1

**PM-1 3½"x4" PHOTOGRAPHIC MICROCOPY TARGET
NBS 1010a ANSI/ISO #2 EQUIVALENT**

PRECISIONSM RESOLUTION TARGETS

PIONEERS IN METHYLENE BLUE TESTING SINCE 1974

1000 COUNTY ROAD 5 BURNINGWELL MN 55307 USA
TEL: 612-435-7887 FAX: 612-435-7887 T.LX: 510808948

National Library
of Canada

Bibliothèque nationale
du Canada

Canadian Theses Service

Service des thèses canadiennes

Ottawa, Canada
K1A 0N4

NOTICE

The quality of this microform is heavily dependent upon the quality of the original thesis submitted for microfilming. Every effort has been made to ensure the highest quality of reproduction possible.

If pages are missing, contact the university which granted the degree.

Some pages may have indistinct print especially if the original pages were typed with a poor typewriter ribbon or if the university sent us an inferior photocopy.

Reproduction in full or in part of this microform is governed by the Canadian Copyright Act, R.S.C. 1970, c. C-30, and subsequent amendments.

AVIS

La qualité de cette microforme dépend grandement de la qualité de la thèse soumise au microfilmage. Nous avons tout fait pour assurer une qualité supérieure de reproduction.

S'il manque des pages, veuillez communiquer avec l'université qui a conféré le grade.

La qualité d'impression de certaines pages peut laisser à désirer, surtout si les pages originales ont été dactylographiées à l'aide d'un ruban usé ou si l'université nous a fait parvenir une photocopie de qualité inférieure.

La reproduction, même partielle, de cette microforme est soumise à la Loi canadienne sur le droit d'auteur, SRC 1970, c. C-30, et ses amendements subséquents.

Canada

**The Long Lake Zinc Mine
and the Ore Chimney Gold Mine,
Southeastern Ontario:
A Geophysical Exploration Guideline**

by

Douglas Allen Irwin, B.Sc.(Hons)

A thesis submitted to the
Faculty of Graduate Studies and Research
in partial fulfilment of
the requirements for the degree of
Master of Science.

Ottawa-Carleton Geoscience Centre

Ottawa, Ontario.

April 15, 1992.

©Copyright

1992, D.A. Irwin

National Library
of Canada

Bibliothèque nationale
du Canada

Canadian Theses Service

Service des thèses canadiennes

Ottawa, Canada
K1A 0N4

The author has granted an irrevocable non-exclusive licence allowing the National Library of Canada to reproduce, loan, distribute or sell copies of his/her thesis by any means and in any form or format, making this thesis available to interested persons.

The author retains ownership of the copyright in his/her thesis. Neither the thesis nor substantial extracts from it may be printed or otherwise reproduced without his/her permission.

L'auteur a accordé une licence irrévocable et non exclusive permettant à la Bibliothèque nationale du Canada de reproduire, prêter, distribuer ou vendre des copies de sa thèse de quelque manière et sous quelque forme que ce soit pour mettre des exemplaires de cette thèse à la disposition des personnes intéressées.

L'auteur conserve la propriété du droit d'auteur qui protège sa thèse. Ni la thèse ni des extraits substantiels de celle-ci ne doivent être imprimés ou autrement reproduits sans son autorisation.

ISBN 0-315-76000-1

Canada

The undersigned recommend to the Faculty of Graduate Studies
and Research acceptance of the thesis

**The Long Lake Zinc-Lead Mine
and the Ore Chimney Gold Mine,
Southeastern Ontario:
A Geophysical Exploration Guideline**

submitted by Douglas Allen Irwin, B.Sc.(Hons)
in partial fulfilment of the requirements for
the degree of Master of Science.

A handwritten signature in cursive script, reading "John Blenkinsop", written over a horizontal line.

Thesis Supervisor

A handwritten signature in cursive script, reading "Frederick A. Mott", written over a horizontal line.

Chairman, Department of Earth Sciences

Carleton University

ABSTRACT

This project encompasses a geological and detailed geophysical study of a known Zn-Pb deposit and a known gold unconformity-type deposit. From this database, guidelines for further exploration of these types of deposits in the Grenville Structural Province are proposed.

Both properties are situated in the Central Metasedimentary Belt of the Grenville Structural Province. The Central Metasedimentary Belt is represented by a thick series of intercalated marbles and arkosic metasedimentary rocks which overlay a basal series of compositionally-variable metavolcanic rocks and gneiss from the Grenville Supergroup. The metavolcanic rocks range from amphibolite to granulite metamorphic grade. The metasedimentary rocks are of Archean-to-Aphebian age and are intruded by two late tectonic intrusive suites.

The Long Lake Zinc Mine is located in a lens-shaped marble enclave that trends northeast-southwest. Other smaller marble units are found to the northwest and southeast. These marble units are surrounded by the Mountain Grove Mafic Intrusion to the north and south, and small McLean Lake Granite plutons and associated pegmatites and veins to the west.

Regional and detailed magnetics (total field) clearly outline the Long Lake Marble and its contacts with the Mountain Grove Mafic Intrusion. Small mineralized veins, trenches, and a gossaniferous (py) microcline on the property have little or no magnetic response. Faults are difficult to delineate on the property. However, the VLF (Very Low Frequency) electromagnetic survey is able to outline two probable faults. Displacement of the faulting is unknown. Anomalous areas of unknown origin have been delineated on the property by VLF, magnetics, and horizontal loop electro-magnetics.

A thorium anomaly over the Long Lake deposit is defined by an airborne radiometrics survey. This anomaly is probably associated with mineralization and may aid in the further development of an ore genesis model.

The Ore Chimney Gold mine is also situated in the Central Metasedimentary Belt. It is located near a regional angular unconformity between the Tudor volcanic rocks of the Hermon Group and the late Proterozoic metasediments of the Flinton Group. The Ore Chimney Formation, a garnet-biotite schist ($\pm$ magnetite), delineates this unconformity.

Detailed magnetics clearly outline the structure of the Flinton Group and Ore Chimney Formation. As well, the VLF and magnetic surveys infer the location of a fault truncating the Flinton Group. Magnetics and VLF have also located an anomalous zone, possibly containing sulphides, in the fault below the Ore Chimney Formation.

ACKNOWLEDGEMENTS

I gratefully acknowledge the assistance given to me by Dr. John Blenkinsop of the Ottawa-Carleton Geoscience Centre, who devoted part of his time, effort and funding to this investigation.

I would also like to thank Dr. Jean Richardson, Dr. John Moore and Dr. George Riley for their initial suggestions and encouragements in this project; Mr. and Mrs. Young who allowed me access to the Long Lake Property; Mr. Albert Banner who allowed me to use some of his exploration data at the Ore Chimney mine; Hendrik Falck, Dan Marshall and Dr. Peter Mustard for their guidance through the infancy of my computer knowledge and, in part, the later, more developed stages; Dr. Keith Bell who helped with observations in my B.Sc. thesis and I regrettably forgot to acknowledge; and Paul Nagerl for moral support and being such a good Bud.

Able field assistance was given by Lindsay Hall, Lissa Wong, Barry Irwin, Jamie Davis, Mike Genkin, Mustafa Fayek, Lyle Dechenne and anyone else who made the trip to Long Lake whom I may have forgotten.

Excellent proof reading of the Ore Chimney section was completed by Dr. Mike Stublely. Dr. Richard Taylor is also gratefully acknowledged for taking time out from his busy schedule to read this thesis. Thanks must also be extended to the Canada-NWT Mineral Agreement office for the use of their hardware in the production of several drafts.

Lastly, I would like to thank the city of Perth for having a Tim Horton's, exactly half way to the Long Lake Property.

TABLE OF CONTENTS

	Page
NOTICE OF ACCEPTANCE	ii
ABSTRACT	iii
ACKNOWLEDGEMENTS	iv
TABLE OF CONTENTS	v
LIST OF TABLES	viii
LIST OF FIGURES	ix

CHAPTER I: INTRODUCTION

Geologic Setting

The Grenville Structural Province	2
The Central Metasedimentary Belt	7

Regional Geophysics

Magnetic Surveys	10
Gravity Surveys	14
Radiometric Surveys	16

CHAPTER II: The Long Lake Zinc Mine: A Case History for Geophysical Exploration Introduction

Introduction	20
--------------------	----

Geology

Regional	23
Local	25
Ore	31
Ore Genesis	32
Mine Description	35

Geophysics

Introduction	35
Geography	36
Geophysical Grid	37
Very Low Frequency Survey	38
Total Field Magnetic Survey	53
Self-Potential Survey	60

Max-Min Horizontal Loop Electro-Magnetic Survey	65
<u>Interpretation and Summary</u>	80
CHAPTER III: The Ore Chimney Gold Mine: A Case History for Geophysical Exploration	
Introduction	84
<u>Geology</u>	
Regional	87
Local	90
Ore Chimney Formation	90
Mine Description	93
<u>Geophysics</u>	
Introduction	94
Geography	94
Geophysical Grid	95
Very Low Frequency Survey	95
Total Field Magnetics Survey	105
Interpretation and Summary	113
CHAPTER IV: An Exploration Guideline	
Stratiform Zn Deposits	117
Unconformity-Associated Quartz Hosted Au Vien Deposits	124
REFERENCES	127
APPENDIX 1: Long Lake Previous Work	134
APPENDIX 2: Previous Geophysical Surveys at Long Lake	136
APPENDIX 3: Long Lake VLF Data	138
APPENDIX 4: Long Lake Magnetometer Data	143
APPENDIX 5: Long Lake Self-Potential Data	147
APPENDIX 6: Long Lake Max-Min HLEM data	150
APPENDIX 7: Geophysics, Geology and Geography Layovers	166
APPENDIX 8: Ore Chimney VLF Data	177
APPENDIX 9: Ore Chimney Magnetometer Data	182
APPENDIX 10: Geophysics and Geology Layovers	191

LIST OF TABLES

Table	Description	Page
II-1	Ore Genesis Models	34
IV-1	Regional Geophysical Study	120
IV-2	Detailed Geophysical Results	121

LIST OF FIGURES

Figure	Description	Page
I-1	Regional Geology of the Central Metasedimentary Belt	6
I-2	Generalized Stratigraphic Column: Grenville Supergroup	8
I-3	Regional Magnetic Survey over the Long Lake Area	13
I-4	Magnetic Profiles over the Long Lake Property	13
I-5	Regional Gravity Survey over both Properties	15
II-1	Location of the Lynx Zn-Pb Mine	22
II-2	Geology of the Long Lake Area	24
II-3	Generalized Geology of the Long Lake Property	28
II-4	Geography of the Long Lake Property	30
II-5	Fraser Filtered VLF Data	41
II-6	VLF Quadrature Data	44
II-7	Textbook Crossovers	45
II-8	VLF Profiles	49
II-9	Total Field Magnetic Data	55
II-10	Magnetic Profile along Line 1+20W	56
II-11	Magnetic Profile along Line 2+00W	57
II-12	Magnetic Profile along Line 0+40W	58
II-13	Half-Width Depth Estimate Method	59
II-14	Magnetic Profile along Line 3+20E	59
II-15	Self Potential Data	63
II-16	SP Profiles along Lines 2+40E and 3+20E	64
II-17	HLEM - 222 Hz Data	69
II-18	HLEM - 444 Hz Data	70
II-19	HLEM - 888 Hz Data	71
II-20	HLEM - 1777 Hz Data	72
II-21	HLEM - 3555 Hz Data	73
II-22	HLEM Profiles along Line 1+60E at 222, 444, 888 Hz	77
II-23	HLEM Profiles along Line 3+20E at 222, 444, 888 Hz	79
III-1	Location of the Ore Chimney Mine	86
III-2	Geology of the Ore Chimney Au Mine Area	89
III-3	Geology of the Ore Chimney Au Mine Property	92
III-4	Fraser Filtered VLF Data	98
III-5	VLF Quadrature Data	99
III-6	VLF Correction Profile	101
III-7	Corrected VLF Profiles	103
III-8	Total Field Magnetic Data	108
III-9	Magnetic Profile along Line 3+00W	110
III-10	Magnetic Profile along Line 1+00E	112
III-11	Magnetic Profile along Line 4+00E	113
III-12	Magnetic Profile along Line 6+50E	114

Chapter I

Introduction

The purpose of this project was to conduct geological and geophysical studies in the areas of the Long Lake (Lynx) Zinc mine and the Ore Chimney Gold mine, southeast Ontario, both within the Grenville Structural Province, with the following objectives:

1. To define the geophysical signature of the properties using at least magnetic and Very Low Frequency (VLF) surveys.
2. To interpret the geophysical signatures and relate them to the geology.
3. To correlate known mineralization at depth with the geophysical signatures and possibly recognize new anomalies.
4. To propose geophysical exploration guidelines for mineral deposits of similar types in the Grenville Province.
5. To provide a geophysical database for Carleton University geology students at the Long Lake Zinc and Ore Chimney Gold mines.

Mineral abbreviations in this thesis follow those suggested by Kertz (1983).

Geologic Setting

The Grenville Structural Province

The Grenville Structural Province, the youngest orogenic belt in the Precambrian Shield, lies mainly in Canada and extends into the Adirondacks in the U.S.A. (Figure I-1 map insert). It is thought to extend to southwest U.S.A. (Texas) and northern Mexico under the Paleozoic overburden (Carter, 1989). A sequence of rocks located in Scandinavia, southeast of the Caledonides (Davidson, 1984) is believed to be a companion terrane. Due to its structural and metamorphic complexity and presumed low mineral potential, the Grenville Province has received little geological exploration.

The Grenville Structural Province has been subdivided by Wynne-Edwards (1972) into six major divisions or subprovinces (**Figure I-1** map insert). These subdivisions are not only separated by geological characteristics but also by structural and metamorphic properties. A detailed description of these subdivisions is given in Moore, 1986.

Wilson (1917) originally recognized the Grenville Structural Province as a change from supracrustal rocks to quartzo-feldspathic gneisses and as a change in metamorphic grade (upper amphibolite to granulite facies) across the Grenville Front (**Figure I-1** map insert). The Grenville Front is a northeast-trending tectonic zone which truncates both the Superior Province and the Nain Province. The northeast trend of the regional structures related to the "Grenvillian" orogeny (1250-1090 Ma (Davis and Bartlett, 1988)) is reflected in the structural trend map constructed by Stockwell *et al.* (1970) and in the magnetic anomaly and gravity maps published by the Geological Survey of Canada.

The geology of the Grenville Province is basically represented by a basement of polydeformed gneisses and amphibolites, on which sediments of the Grenville Supergroup, the Finton Group, Gagnon Group, and the Wakeham Group are deposited. Several pre-"grenvillian" (1500-1220 Ma (Woussen *et al.*, 1986; Windley, 1989)) suites, which include felsic volcanics (rhyolites) and plutonics, major anorthosites, and gabbro and diabase dykes, intrude these rocks. The Grenville Orogeny has resulted in extensive reworking of this crustal material generating the complex geology characteristic of the Grenville Province.

Evidence for northwest-directed thrusting and stacking (increased crustal thickness) associated with the Grenville Orogeny is considerable (Bartlett and Moore, 1985; Davidson, 1986; Hanmer, 1989). Two distinct models are currently under discussion: 1) Intra-continental rifting and thrusting (Woussen *et al.*, 1986) and 2) Continent-Island Arc collision and later Continent-Continent collision (Wilson Cycle) similar to Himalayas (Windley, 1986; 1989). Both models have their

similarities such as initial rifting causing anorogenic magmatism. Differences in opinion are based on the lack of observed oceanic crust, no definitive location of a continent-continent suture, and the origin of the supracrustal rocks. Windley (1989) points out that the suture zone associated with the more recent Himalayas is not easily observed and therefore the much older "Grenvillian" suture between the Central Metasedimentary Belt and the Central Granulite Terrain may be difficult to distinguish. He suggests the Chibougamau-Gatineau lineament defined by Baer (1981) as the suture between the island arc (Central Metasedimentary Belt) and the continent (Central Granulite Terrain) and further north between the continents. Further investigation of this zone may provide evidence for the missing oceanic crust.

Woussen *et al.* (1986) suggests that the supracrustal rocks of the Central Metasedimentary Belt were formed subaerially in a graben system associated with rifting, with limited exposure to a shallow sea. He cites the presence of anhydrite and gypsum for the evidence of a shallow sea. Windley (1986; 1989) interprets the Central Metasedimentary Belt as a remnant island arc, citing pillowed basalts comparable in type and geochemistry to those of modern Island arc and back-arc basin systems as evidence.

Whatever the process, it is apparent that the Grenville event was a mountain building episode, with the exposed rocks of the Grenville Province representing the base of these mountains. It is important for exploration, within the supracrustal rocks of the Grenville Province, to determine an orogenic model, as different depositional environments may dictate different exploration techniques. With a better understanding of these supracrustal rocks, a preferred model may be determined and exploration guidelines, especially geochemical and geological, would aid in the discovery of a economically significant deposit.

Figure I-1

Regional location and geology of the study areas. Note the location of the Ore Chimney Gold mine and the Long Lake Zinc Mine in the Central Metasedimentary Belt.

The Central Metasedimentary Belt

Most of the supracrustal rocks in the Grenville Province, and most of the metallic and non-metallic deposits, are contained within the Central Metasedimentary Belt (**Figure I-1**) as defined by Wynne-Edwards (1972). These deposits have been studied and described by numerous workers (Uglow, 1916; Alcock, 1930; Carter, 1980; 1981; 1984; Gauthier and Brown, 1980; Sangster and Bourne, 1982; Carter and Colvine, 1985).

The Central Metasedimentary Belt is divided into three tectonic domains (**Figure I-1**) from west to east, the Bancroft Terrane, the Elzevir Terrane, and the Frontenac Terrane (formerly named the Westport Terrane) (Brock and Moore, 1983; Bartlett *et al.*, 1984; Easton and Dekemp, 1987). Each terrane is separated by major fault zones and each may represent a thrust sheet. Stratigraphic relationships among the supracrustal rocks across these tectonic boundaries are not well known.

Most of the Central Metasedimentary Belt supracrustal rocks have been assigned to the Grenville Supergroup, which overlie an Archean to Aphebian basement of quartzo-feldspathic gniesses (Sangster and Bourne, 1982). The Grenville Supergroup is a Helikian accumulation of supracrustal rocks consisting of a thick series of intercalated marbles and arkosic metasediments of the Mayo Group conformably overlying a basal series of compositionally-variable metavolcanic rocks of the Hermon Group (**Figure I-2**).

In the Bancroft Terrane, southwest of Bancroft, the 'basal' metavolcanics overlie siliceous clastic metasediments of the Anstruther Group (Bright, 1977). Within the Elzevir Terrane, the volcanic Tudor Formation of the Hermon Group forms the base of the Grenville Supergroup. A U-Pb date of 1286 ± 15 Ma for the Tudor Formation (Silver and Lumbers, 1966) is a suggested deposition age for the Grenville Supergroup. Correlation of the metasedimentary and gneissic units of the Frontenac Terrane with the Grenville Supergroup has not been attempted.

Figure I-2 Generalized stratigraphic column of the Grenville Supergroup. Note the locations of the study areas in the column.

et al., 1986).

