4) Arsenopyrites: Cu, Sb, Ni not detected

Pyrite is generally fine grained and euhedral, but there is some evidence of a porphyroblastic pyrite where grains are larger, and subhedral to anhedral. In two samples anhedral arsenopyrite forms a fine grained, vein-like replacement across pyrite grains.

Chalcopyrite and sphalerite have no apparent zonal distribution with respect to the hanging wall/footwall rocks, in the polished sections examined. They are banded with pyrite, pyrite being subhedral when either chalcopyrite or sphalerite is the major phase.

Magnetite occurs as fine grained (~50 μ), subhedral disseminations in silicates at the hanging wall (stratigraphic footwall) contact.

Schist Lake Mine Mineralogy

The major ore minerals at the Schist Lake Mine are pyrite, chalcopyrite and sphalerite, with accessory minerals arsenopyrite and galena. There are three major sulfide textures; disseminated, stringer and massive. The sulfides are fine grained (.05 - .2 mm) with some porphyroblastic pyrites. Some of the massive ore is banded.

Pyrite is fine grained and euhedral in the disseminated ore where it occurs with only minor amounts of chalcopyrite and sphalerite. In the massive ore, pyrite is coarser grained and subhedral, many of the grains having an aggregate texture (Figure 33).

As in the Flin Flon deposit chalcopyrite is generally concentrated toward the footwall and sphalerite toward the hanging wall. Chalcopyrite and sphalerite are interstitial amongst pyrite grains except in the banded ore where there are bands with very minor pyrite. In the North Zone and Mandy there are greater concentrations of chalcopyrite stringer ore.

In Table XII there is a probe analysis of the arsenopyrite replacing pyrite along a fracture.

White Lake Mine Mineralogy

The major sulfide minerals in the White Lake deposit are pyrite, pyrrhotite, chalcopyrite and sphalerite, with minor amounts of galena and arsenopyrite. The sulfides range from fine to coarse grained (.1 to .3+ mm) and are generally massive, but some disseminated and stringer ore was noted.

Pyrite and pyrrhotite occur in approximately equal proportions. The White Lake Mine represents the only deposit in this study of the Flin Flon Area where pyrrhotite is a major phase. Pyrite is generally medium grained, subhedral in form, and sometimes seen with zoned inclusions of silicates. There is also a second form of pyrite as fine grained euhedral crystals in veins. The pyrrhotite is two-phase, monoclinic plus hexagonal, as shown in Figure 34 for the Dickstone Mine.

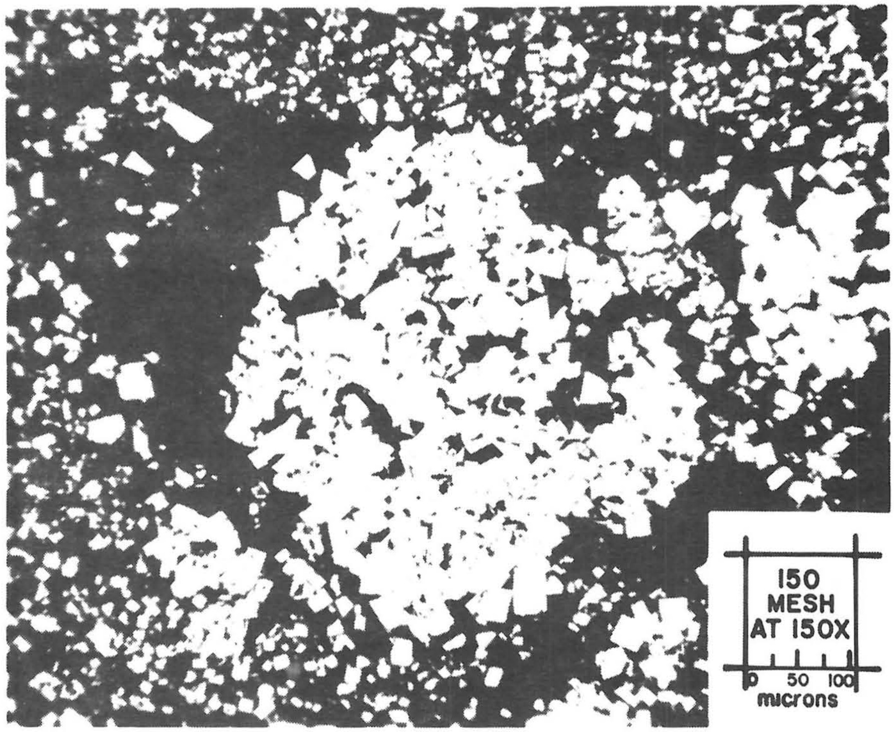

Figure 33 Photomicrograph of a pyrite agglomerate within fine grained disseminated pyrite. Schist Lake Mine sample.

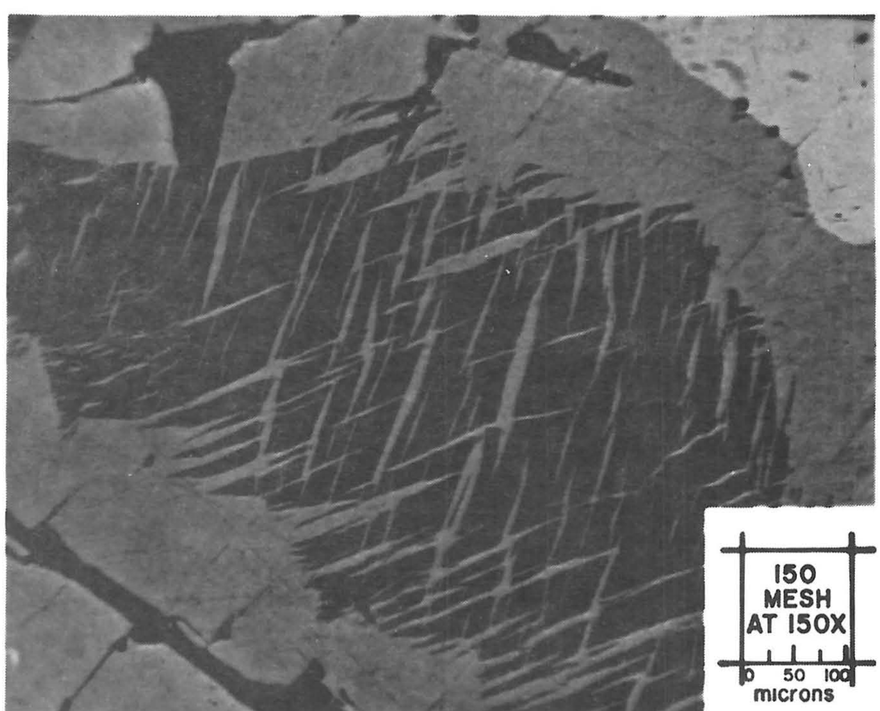

Figure 34 Photomicrograph of a Dickstone Mine sample showing the textural relationships of hexagonal pyrrhotite (dark grey) to monoclinic pyrrhotite (light grey). Sample is etched with HI.

Chalcopyrite and sphalerite are massive and interstitial amongst pyrite and pyrrhotite; banding is sometimes evident.

Galena is minor but is more evident than in the mines described previously Arsenopyrite forms an anhedral replacement of pyrite, as well as coarser discrete euhedral grains.

Dickstone Mine Mineralogy

The No. 1 orebody at the Dickstone Mine is primarily pyrrhotite and chalcopyrite with a considerable concentration of magnetite and minor amounts of pyrite, sphalerite and wehrlite. The sulfides are massive and coarse grained (0.2 to 1.+ mm).

Pyrrhotite is two-phased (hexagonal plus monoclinic) with the characteristic exsolution texture shown in Figure 34. Analyses of some Dickstone Mine pyrrhotites are given in Table XII. The high pyrrhotite concentration in this mine has given rise to ore heating problems. It should be noted that although pyrrhotite oxidizes more readily than pyrite other factors must be considered for this type of heating problem; i.e. amount of water in the mine, pH of water, bacteria content and grain size of sulfides. A sample of the heated ore is described in the summary section.

The chalcopyrite is massive, often pitted and containing blebs of sphalerite.

Magnetite is very common, occuring in large rounded grains with a good cleavage.

Stall Lake Mine Mineralogy

The main ore minerals at the Stall Lake Mine are pyrrhotite, pyrite, chalcopyrite and sphalerite with minor amounts of magnetite and ilmenite. Sulfides are massive and coarse grained with pyrites up to 20 cm across.

The pyrrhotite is primarily the hexagonal type with lesser amounts of monoclinic along fractures and adjacent to silicates.

Pyrite is usually large euhedral crystals, with some rounding in massive chalcopyrite.

Magnetite generally forms large subhedral crystals, often with inclusions of pyrite, pyrrhotite or ilmenite.

Anderson Lake Mine

The Anderson Lake ore deposit is comprised mainly of pyrite, chalcopyrite and pyrrhotite with minor amounts of sphalerite and magnetite. The ore is medium to coarse grained (.02 to 1+ mm) with some large porphyroblasts like the Stall Lake deposit.

136

Pyrite is far more abundant than pyrrhotite. Pyrite crystals are euhedral to subhedral. Pyrrhotite, where observed, is interstitial to pyrite, and is two phase (hexagonal being minor compared to the monoclinic type).

Chalcopyrite is interstitial amongst pyrite, or occurs as blebs in pyrite or silicates.

Magnetite grains are anhedral and show prominent cleavage.

Osborne Lake Mine

The major ore minerals in the Osborne Lake Mine are pyrrhotite, pyrite, chalcopyrite and sphalerite, with minor amounts of arsenopyrite, galena, marcasite, and rutile. The ore is coarse grained, massive, with large porphyroblasts.

The pyrrhotite is two-phase, usually with approximately equal proportions of hexagonal and exsolved monoclinic. The pyrrhotite in this deposit has also resulted in minor ore heating problems. One area within the mine has massive coarse grained hexagonal pyrrhotite with only very minor monoclinic type along fractures (analysis G75-OS8); this particular ore does not heat up. Under the discussion section the products of heating are briefly reviewed. Marcasite and arsenopyrite occur as minor replacements of pyrrhotite.

Pyrite is medium to coarse grained, subhedral to euhedral crystals. The crystals are rounded when in a chalcopyrite matrix.