All the Precambrian rocks, except late diabase dykes, pegmatites and a few small syenite plutons, have been affected by the Grenville Orogeny (Carter *et al.*, 1980). From the supracrustal rocks (1280-1250 Ma (Windley, 1989)) in the Ore Chimney (Moore and Thompson, 1980) and the Belmont Lake areas (Bartlett and Moore, 1985), at least two events, the "Ottawan" (ca. 1100-1050 Ma), which is predominant, and the "Elzevirian" (ca. 1225-1200 Ma), comprised the "Grenvillian" orogenic cycle within the Central Metasedimentary Belt.

Metamorphic grade ranges from upper greenschist to upper amphibolite in most of the belt. Granulite facies is attained in the Frontenac Terrane (Wynne-Edwards, 1972). The lowest metamorphic grade (greenschist), commonly called the Hastings metamorphic low, is present in the Madoc area within the thickest

succession of volcanic rocks in the Elzevir Terrane (Easton *et al.*, 1986).

The Grenville Supergroup is intruded by at least two suites. An older one (ca. 1250-1220 Ma) consists of diorite, gabbro, and tonalite and a younger suite (ca. 1100-1050 Ma) contains granodiorite, granite, and syenite (Easton *et al.*, 1986).

The Grenville Supergroup is unconformably overlain by metasediments of the Flinton Group. The dominant units of the Flinton Group are quartzites, various conglomerates, and marble. The sequence is not cut by any intrusive suites except for late pegmatites. Deposition of the group took place between 1050 and 1080 ± 25 Ma (Moore and Thompson, 1980).

Lower Paleozoic sediments unconformably overlie these units. Upper Cambrian quartzose sandstone of the Potsdam and Nepean Formations are overlain by limestone, dolostone and minor sandstone and shale of Ordovician age (Carter and Colvine, 1985). Sandstone forms the base of the Ordovician sequence in the east, whereas the carbonates occupy the base in the south. These units are overlain by Pleistocene glacial deposits.

Several small mining operations producing either gold, lead, magnesium, iron, silver, zinc and/or uranium have been developed over the last century and a half, including the Long Lake Zinc mine and the Ore Chimney Gold mine. Their stratigraphic locations are presented in **Figure 1-2**. The Long Lake Zinc mine is hosted within a marble enclave of the Mayo Group. The Ore Chimney Gold Mine is stratigraphically located spatially near the unconformity below the Flinton Group. On the property, the ore zone is within the Tudor metavolcanics of the Hermon Group, which are unconformably overlain by the Flinton Group.

The largest and only current producer of zinc in the Central Metasedimentary Belt is the Balmat-Edwards Zinc mine in New York, which supplies the United States with approximately 10% of its zinc (Carter, 1984). Known metallic mineral occurrences, some of which are past producers, are

shown in **Figure 1-1**. A more comprehensive discussion of major deposit types in the Central Metasedimentary Belt is given in Carter (1984).

The geology of many of these mineral occurrences is similar to major producers elsewhere and combined with past production history, significant mineral potential is indicated in the Central Metasedimentary Belt. Although most of the deposits are small, the established infrastructure and favourable geographic locality make these deposits more economically viable. The possibility of discovering a large deposit should not be overlooked.

Regional Geophysics

Three regional geophysical surveys (magnetics, gravity and radiometrics) were studied at various scales over the Long Lake and Ore Chimney areas. Recognition of any patterns, anomalies or features associated with each deposit is attempted. As well, the overall geophysical signatures are examined in an endeavour to correlate regional geology. More emphasis is directed towards the Long Lake area.

Magnetic Surveys

Airborne magnetic surveys are commonly flown using a total field magnetometer. Readings are taken every second for a one half second duration. Flight line spacings and flight altitude of the 1:63,360 scale map (presented here) are one quarter mile and 400 feet respectively. The 1:1,000,000 scale colour map is a compilation of surveys completed by the Geological Survey of Canada (GSC). How the data from the various surveys were reduced to a common denominator (ie: compensating for different heights and line spacings) is not known. However, it is assumed that the base value of 56,000 gammas, the regional magnetic field

for the area, has been subtracted from the readings of both maps.

Magnetic data from these surveys, depending on line spacing and height, represent an average magnetic reading of the magnetic field over a larger area than a ground survey. As well, magnetism at the surface or of limited extent may not be recorded. This results in smoother results reflecting geology at slightly greater depths than a land-based survey. It was anticipated that the size and extent of the property is sufficient enough to be reflected in the airborne surveys.

The 1:1,000,000 Colour Magnetic Anomaly Map (Map NL-18-M) shows few interesting features associated with the Long Lake Zinc mine. At this scale, the Long Lake marble enclave is not observed. However, the larger marble units in the area are represented as magnetically low anomalies (zero gammas). A magnetic high (500 gammas), spatially close to the mine, probably represents high magnetite content within the surrounding mafic and granitic intrusions, or, in the case of the granite, overlying a mafic intrusion with high magnetite content.

The sediments of the Flinton Group in the Ore Chimney Gold mine area are correlated within the -50 gamma contour and the fold structures are commonly depicted as linear bands. A small 175-200 gamma anomaly associated with the Ore Chimney Gold mine and appears to be located near the nose of such a structure. Other low magnetic linear bands also have similar magnetic highs within them.

The 1:63,360 scale total field magnetic map (G.S.C. Map 8880G) exhibits a few more details than the Magnetic Anomaly Map. **Figure I-3** is a portion of Map 8880G over the Long Lake area. The low magnetic signature of the metacarbonates is easily observed and is commonly delineated by magnetic readings of less than 2500 gammas. For example, the large "C"-shaped magnetic low to the northwest closely mimics the location of a large marble unit.

A depression in the 3500 gamma contour north of Long Lake correlates well with the location of the Long Lake Zinc mine marble. The size and shape of

Figure I-3

Aeromagnetic map over the Long Lake Area. The numbered lines across the Long Lake Zn mine (crossed hammers) are specific flight lines used for magnetic profiles.

Figure I-4

Magnetic Profiles across the Long Lake Zn mine marble enclave. Note the location of the mine and the associated magnetic low. The depression to the northwest (left) is a larger metacarbonate unit. The depression to the southeast (right) is Long Lake itself.

Aeromagnetics (Total Field)

Figure I-3

Figure I-4

the anomaly corresponds to that marble enclave. Aeromagnetic profiles of the Flight Lines One and Two across the depression are presented in Figure 1-4.

Magnetic highs to the west and east of Long Lake in Figure 1-3 are associated with magnetic highs in the granitic intrusions. Ford and Charboneau (1979) have also correlated these magnetic anomalies with Airborne Gamma-Ray Spectrometer (uranium) anomalies. From the results of their gravity survey, Read and Thomas (1987) suggest that a gabbro at depth generates a gravity high at these locations. The magnetic high to the north of the Long Lake Zinc mine is associated with a mafic intrusion.

In both the 1:1,000,000 and 1:63,360 scale magnetic maps, there appears to be a change in character across a northeast linear trend separating the Long Lake and the Ore Chimney Gold mine areas. The signature to the southeast (Long Lake area) is of low magnetic relief with high magnetic domal anomalies. The magnetic character to the northwest (Ore Chimney Gold mine area) is of a higher magnetic relief with lower magnetic linear features. This suggests a major geological break defined by the northeast-trending magnetic trend, possibly representing the Robertson Lake Shear Zone, between the two areas.

At these scales, a magnetic survey cannot pick up any high susceptibility minerals in the marble due to the limited extent of the metal concentration. However, regional magnetics can be used as an indirect tool to locate marble enclaves, perhaps buried at depth, which may contain base metals.

Gravity Surveys

Two large-scale gravity surveys (1:1,000,000 and 1:250,000) were reviewed over the study area. These gravity surveys utilized a ground-based static gravimeter which measures the relative change in acceleration due to gravity related to a base station. Therefore, gravity is not measured directly but indirectly from its change (related to changes in rock density) from location to location.

Error is commonly $\pm$ one milligal and there are no terrain corrections on the 1:250,000 scale survey.

The 1:1,000,000 scale map (G.S.C. Manuscript Map No. 44072) and 1:250,000 scale map (Figure I-5, not represented at 1:250,000) revealed nothing of interest at either location. However, several features reflecting regional trend are noted.

Figure I-5 Bouguer anomaly map of the Long Lake and OCM areas. Note the northeast linear trend separating them. See Read and Thomas, 1987 for station locations.

The Ore Chimney Gold Mine is located on the eastern edge of an oblate

gravity low (-40 to -45 milligals) parallel to regional structures. This low is probably associated with oblate granitic intrusions. In contrast, the Long Lake Zinc mine is located near the southwestern boundary of a gravity high associated with a granitic intrusion. This gravity high does not have any relation to the zinc mineralization and, as mentioned earlier, is probably associated with a gabbro body at depth.

Other regional features involve the apparent change in gravity signature across a northeast linear gravity trend (Figure 1-5), possibly the Robertson Lake Shear Zone. To the northwest of the zone, the character is more convoluted with lower readings suggesting a complex geological structure and a thickening of crustal material. To the southeast of the zone, the signature is smoother with higher gravity readings implying a less complex geology and thinner crustal material. Read and Thomas (1987) suggest that most of the observable features in the Central Metasedimentary Belt are less than four kilometres deep. A major northeast-trending geological break coincident with the Robertson Lake Shear Zone is represented by the northeast linear gravity trend transecting Figure 1-5.

Radiometric Surveys

Airborne Gamma-Ray Spectrometry detects gamma rays emitted from certain elements near the surface (ie: uranium, potassium and thorium). The gamma rays are only able to penetrate one half to one metre below the surface, depending on the induration of the material. Despite this limitation, Airborne Gamma-Ray Spectrometry has become very useful in geology and mineral exploration.

Gamma rays generate two effects when emitted, 1) they ionize air (or gas) when passing through it and 2) produce small flashes of light when striking certain crystals (ie: zinc sulphide, scheelite, etc..) (Parasnis, 1983). Using a Scintillation Counter (shielded from all sides except facing down) with crystals of sodium iodide, certain radio-elements can be detected depending on the energy of the

gamma rays emitted. For uranium and thorium, the results of the survey are converted into equivalent amounts measured in parts per million (ppm) according to the counts per second (cps) recorded at each energy window. Thorium and uranium are measured indirectly using the daughter products ^{208}Ti and ^{214}Bi , respectively. Potassium is directly measured in percentage depending on the cps at its energy level. Total Count is the counts per second over an energy window that encompasses all (and more) the surveyed radio-elements.

Initially, Gamma-Ray Spectrometry was suggested by M. Easton (per. comm., 1988) as another possible survey technique which may yield interesting results. It was expected that radiometric lows would be found over the marble enclaves.

From 1974 to 1977, Airborne Gamma-Ray Spectrometry was flown over the Long Lake/Sharbot Lake area with one kilometre spacing, at a height of 400 feet, and readings were measured over one second intervals. Seven maps were produced, contouring results from Equivalent Uranium (ppm), Potassium (%), Equivalent Thorium (ppm), Equivalent Uranium/Potassium, Equivalent Thorium/Potassium, Equivalent Uranium/Thorium and Total Count (Ur). All seven maps were reviewed by the author with respect to the Long Lake marble and other marbles in the immediate area. The significance of the total survey results is discussed in Ford and Charboneau (1979).

As counts were low in the survey (ie: 20-40), precision may be lacking and the data, and therefore the observations discussed, may not be reliable. As a "rule of thumb", error is the square root of the total number of counts per interval. Hence a larger number of counts yield better precision.

The Equivalent Uranium/Potassium and Equivalent Uranium/Equivalent Thorium yielded inconclusive results. No anomaly pattern was observed over the study area.

The Total Count, Equivalent Uranium and Potassium displayed low

anomalies over the metacarbonates. The lows over the Long Lake marble are represented as deflections in contouring parallel to the strike length of the enclave. These lows are to be expected as potassium and uranium are not major or minor constituents of marble.

Equivalent Thorium and Equivalent Thorium/Potassium yielded high anomalies, suggesting a concentration of thorium associated with the Long Lake marble. This high is represented by a deflection in the contouring parallel to the strike length to the enclave. The high thorium concentration is associated only with the Long Lake marble. Other marbles display low concentrations of thorium. The reason for the thorium concentration at Long Lake is uncertain. High thorium concentrations are recorded in nearby granitic intrusions and it is possible that the thorium concentration is associated with cross-cutting pegmatite and granitic stringers in the marble. However, it can be expected that the other marbles are also crosscut by similar stringers and pegmatites and therefore this explanation seems to be insufficient.

Whatever the cause, it is apparent from a exploration standpoint that any anomalous ratio change constitutes an abnormality in the survey and may be associated with mineralization.

Chapter II

The Long Lake Zinc Mine: A Case History for Geophysical Exploration

Introduction

The Long Lake Zinc mine is one of several Zinc deposits in the Central Metasedimentary Belt, all of which are confined to Precambrian marbles. It is a stratiform Zn-Pb deposit within a "Grenvillian" calcitic marble enclave intruded by intrusive suites, the Mountain Grove Mafic Intrusion and the younger McLean Granitic pluton. Several similar marble enclaves are also preserved within these two intrusions. Although generally smaller in extent than the Long Lake marble, many of these marbles have known zinc mineral occurrences. Within the supracrustal rocks of the Central Metasedimentary Belt at other locals (ie: Mont Laurier Basin), similar Zn deposits also occur, including the Balmat-Edwards mine in New York.

The Long Lake Zinc mine, five kilometres from Parham on Highway 38 and twenty kilometres southwest of Highway 7 at Sharbot Lake, is readily accessible (150 km) from Ottawa (**Figure II-1**). Currently, the use of the land is restricted to the production of maple syrup from a sugar bush located on the property. The property is frequently visited by groups from Queens and Carleton Universities.

Since 1896, several mining operations have been undertaken on the property, the most recent completed in 1973 by Lynx-Canada Exploration Limited and Reynolds Metals Limited. Presently the surface rights are owned by Mrs. Young of Long Lake, Ontario, and the subsurface rights are currently held by Les Ressources Yorbeau Inc. of Montreal, Quebec.

Previous work completed on the Long Lake property has included several geophysical surveys, at least one soil geochemical study, three B.Sc. theses (Jury, 1952; Aikin, 1973; Cone, 1976) and one M.Sc. thesis (MacKay, 1941). The Zn-Pb soil geochemical survey was completed in 1970 by Wm. Beaton of Lynx-Canada Exploration Limited. In 1971, vertical magnetics, induced polarization and spontaneous polarization were conducted by V.A. Saull. In the same year (1971), H.O. Siegel conducted a gravimetric survey. W.M. Telford completed telluric and

Figure II-1

Location of the Long Lake Zinc mine. Note the shaded box for the location of the mine and the map insert for the regional location of the study area.

Figure II-1

electromagnetic surveys in 1972. Results of these studies are outlined in Brown (1976) and Wolff (1982).

Work performed on the property for this paper consisted of geological (including geographical) mapping on a 20 by 40 metre grid, sampling of the ore and major rock types (35 thin sections), and several geophysical surveys. The thin sections were used to determine the relative amounts of high susceptibility minerals (eg: magnetite) in the different rock types. A literature search was also initiated to compile surface and underground descriptions (both geology and ore/mine extensions) and to correlate and compare them with the produced geology and geography maps. Detailed magnetic, very low frequency (VLF) electromagnetic, self potential (SP), and Horizontal Loop electromagnetic (Max-Min, HLEM) surveys were performed at the Long Lake property in anticipation of outlining the intrusive-marble contact and anomalous zones on strike with earlier known ore zones. Computer programs, which included Surfer, Lotus 1-2-3, Autocad and Harvard Graphics, were used to reduce and present the data.

Geology

Regional

The Long Lake study area (44° 41.3'N lat., 76° 46.3'W lat.) is situated in the Frontenac Axis Segment (Wynne-Edwards, 1972) of the Central Metasedimentary Belt of the Grenville Structural Province. The study area is bounded to the northwest by the Robertson Lake Shear Zone (Wolff, 1982; Easton and DeKemp, 1987) and to the southeast by a partially "healed" shear zone (Wolff, 1985). The Robertson Lake Shear Zone separates two structurally different zones of the Central Metasedimentary Belt: 1) the tightly folded supracrustal rocks of the Kaladar-Dalhousie Trough (Hewitt, 1956), a part of the Elsevier Terrane and 2) the late stage domal intrusions within broad synforms of metavolcanics and metasediments of the Frontenac Axis (Wynne-Edwards, 1972) or Terrane (Wolff,

1982). The "healed" shear zone to the southeast separates two zones of different metamorphic grade, upper amphibolite grade to the northwest and granulite grade to the southeast (Wolff, 1985).

Figure II-2 Geology of the Long Lake Area. Note the location of the Long Lake Mine (shaded box).

The oldest rocks in the Long Lake area are mafic to felsic gneisses and anatexites (Figure II-2). These are possible high grade (upper amphibolite to granulite) metavolcanic equivalents of the Hermon Group (Wolff, 1982; Sangster *et al.*, 1982).

Metasedimentary rocks include clastic siliceous gneisses, schists and marbles. The clastic gneisses and schists are discontinuous lenses within the younger, highly deformed, metacarbonates. Wolff (1982) has divided the metacarbonates into three major groups: calcite marble, dolomite marble and dolomite-calcite marble. The dolomitic marbles commonly host deposits of galena, pyrite, sphalerite, galena and/or molybdenite (Wolff, 1982).

The metacarbonate sequences are preserved as enclaves within the late-tectonic Mountain Grove Mafic Intrusion and the post-tectonic McLean Granitic Pluton (Wolff, 1982) (Figure II-2). The Mountain Grove Mafic Intrusion has several phases consisting of gabbro and quartz gabbro to anorthosite, monzonite and syenite (Wolff, 1982). The McLean Granitic Intrusion, in contrast, is a late stage trondhjemitic to granitic combination of partial melting and granulation of pre-existing rocks (Wynne-Edwards, 1967). Pegmatites of this granite crosscut most units.

Local

Since the discovery of the Long Lake Zn deposit, the geology and the petrology of the rock units have been extensively studied by many authors (Uglow, 1916; Alcock, 1930; MacKay, 1941; Jury, 1957; Aikin, 1973; Cone, 1976; Wolff, 1982). The mine is located in a northeast-trending lensoidal marble enclave, 1200 metres long and 180 metres wide. The study area itself encompasses the eastern two-thirds of the enclave. Most of the mine workings are to the west of the study area (Figures II-3 and II-4).

For the purpose of this paper, only a generalized geology map (Figure II-3) separating the major rock types is presented for geophysical comparison. Figure II-3 separates the granitic phases (commonly the McLean Granite), the mafic intrusive phases (the Mountain Grove Mafic Intrusion) and the marbles. Due the mapping scale, granitic stringers and pegmatites, which are common, are not included. They should not have a significant effect on the geophysical techniques

used in this project. A brief description of each rock type, which are taken from literature (reference given) and my observations, is presented below.

The marble has a granoblastic texture with calcite crystals up to 5 cm long. The coarse-grained texture is best displayed near the contact with the Mountain Grove Mafic Intrusion. The marble becomes finer-grained near the centre with fine- and medium-grained bands. The weathered surface is dark grey to black, while the fresh surface is grey-banded to white. Foliations in the marble are defined by the fine- and medium-grained bands, phlogopite-rich, biotite-rich and disseminated graphite bands. These foliations have a general orientation of 250/65-80N which reflects the regional structural trend. The thin (commonly ≤ 1 centimetre) graphite layers, being conductive, may generate anomalies in the electromagnetic surveys.