Chisel Lake Mine

The major ore minerals in the Chisel Lake Mine are pyrite and sphalerite, with lesser amounts of chalcopyrite, pyrrhotite and galena and minor amounts of arsenopyrite, tetrahedrite, marcasite and rutile. The sulfides are very coarse grained and massive. Unlike the deposits described previously, the major product of Chisel Lake Mine is zinc, not copper.

Pyrite grains, a few mm in size, are usually rounded. The sphalerite is interstitial to pyrite in very coarse grained massive material.

Galena and tetrahedrite occur as blebs in massive sphalerite. The tetrahedrite has Ag in solid solution. Arsenopyrite, usually associated with galena, is medium grained and euhedral in form.

Fox Lake Mine

The major phases at the Fox Lake Mine are pyrrhotite, pyrite, sphalerite and chalcopyrite, with minor amounts of ilmenite, magnetite and arsenopyrite. The ore consists of fine to medium grained disseminated and coarse grained massive sulfides.

Pyrrhotite and pyrite are the main sulfides and they occur in varying proportions. Pyrrhotite is two-phase with a predominance of the hexagonal type compared to the exsolved monoclinic type. Pyrite is subhedral to euhedral with sharp pyrrhotite/pyrite boundaries.

Sphalerite and chalcopyrite are interstitial with sphalerite more abundant.

Magnetite and arsenopyrite are minor. Magnetite forms anhedral grains while arsenopyrite forms euhedral crystals.

Ruttan Lake Mine

The major ore minerals in the Ruttan Lake Mine are pyrite, chalcopyrite, and sphalerite, with lesser to minor amounts of ilmenite, pyrrhotite, arsenopyrite, galena, rutile and magnetite. The ore consists of fine to coarse grained disseminated and coarse grained massive sulfides.

Pyrite in the disseminated ore is euhedral but in the massive ore it forms anhedral aggregates. Rarely arsenopyrite replaces pyrite. Pyrrhotite, where observed, is with pyrite and it is two-phase (hexagonal plus monoclinic).

Chalcopyrite and sphalerite are interstitial in pyrite, usually in small amounts.

Ilmenite needles and blebs are fairly common, often occurring with lesser amounts of magnetite and rutile.

Lynn Lake Mine

The Lynn Lake Mine is a major producer of nickel, as well as copper. The major ore minerals are pyrrhotite, pentlandite, and chalcopyrite, with lesser to minor amounts of magnetite, pyrite, marcasite and ilmenite. The sulfides are medium to coarse grained, disseminated to massive.

Pyrrhotite is the major sulfide. It is the monoclinic type and is often pitted.

Pentlandite is present as discrete grains and flame-like exsolutions which are often along fractures. Coexisting with pentlandite is chalcopyrite in lesser amounts.

Pyrite is usually anhedral, often being replaced by marcasite.

Magnetite is generally anhedral, sometimes associated with minor amounts of ilmenite.

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

The above mineralogical descriptions, based on routine ore microscopy, represent the initial phase of this project's investigation in the copper-zinc deposits. Some electron microprobe analyses have been completed and they are

138

presented in Table XII. Continued study of the following minerals might help interpret the genesis of these deposits.

(1) Pyrrhotite:
  a) presence or absence in deposit
  b) textural relationships with other sulfide phases
  c) composition(s) of phase(s)
  d) correlation of Fe atomic percent with metamorphic grade
  e) trace element geochemistry of barren and ore-associated pyrrhotites

(2) Pyrite:
  a) zonal distribution of Co, Ni, Cu (if present) and its correlation to pyrite genesis

(3) Sphalerite:
  a) composition and homogeneity index correlated with geological environment
  b) geobarometer

(4) Arsenopyrite:
  a) comparison of composition, cell dimensions, form and homogeneity index with geological environment
  b) As:S geobarometer

Although the above minerals are not always major phases, they are ubiquitous and could thus be used in comparisons of a wide range of geological environments.

Pyrrhotite

Pyrrhotite from the massive Cu (±Zn) deposits is invariably two-phase upon etching. From the Dickstone and Osborne Lake samples already analyzed it appears that the two phases are: a) hexagonal (dark etch) with an average of 47.42 atomic % Fe, and 2) monoclinic (light etch) with an average of 46.63 atomic % Fe. Cu, Co and Ni were not detected by the electron microprobe and are thus less than .03 wt. %.

The textural relationship between the two pyrrhotite phases is consistent for all deposits investigated. It is typically that shown in Figure 34, a hexagonal core surrounded and crosscut (crosscut intersections $\sim 120^{\circ}$) by monoclinic. This texture is one probably caused by crystallographic inversion due to a change in physical parameters, i.e. a lowering of temperature and/or pressure, to invert the hexagonal structure to the monoclinic structure. It should be noted that the texture just described is not like that of Figure 35 for the massive pyrrhotite at Osborne Lake Mine, or that of Figure 28 for the Pipe Mine, which is more typical for the Ni deposits. This texture, where the monoclinic pyrrhotite parallels fractures and silicate boundaries, is probably controlled by changes in chemical parameters; i.e. oxidation or desulfurization of the hexagonal phase resulting in the monoclinic phase.

The Dickstone and Osborne Lake Mines have had problems with ore heating, with the high concentrations of pyrrhotite. The ore that was heating at Osborne,

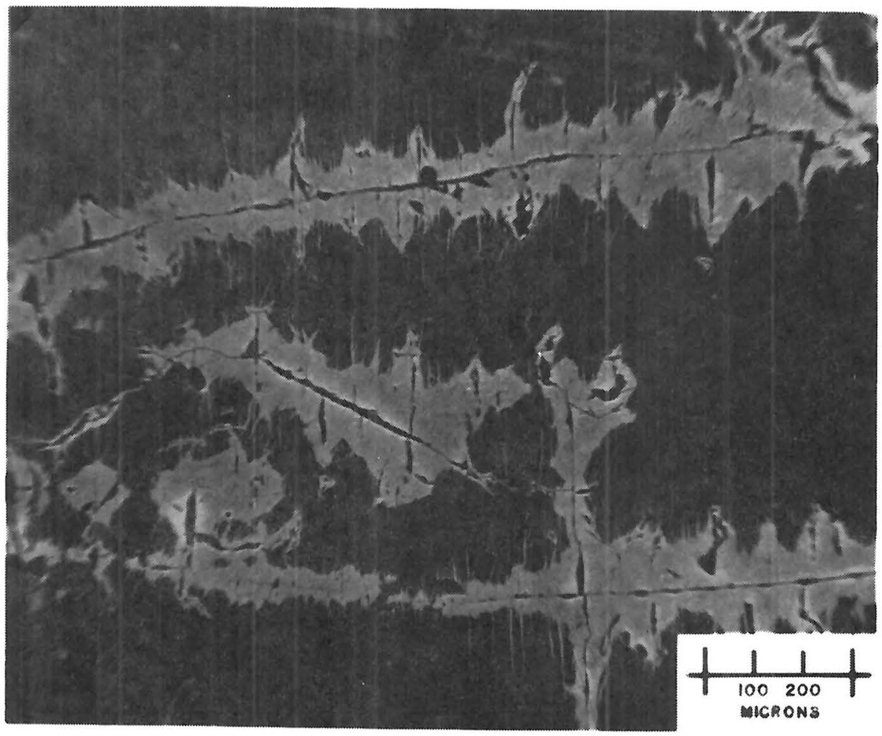

Figure 35 Photomicrograph of a sample of massive hexagonal pyrrhotite (dark etch) with monoclinic pyrrhotite (light etch) localized along fractures. Osborne Lake Mine.

140

and dumped, is a good example of Taylor's (1971) low temperature oxidation series; hexagonal pyrrhotite → monoclinic pyrrhotite → pyrite → geothite. For the Dickstone ore these oxidation reactions are probably realized, but no evidence has been seen of them being due to self-combustion of the ore. The resulting "burnt ore" is shown in Figure 36, with a corresponding photomicrograph in Figure 37. The combustion in air gives rise to a series of desulfurization reactions:

(1) chalcopyrite + O_2 $\xrightarrow{\text{heat}}$ bornite + yellow phase + magnetite + $SO_2\uparrow$

(2) pyrrhotite + O_2 $\xrightarrow{\text{heat}}$ troilite + magnetite+$SO_2\uparrow$

In Table IX the analysis labelled "yellow" has a formula $(Fe_{2.59}\ Cu_{1.76}\ Zn_{.06})\ S_4$ which is similar to haycockite; but unlike haycockite the X-ray powder pattern appears to be cubic with a = 5.305(2)A. Unfortunately the quality of the pattern does not permit a more detailed interpretation at this time. The phase labelled "orange" is most likely an admixture of bornite and "yellow", similar to that described as orange bornite by Satapeva et al. (1974).

Arsenopyrite

Two arsenopyrite analyses have been completed and are presented in Table XII. The arsenopyrite from Flin Flon Mine is euhedral, coarse grained (∿ 250 μ) and coexisting with pyrite. The Schist Lake Mine arsenopyrite forms a fine grained (∿ 40 μ), anhedral replacement of pyrite. The Schist Lake arsenopyrite is notably lower in Co and higher in As than the Flin Flon arsenopyrite.

These arsenopyrite samples were chosen from mines with similar host rocks (chlorite schist) and hence probably similar metamorphic histories. The evident difference in the As:S ratio for these two samples could bring serious doubts to Clark's (1960) arsenopyrite geothermometer/geobarometer, which is based on this ratio. It is apparent from these very limited results that there are several factors that must be considered when choosing arsenopyrites for geological interpretations.

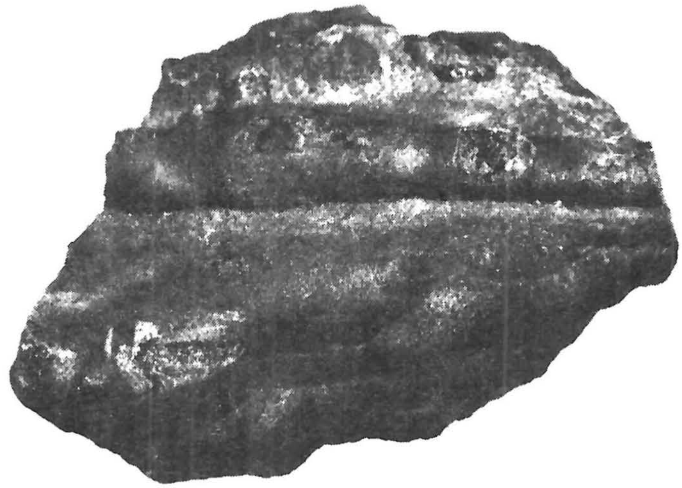

Figure 36 Photograph of a lump of Dickstone Mine "burnt ore". Sample size 4 x 2.5 cm.