Structural foliations in the marble are represented by flow-type structures (Wolff, 1982), folding, and shear planes within the marble. Small shears parallel and along foliation show no observed sense of movement in the horizontal and may represent vertical movement along foliation.

Boudined calc-silicate lenses and pods of diopside and quartz ($\pm$ biotite, $\pm$ phlogopite, $\pm$ calcite) (Aikin, 1973), alternating grain-size differences, and phlogopite-rich, biotite-rich and disseminated graphite layers, orientated parallel to the foliation, are thought to indicate bedding. These layers are also on strike with other Grenville metasedimentary rocks displaying primary bedding (MacKay, 1941).

Approximately 100 metres north of the marble, a smaller parallel marble enclave is intruded by gabbro and granitic dykes. A small skarn of diopside and pyrite occurs at the contact of the marble and a granitic dyke. Several other minor non-economic skarns are present on the property. Two such skarns are located at 0+20E, 0+20N, and at 2+80E, 0+20N (Figure II-3). Calc-silicate minerals, diopside and an amphibole, occur within these skarns.

Locally, the Mountain Grove Mafic Intrusion varies compositionally from a gabbro to a diorite. The intrusion is massive to gneissic and is generally medium-

Figure II-3 .
Generalized Geology of the Long Lake Property

Figure II-4

Geography of the Long Lake mine property. The ore bodies (20 to 30 metres deep) and mine workings are projected to surface.

to-coarse grained. North of the marble, laths of feldspar several centimetres long are observed. Elsewhere, the gabbro is fine-grained with phenocrysts of feldspar, or grades into pegmatitic syenite phases containing tourmaline (Aikin, 1973). The weathered surface is typically dark grey and the fresh surface is black. Foliation in the Mountain Grove Mafic Intrusion is parallel to the foliation in the marble and to the trend of the marble enclave.

The McLean Granite is generally massive and coarse-grained and, locally, it varies from aplitic to pegmatitic. It consists of approximately 60% K-feldspar (orthoclase, microcline, albite), 30% quartz, and 10% hornblende, biotite and magnetite (Aikin, 1973). It occurs as small, relatively undeformed plutons, pegmatites and veins. The granite crosscuts a sulphide vein on surface and granitic pegmatites and veins are known to crosscut the ore bodies (Alcock, 1930). The granite does not contain any metallic minerals except for magnetite. No rocks younger than the McLean Granite occur on the property.

Possible faults, parallel to the foliation (Figure II-3), transect the property. They occur in the centre of the property near the southern marble-Mountain Grove Mafic Intrusion contact, within the marble. Displacement of the faults are not known.

Ore

The ore consists of either coarse-grained sphalerite with minor amounts of pyrite and pyrrhotite or disseminated sphalerite, galena, pyrite ($\pm$ marcasite), pyrrhotite and minor chalcopryite. Both ore types commonly have a calc-silicate halo at the carbonate contact (Wolff, 1982). Graphite, chalcopryite and molybdenite are disseminated throughout the marble. Minor silver and mercury are contained within the ore and have been found to be excellent pathfinders for soil geochemical exploration (Brown, 1976). Gangue consists chiefly of calcite and calc-silicate minerals (epidote and tremolite) with minor quartz and dolomite. Ore petrology has been extensively studied by MacKay (1941) and Cone (1976).

Most of the ore has developed near the northern marble-intrusive contact as discrete massive sulphides zones (up to 52% Zn (Aikin, 1973)). The lenses or pods are steeply-dipping and conformable within the marble (Uglow, 1916 and Alcock, 1930). Ore also occurs as banded partial replacements near the massive sulphide zones (Cone, 1976). Minor base metal assemblages (mostly pyrite) form iron-rich gossans in microcline-rich units (meta-arenite?) and disseminated grains within the marble.

The massive sulphide ore lenses are stratabound and vary in size. Locally, the ore lenses have lengths from two to thirty metres and from a few centimetres up to 4 metres wide (Aikin, 1973). There are thin layers of disseminated sulphides between the massive sulphide lenses. The banded ore (hematite bands) is thought to represent post-metamorphic supergene processes (Cone, 1976).

Ore Genesis

Three depositional models (syndimentary and early diagenetic, pyrometasomatism, or volcanic exhalative) have been suggested for the Long Lake deposit and similar monometallic Zn deposits. A brief outline of the evidence for each genetic model is outlined in Table II-1.

Uglow (1916), Brown (1976) and Cone (1976) have proposed a Mississippi-Valley-Type origin in which the metallic minerals were remobilized into structurally-controlled zones during heating and ductile deformation of the Grenville Orogeny. This model is partially based on the lack of evidence for an epigenetic hydrothermal origin. Cone (1976), in support of this model, has suggested a sulphide paragenesis with primary sphalerite, pyrite, galena and molybdenite. Alcock (1930), MacKay (1941) and Thompson (1952) support a pyrometasomatic origin where hydrothermal solutions from a large, neighbouring granite intrusion deposited metals along foliation into structurally-preferred zones. Evidence includes skarns, high temperature minerals and the calc-silicate minerals associated with the ore. Wolff (1982), Gauthier and Brown (1980), and Brown

(1982) provide the most convincing evidence for a synsedimentary volcanic exhalative model. Wolff (1982) envisions a stratabound mesothermal Zn-Pb deposit where ductile deformation has remobilized the metals into structurally-created cavities. Based on monometallic Zn deposits in Mont Laurier Basin in Quebec, Gauthier and Brown (1980) and Brown (1982) also suggest a subaqueous sediment-hosted exhalative model for monometallic zinc deposits in the Central Metasedimentary Belt, combined with a remobilization of the metals during the Grenville Orogeny.

Further evidence for ore genesis may be associated with the thorium concentration in the radiometric survey discussed in the previous chapter. Darnley and Ford (1987) suggest that radioactive anomalies are associated with zinc mineralization, due to either 1) radioactive elements associated with the ore minerals or 2) that mineralization changes the radioactive ratios in the surrounding rocks. As uranium-bearing minerals are susceptible to dissolution under hydrothermal (low temperature) conditions (Darnley and Ford, 1987), they further suggest that hydrothermal conditions during mineralization can be indicated by the separation of uranium from potassium and thorium in the original environment. Therefore a second and third possible scenario relating to the thorium anomaly becomes apparent. The thorium concentration (and the relative lack of potassium and uranium) may suggest that either a hydrothermal process is responsible for the zinc mineralization or the deposit was originally metasomatic and a later lower temperature process drove off the uranium, and possibly potassium, leaving the thorium.

The cause of the thorium anomaly is further complicated by the work of Grojek and Prichystal (1985) in central Czechoslovakia. They correlate a strong potassium alteration with zinc enrichment. This relationship is not apparent at Long Lake. Further on-site work should be completed to determine the source of the thorium concentrations. This anomaly could be related to ore genesis and may represent a lower temperature process (exhalative) compared to a higher

temperature (pyrometasomatic) process.

All the models have at least one common feature which aids in exploration (geologically and geophysically). The ore is structurally controlled along preferred strata. Therefore it is feasible that in all models, ore extensions occur along or down strike.

Table II-1 Ore Genesis Models

<u>Models</u>	<u>Evidence</u>	<u>Concentration of Ore</u>
Mississippi-Valley-Type Uglow (1916) Brown (1976) Cone (1978)	1) lack of wall alteration and skarns. 2) no zoning in ore bodies or minerals. 3) sharp contacts between ore bodies and marble. 4) granitic dykes crosscut ore and marble 5) massive ore in stratigraphic horizons as lenses. 6) delicate colloform textures 7) simple base metal ore mineralogy. 8) lack of copper in the ore.	1) initial deposition due to diagenetic processes (ie: compaction of associated shale basin 2) folding and metamorphism remobilized ore minerals into structurally preferred zones.
Epigenetic, Hydrothermal, Pyrometasomatic Alcock (1930) MacKay (1941) Thompson (1952)	1) high-temperature minerals. 2) proximity of neighbouring late-stage granite. 3) lack of bedding in the ore bodies. 4) grain nature and texture of the ore. 5) minor skarns on the property and calc-silicate minerals in the ore.	1) hydrothermal solutions from a large, neighbouring granitic intrusive deposited metals in structurally preferred areas (along foliation)
Synsedimentary, Volcanic Exhalative Aikin (1973) Gauthier and Brown (1980) Brown (1982) Wolff (1982) Carter <u>et al.</u> (1985)	1) boudined, stratiform nature. 2) disseminated sulphides along and across strike between ore bodies. 3) sulphur isotope studies indicate sedimentary origin. 4) lead-lead ratios indicate a single-stage lead model similar to Balmat-Edwards zinc mines which have a proposed sedimentary origin. 5) association with distal iron-rich sediments along strike and with a marble-clastic metasediment transitional contact (Mont Laurier Basin). [*] 7) Zn influx into Mountain Grove Mafic Intrusion during differentiation indicating that Zn was already present in the marble. ^{**} 8) cavities away from the ore zones are filled with calc-silicates and quartz.	1) Zn deposited as submarine exhalative sediments under reducing conditions in carbonates. 2) folding and plastic deformation concentrate the sulphides in structurally-preferred areas. When cavities are formed adjacent to the deposits, the base metals moved in. 3) Metamorphism caused recrystallization of the ore minerals producing coarse-grained sphalerite and calcite zones.

^{*} Gauthier and Brown (1980) and Brown (1982); evidence from studies in the Mont Laurier Basin of monometallic Zn deposits. They include the Long Lake deposit in this category and speculate on a similar mode of mineralization.

^{**} Suggestion by Wolff (1982) from geochemical data completed on the Mountain Grove Mafic Intrusion.

Mine Description

The Long Lake Property has supported several small mining operations since 1896 (see **Appendix 1**). The property has been referred to as the Richardson Zinc mine, the Olden Zinc mine, the Lynx mine and more commonly the Long Lake (Zinc) mine.

The surface showings were first mined by Leslie Benn in 1901. By 1915, five shafts (**Figure II-4**) up to 40 metres deep had been excavated. One hundred (100) metres of drifting, 3 open cuts (up to 20 metres long and 12 metres deep) and twenty pits and trenches were also completed. Using M.E. Wilson's notes, Alcock (1930) described the ore and workings in each shaft at that time. Until 1970, intermittent minor work was done on the property.

In 1971, an exploration program was set-up and three (A,B,C) new ore bodies were discovered (Brown, 1976). The B ore zone was the largest body, extending 45 metres along strike with a width of 5 metres and a vertical dimension of 30 metres (Brown, 1976). Shaft five (**Figure II-4**) was re-opened to gain access to the ore extensions. Between the years 1972 and 1974, 82,371 tons of 11.9% zinc (Brown, 1976) were mined by Lynx-Canada Explorations Limited and Canadian Reynolds Metals Limited.

Geophysics

Introduction

The distinctive geophysical signatures at the Long Lake mine can make an excellent exploration tool for similar marble-hosted Zn-Pb deposits. For example, magnetite is not observed in the Long Lake marble but occurs in varying concentrations in both intrusions. Minor pyrrhotite is found with the sulphide ore zones within the marbles. As both minerals are commonly magnetic, they can be delineated by a magnetic survey. Therefore the marble should have a weak magnetic signature compared to the surrounding intrusions and the ore zones, the

marble-intrusive contact and anomalous zones which may contain metallic minerals (Zn, Pb, Cu, +po) can be delineated. In addition, electrical and electromagnetic surveys should be able to detect, assuming electrical continuity, the electrical conductors in the ore zone, confirming the magnetic results.

Four geophysical surveys were conducted over the property by the author between 1987 and 1989; a magnetic survey, a VLF survey, a SP survey and a Max-Min Electromagnetic survey. Results of these surveys and their correlation with the geology and ore zones are discussed in the following pages. **Appendix 7** contains the results of each survey as contoured overlays for the geology and geography maps.

Other geophysical surveys, conducted by Lynx-Canada Exploration Limited and Canadian Reynolds Metals Limited from 1970-1972, are outlined in **Appendix 2**. Five main anomalies (Zone I-V) were discovered by these surveys and are shown **Figures II-3 and II-4**. Induced-Polarization (IP) best delineated the anomalies associated with the Zn mineralization.

Geography

Geography is an important aspect of a geophysical survey, as many topographic or man-made features can affect the instrument response (e.g. diamond drill hole sites). This section is an attempt to describe the geography that might affect the survey.

An active hydroelectric transmission line transects the southwest corner of the property in a northwestern direction (**Figure II-4**). Due to the electromagnetic field generated by the electrical current pulsating through the lines, it probably has the most significant effect on the instrumentation. The north-south extension of the powerline is inactive and should not affect the equipment.

An ore/waste dump, a tailings pond and several observed drill collars, which are magnetized, may cause responses. Other drill hole locations (not observed) reported in from the literature are plotted on **Figure II-4**. The tailings pond is clay-

and metal-rich (conductive) and could mask or reduce both magnetic and electromagnetic anomalies.

The mine workings are presently filled with water and all the entrances, pits, and trenches are fenced or sealed. Several pits and trenches, parallel to foliation, are distributed throughout the property and marked on **Figure II-4**. No equipment or large structures remain on site, but several building foundations are still present, mostly at west end of the property. These areas have variable amounts of metal and may generate false anomalies.

Local relief commonly varies between two to three metres, attaining a maximum of approximately five to six metres near the centre of the southern property boundary. A local topographic low trends northeast down the middle of the eastern half of the property, coinciding with the marble. The west end (mine site) generally has a higher elevation than the east. Another topographic low is located adjacent to and north of the mine workings. Swamps define the topographic lows and occupy approximately a third of the property (**Figure II-4**). The higher elevations commonly consist of outcrop.

Geophysical Grid

A grid was originally constructed by Lynx-Canada Explorations Limited in 1970 as a reference for geophysical and geochemical surveys, but its exact location could not be determined. A new grid was constructed approximately coincident with the earlier grid. The geophysical anomalies from the 1970-1973 survey (**Figure II-4**) were approximately located on the new grid from the available information.

The baseline has a length of 600 metres with an azimuth of 076° . The 0+00 location is six metres northwest (azimuth of 338°) of the last hydroelectric pole of the north-trending inactive powerline near the centre of the property (**Figure II-4**). A cairn of marble debris on the waste dump marks the location. The baseline and the 0+00 base station (cross-hairs on the geophysical maps) are plotted on most

maps.

The northwest-southeast (or grid north-south) cross lines have a separation of 40 metres along the baseline. Readings were taken at 20 metre intervals along the crosslines. Data were not collected north of the baseline on lines 2+00W to 1+20W and south of the baseline on line 1+20E due to the presence of the swamps.

Very Low Frequency Survey

The very low frequency (VLF) survey is an electromagnetic survey which utilizes carrier signals from globally distributed naval communication stations. These stations transmit signals with frequencies between 15 and 30 kHz (Sayham and Boniwell, 1989). As the transmitter is basically a long vertical wire and the distance between the transmitter (naval station) and receiver is large compared to the wavelength, the produced electromagnetic field is uniform and planar. The horizontal (magnetic) component of the field, when in the vicinity of a conductor, induces a voltage into the conducting body which generates a current and a secondary magnetic field. The secondary field lags behind the primary by 90 to 180 degrees, depending on the quality of the conductor. The combination of primary and secondary fields gives rise to a elliptically polarized field. The VLF technique measures the orientation of this field via the major axis of the ellipse, which is inclined from the horizontal in the presence of a conductor. This conductor is delineated when the inclination angle (dip angle) rapidly changes from positive to negative in the direction of traverse. The zero value (crossover) approximates the center of the conductor projected to surface.

The minor axis/major axis ratio, defined as the ellipticity, is also measured. The ellipticity depends partially upon the phase and therefore on the conductivity of the body (Beck, 1981). A zero value associated with a crossover commonly indicates a good conductor.

VLF was chosen as a survey technique due to the presence of pyrite,

pyrrhotite and chalcopyrite in the zinc ore and because it is a quick and inexpensive method. These metals are electrical conductors and therefore, the ore bodies should generate electromagnetic anomalies.

The VLF survey was conducted using a Geonics EM-16 rented from Exploranium Ltd. in Bolton, Ontario. It has a resolution of $\pm 1\%$ on the in-phase (% Dip) and quadrature scales. Annapolis, Maryland (NSS - 21.4 kHz) was used as the transmitting station. Readings were taken at 20 metre interval with the operator facing in a northerly direction. Hence real crossovers (positive approaching the conductor and negative retreating from the conductor) are from grid-south to grid-north (left to right on profiles). The raw data are presented in **Appendix 3**.

The data (% Dip) were reduced using the Fraser Filtering technique (Fraser, 1969). This technique enables contouring of the data by converting the real crossovers into positive peaks and false crossovers into negative peaks. Negative values are generally not used in the contouring. Reduction is done by using the formula $FF = (s1 + s2) - (s3 + s4)$ where $s1$, $s2$, $s3$, $s4$ are the readings at each station location along the traverse. FF is the Fraser Filtered value at the midpoint between station 2 and 3. The next FF value is calculated between station 3 and 4 by using the values at stations 2, 3, 4 and 5, and so on. **Figure II-5** is a contoured diagram of the % Dip data (top diagram) and a 3-D surface illustration of that data. Only the positive data are represented in the contoured diagram.

The most prominent feature in these two diagrams is an east-west trending anomaly transecting the property. The isolated peak to the south is a one station anomaly and probably represents the effect of the powerline along that survey line. The main east-west anomaly is confined to the marble and is closely associated with the marble-Mountain Grove Mafic Intrusion contact. This linear anomaly may be attributed to a resistivity contrast along the marble-intrusive contact. However, stronger readings occur within this anomaly and these will be examined more closely.

Figure II-5

Fraser Filtered VLF Data. Negative values on the border reflect either west or south

grid locations. North is towards the top of the contoured diagram.

Figure II-5

The strongest anomalous readings (50-70 % Dip) are centred at 3+20 E and 0+40 N. The anomalous zone extends along strike from 2+60E to 3+80E and has a width of approximately 40 metres. Depth estimates are inferred from the profiles across the conductor and are discussed later. The profile symmetry of this anomaly suggests a sub-vertical elongated body (parallel to foliation). For example, contour spacing on the south side of the anomaly is more closely spaced than on the north side. This suggests a dip component towards the north. The anomaly appears not to be related to any geographic or man-made phenomena.

The other anomalies may be associated with geographical effects. For instance, the anomaly between 0+40W, 0+20N and 0+80W, 0+40N is related to the old mine workings closely associated with the northern contact, both at surface and depth. The curved shape of this anomaly may also indicate that the marble-Mountain Grove Mafic Intrusion contact diverges 20 to 30 metres to the northwest through the swamp. The two anomalies between 0+40E, 0+00 and 0+60E, 0+20N are associated with three trenches, two filled with water and the other containing a small (<3 cm in width) mineralized vein. The moderate readings between 1+40E, 0+20N and 2+00E, 0+60N can be explained by the presence of the swamp and possibly the effect of several diamond drill hole sites and the fence surrounding the pits.

The quadrature data (or ellipticity) are presented in Figure II-6. As suggested earlier, a zero quadrature at a real crossover commonly indicates the presence of a good conductor. The zero contour, slightly offset to the north, closely follows the % Dip positive peaks. It also appears closely related to the marble-Mountain Grove Mafic Intrusion contact. Reasons for this coincidence are unclear. The zero contour curves to the northwest at 0+40W and 0+20N also indicating the contact may be 20 to 30 metres further north.

Positive quadrature peaks associated with crossovers commonly indicate faulting (EM-16R Manual). It is suggested that between 3+95E, 0+00 and 2+40E, 0+40N, faulting occurs closely associated with the southern boundary of the

Figure II-6

VLF Quadrature Data. Negative values on the border reflect either west or south grid

locations. North is towards the top of the contoured diagram.

Figure II-6

Chapter II Long Lake Zn Mine - Geophysics

swamp. This positive trend is offset 20 to 30 metres to the south from the positive % Dip peaks. A second positive reading is located between 0 + 40E, 0 + 20S and 1 + 20E, 0 + 00 and is associated with an observed lineament in the marble near the southern marble-Mountain Grove Mafic Intrusion contact. Areas of negative quadrature are closely related to the swamps.

For a more comprehensive study of the survey, individual profiles from the 3-D figures are examined. Depth to the top of a conducting body can be estimated by calculating the distance between the positive and negative % Dip peaks associated with the crossover (Klein and Lajoie, 1980). The quadrature profile can indicate the quality of the conductor (zero value = good conductor), the

Figure II-7 "Textbook" crossovers (left to right) caused by an overhead powerline.

presence of conductive overburden (negative to positive readings across conductor (Saydam and Boniwell, 1989; EM-16R Manual), and can delineate faulting (large positive readings).

Approximately a third of the profiles are influenced by the powerline to the southwest. Filtering of the profiles is difficult as the powerline effect is seen across most of the survey line superimposed on the true data. Estimating the effect, in this case, is very unreliable. One would have to estimate the filter values to apply. These profiles, however, show "textbook" crossovers of a good VLF conductor (Figure II-7) at the powerline.

Figures II-8a, b, c & d represent the VLF profiles over the smaller anomalous zones in the large east-west trending anomaly. Lines 0+80W, 0+40W and 0+00 do not have crossovers which go from positive to negative % Dip readings, but the conductor is revealed by the change in % Dip of the readings from a less negative to more negative numbers. The geographic noise (ie: surface conductors such as the ore/waste, wire fences, the remains of a car, and various pieces of metal) in this area is high and the crossover is masked. The midpoint of the steepest part of the slope is estimated as the crossover.

The quadrature, close to zero at the crossover, indicates a good conductor. Depth estimates, calculated by determining the distance between the maximum and minimum peaks on either side of the crossover, suggest a depth from 30 to 40 metres to the top of the body. This anomaly correlates well with both depth and location of the old workings of Shaft #2, 3, and 4, presently filled with water.

The increase in % Dip at the northern end of the survey line is probably caused by the east-west trending property fence that is perpendicular to the primary electromagnetic field (positive % Dip approaching a conductor). The negative % Dip decrease to the south is caused by the effect of the powerline (negative % Dip retreating from a conductor).

Small crossovers at lines 0+40E, 0+80E and 1+20E coincide with a east-west stream in a lineament. The shape of the quadrature (positive to negative) and

its positive value indicate a non-conductive surface with a weak conductor at surface, thus supporting this observation. The small positive quadrature peak (especially Line 0+80E) offset 10 metres to the south suggests the presence of a fault.

Lines 1+60E, 2+00E and 2+40E have crossovers from 0+30N to 0+40N. The quadrature and its shape on line 1+60E indicate a good conductor near a non-conductive surface. The shape of the % Dip curve (a shallower 'roll-off' to the north than south) indicates a subvertical body with a dip component to the north (Telford *et al.*, 1981). The positive quadrature at the crossovers on lines 2+00E and 2+40E indicates a weak conductor near surface. However, depth estimates of these three profiles range from 60 to 80 metres. These three profiles are closely related to the old mine workings (water in the tunnels, ore/waste debris), a fence and a swamp. The quadrature peak on line 2+40E at the crossover suggests faulting near or at the conductor. This peak is present further south in the next three profiles.

Lines 2+80E, 3+20E and 3+60E have the most interesting % Dip and quadrature responses. Crossovers are located from 0+40N to 0+80N and the quadrature (near zero) indicates a good conductor. The shape of the % Dip profile (steep slope between maximum peaks) indicates a tabular body that steeply dips to the north, parallel to foliation and spatially close to the northern marble-Mountain Grove Mafic Intrusion contact. Depth estimates to the top of the conductor range from 65 metres on line 2+80E, 80 metres on line 3+20E and 60 metres on line 3+60E. This suggests a curved upper surface of a possible lens with a length of at least 80 to 120 metres. The positive quadrature peak 25 metres south of the anomaly suggests the presence of a fault near the southern boundary of the swamp, possibly the extension of the peak discussed for Line 2+40E.

Figure II-8

II-8a VLF profiles across Lines 0+80W to 0+00. Pseudo-crossovers occur at 0+20N.

II-8b VLF profiles across Lines 0+40E, 0+80E and 1+20E. The real crossovers (left to right) are located between 0+20S and 0+00.

II-8c VLF profiles for Lines 1+60E, 2+00E and 2+40E. The real crossovers (left to right) are located at 0+40N.

II-8d VLF profiles for Lines 2+80E, 3+20 and 3+60E. Real crossovers (left to right) are located between 0+40E and 0+60E.

Figure II-8a

Figure 11-8b

Figure II-8c

Figure II-8d

Total Field Magnetism Survey

The total magnetic field intensity was measured using a proton precession magnetometer. This instrument utilizes the precession of spinning protons or nuclei of the hydrogen atoms in a hydrocarbon fluid to measure the total magnetic intensity (Breiner, 1980).

Magnetic surveys record disturbances in the earth's magnetic field and reflect the presence of materials and minerals that have magnetic properties. Magnetite (and associated minerals), pyrrhotite, and iron artifacts (generally man-made) are the most common sources of magnetic field perturbations and are present at Long Lake. Most importantly, pyrrhotite is contained within the marble-hosted zinc ore. Any magnetic anomalies within the marble enclave may reflect the proximity of a pyrrhotite-bearing (zinc ore?) body.

The survey was carried out using a G-826 Proton Magnetometer (with a backpack) rented from Exploranium Ltd. in Bolton, Ontario. The total intensity of the magnetic field was measured on a digital readout with a sensitivity of ± 1 gamma. Readings were not corrected for diurnal variations in the magnetic field and the regional magnetic value of 56,000 gammas has not been subtracted from the readings. The regional magnetic total field can be estimated from contour maps of the earth's total magnetic intensity. Such maps are found in most texts dealing with magnetic surveys (ie: Breiner, 1980).

Readings were taken at 20 metre intervals on north-south grid lines with a east-west separation of 40 metres. **Appendix 4** contains the raw data for the magnetic survey. The magnetic field inclination is approximately 76° north and can be assumed to be vertical when modelling profiles (Breiner, 1980).

The Total Field Magnetic contour map and its 3-D surface representation are presented in **Figure II-9**. The most prominent feature is the east-west trending magnetic low across the property. The marble typically has a magnetic reading of 56,000 gammas (or lower) whereas the Mountain Grove Mafic Intrusion commonly has a magnetic intensity near 58,000 gammas. The granite has a

Figure II-9

Total Field Magnetic data. North is towards the top of the contour map.

Contour interval is 750 gammas. Grid south and west are the negative values.

Note the magnetic low outlining the marble enclave.

Figure II-9

slightly lower signature (57,000 to 57,500 gammas) than the Mountain Grove Mafic Intrusion. This is expected as granitic rocks commonly have a lower magnetite content than mafic intrusive rocks.

The 56,500 gamma contour closely follows (within 20 metres) the marble-Mountain Grove Mafic Intrusion contact. This is especially true for the northern contact. The southern 56,500 gamma contour diverges from the marble-Mountain Grove Mafic Intrusion contact between 1+20E and 2+60E. A series of magnetic highs within this magnetic low continue to approximate the contact. By comparing the magnetic contour map with the geography and geology maps, this magnetic low can be attributed to any of several factors, but it is influenced by the lack of survey data on Line 1+20E, south of the baseline. The magnetic low has probably resulted from extrapolation of the computer program and therefore is not real and not significant.

Figure II-10 is a typical magnetic profile across the property. The marble is defined by a magnetic low and the intrusive rocks produce the magnetic highs on either side. The shape of the trough is asymmetrical suggesting that the marble enclave has a dip component. A positive asymmetrical anomaly (ie: a dyke) in a vertical (or near vertical)

Figure II-10 Magnetic profile along Line 1+20W.

magnetic field which has a steep south side dips to the north (Breiner, 1980). Conversely, if a negative anomaly (ie: marble) has a steep side to the south, then it dips to the north. For example, the magnetic field intensity should decrease more abruptly when approaching a marble from the south, that dips towards the north.

The marble-Mountain Grove Mafic Intrusion contact is defined to the south by the sharp increase in magnetic intensity and to the north by a more gradual increase. The VLF survey suggested that the marble-Mountain Grove Mafic Intrusion contact is located approximately 20 to 30 metres further north. Since the marble dips to the north, perhaps the VLF survey is reflecting the contact at a greater depth than the magnetic survey, thus picking up the contact further north.

Man-made features have affected the magnetic signature of several survey lines, generating noise on these profiles. Lines 2+00W (Figure II-11) and 3+95E are smooth, flat profiles generated by a north-south trending wire fence. East-west trending fences tend to generate small positive anomalies. Since long north-south (parallel to the ambient magnetic field) conductors (wire fences) are magnetized along their length (Breiner, 1980) and therefore the magnetic flux lines are horizontal away from the ends, the total field magnetometer records only the regional magnetic field (with no perturbations) throughout its length. A long east-west conductor generates perturbations (as a line of dipoles) that is recorded by the magnetometer.

Figure II-11 Smooth magnetic profiles along Line 2+00W caused by north-south wire fence.

By comparing the geography map with the contour map, suspect anomalies are delineated. The negative anomaly at 0+00 and 0+80S is associated with the southern edge of a swamp and the intersection of two powerlines (with hydro-pole) within the Mountain Grove Mafic Intrusion. The small positive anomaly at 0+40E and 0+40N is closely associated with a group of diamond drill holes (some

observed). The only anomaly within the marble (1+60E, 0+40N) is probably

caused by the old mine workings of Shaft #1, and its wire fence.

Using the geology map, other anomalies can be examined. For instance, the anomaly at 0+80E, 0+40S is a small magnetic high over a gossaniferous (pyrite) unit. A second magnetic high (2+80E, 0+20s) is associated with small skarns (+pyrite, magnetite?) close to the marble-intrusive contact. Although these anomalies are small, they are mentioned in an attempt to explain the anomalous readings in an area.

The largest and most interesting magnetic anomaly is located along Line 0+40W between 0+40N and 1+00N. Figure II-12 represents the magnetic profile along this survey line. Depth is estimated by using the half-width depth estimate (Breiner, 1973). This method, depicted in Figure II-

Figure II-12 Magnetic profile along Line 0+40W with an anomaly at 0+80N. Depth estimate is 25-30 metres to centre of body.

drawn from the maximum amplitude of the anomaly to the base. The midpoint of the vertical line is calculated and then extended perpendicular to the profile curve. A second vertical line is drawn from the intersection to the base. The distance between the lines is measured from the distance axis. The value calculated is the half width ($X^{1/2}$) and is multiplied by either 2 (sphere, horizontal cylinder), 1.3 (vertical cylinder) or 1 (narrow dyke), depending on the assumed shape of the causative body.

Depth estimates for the anomaly in Figure II-12 suggest a depth of 40 metres (assuming a sphere) and 26 metres (assuming a vertical cylinder) to the centre of the anomaly. As this anomaly is within the Mountain Grove Mafic Intrusion, the magnetic high is probably caused by an increase in magnetite within

the unit. However, it is interesting to note that the depth(s) of this anomaly and its location are nearly coincident with a VLF anomaly discussed earlier. The low magnetic reading at the end of the profile is caused by the small marble enclave (Figure II-3). The shape of the anomaly (in plan view, Figure II-9, top diagram) and other small magnetic highs a few metres north outline the S-shape of the smaller marble enclave between them. As well, the eastern flank of the anomaly closely mimics the contact between mafic and granitic intrusive phases.

It should also be noted that a magnetic low (3+20E, 0+50N) is coincident with the main VLF anomaly. A second magnetic low (2+40E, 0+40N) is spatially close. Figure II-14 is the magnetic profile across Line 3+20E that contains the one point anomaly correlating to the VLF anomaly. Generally, this anomaly would be ignored, but as it coincides with the

VLF anomaly, it is more interesting. Depth to the center of the anomaly is estimated at 20 metres. This estimate, unfortunately, does not correlate with the VLF depth estimate of 85 metres and therefore may either represent a different

Figure II-13 Half-width depth estimate method.

Figure II-14 Magnetic profile along Line 3+20E.

causative body or an area of different physical properties in the causative body. The coincidence of the magnetic and the VLF anomalies is interesting.

Overall, the magnetic survey failed to delineate any definite areas of interest, although it outlined the marble-Mountain Grove Mafic Intrusion contact quite closely.

Self-Potential Survey

Self-Potential (SP) is an electrical exploration technique which is based on naturally-occurring direct currents flowing in the ground. These currents are generated by several well known factors which include water streaming through rock pores, variations in concentration of electrolytes in ground water and other electrochemical processes (Parasnis, 1983). Background voltages range from a few millivolts to tens of millivolts. Anomalous readings of a few hundred millivolts commonly indicate a body containing either sulphides (py, cp, po), oxides, or graphite (Telford *et al.*, 1981). These anomalous readings are always negative.

Due the presence of pyrite, chalcopyrite and pyrrhotite within the ore bodies and the depth of the known ore bodies (30 metres), SP was chosen as a potentially useful geophysical technique. As well, previous work has indicated that sphalerite, even though a poor conductor, occasionally generates SP anomalies. (Telford *et al.*, 1981).

The most accepted cause for negative anomalies over electrical conducting body is an oxidation potential difference between the upper and lower parts of a conductor (Hallof, 1980; Telford *et al.*, 1981; Parasnis, 1983). Although a few SP anomalies have been reported from bodies below the water table, this effect commonly occurs when a sulphide body straddles the water table. Differences between the rates of oxidation of the lower and upper surface create a electrochemical cell in which electrons flow through the body to the upper surface where ions are being lost. The upper surface becomes negatively charged generating a negative SP anomaly. By placing two non-polarizing electrodes

(connected to a high impedance voltmeter) in the ground, potential differences (voltage) can be measured along survey lines.

The SP survey was conducted using a RSP-6 D.C. Resistivity and Self-Potential Unit with a sensitivity of 0.2 millivolts (mV) and an accuracy ± 0.5 mV. Using a reference station (0+80E, 1+60N) with increasing separation between the non-polarizing electrodes, the whole geophysical grid was covered. Readings were recorded at 20 metre intervals along north-south grid lines which have a east-west separation of 40 metres. Anomalous readings are commonly defined by negative readings of 100 mV (sulphides) or more. Smaller negative readings usually have biological or man-made causes. **Figure II-15** displays the contoured diagram and the 3-D surface representation of the data.

SP commonly has a limited depth of penetration to the top of the water table (RSP-6 Instruction Manual) or to 60 metres (Telford *et al.*, 1981). Consequently, any sulphide bodies completely below the water table should have very weak responses. As well, frozen ground does not produce good SP results. This survey was conducted during mid-fall and, although the ground was not frozen, snow was present and the electrodes (a copper electrode in a solution of copper sulphate in porous porcelain pots) were partially frozen by the end of the day.

Four anomalous zones are delineated within the marble, two positive and two negative. A north-south positive ridge across the property on Line 0+00 can be observed. This ridge is possibly caused by the powerline.

The two positive peaks at 1+20W, 0+80S and 2+00E, 0+20N are not significant. Positive peaks in SP are commonly caused by discharging (corrosion) and in these cases, the more westerly peak is attributed to a building foundation, and the easterly peak to either a trench, or a culvert under the road.

The eastern negative peaks (2+40E, 0+40N and 3+20E, 0+60N) are both interesting anomalies (**Figure II-16**). The anomaly on Line 2+40E is not large enough in amplitude (Parasnis, 1983) to warrant economic interest. This anomaly is probably caused by the narrowing of the swamp forming a small, slow moving,

Figure II-15

Self Potential data Negative values on the border reflect either west or
south grid locations. North is towards the top of the contoured (top)
diagram

stream and may represent fluid streaming (**Figure II-4**). However, it may also represent a weak response from a sulphide body below the water table, perhaps the ore bodies and water associated with Shaft #1.

Figure II-16 SP profiles on Lines 2+40E and 3+20E containing the anomalous negative peaks.

The anomaly on Line 3+20E is only one point but the anomaly is in the realm of sulphide anomalous readings and it is interesting that this reading correlates well with a VLF and magnetic anomaly. The half-width method, as defined in the magnetics section, is a semi-quantitative estimate of depth to the top of the body in a SP survey (personal communication, Blenkinsop, 1987; Parasnis, 1979). Estimated depth (half-width method) to the top of the body (assuming a sphere or horizontal cylinder) is 20 metres. This estimation, however, does not

correlate well with the VLF estimates but does with the magnetic anomaly, another one point anomaly.

No other interesting features are apparent in the profiles. Minor changes in SP profiles are noted, but are not recognized as anomalous. If sulphide bodies are completely or mostly below the water table, they are not recognized.

Horizontal Loop Electro-Magnetic Survey

The Horizontal Electro-Magnetic (HLEM) survey is a moving source (transmitter) and receiver technique, involving two horizontal coplanar coils. The electromagnetic theory behind the HLEM survey is the same as discussed in the VLF section, with a few features characteristic of moving source-receiver techniques. Firstly, as the transmitting coil is able to generate electromagnetic fields of different frequencies, the surveyor is able to compare surveys conducted at various values. Secondly, the magnetic component of the generated electromagnetic field is vertical in contrast to the VLF method, in which the field is horizontal. In contrast to VLF, only the induced secondary magnetic component is measured. As well, instead of a crossover recording the presence of a conductor, electromagnetic lows or troughs delineate conductors in profile. The induced magnetic field is measured as a percentage (%) of the primary field.

Two readings are taken, the in-phase (real) component and the out-of-phase (quadrature) component. Anomalous in-phase readings in profile are of the order of -30%. The amplitude (resolution) of these readings depends on the frequency and the depth of the causative body.

Depth of penetration is dependant on the frequency of the transmitted field, the separation of the coils, and the conductivity of the ground. The lower the frequency and the larger the coil spacing, the greater the depth of penetration. However, at lower frequencies, resolution (ie: amplitude of the anomalies) is forfeited.

Depth, conductivity, conductor width, and dip of the causative body can be

estimated by analyzing these anomalies in profile. Depth penetration is commonly equal to half the coil separation (Telford *et al.*, 1981). Depth to the top of the conductor and the conductance of the body are estimated by comparing laboratory-tested responses of the maximum in-phase and quadrature components to maximum in-phase and quadrature field results. The dip can be approximated by comparing the height of the roll-off shoulders on either side of the anomalous reading. These relationships are available in most texts as Phasor or Argand Diagrams (Grant and West, 1965; Klien and Lajoie, 1980; Telford *et al.*, 1981; Figure 7.51).

Conductor quality can also be estimated by using the ratio in-phase/quadrature (IP/OP), where a ratio greater than one indicates a good conductor. For example, if the quadrature is near zero over an anomalous in-phase reading, the body is a very good conductor. Due to conductor thickness and current gatherings, a decrease in the IP/OP ratio, compared to the laboratory results, is generally observed in the field. These phenomena are eliminated to some extent by using lower frequencies and larger coil spacings (Telford *et al.*, 1981).