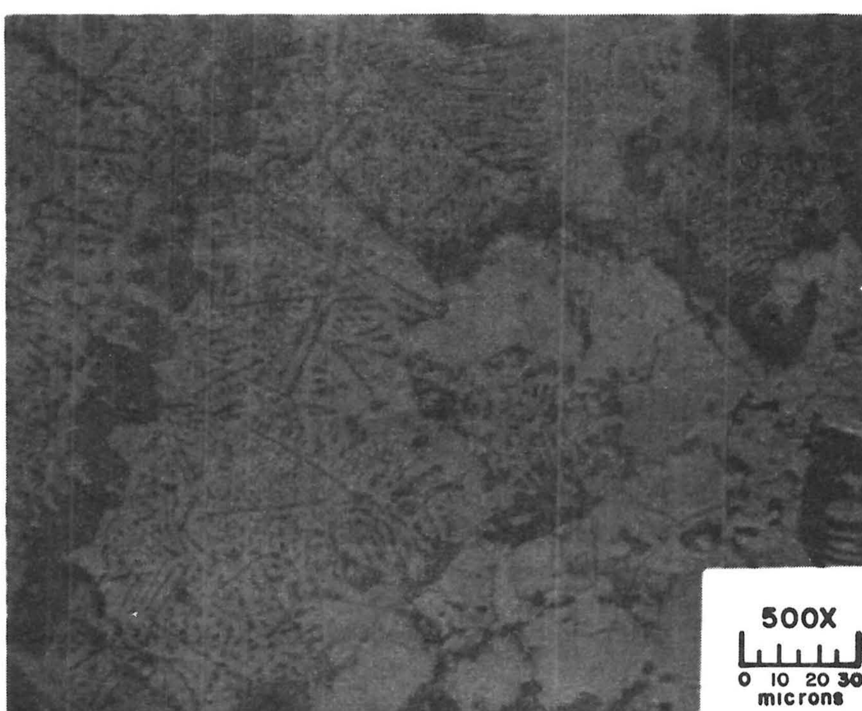

Figure 37 Photomicrograph of the Dickstone Mine "burnt ore" showing the fine intergrowth of magnetite (dark grey) and troilite (light grey).

142

ACKNOWLEDGMENTS

As the Non-renewable Resources Evaluation Program (NREP) is jointly sponsored by the Federal and Provincial Governments, and requires the co-operation of all the mining companies operating mines within Manitoba, it would be practically impossible to acknowledge individually all those who have contributed to this portion of the project.

The author would like to extend his personal thanks to the following individuals who organized mine tours and in many instances provided additional samples: Mr. L Thompson and Mr. P. Rush of International Nickel Company of Canada Limited; Mr. P. Green of Falconbridge Nickel Mines Limited; Mr. P. Deveaux, Mr. M. Smith and Mr. F. Bill of Hudson Bay Mining and Smelting Company Limited; and Mr. A. DeCarle of Sherritt Gordon Mines Limited.

The advice and technical assistance of the CANMET staff was greatly appreciated. In particular I would like to thank Mr. P. Bélanger for the X-ray identifications, Mr. Y. Bourgoin for the polished sections and mineral separations, and Mr. P. Carrière for the probe analyses and photomicrographs.

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APPENDIX I. SAMPLE COLLECTION OF THE BASE METAL DEPOSITS IN THE THOMPSON, SNOW LAKE, FLIN FLON AND LYNN LAKE AREAS

Mine	Company	Date visited	No. of Samples
Thompson	Inco	07/22-23	37
Birchtree	Inco	07/24	15
Pipe	Inco	07/25	16
Manibridge	Falconbridge	07/28	13
Schist Lake	HBMS	07/30	26
Flin Flon	HBMS	07/31	24
Dickstone	(HBMS +)	08/01	9
White Lake	HBMS	08/05	10
Centennial	HBMS	08/05	6
Stall Lake	HBMS	08/07	14
Anderson Lake	HBMS	08/07	6
Osborne Lake	HBMS	08/08	14
Chisel Lake	HBMS	08/08	9
Farley	Sherritt Gordon	08/12	11
Fox Lake	Sherritt Gordon	08/13	17
Ruttan Lake	Sherritt Gordon	08/14	14

APPENDIX II. METHOD OF INVESTIGATION

Polished sections were prepared of selected pieces of each sample collected in the mines. These were studied under an ore microscope to identify the opaque minerals and to study their textures and grain sizes. Phases that could not be identified by their optics alone were dug out for powder X-ray analysis or were analyzed for their major elements by energy dispersive techniques on the electron microprobe.