The HLEM survey was conducted using an Apex Maxmin III Portable EM rented from Geoform Limited in Ottawa. It has a resolution of $\pm 0.5\%$ on the in-phase and quadrature scales. Five frequencies (222, 444, 888, 1777, 3555 Hz) were used with a coil separation of 100 metres and therefore the depth of penetration is about 50 metres. Readings were taken at 20 metre intervals with the receiver coil to the north and the transmitter coil to the south. As the topography is relatively flat, terrain or slope corrections were not used. No data were collected on Line 1+20E due to the swamp south of the baseline. The raw data are presented in **Appendix 6**.

Because of the limited size of the property and the depth of penetration desired, only a small portion of the property, 0+00, 0+40W to 0+00, 3+60E and everything north, was covered. However, this area includes the correlated VLF,

SP and magnetic anomaly centred at 3+20E, 0+50N. As well, most of the marble enclave was covered. It was anticipated that the low frequencies and the small station spacing (20 metres) would reproduce the VLF responses and aid in determining more specific details of the conducting body.

Figures II-17 to II-21 represent the reduced contoured data and its 3-D surface representation for each frequency. Overall, no spectacular anomalies are observed. Most of the in-phase and out-of-phase readings are negative, suggesting that throughout the survey area, a conductive surface is present (Parasnis, 1983). This is reflected in the fact that the higher frequencies (1777 Hz and 3555 Hz) display larger areas of anomalous in-phase readings, indicating near or at near surface conductors. Generally, these areas are coincident with areas of high geographic noise, reflecting features such as the sugar shack (3+20E, 1+00N), drill holes and waste debris between Lines 1+60E and 200E (40N). Other smaller anomalies at the higher frequencies can possibly be attributed to current gatherings. For example, at 1+60E, 1+00N, a small anomaly is coincident with the granite-mafic intrusion-marble contact, a good candidate for this effect. As better depth penetration is achieved with the lower frequencies, these anomalies disappear. Anomalies associated with the lower frequencies are discussed next in more detail.

One of the larger anomalies, between 2+80E, 1+20N and 3+60E, 1+20N, is situated in the Mountain Grove Mafic Intrusion, quite possibly associated with either swamp edge effects or a metal concentration within the intrusion. This anomaly, up to -10%, is observed at all frequencies. The IP/OP ratio ranges from 9 (good conductor) at the lower frequencies to near zero at the higher frequencies. This anomaly is discussed in more detail later in this section by considering its profile.

Figure II-17 to 21

A contour map and its 3-D representation of the HLEM survey at the frequencies of 222, 444, 888, 1777 and 3555 Hz, respectively.

Figure II-18

Figure II-19

Figure II-20

Another large anomaly, located between 2+00E, 0+30N and 2+80E, 0+20N, is closely associated with the southern marble-Mountain Grove Mafic Intrusion contact. A gossaniferous unit and skarns occur at these locations. However, as no readings were taken south of 0+20N, this anomaly is only partially observed and the shape and extent is not known. The lower frequencies indicate a good conductor, while the higher frequencies (except directly over the gossan) indicate a poor conductor. Overall, this anomaly probably represents a contact and/or swamp edge effect (ie: current gathering). The gossaniferous unit may extend to deeper levels, as indicated by the lower frequencies, or the survey may be detecting some feature associated with Shaft # 1. At 1777 Hz, the overall anomaly, as discussed earlier, extends to 1+60E and 0+80N detecting the old surface workings associated with Shaft # 1. This anomaly correlates well with a VLF anomaly attributed to the swamp and mine workings.

The last interesting feature of the HLFM survey is the apparent northeast-southwest trend (parallel to foliation) of four small anomalies located at 0+00 and 0+20N, 0+80E and 0+40N, 1+60E and 0+40N, and 3+20E and 0+60N. These anomalies are best represented in the lower frequencies and are not apparent at all frequencies. The first anomaly (0+00, 0+10N) is the result of the old mine workings at surface and depth. The second anomaly is caused by a mineralized vein in a small pit. The third and fourth anomalies, on strike with the first two anomalies, are of unknown origin and therefore more interesting.

Figures II-22 and II-23 represent the profiles across these last two anomalies at the three lowest frequencies. They are small in extent ($<20\text{m}^2$), possibly indicating the top of a conductor at depths greater than 50 metres. The fourth anomaly (3+20E, 0+60N) closely correlates with the 60 metre deep VLF main anomaly.

As the survey does not extend south past 0+20N, the extent of the anomaly (0+40N) on Line 1+60E (**Figure II-20**) is not known and estimates at all frequencies are suspect. Correlating with the geology, however, this anomaly

appears to be the result of a gossaniferous pyrite unit. Using the figure 7.51 from Telford *et al.* (1981), depth estimates (at the lower frequencies) to the top of the conducting body are 60 metres. Optimistically, this may suggest a deeper conducting body down strike. The IP/OP ratio indicates a good conductor (quadrature equals approximately zero) except for the 222 Hz survey, which indicates a poor conductor.

Line 3+20E (Figure II-22) contains two anomalies, one at 0+60N and other at 1+20N. As indicated by geological observations, the ore lenses are no more than a few metres wide, and as the separation between the two anomalies is much greater, it can be assumed that there are two conductors and not a large anomaly attributed to one body (ie: horizontal tabular body). Therefore each anomaly will be discussed separately. The anomaly at 1+20N in the higher frequencies is probably caused by a contact or swamp edge effect. However, this anomaly at the lower frequencies is of unknown origin, possibly attributed to a metallic mineral concentration in the mafic intrusion. The anomaly of more interest is at 0+60N, closely related to the VLF (and SP and magnetics) anomaly. Except for the 222 Hz survey, the IP/OP ratio suggests a good conductor. Depth to the top of the conductor is estimated at 57 metres, correlatable with depth estimates in VLF survey. Resolution of the readings was not good enough to determine dip and conductor width.

HLEM is one of the more powerful tools to use in a geophysical survey, as many aspects of a conducting body can be determined. However, at the smaller scale on Long Lake, anomalies and their details are not easily determined. The 100 metre spacing failed to definitely delineate any anomalous zones at depth. Two correlations with VLF anomalies, one of which (3+20E, 0+50N) is correlatable with SP and magnetic anomalies, are recognized. Unfortunately, depth of penetration, detail and areal extent of this survey was not enough to "see" clearly.

Large coils spacing may increase depth penetration, if one assumes that a conductive layer over the area has not reduce the depth resolution. However, a

Figure II-22

HLEM Profiles across Line 1+60E at the frequencies 222, 444, 888 Hz.

Figure II-22

Figure II-23

HLEM profiles across Line 3+20E at frequencies of 222, 444, 888 Hz.

Figure II-23

more detailed (ie: 5 metre station spacings) survey with a greater areal extent along north-south grid lines may produce profiles that could be better interpreted. All in all, the HLEM survey was not as illuminating as expected.

Interpretation and Summary

The four surveys performed over the property outline several interesting features. Total field Magnetism, VLF and HLEM anomalies could be correlated with several geological features. Magnetism was able to define the marble-intrusion contact; in this case, with the 56,500 gamma contour. This contour closely (within 20 metres) mimics the marble-Mountain Grove Mafic Intrusion contact. HLEM displays the marble-Mountain Grove Mafic Intrusion contact, in places, as a negative anomaly (contact effect). Furthermore, a magnetic contour is closely correlated with the assumed mafic-granitic contact north of the marble. The asymmetry of the magnetic profiles also suggest that the marble enclave is steeply-dipping towards the north, parallel to foliation.

Positive quadrature peaks on the VLF profiles imply the presence of two northeast-trending faults that transect the property (**Figure II-3**). These peaks correlate well with the presence of a lineament and associated swamp within the marble. Negative quadrature readings commonly define the swamps and the tailings pond.

All four surveys appeared to be affected by geography. For instance, the presence of the powerlines greatly influences the VLF readings. Furthermore, VLF responded to other geographic effects such as pits, wire fences, drill hole collars and the old workings at depth. Magnetism appeared not to be affected by powerlines except for a small magnetic low near one of the power poles. However, wire fences did affect the magnetic response. North-south fences caused a smooth magnetic profile, and east-west fences generate small positive peaks. Geography also affected the SP response. For example, corroded metal and building foundations caused positive peaks in the readings.

Although there is no correlation with earlier (1970-2) geophysical anomalies,

VLF, SP and HLEM define an anomalous zone from 2+80E, 0+40N to 3+60E, 0+80N. Total field magnetics exhibits a small magnetic low over the anomalous zone. According to geophysical responses, this zone may contain sulphides. Firstly, VLF and HLEM surveys delineate conducting (sulphide) bodies, and as indicated by geological observation, the only conducting bodies within the marble are the zinc and associated sulphide bodies, and thin graphite layers. Furthermore, the amplitude of the SP anomaly and the weak magnetic low (pyrrhotite?) indicate the presence of sulphides in the causative body. However, graphite is present on the property and should not be entirely ruled out as a source. The graphite occurs in thin layers, and the extent and width of the anomaly does not suggest a thin layer. As well, observed graphite layers on the surface do not give anomalous readings in any of the surveys.

This zone also appears to extend along and down strike, closely associated with the northern contact, from the old workings (Shaft #5, Shaft #1) to the west. This association with the northern contact was noted in previous work completed on the property and can be observed in **Figures II-3 and 4**. Estimates, assuming a horizontal cylinder or sphere, indicate a depth of 60 to 80 metres to the top of the body, approximately twice the depth of the A, B, and C zones of the 1972-3 mining. Estimates also indicate a north-dipping lens-shaped body parallel to previous ore bodies with a strike length of 80 metres. VLF and HLEM also suggest a good conductivity of the zone.

Several factors may warrant closer inspection of the anomaly. For instance the size and strike length of approximately 80 metres could indicate a series of zinc bodies. As the ore bodies are historically of small dimensions and high grade, a series of bodies could provide enough reserves to make exploitation viable. The fact that the anomaly is on strike with previous working, and is closely associated with the northern contact, increases the possibility that the causative body is zinc and associated sulphides. Although all the surveys, except VLF, gave weak responses, sphalerite is a weak conductor and would not show up well on electric or electromagnetic surveys. As well, the conducting sulphides may not be

electrically continuous and therefore display weak responses, possibly indicating massive sphalerite insulating the conducting sulphides.

Further work over the anomalous area could include either drilling, a detailed gravity survey, an IP survey over the eastern portion of the property, or a more detailed electromagnetic survey (ie: HLEM). A gravity survey would be able to differentiate between possible sulphide bodies and false anomalies such as graphite layers in the marble. Gravity, although an expensive method, is a less expensive method of determination than drilling.

To make a deposit viable at Long Lake, a large tonnage with a high grade is needed, especially at the depth indicated. Although the Long Lake deposit is known for its high grade, tonnage (small pods) maybe too low. However, the use of the old workings will reduce the costs of exploration and development. When zinc prices rise, the property could have economic potential.

Whatever the deposit-type, it is apparent from previous work that the ore lenses are confined to marble and stratigraphically correlatable along and down strike within the marble. It was on this basis, that three new ore lenses were discovered at Long Lake in 1971. Therefore it is interesting that the anomaly, centred at 3+20E, 0+50N, also appears to be on strike with previous ore lenses.

Although the geophysical surveys did not contribute any indication of a preferred ore genetic model, regional Gamma-Ray Spectrometry indicated a correlation between increased thorium reading and zinc mineralization. Further work at Long Lake in this area has to be completed in order to get a better understanding of this correlation. Local geophysics only suggests the shape (lens) and extent of anomalous zones on strike (stratiform) with previous ore bodies. Evidence supporting a genetic model may be found in fluid inclusion work of the ore. Temperature, pressure and composition of the metal-bearing solutions could help to solve this problem.

Chapter III

The Ore Chimney Mine: A Case History for Geophysical Exploration

Introduction

In contrast to the Long Lake mine described in the preceding chapter, the Ore Chimney Mine is hosted by metavolcanics and clastic metasediments. However the geological and geophysical characteristic of the Ore Chimney Mine also provide an excellent example of the use of geophysics in defining both geology and potentially economic anomalies.

A sequence of basal metavolcanics (The Hermon Goup), unconformably overlain by late Precambrian metasediments (The Flinton Group), hosts the Ore Chimney deposit. The Ore Chimney Formation, a garnet-biotite to biotite schist that defines the unconformity, lies between the basal metavolcanics and the overlying metasediments. It has a distinct magnetic signature. An associated muscovite schist ($\pm$ magnetite) at the base of the metasediments and in contact with the Ore Chimney Formation also has a strong magnetic signature. Both units with their distinct magnetic character outline the geological structures of the Ore Chimney Mine area.

Of the 27 gold deposits in the Flinton-Fernleigh area, many are associated with the Ore Chimney Formation near the base of the Flinton Group (Harnois, 1987). The distinctive characteristics of the Ore Chimney Formation, both petrologically and geophysically, makes the Ore Chimney Formation an excellent exploration target for similar, unconformity-associated, gold deposits in the area.

The Ore Chimney Gold Mine, approximately 100 kilometres northwest of Kingston (94° 46.5' N lat., 77° 09' W long.), is located two kilometres along Harlowe Road from Highway 41 near the village of Bishop Corners (**Figure III-1**). The use of the land is restricted to academic visits from Carleton University and sporadic exploration projects which include geophysics (1987), trenching (1989) and mine waste Au recovery (1991). Sands Mineral Corporation from Toronto, Ontario, performed three geophysical surveys (VLF, total field magnetics, and self-potential) on the property. At least one PhD study addressed the Ore Chimney

Figure III-1

Location of the Ore Chimney mine (OCM), southeastern Ontario, is indicated by
the shaded box

Figure III-1

Mine (Harnois, 1987)

Detailed Magnetism was performed over the Ore Chimney Mine property by students of Carleton University under the supervision of the author. Results of this study, combined with the other geophysical surveys and geological information, outline the folding of the Flinton Group and the Ore Chimney Formation into a syncline and an anticline. A fault and small sulphide mineralized zones within the metavolcanics are also delineated.

Geology

Regional

The study area is within the Elzevir Terrane (or Subzone IV) of the Central Metasedimentary Belt (Wynne-Edwards, 1972; Davidson, 1986) in the Grenville Structural Province (refer to **Figure I-1**). In comparison to other rocks in the Grenville Structural Province, this area has a low metamorphic grade (lower amphibolite facies grade). As all rock units discussed are metamorphosed to some extent and their protolith is generally known, the prefix "meta" is herein omitted but assumed.

The geology, which has been described by many authors (Harding, 1944; Meen, 1944; Sethuraman and Moore, 1973; Moore and Thompson, 1980; Wolff, 1982; Moore and Morton, 1986), consists of an area underlain by late Precambrian volcanics and sediments of the Grenville Supergroup (**Figure III-2**). The oldest rocks are tholeiitic basalts with minor intermediate pyroclastic rocks (Sethuraman and Moore, 1973) of the Hermon Group. Overlying these units are basaltic to felsic subalkaline volcanic rocks of the Mazinaw Lake and the Kashwakamak Formations (Harnois and Moore, 1987) and clastic and carbonate sedimentary rocks. Granitoid plutons and pegmatites of the Northbrook and Elzevir Batholiths intrude the sequence.

The Ore Chimney Formation, a black, aluminous schist, is conformably

**PM-1 3½"x4" PHOTOGRAPHIC MICROCOPY TARGET
NBS 1010a ANSI/ISO #2 EQUIVALENT**

PRECISIONSM RESOLUTION TARGETS

PIONEERS IN METHYLENE BLUE TESTING SINCE 1974

THREE COUNTY ROAD 6 BURLINGAME MIN 55227 USA
TEL 612 425 7887 FAX 612 425 7887 TLE 612 425 7887

Figure III-2

Regional geology of part of eastern Ontario showing the location of the Ore Chimney Mine. Roads and county boundaries are plotted to provide map location. Refer to **Figure I-1** for regional location in eastern Ontario. The Northbrook Batholith is in the southwest corner of the map. The Elzevir Batholith and the Mazinaw Lake Granite are not shown.

Figure III-2

overlain by Proterozoic clastic sediments of the Flinton Group (Moore and Thompson, 1980). These rocks occur along a major angular unconformity above the older rocks of the Grenville Supergroup, locally the Tudor Formation of the Hermon Group.

Local

The Flinton Group consists of the Bishop Corners Formation and the Lessard Formation. The Bishop Corners Formation contains a clastic siliceous succession composed mainly of fine-grained quartzite and quartzofeldspathic sediments containing some conglomeratic material (Harnois, 1987). The Lessard Formation, carbonate-bearing clastic sediments, is not recognized in the immediate mine area. Pre-Flinton Group geology is described in the regional geology section.

At the base of the Bishops Corner Formation above the Ore Chimney Formation, a 5 metre thick layer of magnetite-bearing muscovite-quartz schist is present. Fifteen metres of fine grained quartzite with hematite laminated cross-bedding overlie the muscovite-quartz schist. Above the quartzite, up to 60 metres of orthoconglomerate and 20 to 100 metres of paraconglomerate (psammitic) are present. These units are deformed into upright, steeply plunging isoclinal folds (**Figure III-3**). The dominant fabric on the property is axial planar to the mapped folds and strikes 230° to 265° and dips 80° to 90° northwest.

Ore Chimney Formation

The Ore Chimney Formation is a mid-Proterozoic pelitic unit between the mafic to intermediate volcanics of the Grenville Supergroup and the sediments of the Flinton Group (Moore and Thompson, 1980). It is a distinct, massive to poorly-layered black garnet-biotite to biotite schist interpreted as paleoregolith (Harnois, 1987) and is traceable for 40 kilometres. Pinching in and out, the Ore Chimney Formation is commonly less than 10 metres thick. It is observed only overlying older metavolcanic rocks, but is not included in the Flinton Group as defined by

Figure III-3

Generalized geology and geography map of the Ore Chimney Mine area (modified after Harnois, 1987). The finely dashed line represents the unconformity. Note the location of the mine shaft in the Tudor volcanics and near the hinge of the syncline. The ore zone occurs 30 metres below the OCF. The structure near the centre of the map denotes the location of the mill site.

Moore and Thompson (1980). Porphyroblasts of garnet with variable amounts of magnetite and sulphide minerals including pyrite and pyrrhotite are also present in the Ore Chimney Formation. Minor amounts of hematite, staurolite, kyanite and epidote and/or hornblende are also recognized (Harnois, 1987).

The Ore Chimney Formation and associated unconformity are close spatially to polymetallic, gold-bearing mineral occurrences. The Ore Chimney Mine gold occurrence is 30 metres below the Ore Chimney Formation. The nearby Addington Mine, a former gold producer, is also closely associated the Ore Chimney Formation. Hence, the Ore Chimney Formation makes an excellent exploration target.

Mine Description

The Ore Chimney Mine gold deposit was discovered in 1902. In 1909, a 400 foot shaft was sunk with northeasterly drifting into the hinge of the easternmost fold (**Figure III-3**). In 1915, a stamp mill operated for a short while, but there are no records of any shipments of ore or concentrate from the mill. Intermittent drilling and underground development continued to 1958. In 1983 the mine was de-watered and re-examined by the present owner (Harnois, 1987).