Samples containing pyrrhotite were etched with pure hydriodic acid (HI) for 15 to 30 seconds. This etch delineates the different polymorphs of pyrrhotite, since the hexagonal phase etches more readily than the monoclinic phase, as verified by electron microprobe analyses. The discrepancies found in the literature as to which dimorph etches more readily are probably due to the fact that changes in crystallographic orientation also alter the degree of etching. Grains cut perpendicular to the c-axis etch less than those cut oblique to the c-axis, due to the alternating layers of Fe and S atoms perpendicular to the c-axis. In some fine grained samples a chromic acid stain (Gaudin, 1935) was used to enhance pentlandite as well as the pyrrhotite phases.

All mineral compositions reported here were obtained by electron microprobe analyses. The analyses were done by Mr. P. Carrière using a Materials Analysis Company Model 400 electron microprobe. Each analysis shown is an average of ten spot analyses made on different grains where possible. Ten second counts were taken except when analyzing for precious metals, where the techniques described by Cabri and Laflamme (1976) were used. Using 100 second counts, the minimum detection limits for the precious metals were: .03% for Pt, .02% for Pd and .07% for Rh. Synthetic standards close to the composition of the mineral being analyzed were used wherever possible.

NM 7511 MINERAL ECONOMIC STUDIES - by L. Skinner and R. Bagnall

Mineral Production Analysis

During the 1975-76 project year only a limited amount of research was allotted to this project due to the commitments on Provincial and internal studies.

During this time attempts were made to collect and analyze historical data on production by the present producing mining companies. Difficulties were encountered in this data collection since companies such as Inco and Falconbridge publish data on total company production and do not separate out in detail their Manitoba operations. Historical production information on Sherritt Gordon and Hudson Bay, on a mine by mine basis, is available and is summarized in Tables XIII and XIV.

Historical data on employment, on a mine by mine basis, have been collected, with emphasis on those mines on which the mining communities of Flin Flon, Lynn Lake, Leaf Rapids and Thompson depend for their existence. Communities such as Wabowden and Lac du Bonnet are also included in the analysis. Tables XV and XVI summarize historical employment levels of Manitoba's mining industry.

Meaningful analysis of such parameters of a "life indexing" model as reserves, extensions, depletion rates, mine by mine production forecasts and the socio-economic consequences of future mineral development will have to await data generated by the individual commodity geologists.

Economic Exploitability of Mineral Resources

This project was undertaken by R. Cairns from about June 1975 until his departure in September 1975.

Activity in this period involved establishing various contacts to obtain capital and operating costs which would be used in a computer model. The model to be used is one developed at The Pennsylvania State University. The release of the Penn State model is awaiting authorization from The U.S. Bureau of Mines, Washington. This is expected in June or July of 1976. Parallel to this, a computer model for economic evaluation of a mineral deposit (using the Monte Carlo technique) is being developed by A. Azis of Mineral Development Sector, EMR, Ottawa. This model is now operating for Ontario and should be ready for Manitoba application later this year.

No further work was done on the project until March 1976 when it was undertaken by Robin Bagnall. The Penn State model was still not available, so work began on a model that might be applicable to Manitoba. During March, a computer program was developed to calculate and minimize royalties as they would apply to a project subject to assessment under the Metallic Minerals Royalty Act.

This will become part of a program to (1) calculate [and minimize] income taxes on a project; (2) calculate profits on a project, and (3) calculate cash flows and the IRR. The program may eventually be developed to the point where it would calculate the optimum size of project for development of an ore body.

TABLE XIII SHERRITT GORDON MINES LTD. - PRODUCTION 1953-1975

YEAR	TONS MILLED	% Ni*	% Cu*
Lynn Lake Mine			
1953	13,324	1.36	0.58
1954	557,589	1.94	0.82
1955	761,584		
1956	749,506		
1957	833,443		
1958	892,423		
1959	988,541		
1960	1,151,419		
1961	1,219,157		
1962	1,262,502		
1963	1,346,192		
1964	1,362,693		
1965	1,363,583		
1966	1,205,318		
1967	1,071,490		
1968	1,276,517		
1969	1,258,193	0.84	0.55
1970	1,090,000	0.77	0.51
1971	1,158,000	0.66	0.41
1972	995,000	0.67	0.38
1973	676,000	0.84	0.39
1974	432,000	0.87	0.43
1975	352,000	0.84	0.43
Total	22,016,474		

* Ni and Cu grades for years 1955-1968 not published.

	TONS MILLED	% Cu	% Zn
Fox Lake Mine			
1970	389,000	3.07	1.13
1971	1,022,000	2.86	1.54
1972	946,000	2.14	1.40
1973	963,000	2.01	2.07
1974	1,008,000	2.10	1.98
1975	1,007,000	1.74	1.81
Total	5,335,000	2.23	1.71
Ruttan Lake Mine			
1973	1,871,294	1.14	1.85
1974	3,358,000	1.07	1.68
1975	3,341,000	.96	1.90
Total	8,570,294	1.04	1.80

TABLE XIV

PRODUCTION OF HUDSON BAY MINING AND SMELTING CO. LTD., 1931-1975

Hudson Bay Mining and Smelting Co. Ltd.