Networks of gold-bearing quartz and quartz-carbonate veins on or near the unconformity make up the Ore Chimney Mine deposit. The vein system is hosted by a 4 metre thick biotite schist within the metavolcanics. The mineralized zone has been traced for about 550 feet and to a depth of 600 feet towards the northeast. The sulphide mineral assemblage consists of galena, sphalerite, pyrite, chalcopyrite, pyrrhotite, and sulphosalt-illemnite (Harnois, 1987). Vein formation and mineralization occurred during the main episode of Proterozoic metamorphism and deformation. The gold was probably deposited at the unconformity by metamorphic fluids from other gold concentrated sites (Harnois, 1987).

Geophysics

Introduction

Four geophysical surveys were conducted over the property between 1987 and 1989; two magnetic surveys, one VLF survey, and a self-potential survey. The first magnetic survey, and the VLF and self-potential surveys were conducted by Sands Minerals Corporation in 1987. The second magnetic survey was conducted by students of Carleton University during field school in the springs of 1988 and 1989. The Self-Potential survey delineated nothing of interest and is not included in this section. **Appendix 10** contains the results of each survey as contoured overlays for the geology map.

Geography

Geography is an important aspect of a geophysical survey such as this, as many topographic or man-made features can affect the instrument response. This section is an attempt to describe the geography that might affect the survey.

A hydroelectric transmission line transects the property in a northeastern direction (**Figure III-3**). It has a most significant effect on the electromagnetic instrumentation.

Recent minor drilling and trenching (1988), especially a few metres northwest of the baseline from 3+00E to 6+00E (feet) may also cause responses. Drill collars are magnetized and cause magnetic anomalies. The trenches, which trend approximately perpendicular to the base line, and building foundations have minor amounts of scrap metal associated with them. This may also generate magnetic or VLF anomalies.

The mine workings are presently flooded and the shaft is capped. No equipment or large structures remain except for the headframe. Several building sites (foundations) are still present, the most prominent being the mill site. These areas have variable amounts of metal and may generate false anomalies.

The property is generally hilly with the local relief not exceeding 30 metres. The higher elevations commonly consist of outcrop. The highest elevation occurs near the centre of the map area, east of the road and north of the mill area, in the conglomerate (**Figure III-3**). The Ore Chimney Formation and folding is best observed in this area. Intervening valleys or low-lying areas are swampy. The largest swamp is between the mine shaft and north-south mine road, and extends east-west along the inferred fault.

Geophysical Grid

The baseline was cut originally by Minex Exploration Services of Toronto, Ontario in February of 1987. It was cut along the trend (035°) of the main mineralized zone and is at least 2000 feet long, with the 0+00 station located near the mine shaft (refer to **Figure III-3**). The 0+00 station (cross-hairs) and the base line are plotted on all data contoured maps.

The northwest-southeast (or grid north-south) cross lines generally have a separation of 100 or 200 feet along the base line. For the second magnetic survey, pace and compass was used along these lines (25 to 50 foot stations) and some lines merge. For the surveys conducted by Sands Mineral Corporation, the readings were taken at 50 foot spacings along the cross lines.

Very Low Frequency Survey

In 1987, a VLF (Very Low Frequency) survey was performed by Sands Mineral Corporation over the Ore Chimney Mine area. The survey was conducted using a Geonics EM-16 that has a resolution of $\pm 1\%$ on the in-phase and quadrature scales. Annapolis, Maryland (NSS - 21.4 kHz) was used as the transmitting station.

Readings were recorded at 50 foot intervals along grid north-south cross lines with the operator facing in a northerly direction. Hence real cross-overs are from grid-south to grid-north (left to right on profiles). The raw data are presented

in **Appendix 8**. Corrected data are not presented.

The data (% Dip) was reduced using the Fraser Filtering technique. This technique converts the real cross-overs into positive peaks which enables data contouring. **Figure III-4** is a contoured diagram of the % Dip data (top diagram) and a 3-D surface illustration of that data.

The positive ridge on the 3-D surface diagram (**Figure III-4**) has a linear trend that approximates the location of the fault inferred by geology (**Figure III-3**). Symmetry of this anomaly suggests a sub-vertical tabular body with a component of dip towards the south or southeast, because the contour spacing to the northwest is more closely spaced. The broad depressions southeast of 5+50S were interpolated by the computer program and are not significant as no VLF data were recorded in this area. However, the computer interpolation illustrates that the % Dip is decreasing towards the powerline.

Depressions in the quadrature data contouring (**Figure III-5**) over weak anomalous zones (assumed to be a fault) commonly indicate disseminated sulphides in that fault (EM-16R Instruction Manual!). Positive quadrature peaks over weak anomalies suggest the presence of a fault with no sulphides. Both situations occur on the property associated with the % Dip anomaly. Positive peaks arise on the east and west extents of the northeast-trending % Dip anomaly and the negative quadrature readings occur near the centre. The strongest % Dip readings/peaks occur near the negative quadrature readings, which are slightly offset to the north. Overall, the quadrature data increases towards the south (and the powerline), opposite to that of the % Dip.

For a more comprehensive study of the survey, individual profiles over the survey area are examined. However, due to the influence of the powerline to the southeast, a correction factor is needed. A correction factor, which can enhance recognized crossovers, may provide better estimates of conductor locations and perhaps distinguish other crossovers near the powerline.

Figure III-4

Fraser Filtered VLF data. Negative values on the border reflect either west or south grid locations. North is towards the right corner on the contoured (top) diagram.

Figure III-4

Figure III-5 VLF Quadrature data. Negative values on the border reflect either west or south grid locations. North is towards the right corner on the contoured (top) diagram

Figure III-6 depicts the VLF profile of Line 6+00E, where the effect of the powerline is observed. Line 6+00E is used as the correction profile as it best represents the proximity of the powerline at the end of the survey, similar to the grid-west survey lines containing the anomalies. Furthermore, lithology on Line 6+00E is fairly constant and non-conductive, imparting relatively consistent

readings. As folding is steeply plunging, the lithology at depth should also be consistent. The lines traced on the profile represent the estimated correction factor for both the quadrature and the % Dip. This correction is similar to a regional gradient correction in a magnetic survey. The lines are traced on the profile in an attempt to best eliminate the effect of the powerline within that survey line. The steep increase (or decrease) at the end of the line reflects the influence of the powerline. Hence, a line is traced between the first few readings, which are least affected, and extended to the end of the profile. The difference between this linear correction and the profile line at each station on Line 6+00E is subtracted from the readings with the same locations along the other profiles containing the anomalies. This is a crude correction but some of the powerline effect is compensated.

A possible regional increase to the south can be still observed. This may still be due to the increasing effect of the powerline and a larger correction may be needed. However, this correction should, at least partially, enhance the readings.

After the correction (**Figures III-7a & b**), the anomalous zone is still defined by the crossovers, in most cases actually crossing the 0 axis. The quadrature does not cross the 0 axis, but a general pattern can be recognized. Similar corrections to the grid-eastern survey lines produced nothing of interest.

Crossovers on the corrected profiles extend from 10+00W to 0+00 and the anomalous zone is approximately 300 feet wide. Depth estimates of the zone range from 75 to 100 feet. The trend of the zone closely mirrors anomalies in the Fraser Filtered data and the trend of the inferred fault and associated swamp.

The quadrature data reveal several interesting details about the zone. Lines 0+00, 8+00W, and 10+00W show a positive peak in the quadrature at the crossover. Lines 2+00W and 4+00W display negative peaks which may indicate sulphides in a fault. Overall, however, the quadrature curve does not suggest for any certainty anything about the conductivity since it does not cross the zero (good

Figure III-6 The traced lines on this VLF profile represent the correction factor used for all the VLF profiles to compensate for the effect of the powerline.

conductor) axis. However, with a larger correction, the quadrature would cross the zero level over the anomaly. The shape of the quadrature (positive to negative from southeast to northwest) also suggests a non-conductive surface. Fluid in the fault should not be discounted as a causative source.

Lines 8+00W, 6+00W, 4+00W, and 2+00W also display a second crossover between 4+00S and 4+50S. Depth estimates (as discussed in Chapter II) of these anomalies result in a depth to the top of the conductor of approximately 50 feet. The Quadrature indicates the presence of a weak conductor, not likely to be a fault. As the anomaly occurs near the end of the survey line, the influence of the powerline has probably not been totally eliminated by the corrections. A geological contact effect could also explain this small anomaly.

Figure III-7

III-6a Corrected VLF profiles for Lines 10+00W to 6+00W. Real crossovers are from southeast to northwest (left to right).

III-6b Corrected VLF profiles for lines 4+00W, 2+00W, and 0+00. Real crossovers are southeast to north west (left to right).

Figure III-7a

Figure III-7b

Total Field Magnetism Survey

The survey was carried out using a G-826 Proton Magnetometer rented from Exploranium Ltd. in Bolton, Ontario. The total intensity of the magnetic field was measured on a digital readout with a sensitivity of ± 1 gamma. Readings were not corrected for diurnal variations in the magnetic field. The regional magnetic value of 56,000 gammas has been subtracted from all readings.

The area covered in 1988 was delineated by 3+50S, 1+50N, 5+00W, and 10+00E. In 1989, the grid north-south cross-lines were extended to 9+00S between lines 0+00 and 4+00W, and more grid North-South cross-lines were added between existing lines to get more detail. Further data from Sands Minerals Corporation (1987) were used to complete the grid to 1000 feet west (lines 6+00W, 8+00W, and 10+00W). The grid north-south grid lines generally have a separation of 100 or 200 feet. Pace and compass was used along these lines (25 to 50 foot stations). **Appendix 9** contains the raw data for the Total Field magnetic survey.

Different operators, and the uncertainty in station locations of the magnetic surveys does not make the survey ideal. Certainly, a precision of $\pm$ one gamma is not realistic. However, for the purposes of this study and because the susceptibility contrasts between the units is large, the survey is more than adequate.

The Total Field Magnetic contour map and its 3-D surface illustration are presented in **Figure III-8**. The most prominent feature is an apparent fold structure near the centre of the map. The structure extends from 10+00E to 2+00W and 1+00S to 4+00S. Magnetic readings tracing the fold range from 2000 gammas up to 6000 gammas near the hinge. Two folds can actually be visualized in the pattern; the more southerly is truncated by relatively low magnetic readings immediately to the southeast that create a southwest trend.

Comparing the geology and the geophysical signature, it is apparent that the high magnetic readings from 2000 gammas to 6000 gammas closely reflect the location of the Ore Chimney Formation and the muscovite-schist which defines the

the fold structure. It is also apparent that the truncation of the high magnetic readings outlining the folds closely mirrors the position of the fault suggested by the geological interpretation.

An interesting feature associated with the fold is the hinge, which appears to be elongated towards the southwest. The 1500 gamma contour does not parallel the 2000 gamma contour. Instead it extends 350 feet further southwest creating an anomaly. As well, VLF has indicated the presence of possible sulphides (negative quadrature) at this location. Magnetics could be picking up a pyrrhotite and/or magnetite concentration in the volcanics. Pyrrhotite is one of the sulphides associated with the gold mineralization. A second similar parallel anomaly occurs 200 feet to the southeast. VLF suggests faulting between the two anomalies but does not give any indication of sulphides at the second anomaly. These two magnetic anomalies are similar in shape (although not in magnitude) and seem to be related to the fault.

The widening of the magnetic contouring on the north limb of the fold and the anomaly located at 5+00E and 1+00N are possibly associated with observed sulphides or magnetite concentrations in nearby Tudor volcanic outcrops.

Two small isolated magnetic highs (1000 gammas) between 6+00W and 3+00W at 9+00S are associated with muscovite-schist and Ore Chimney Formation outcrops. The high magnetic susceptibility of these outcrops was confirmed with a hand-held "susceptometer" rented from Exploranium Inc. that measured magnetic susceptibility. The anomaly at 4+00S and 4+25E is a single reading and either due to noise (observed scrap metal) at mill site or initial user error.

The powerline, which generates an electromagnetic field, certainly does not have the effect on the magnetic survey that it had on the VLF survey. However, a slight positive linear trend coincident with the powerline can be visualized on the magnetic contour map. This trend may be caused by the alternating current in the powerline affecting the signal received by the detector coil.

Figure III-8

Total Field Magnetic data. North is towards the top right corner of the contour data map. Contour interval is 500 gammas. Grid south and west equal negative values. Note the fold structure.

Figure III-8

For a more detailed study of the more interesting anomalies, four profiles were chosen which cross the areas of interest. No corrections were performed on these profiles, such as was applied on the VLF profiles.

Figure III-9 is the magnetic profile along Line 3+00W. Several interesting features from southeast to northwest (left to right) are noted. The largest magnetic peak (2600 gammas) between 9+00S and 8+00S, as discussed earlier, is generated by the Ore Chimney Formation and muscovite schist that crop out nearby. Both units contain magnetite.

From geological observations and from the shape of the profile, a sub-vertical sheet or dyke (ie: bedding) is assumed as the causative source. An approximate maximum depth (half-width method; Breiner, 1980) of 20 feet (6 metres) to the centre of the body indicates that, indeed, the causative body is near or at the surface. As with the VLF method, depth estimates are semi-quantitative and true depth can be up to $\pm 50\%$ that of the calculated. The half-width method is described in Chapter II.

The small positive peak at 7+00S is probably due to the influence of the powerline. A similar small positive trend is present in most profiles across the property. The peak commonly ranges from 100 (Line 3+00W) to almost 1000 gammas (Line 1+00E). The cause of the associated depression that occurs on line 3+00W is unknown, most likely due to geography (swamp).

The anomaly at 4+00S, associated with the south side of the inferred fault, is the second parallel anomaly discussed earlier. Assuming a vertical sheet, depth is calculated at an approximate maximum of 25 feet (8 metres) to the centre of body. This peak of 300 gammas is not of any major significance (possibly a contact effect), however it is interesting since it parallels and is similar (although of less magnitude) to the anomaly at 1+50S which has been delineated by both magnetics and VLF. The flat area at 3+00S between the two peaks is the approximate location of the inferred fault.

The larger anomaly (2000 gammas) at 1+50S is associated with the

Figure III-9 Total Field Magnetic profile of Line 3+00W. Negative station locations represent south station location.

northern edge of the inferred fault, and corresponds to a VLF anomaly. As discussed earlier, the quadrature of the VLF suggests the presence of sulphides, possibly in a fault. This anomaly also coincides spatially with the nose of the fold. However the lower magnitude of the anomaly suggests that the anomaly may not be caused by variations in susceptibility of the Ore Chimney Formation. From geological observation, it is found that the syncline plunges towards the northeast. Therefore, the anomaly is probably not caused by the Ore Chimney Formation at greater depths. Conversely, it could be suggested that magnetite concentration may be lower in the fold nose and therefore displays a lower reading. But assuming a subvertical sheet or dyke, as suggested by the shape of the anomaly on the magnetic contour map, the approximate maximum depth to the centre of the body is 125 feet (42 metres). This estimate is similar to the VLF depth estimate of 100 feet (30 metres).

Figure III-10 Total Field Magnetic Profile of Line 1+00E. Negative station locations represent south station locations.

Figure III-10 represents the magnetic profile across Line 1+00E. The largest anomaly (5600 gammas) along this line is located at 2+00S and has the characteristic high magnitude of the Ore Chimney Formation and muscovite schist. This is confirmed by outcrops in the area. The peak itself represents the location of the fold hinge, with the Tudor volcanics to the north and the conglomerate and fault to the south. Assuming a vertical slab, the depth estimate to the centre of the body is approximately 50 feet (16 metres). Calculation of depth in this case is not important as the Ore Chimney Formation is used only as a marker bed for geology and geophysics. The sharp decline on the south (left) side of the anomaly (3+00S) is indicative of a fault between two rock types of different susceptibilities (Breiner, 1973). As the difference in susceptibility in this case is large, the typical shape is exaggerated.

Other interesting features on the profile include the effect of the powerline

at 6+50S (2000 gammas) and the depression coincident with a small body of water north of and parallel to the powerline.

Figure III-11 Total Field Magnetics of Line 4+00E. Negative station locations represent south station locations.

The magnetic profile across Line 4+00E is illustrated in **Figure III-11**. The 5600 gamma anomaly at 1+25S is associated with the north limb of the syncline and the Ore Chimney Formation and muscovite schist. The peak width has narrowed suggesting the units have also thinned. This is evident in a small pit near an old root cellar (3+25E, 1+00S), where the muscovite schist and the Ore Chimney Formation combined is less than four metres wide. A minor amount of noise is produced near the site of the mill (4+00S) where scraps of metal were observed. Again, a small positive peak is associated with the position of the powerline (6+50S).

There are two large anomalies in the magnetic profile on Line 6+50E (**Figure III-12**). The anomaly at 1+50S is due to the Ore Chimney Formation and

Figure III-12 Total Field Magnetics of Line 6+50E. Negative station locations represent south station locations.

the muscovite schist, however the second peak at 0+50S poses a problem. Due to the lack of outcrop in the area, this apex could either indicate the presence of pyrrhotite or magnetite in the Tudor volcanics, or an Ore Chimney Formation parasitic S-fold. Disseminated sulphides (py) were observed in the volcanic rocks in nearby outcrops.

The usual noise associated with the mill site (3+50S to 4+50S) is observed, as well as the magnetic low coincident with a small body of water (5+25S) parallel and adjacent to the powerline.

Interpretation and Summary

The two surveys performed over the property outline several interesting features, both geologically and economically. VLF best delineates the fault and an anomalous zone possibly containing sulphides in that fault. Total field magnetics

also delineates the fault and the associated anomalous zone ($\pm$ po). The top of the zone, assuming a subvertical sheet, is approximately 100 feet (30 metres) below the surface. The location of this anomalous body seems to fit the geology of the ore bodies which occur at deeper levels below the Ore Chimney Formation in small northeast shear zones in the Tudor volcanics. This area has not been explored underground, nor has it, to the knowledge of the author, been drilled, although there are small trenches nearby.

Magnetics best traced the location of the Ore Chimney Formation and the muscovite schist outlining the syncline and its eventual truncation by the fault. Here, however, geophysics and geology seem to conflict. Outcrop is sparse in the swamp and geological interpretation of the anticline suggests an extension of the limb into the area. However magnetics suggests that the anticline is faulted approximately 50 to 75 feet (16 to 23 metres) further north than indicated by **Figure III-3**.

Magnetics also picked up the location of Ore Chimney Formation beds in other areas of the property with the characteristic high magnitude (4000-6000 gammas) as well as smaller contact effects and geographical anomalies. The Ore Chimney Formation seemed not to influence the VLF survey, implying that the Ore Chimney Formation is not a good conductor.

Magnetics was least influenced by the powerline while the VLF was greatly influenced, causing an increase in the quadrature and an decrease in the % Dip. It is possible, in some cases, to correct for the influence of powerlines in a VLF survey.

An area that deserves closer inspection (defined by magnetics) is the northern corner of the survey. Here the survey is inconclusive in that an anomaly is present but the source could be sulphides in the Tudor volcanics and/or a parasitic S-fold containing the Ore Chimney Formation and the muscovite schist. The similarity of the two anomalies and lack of a VLF anomaly (a non-conductor) seem to indicate a fold structure. Magnitude and shape of the anomalies (4300

gammas) also suggest that the Ore Chimney Formation and muscovite schist are the causative bodies. However, there is no indication of parasitic folding in the conglomerate which outcrops to the southwest. As well, a similar anomaly at 5+00E and 1+50N (**Figure III-8**), away from the debated area, suggests the concentration of magnetic material in the Tudor volcanics.