Year	Flin Flon Tons % Cu % Zn	Schist Tons % Cu % Zn	North Star Tons % Cu	Don Jon Tons % Cu	Birch Lake Tons % Cu	Chisel Tons % Cu % Zn	Coronation Tons % Cu % Zn	Stall Tons % Cu % Zn	Osborne Tons % Cu % Zn	Flexar Tons % Cu % Zn	Anderson Tons % Cu	Dickstone Tons % Cu % Zn	White Tons % Cu % Zn	Ghost Tons % Cu % Zn	Total Tons % Cu % Zn
1931-53	40,390,878 2.22 4.61														40,390,878 2.22 4.61
1954	1,524,441 3.10 5.00	53,618 5.23 7.00													1,587,059 3.17 5.07
1955	1,467,347 2.62 4.30	118,206 5.34 8.60	57,115 6.87	22,321 3.20											1,664,989 2.97 4.40
1956	1,396,292 2.63 4.40	154,968 3.59 8.00	68,418 5.93	31,586 3.11											1,651,264 2.87 4.04
1957	1,377,751 2.63 4.70	73,346 2.65 7.80	106,647 5.96	33,538 2.99	53,025 5.11										1,644,307 2.93 4.29
1958	1,518,014 2.77 4.20	60,400 1.86 10.30	34,240 5.64		79,896 6.76										1,692,550 2.98
1959	1,453,559 2.57 4.30	98,108 3.41 9.70			132,032 5.84										1,683,699 2.88 4.28
1960	1,250,026 2.25 4.70	114,686 4.26 7.60			35,866 7.95	104,903 0.42 13.10	192,775 4.33 0.20								1,698,256 2.63 4.80
1961	1,014,925 2.45 4.00	98,802 3.67 7.70				271,877 0.46 15.30	312,145 4.73 0.30								1,697,749 2.62 5.34
1962	925,030 2.47 4.40	88,316 2.56 7.00				338,377 0.40 13.40	347,731 4.28 0.24								1,699,454 2.43 5.48
1963	924,616 2.41 4.00	81,150 5.45 8.80				300,065 0.49 12.90	292,650 4.29 0.20								1,598,481 2.55 5.22
1964	789,918 2.27 3.20	72,438 7.06 9.90				267,630 0.61 11.10	185,069 3.70 0.10	264,645 4.90 0.70							1,579,700 2.82 4.06
1965	873,934 2.20 3.20	109,010 4.76 9.00				293,221 0.59 10.30	82,491 3.30 0.50	284,392 5.00 0.70							1,643,048 2.62 4.28
1966	1,044,206 2.00 2.90	99,079 4.78 6.31				250,524 0.83 9.98		291,826 4.89 0.70							1,685,635 2.49 3.77
1967	943,811 2.24 3.00	121,516 4.61 8.52				254,118 0.63 10.56		268,729 5.02 0.77							1,588,164 2.63 4.25
1968	806,507 2.40 3.10	121,000 5.00 9.10				278,400 0.60 14.40		230,800 4.50 0.70	177,400 4.60 1.60						1,614,107 2.83 4.99
1969	622,406 1.70 3.30	122,600 4.20 5.50				282,400 0.70 13.70		204,100 4.10 0.60	376,100 4.30 1.50	93,400 4.00 0.60					1,701,006 2.70 4.31
1970	622,316 1.80 3.80	100,700 4.30 5.90				281,500 0.80 10.30		179,200 4.30 0.70	319,000 4.00 1.16	120,700 3.90 0.40	59,600 3.80	26,100 2.1 3.7			1,709,116 2.68 3.80
1971	272,256 2.00 3.50	50,100 4.70 5.00				163,200 1.00 8.40		11,700 5.80 1.60	153,900 3.50 1.20	66,300 3.70 0.40	224,400 4.20	140,800 2.0 4.8			1,082,656 2.79 4.08
1972	469,247 1.90 3.30	110,200 4.30 4.30				209,100 0.90 9.30		44,600 4.90 1.20	277,400 3.40 1.80	56,900 3.20 0.50	351,400 3.80	258,600 2.5 3.3	82,500 1.90 4.40	35,000 1.80 9.4	1,894,947 2.61 3.06
1973	593,177 2.10 3.10	93,300 3.50 4.10				182,400 0.60 9.40		172,000 4.30 0.80	59,800 3.20 2.40		298,400 2.90	179,000 2.6 2.7	133,000 2.00 4.20	99,700 1.90 11.7	1,810,777 2.43 3.55
1974	551,500 1.90 2.10	68,200 3.70 4.50				169,800 1.00 10.10		143,100 3.90 0.90	131,700 2.80 1.60		200,300 2.90	132,000 2.70 2.00	103,500 2.20 4.50	68,700 2.00 11.50	1,568,800 2.45 3.21
1975	573,775 1.80 2.00	45,303 4.10 4.40				119,639 0.70 10.80		163,366 4.20 0.70	191,490 2.60 2.50		110,072 3.20	118,197 2.60 2.50	104,300 2.50 4.90	43,963 1.40 10.60	1,470,105 2.36 3.06
TOTAL	61,405,932 2.28 4.37	2,055,036 4.22 7.01	266,420 6.11	87,445 3.07	300,819 6.21	3,767,154 0.63 11.66	1,412,861 4.26 0.24	2,258,458 4.32 0.75	1,686,790 3.71 1.70	337,300 3.77 0.47	1,244,172 3.46	854,697 2.47 3.13	423,300 2.15 4.48	247,363 1.82 11.12	76,347,747 2.44 4.44

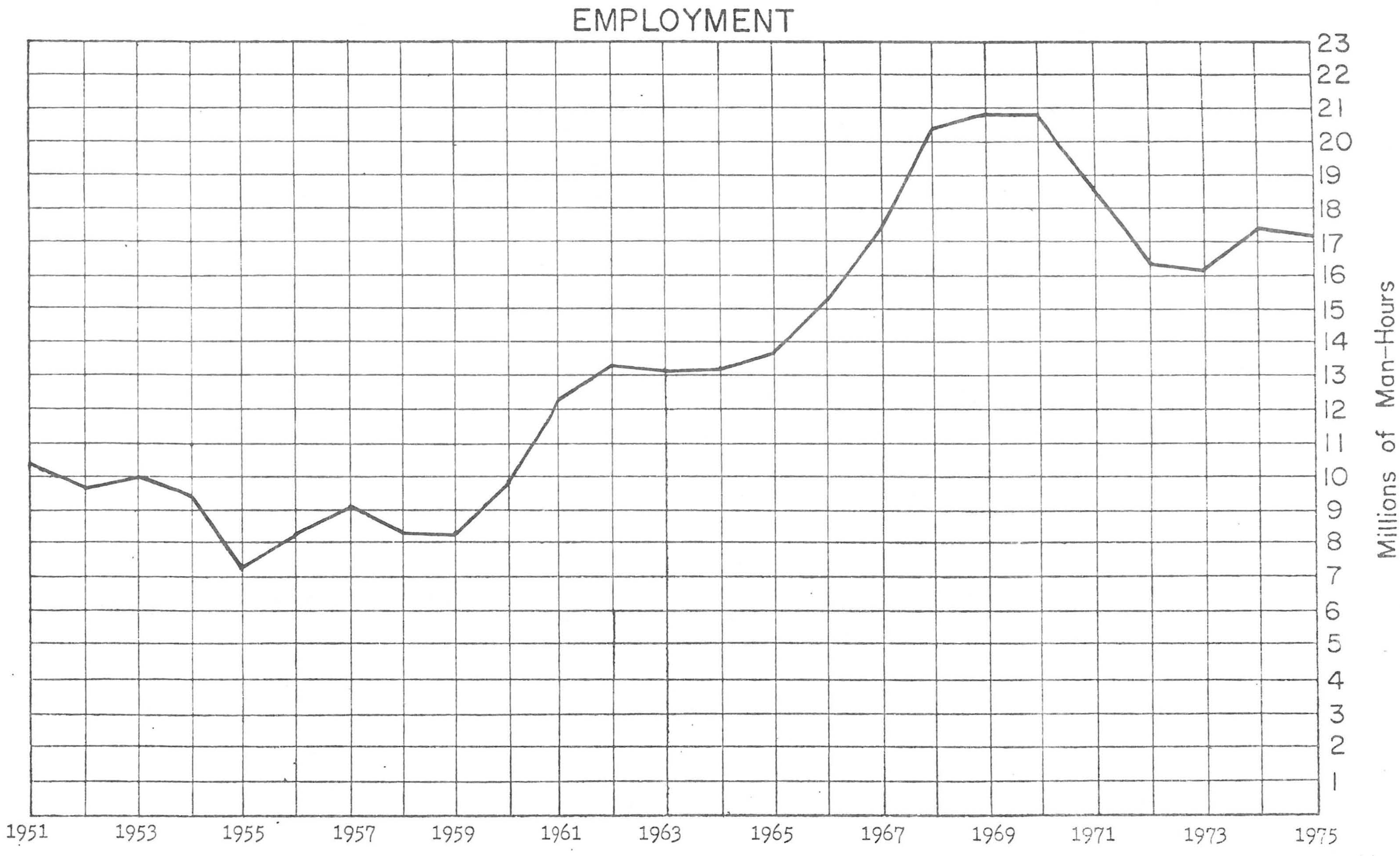
TABLE XV EMPLOYMENT - ALL MINING OPERATIONS - 1965-1975

(Number of Employees Reported Monthly - Average for 12 Months)

Year	Producing* Mines	Developing Mines and Mining Contractors	Mine Construction Contractors	Quarries	Sand and Gravel Pits, Clay, Peat	Contract Diamond Drilling	Total
1975	7169	217	162	190	675	144	8557
1974	7226	265	248	176	601	278	8794
1973	7166	198	133	138	511	242	8388
1972	6956	474	192	122	456	296	8496
1971	7398	670	342	114	327	455	9306
1970	7259	914	506	129	375	639	9822
1969	6674	1085	742	142	436	499	9578
1968	5872	939	1070	161	441	474	8957
1967	5496	752	737	179	469	459	8092
1966	5018	617	-	173	568	476	6852
1965	5006	323	-	177	481	388	6375

* Includes mining, milling, smelting, refining and support personnel.

TABLE XVI MAN HOURS WORKED AT MINING OPERATIONS



150