In summation, a possible northeast trending sulphide body occurs between 5+00W and 2+00W at an approximate depth of 100 feet (30 metres) while a second anomaly at 6+00E deserves closer inspection. The fold structure, which is outlined by the Ore Chimney Formation and the muscovite schist, can be traced with Total Field Magnetism where outcrop is sparse. The fault, truncating the folds, is delineated by both Total Field Magnetism and VLF, while the VLF suggests that it is subvertical with a southeast dip component.

On a regional exploration scale, magnetism can be used to at least identify the location of the unconformity (via the Ore Chimney Formation) and delineate areas warranting further exploration. VLF, combined with magnetism, could be used as a secondary, more detailed, follow-up survey studying anomalous or interesting features in the regional magnetic survey. As well, if the Ore Chimney Formation or muscovite schist is present, magnetism at any scale can be used to outline the structure of the Finton Group and possibly help to solve some of its more interesting problems.

Chapter IV

An Exploration Guideline

In this study, two specific deposits, stratiform Zn and unconformity-associated quartz-hosted Au veins, were geologically and geophysically studied in detail. From the geophysical (VLF, SP, HLEM, and magnetics), geochemical and geological work, an exploration guideline is proposed for each deposit-type. The findings of the regional geophysical surveys are outlined in **Table IV-1**. **Table VI-2** summarizes the findings of the detailed geophysical surveys from the properties.

Stratiform Zn Deposits

Any exploration project in the Central Metasedimentary Belt must take into account the importance of Zn potential that may be contained in the vast areas of marble of the Central Metasedimentary Belt. It is therefore important to attempt to define geological, geochemical and geophysical exploration guidelines for these monometallic deposits. From work completed by the author and previous researchers at Long Lake, and from research completed by Gauthier and Brown (1982) in the Mont Laurier Basin, an exploration guideline can be suggested. Although there are differences in the geologic setting between the two areas, most proposed exploration techniques should hold true for both areas.

Geological Exploration:

Several geological features of the stratiform Zn deposits studied can be used as exploration tools:

- 1) The stratiform nature itself can be used to trace observed disseminated sulphides in the marble along or down strike to more massive deposits. For instance, in the marbles of the Mont Laurier Basin, it was discovered that Zn mineralization is commonly associated with a transitional contact between the marble and overlying clastic metasediments and is on strike with a magnetite-magnesite-graphite unit (a metamorphosed magnesio-siderite iron formation). This feature is not observed at Long Lake, due perhaps to the limited extent of the marble enclave. However, the larger marbles in the area are associated with clastic sediments and may display this characteristic.

- 2) Where stratigraphy is correlatable, Zn mineralization is commonly stratigraphically above major successions of metavolcanic rocks within Mayo Group marbles.
- 3) Although the Long Lake locality is an exception, Zn mineralization is commonly associated with dolomitic marble. Distinguishing between dolomitic marble and calcitic marble could hasten exploration.
- 4) Quartz and calc-silicate vugs reveal the presence of structurally-controlled open-space filling that may indicate an area of localization of Zn mineralization nearby, possibly along strike.

Geochemical Exploration:

Several geochemical features of the stratiform Zn deposits studied can be used as exploration tools:

- 1) Both detailed and regional soil, rock and stream geochemical surveys are useful exploration tools. Zn and Pb are best as pathfinder elements. Mercury was also found to be useful on a more detailed study at the Long Lake Zn mine (Brown, 1976).
- 2) A high Fe/low Zn ratio (ie: pyrite versus sphalerite) associated with extremities of the ore lenses can be used to estimate the proximity of the ore along strike (Brown, 1976). A more comprehensive discussion is given in Gauthier and Brown (1980).

Geophysical Exploration:

Historically, geophysical techniques, both regionally and locally, have generally given poor responses to the delineation of Zn mineral deposits. Both the SP and HLEM surveys gave poor responses for various reasons as discussed in the preceding chapters. HLEM was expected to confirm the VLF results. This was not

Table IV-1

Regional Geophysical Study

<u>Long Lake Mine Area</u>	Regional Patterns	Local Patterns	Exploration Guidelines	Comments
<p>Magnetics</p> <p>(regional magnetic intensity subtracted)</p>	<p>1) Mafic intrusions generally have higher magnetic readings than the granitic intrusions.</p> <p>2) Large marble enclaves are observed as magnetic lows (0 gammas) on the 1:1,000,000 scale colour map.</p> <p>3) Marbles are commonly less than 2500 gammas on the 1:63,360 scale map.</p>	<p>1) Detail of pattern depends on scale; 1:1,000,000 map outlines the location of intrusions. The marbles are not easily observed.</p> <p>2) Long Lake marble is defined by a deflection in 3500 gamma contour on the 1:63,360 scale map. Deflection outlines the strike and length of the enclave.</p>	<p>Magnetic lows define extent and orientation of marble enclaves</p>	<p>1) Change in magnetic character between the study areas across a northeast magnetic trend. Defines a major geological break.</p> <p>2) Not a particularly useful exploration tool at the larger scales.</p>
Gamma Ray Spectrometry	See Ford and Charbonneau, 1979	<p>1) Total Count, Equivalent Uranium and Potassium outlined the Long Lake marble as a low parallel to strike and extent of the enclave. Larger nearby marbles are also defined as lows.</p> <p>2) Equivalent Thorium had a high anomaly over the Long Lake Marble parallel to strike and extent. Lows were observed in the larger nearby marbles.</p>	<p>1) Lows define extent and orientation of marble enclaves.</p> <p>2) Thorium highs possibly associated with marbles containing Zn mineralization.</p>	<p>Thorium concentration unknown. Further on-site work needed and correlation to other marbles with Zn deposits.</p>
Gravity	Large circular or domal features in the Long Lake study area	<p>1) Long Lake marble located adjacent to circular gravity high correlated to a mafic intrusion under a thin granite.</p> <p>2) No other pattern.</p>	<p>A more detailed scale could possibly delineate zones of higher density in the marble.</p>	<p>1) Change in gravity character across a northeast gravity trend indicating a major geological break between the study areas.</p> <p>2) Not a useful exploration tool at these scales.</p>
<u>Ore Chimney Mine Area</u>				
<p>Magnetics</p> <p>(regional magnetic intensity accounted for)</p>	<p>1) Flinton Group sediments are commonly correlatable with -50 gamma readings at the 1:1,000,000 scale.</p> <p>2) The synforms of the Flinton group are observed as linear forms.</p> <p>3) Magnetic character change across northeast magnetic lineament between study areas.</p>	<p>175 to 200 gamma anomaly associated with OCM at 1:1,000,000 scale.</p>	<p>Magnetic highs associated with Flinton Group, especially near the apex of fold structures.</p>	<p>1) As above</p> <p>2) Magnetic highs associated with OCF not necessarily associated with Au mineralization</p>
Gravity	Contouring has higher relief and more convoluted contouring	Property located on edge of oblate gravity low possibly associated granites.	Lows are associated with the Flinton Group accompanied by a magnetic high near the edge of the gravity low.	Not a useful exploration tool at the regional scale.

Table IV-2

Detailed Geophysical Results

	Geographical Responses	Geological Responses	Delineated Anomalies	Comments
<u>Long Lake Zn Mine</u>				
VLF	1) Old mine workings and trenches filled with water. 2) Trenches with small mineralized veins (py. sph. ± galena) 3) Powerline has "textbook" crossover, positive to negative quadrature through crossover. 4) Drill holes, wire fences, swamps give moderate readings.	1) Zero quadrature mimics MGMI-marble contact. 2) Positive quadrature delineates faulting in marble.	Anomaly suggested at northeast end of positive ridge on Fraser Filtered diagram. The anomaly extends from 2+80E, 0+40N to 3+80E, 0+80N. Depth is estimated from 65 metres at the ends to 80 metres in the middle suggesting a curved upper surface. Shape of the profile suggests a steeply north-dipping body.	Northeast-trending anomaly associated with northern marble-intrusive contact. On strike with earlier ore bodies, also associated with the northern contact.
Magnetics	1) Tailings pond partially masks readings. 2) East-west wire fences cause a small positive anomaly. 3) North-south wire fence tend to smooth profile. 4) Positive anomalies are caused by drill holes and or collars. 5) Negative anomaly associated with intersection of north-south (inactive) and east-west (active) powerlines.	1) Outlines Marble-MGMI contact (58,500 gamma contour) within 20 metres. 2) Typical gamma readings: Marble - <58,500 gammas MGMI - ≥58,000 gammas Granite - 57,000 to 57,500 gammas. 3) Determine attitude of marble from profile. 4) Delineated small marble enclave to the north. 5) Small highs generated by py gossans and skarns.	1) No anomalies delineated in marble. A magnetic low over VLF anomaly. 2) A 20-30 metre deep anomaly in the MGMI probably due magnetite concentration.	Marble enclave subvertical with dips towards the north. Magnetics is best used as a tool for geology. Not enough pyrrhotite or magnetite in ore to be detected easily at depth.
SP	1) North-south powerline (inactive) causes positive trend. 2) East-west powerline (active) does not affect readings. 3) Positive peaks associated with corrosion of metal. 4) Small (30 to 40 mV below norm) negative anomalies reflect fluid streaming.	One point anomaly over VLF anomaly, possibly sulphide body below water table	Anomaly at 3+20E, 0+80N. One point anomaly of -140 mV. Depth estimated at 20 metres.	A time-consuming survey that did not produce any significant results. One point anomaly correlates well with VLF anomaly.
HLEM	1) Readings increase with topography 2) Affected by the metal associated with sugar shack. 3) Delineated old workings, mineralized veins and pits.	1) Delineates marble-MGMI contact (~10%) as current gatherings. 2) Estimates of dip and depth from the shape of anomaly profile. 3) Py gossans and skarns are delineated. 4) Lower frequencies indicate good conductivity.	Conductor correlated with VLF anomaly. Depth estimated at 57 metres. This depth is at the edge of depth of penetration, therefore weak. All frequencies, except 222 Hz, indicate a good conductor.	Increased spacing may have produced better results as conductor at a greater depth than first thought. HLEM is best used for larger areas and larger surveys.
<u>Ore Chimney Au Mine</u>				
Magnetics	1) Slight positive trend associated with main powerline (100 to 1000 gammas). 2) Anomalies caused by scrap metal associated with building foundations.	1) Delineates fold structure, ranging from 2000 to 8000 gammas, truncated by fault. 2) Infers position of fault. 3) Small anomalies in metavolcanics associated with observed sulphides.	Two parallel anomalies, 2+00W, 2+00S to 5+00W, 1+50S and 3+00W, 4+00S to 5+00W, 4+00S. Depth estimated to 125 feet for the northern anomaly. Correlates well with sulphide VLF anomaly.	Traces OCF to define the Flinton Group folding.
VLF	1) % Dip decreases towards powerline from the north. 2) Quadrature increases from the north towards the powerline.	1) Positive quadrature indicates faulting. 2) Negative quadrature indicates presence of sulphides. 3) Large % Dip anomaly across property associated with faulting and possible fluid streaming within.	1) Northeast-trending anomaly from 0+00, 2+50S to 6+00W, 2+00S. Negative (sulphides in fault) and positive (fault) quadrature readings associated with anomaly. Southeast-dipping body estimated from profile. Depth estimated at 75 to 100 feet over strongest % Dip reading with negative quadrature.	Anomaly associated with faulting.

particularly apparent. Conversely, in the Mont Laurier Basin, Electro-Magnetic (EM) techniques have the best responses, as they are used to trace the graphite-pyrite-pyrrhotite paragneiss and the metamorphosed iron formation which are thought to be closely associated with Zn mineralization (Brown, 1982).

On a more positive note, some geophysical techniques can still be useful in exploration. For instance, magnetics can be used, both regionally and locally, as a geological tool, as it closely outlines the extent of the marble enclave. From previous work at Long Lake, induced-potential (IP) gave the best responses to the known ore bodies. However, no other geophysical techniques produced well defined anomalies correlatable to these IP anomalies. As IP is an expensive and time-consuming technique, the author was not able to confirm or refute the results of the IP survey, but it is a suggested exploration technique (Brown, 1976; Lajoie and Klien, 1979) for marble-hosted Zn deposits.

From the database collected from the Long Lake locality, a suggested geophysical exploration guideline for Stratiform Zn deposits in Grenville supracrustal rocks is summarized below:

At the Regional Level: (in association with the suggested geological characteristics and geochemical surveys)

- 1) Regional magnetics used in correlation with a geological map to identify potential exploration areas. Magnetic lows commonly delineate the extent and orientation of marble units. Geological correlation need not occur, as either previously unmapped or buried marble enclaves may be the result. Geochemical anomalies in such lows are considered anomalous.
- 2) Regional Gamma Ray Spectrometry used in correlation with a geological map to identify potential exploration targets. Lows in Equivalent Uranium, Potassium (%) and Total Count similar to the magnetics lows are expected over marbles. Anomalous Equivalent Thorium over the Long Lake Zn mine may or may not be associated with mineralization in the marble. It may prove interesting to follow up Equivalent Thorium highs associated with

- 3) Regional gravity was unable to delineate marbles enclaves due to the scale of the survey. Perhaps at a more local scale, a gravity survey would prove more useful in delineating higher densities in the marble associated with the ore.

At the Local Scale: (in association with the suggested geological characteristics and geochemical surveys)

- 1) The use of total field magnetics to define the extent and attitude of the marble contact. Areas of elevated geochemical readings within the marble are considered anomalous.
- 2) HLEM and VLF surveys can delineate anomalous zones, as well as determining depth, attitude, shape and conductivity of the body. Determining the needed depth of penetration before conducting the HLEM survey (depth of penetration = $1/2$ coil spacing) is recommended. If coil spacing is not large enough for the depth of the conductors, anomalous readings are weak and may not be recognized even at the lower frequencies. The size of the property being examined is also a factor as the desired coil spacing may be too large to make a survey practical.

HLEM and VLF anomalies correlated with geochemical anomalies and associated surface mineralization (either along or down strike from the geophysical anomalies) are considered anomalous. As well, due to the stratiform and boudined nature of the ore lenses, lens-shaped geophysical anomalies elongated and dipping parallel to strike are considered anomalous

- 3) SP proved to be of little use at the Long Lake Zn mine, possibly due to the depth of the ore (below the water table). IP, however, proved more useful at Long Lake. SP anomalies (one point) are considered interesting if associated with geochemical and other geophysical anomalies, but the resulting body is small and probably not economic.

Unconformity-Associated Quartz-Hosted Gold Vein Deposits

The following exploration techniques described are applicable to Ore Chimney Au mine type deposits. These deposits are spatially associated with the unconformity at the base of the Flinton Group, folding of the Flinton Group, the Ore Chimney Formation, and are hosted in quartz ($\pm$ carbonate) veins with minor sulphides. Deposits of this type are commonly restricted to areas of relatively low-grade (greenschist to upper amphibolite) metamorphism.

Two types of these quartz-Au vein deposits occur (Carter and Colvine, 1985): 1) a stratabound network of quartz, quartz-dolomite and dolomite veins, and 2) a discordant quartz and quartz-ankerite veins. The first occurrence is commonly a non-producer. The second discordant quartz-Au vein occurrence is found in different geologic locals such as within shear zones in late intrusive rocks, within crosscutting fractures in marble, metaclastic and volcanic rocks, and within shear zones spatially close to the unconformity at the base of the Flinton Group. Carter and Colvine (1985) give a more comprehensive discussion.

Overall, geophysical techniques employed, both regionally and locally, were useful in the delineation of the Flinton Group sediments and its fold structures (refer to Table IV-1 & 2). Where the Ore Chimney Formation or the Muscovite schist was present, magnetics was able to locate the base of the Flinton Group and trace its form. VLF was able to suggest a possible sulphide body within a transecting fault across the Ore Chimney mine property proposed by both magnetics and VLF. Other sulphide enriched areas in the metavolcanics stratigraphically below the Flinton Group were observed by the author and delineated by the magnetic survey. SP gave inconclusive responses on the property.

From the data collected at the Ore Chimney locality, a suggested geophysical exploration guideline for Ore Chimney-type deposits in Grenville supracrustal rocks is summarized below:

At the Regional Level: (in association with the suggested geological characteristics and appropriate geochemical surveys)

- 1) Regional magnetics define the Flinton Group as magnetic low linear bands. Investigating the magnetic highs in the Flinton Group associated with folding of the Ore Chimney Formation may prove beneficial. These areas may indicate a thickening of the Ore Chimney Formation associated with the apex of a fold and increased likelihood of fracturing and late-stage quartz (+ carbonate) veining associated with the Au deposition.
- 2) Regional gravity was able to outline areas of gravity lows apparently associated with granites. Gravity, as a geophysical tool, was able to separate areas of different geological character in the Central Metasedimentary Belt. Perhaps at a more local scale, a gravity survey would prove more useful in delineating either the fault or the possible sulphide bodies within the fault.

At the Local Scale: (in association with the suggested geological characteristics and appropriate geochemical surveys)

- 1) Ground level total field magnetics can be used as a geological aid for the Flinton Group Structures. With the presence of the Ore Chimney Formation and/or the muscovite schist, the base of the Flinton Group is traceable. Certain anomalies stratigraphy spatially near the unconformity can be correlated to either geology or anomalous bodies in the underlying unit (ie: sulphides in underlying metavolcanics).
- 2) VLF is used to define anomalies within the shear zones or faults. VLF is also used to delineate the faulting itself by either a real cross-over (fluid streaming) and as a positive peak in the quadrature closely associated with the cross-over. A negative quadrature peak commonly indicates the presence of sulphides in the fault.

In summation, this project has generated a geophysical, geochemical and geological database from which an exploration guideline for the two classes of

deposits can be proposed. In addition, anomalies on both properties were delineated and further work was proposed to investigate them in terms of exploration and ore genesis, as is the case at Long Lake.

REFERENCES

- Aikin, B.R. 1973. The Long Lake Zinc Deposit, Olden Township, Ontario. Unpublished BSc. Thesis, Queens University, Kingston, Ontario. 36 pp.
- Alcock, F.J. 1930. The Long Lake Deposit. *In* Economic Geology, Series No. 8. pp. 146-151
- Baer, A.J. 1981. A Grenvillian Model of Proterozoic Plate Tectonics. *In* Precambrian Plate Tectonics. *Edited by* A. Kroner. Elsevier, Amsterdam, The Netherlands, pp. 353-385.
- Bartlett, J.R., Brock, B.S., Moore J.M. Jr., and Thivierge, R.H. 1984. Grenville Traverse A, Cross-Sections of Parts of the Central Metasedimentary Belt. Geological Association of Canada-Mineralogical Association of Canada, Field Trip 9A/10A Guidebook, London. 64 pp.
- Bartlett, J.R. and Moore, J.M. Jr. 1985. Geology of the Belmont, Marmora, and Southern Methuen Townships, Peterbrough and Hastings Counties. Ontario Geological Survey, Open File Report 5537.
- Breiner, S. 1973. Applications Manual for Portable Magnetometers. Geometrics, Sunnyvale, California 94086. 58 pp.
- Breiner, S. 1980. Magnetics: Applications for Portable Magnetometers. *In* Practical Geophysics for the Exploration Geologist. *Compiled by* Richard Van Blaricom. Northwest Mining Association, W. 1020 Riverside Ave., Spokane, WA. pp. 205-238.
- Bright, E.G. 1977. Regional Structure and Stratigraphy of the Eels Lake Area, Haliburton and Peterborough County. *In* Summary of Field Work, 1977, by the Ontario Geological Survey. *Edit by* V.G. Milne, O.L. White, R.B. Barlow and J.A. Robertson. Ontario Geological Survey Miscellaneous Paper 75. pp. 110-117.
- Brown, A.C. 1976. The Long Lake Zinc Mine, Frontenac County, Ontario, Case History. Report 76-2. Department of Mineral Engineering, University of Montreal. 32 pp.
- Brown, A.C. 1982. Grenville Iron-Formations and Associated Stratiform Zinc Mineralization, Roddick Lake Area, Mount Laurier Basin, Quebec. Canadian Journal of Earth Sciences, vol. 19. pp. 1670-1679.
- Brock, B.S., and Moore, J.M. Jr. 1983. Chronology, Chemistry, and Tectonics of Igneous Rocks in Terranes of the Grenville Province, Canada. Geological Society of America, Abstracts, vol. 15. pp. 533.

- Carter, K. 1989. Grenville Orogenic Affinities in the Red Mountain Area, Llano Uplift, Texas. *Canadian Journal of Earth Sciences*, vol.26, pp. 1124-1135.
- Carter, T.R. 1980. Metallic Mineral Deposits of the Grenville Province, Southeastern Ontario. *In* Summary of Field Work, 1980, by the Ontario Geological Survey. *Edited By* V.G. Milne, O.L. White, R.B. Barlow, and A.C. Colvine. Ontario Geological Survey Miscellaneous Paper 96. pp. 169-174.
- Carter, T.R. 1981. Metallic Mineral Studies in the Grenville Province, Southeastern Ontario, Zinc and Graphite. *In* Summary of Field Work, 1981, by the Ontario Geological Survey. *Edited By* J. Wood, O.L. White, R.B. Barlow, and A.C. Colvine. Ontario Geological Survey Miscellaneous Paper 100. pp. 196-202.
- Carter, T.R. 1984. Metallogeny of the Grenville Province, Southeastern Ontario. Ontario Geological Survey. Open File Report 5515. 422 pp.
- Carter, T.R. and Colvine, A.C. 1985. Metallic Mineral Deposits of the Grenville Province, Southeastern Ontario. *Canadian Institute of Mining and Metallurgy, Bulletin*, vol. 78, No. 875. pp. 95-106
- Carter, T.R., Colvine, A.C., and Meyn, H.D. 1980. Geology of Base Metal, Precious Metal, Iron and Molybdenum Deposits in the Pembroke-Renfrew Area. Ontario Geological Survey. Mineral Deposits Circular 20. 186 pp.
- Cone, R.D. 1976. Petrology and Metamorphism of the Long Lake Zinc Deposit. Unpublished BSc. Thesis, Carleton University, Ottawa. 37 pp.
- Darnley, A.G. and Ford, K.L. 1989. Regional Airborne Gamma-Ray Surveys: A Review. *In* Proceedings of Exploration '87: Third Decennial International Conference on Geophysical and Geochemical Exploration for Mineral and Groundwater. *Edited by* G.D. Garland, Ontario Geological Survey, Special Volume 3, pp. 229-240
- Davidson, A. 1984. Tectonic Boundaries within the Grenville Province of the Canadian Shield. *Journal of Geodynamics*, vol. 1. pp. 433-444.
- Davidson, A. 1986. New Interpretations in the Southwestern Grenville Province. *In* The Grenville Province. *Edited by* J.M. Moore, A. Davidson, and A.J. Baer. Geological Association of Canada, Special Paper 31. pp. 61-74.
- Davis, D.W. and Bartlett, J.R. 1988. Geochronology of the Belmont Lake Metavolcanic Complex and Implications for Crustal Development in the Central Metasedimentary Belt, Grenville Province, Ontario. *Canadian Journal of Earth Sciences*, vol. 25, pp. 1751-1759.

- Easton, R.M., Carter, T.R., and Springer, J.S. 1986. Mineral Deposits of the Central Metasedimentary Belt, Grenville Province, Ontario and Quebec. Geological Association of Canada, Mineralogical Association of Canada, Canadian Geophysical Union, Joint Annual Meeting, Ottawa '86, Field Trip 3: Guidebook. 55 pp.
- Easton, R.M. and Dekemp, E.A. 1987. Darling, Lanark and Renfrew Counties. *In* Summary of Field Work and Other Activities. *Edited by* R.B. Barlow, M.E. Cherry, A.C. Colvine, Burkhard O. Dressier, and Owen L. White. Ontario Geological Survey Miscellaneous Paper 137. pp. 220-228.
- Ford, K.L. and Charbonneau, B.W. 1979. Investigation and Regional Significance of Airborne Gamma Ray Spectrometry patterns in the Sharbot Lake Area, Eastern Ontario. *In* Current Research, Part B, Geological Survey of Canada. Paper 79-1B. pp. 207-222.
- Gauthier, M. and Brown, A.C. 1980. Lithologic and Stratigraphic Setting of Zinc Mineralization in Grenville Metasediments, Quebec. *Mineralium Deposita*, vol. 15. pp. 1633-174.
- Grant, F.S. and West, G.F. 1965. Interpretation Theory in Applied Geophysics. New York, McGraw-Hill.
- Gnojek, I. and Prichystal, A. 1965. A new Mineralization Detected by Airborne Gamma-Ray Spectrometry in Northern Moravia (Czechoslovakia). *Geoexploration*, Volume 23, pp. 491-502.
- Hallof, P.G. 1980. Electrical: Grounded Electrical Methods in Geophysical Exploration. *In* Practical Geophysics for the Exploration Geologist. *Compiled by* Richard Van Blaricom. Northwest Mining Association, W. 1020 Riverside Ave., Spokane, WA. pp. 39-152.
- Hanmer, S. 1988. Ductile Thrusting at Mid-Crustal Level, Southwestern Grenville Province. *Canadian Journal of Earth Sciences*, vol. 25, pp. 1049-1059.
- Harding, W.D. 1944. Geology of the Grimsthorpe-Barrie Area. Ontario Department of Mines, Fifty-first Annual Report (1942), vol. LI, Part IV. pp. 51-74.
- Harnois, L. 1987. Geochemistry of the Ore Chimney Formation and Associated Metavolcanic Rocks and Gold Deposits in the Flinton-Harlowe Area, Grenville Province, Southeastern Ontario. Unpublished PhD Thesis, Carleton University, Ottawa. 237 pp.
- Hewitt, D.F. 1956. The Grenville Region of Ontario. *In* The Grenville Problem. Royal Society of Canada, Special Publication 1. pp. 22-41.

- Jury, R.G. 1957. Geochemical Investigations at the Long Lake Zinc Mine, Ontario. Unpublished MSc. Thesis, Queen's University, Kingston, Ontario.
- Kertz, R. 1983. Symbols for Rock-forming Minerals. *American Mineralogist*, vol. 68. pp. 277-279.
- Klein, J and Lajoie, J.J. 1980. Electromagnetics: Electromagnetic Prospecting for Minerals. *In Practical Geophysics for the Exploration Geologist. Compiled by Richard Van Blaricom. Northwest Mining Association, W. 1020 Riverside Ave., Spokane, WA. pp. 239-288.*
- Lajoie, J.J. and Klein, J. 1979. Geophysical Exploration at the Pine Point Mines Ltd. Zinc-Lead Property, Northwest Territories, Canada. *In Proceedings of Exploration 77: Geophysics and Geochemistry in the search of Metallic Ores. Edited by Peter J. Hood. Economic Geology Report 31. pp. 653-664.*
- Mackay, D. 1941. The Zinc Deposit at Long Lake, Ontario. Unpublished MSc. Thesis, Queen's University, Kingston, Ontario.
- Malczak, J., Carter, T.R., and Springer, J.S. 1985. Base Metal, Molybdenum and Precious Metal Deposits of the Madoc-Sarbot Lake Area, Southeastern Ontario. Ontario Geological Survey Open File Report 5548. 374 pp.
- Meen, V.B. 1944. Geology of the Grimsthorpe-Barrie Area. Ontario Department of Mines, Fifty-first Annual Report, Volume LI, Part IV. pp. 1-50.
- Moore, J.M. Jr. 1986. Introduction. *In The Grenville Province. Edited by J.M. Moore, A. Davidson, and A.J. Baer. Geological Association of Canada, Special Paper 31. pp. 1-11.*
- Moore, J.M. Jr. and Morton, R.L. 1986. Geology of the Marble Lake Area, Counties of Frontenac and Lennox and Addington. Ontario Geological Survey, Report 238. 63 pp.
- Moore J.M. Jr., and Thompson, P.H. 1980. The Flinton Group: A Late Precambrian Metasedimentary Succession in the Grenville Province of Eastern Ontario. *Canadian Journal of Earth Sciences*, vol 17. pp. 1685-1707.
- Parasnis, D.S. 1983. Methods in Geochemistry and Geophysics: Mining Geophysics. Elsevier Scientific Publishing Company, New York. 392 pp.
- Read, D., and Thomas, M.D. 1987. Gravity Models within the Southern Central Metasedimentary Belt, Grenville Province, Ontario. *In Current Research, Part A, Geological Survey of Canada, Paper 87-1A, p. 763-772, 1987.*

- Sands Mineral Corporation, 1987. Unpublished Report to Albert Banner.
- Sangster, A.L., and Bourne, J. 1982. Geology of the Grenville Province and Regional Metallogensis of the Grenville Supergroup. *In* Precambrian Sulphide Deposits. *Edited by* R.W. Hutchinson. Geological Association of Canada, Special Paper 25. pp. 91-125.
- Sayham, A.S. and Boniwell, J.B. 1989. VLF Method. *In* A Geophysical Handbook For Geologist. *Edited by* Melvyn E. Best and John B. Boniwell. The Canadian Institute of Mining and Metallurgy, Special Volume 41. pp. 111-124.
- Sethuraman, K. and Moore, J.M. 1973. Petrology of Metavolcanic rocks in the Bishop Corners-Donaldson Area, Grenville Province, Ontario. *Canadian Journal of Earth Sciences*, vol. 10. pp. 589-614.
- Silver, L.T. and Lumbers, S.B. 1966. Geochronologic Studies in the Bancroft-Madoc Area of the Grenville Province, Ontario, Canada. *Geological Society of America*, Special Publication 87. pp. 156.
- Stockwell, C.H., McGlynn, J.C., Emslie, R.F., Sanford, B.V., Norris, A.W., Donaldson, J.A., Fahrig, W.F. and Currie, F.L. 1970. Geology of the Canadian Shield. *In* Geology and Economic Minerals of Canada. *Edited by* R.J.W. Douglas. Economic Geology Report No. 1. 838 pp.
- Telford, W.M., Geldart, L.P., Sheriff, R.E., and Keys, D.A. 1981. *Applied Geophysics*. Cambridge Press, New York. 860 pp.
- Thompson, J.E. 1952. Long Lake Zinc Mine. Unpublished Report. Available at Regional Geologist Office in Tweed, Ontario.
- Uglow, W.C. 1916. Ore Genesis and Contact Metamorphism at Long Lake Zinc Mine, Ontario. *Economic Geology*, vol. 11. pp. 231-345.
- Wilson, M.E. 1917. Geological Survey of Canada, Summary Report, Part E. pp. 29E-42E.
- Windley, B.F. 1986. Comparative Tectonics of the Western Grenville and the Western Himalaya. *In* The Grenville Province. *Edited by* J.M. Moore, A. Davidson, and A.J. Baer. Geological Association of Canada, Special Paper 31. pp. 341-349.
- Windley, B.F. 1989. Anorogenic Magmatism and the Grenville Orogeny. *Canadian Journal of Earth Sciences*, vol. 26, pp. 479-489.

- Wolff, J.M. 1978. Geology of the Kaladar Area, Frontenac and Lennox and Addington Counties, Southern Ontario. Ontario Geological Survey, Open File Report 5252. 126 pp.
- Wolff, J.M. 1982. Geology of the Long Lake Area, Lennox and Addington and Frontenac Counties. Ontario Geological Survey, Report 215. 94 pp.
- Wolff, J.M. 1985. Geology of the Sharbot Lake Area, Frontenac and Lanark Counties, Southeastern Ontario. Ontario Geological Survey Report 228. 70 pp.
- Woussen, G., Roy, D.W., Dimroth, E. and Chown, E.H. 1986. Mid-Proterozoic Extensional Tectonics in the Core Zone of the Grenville Province. *In The Grenville Province. Edited by J.M. Moore, A. Davidson, and A.J. Baer.* Geological Association of Canada, Special Paper 31. pp.297-310.
- Wynne-Edwards, H.R. 1967. Westport Map Area, Ontario. Geological Survey of Canada, Memoir 346.
- Wynne-Edwards, H.R. 1972. The Grenville Province. *In Variations in Tectonic Styles in Canada. Edited by R.A. Price and R.J.W. Douglas.* Geological Association of Canada Special Paper 11. pp. 263-334.

APPENDICES

APPENDIX 1

Long Lake Previous Work

<u>Owner /Worker</u>	<u>Date</u>	<u>Work Completed</u>
	1898	Small base metal deposit reported at Long Lake on the farm of Howard Ritchie. Small mine developed by Leslie Benn, 100 tons of zinc mined in the first years.
James Richardson and Sons, Limited	1901-1915	Owners in Kingston, Ont. The mine was worked intermittently until 1925 which included trenching, pitting, drifting and crosscutting. Five shafts completed (see Figure II-3) ranging from 18 to 40 metres. Ore concentrated on site and shipped to Antwerp, Belgium for smelting. By 1925, 3,442 tons of zinc ore (\$41,550) were mined.
Long Lake Zinc Co.	1914-15	Optioned; Dewatered and examined mine workings. 1000 feet of diamond drilling completed. No further exploration work was done.
M.E. Wilson	1927	Pits and shafts dewatered and examined by M.E. Wilson of the G.S.C. No other work was done.
Rochette Gold Mines Ltd.	1947-1950	Mine leased from Richardson and Sons Limited. A new headframe was erected and shaft No. 2 was retimbered and dewatered to the 30 metres level. 100 metres of drifting and diamond drilling (25 holes) was completed. A flotation unit was installed (35 tons/day). 1674 tons of ore milled producing 240 tons of zinc concentrate (230,323 lbs Zn) and 15 tons of lead concentrate (18,120 lbs Pb). An attempt was made to concentrate the oxidized ore in an old dump. No shipments reported to the Ontario Department of Mines.
Consolidated Rochette Mines Limited	1949-1952	7066 feet of underground drilling. Operation ceased in 1952.
Gerald Cronk	1966	Owner in Kingston, Ont.
Mid-South Exploration Ltd.	1969	Surface exploration
Lynx-Canada Exploration Limited (45%)/Canadian Reynolds Metals Limited (55%)	1970-1974	In 1970, Dr. W.D. Beaton proposed the Kingston Project to test the Long Lake zinc deposit for deeper extensions. Diamond Drilling consisting of 134 surface holes and 114 suburface holes (30,000 feet total). Geochemical and geophysical surveys conducted over property (see Appendix A.2 Exploration delineated 3 ore zones with reserves of 84,750 tons of 21.6% zinc. 15 stopes 4 metres wide were developed at a maximum depth of 35 metres. 200 tons/day were shipped to Baillet smelters. By 1974, 82,371 tons of 11.9% Zn were mine resulting in 48,617 tons of concentrate (18,935,131 lbs Zn). December 31, 1974, the mine was allowed to flood.
Les Ressources Yobreau Inc.	1988	Hostile take-over of Lynx-Canada Explorations Limited.

References: Alcock (1930); Harding (1951); Thomson (1952); Aldin (1973); Brown (1976); Cone (1976); Wolff (1982); Malczak et al. (1985)

APPENDIX 2

Previous Geophysical Surveys

<u>Worker</u>	<u>Work Employed</u>	<u>Results and Comments</u>
Saul, V.A.	Vertical Magnetics Fluxgate Magnetometer	1) Correction for drift or magnetic variations not done. 2) Boundaries of the carbonate trough and adjacent intrusives were located. 3) Possible intiers of magnetic rocks were suspected.
	Induced Polarization Sharp IPU Mark V-8 Time-Domain Unit	1) 5 distinctively anomalous IP zones identified within the carbonates. See Figure II-2 and II-3. Zone I: probable geologic significance after drilling. Zone II: clay-lined trench Zone III: old workings; ore extensions at depth; increased spacing of electrodes to 200 feet indicates a depth estimate of 150 feet; better readings with increased spacing. Zone IV & V: not considered important, smaller anomalies. Attributed to disseminated sulphides within mafic intrusion near the marble-intrusive contact. 2) Carbonate trough was delineated.
	Spontaneous Polarization Copper/Copper Non-polarizable Electrodes Leeds and Northrup Thermocouple Potentiometer	1) Reading difficulties caused by high soil resistances and low voltages. 2) Indicated 6 to 30 metres to top of ore bodies. Very tentative estimates. 3) Bodies have vertical to near vertical attitudes. Not reliable results.
Siegel, H.O.	Gravimeter	1) Located one anomaly 2) Drilled anomaly, found only gneisses and diorite.
Telford, W.M.	Tellurics	1) Tested to distinguish between ore grade mineralization and uneconomic mineral zones. 2) No clear evidence was found.
	VLF-EM	1) No useful signals were observed due to proximity of power lines and lack of resistivity contrast between intrusive and carbonate rocks.

Work completed between 1970 and 1974.

(Brown, 1976; Wolff, 1982)

APPENDIX 3

Appendix 3 contains the raw from the VLF (Very Low Frequency) survey over the Long Lake mine. The survey was conducted using a Geonics EM-16 rented from Exploranium Limited in Bolton, Ontario.

The data is divided by grid location (metres), Dip Angle (% Dip), and Quadrature (%). Fraser Filtering (Fraser, 1969) which allows contouring of VLF data is also included in Appendix A.3. X and Y are the grid coordinates and Z is the filtered reading at that node. Negative grid locations represent south and west locations.

Presentation of the raw data was produced through Lotus 1-2-3 and an add-on program called Always distributed Funk Industries. Reduction of the data contouring and surfacing was produced through Surfer, a program distributed by Golden Software Inc.

LONG LAKE MINE						
VLF (Very Low Frequencies) DATA						
VLF PROFILES				VLF FILTERED DATA		
<i>(Grid Locations in metres)</i>				<i>(Fraser Filtering)</i>		
E-W	N-S	Dip Angle	Quad	(X)	(Y)	(Z)
395	-60	-12	12	395	-30	-46
395	-40	-7	-2	360	-50	-67
395	-20	7	10	360	-30	-53
395	0	20	18	360	-10	-52
360	-80	-40	18	360	10	-16
360	-60	-19	14	360	30	53
360	-40	-2	7	360	50	68
360	-20	10	6	360	70	34
360	0	22	14	360	90	-10
360	20	38	8	320	-50	-64
360	40	10	1	320	-30	-43
360	60	-3	1	320	-10	-55
360	80	-17	-6	320	10	-17
360	100	-10	4	320	30	70
360	120	0	15	320	50	76
320	-80	-40	11	320	70	28
320	-60	-11	7	320	90	-10
320	-40	2	4	280	-50	-57
320	-20	11	9	280	-30	-42
320	0	23	13	280	-10	-46
320	20	45	23	280	10	-8
320	40	6	1	280	30	63
320	60	-8	-2	280	50	64
320	80	-17	-4	280	70	23
320	100	-13	3	280	90	-2
320	120	-2	15	280	110	-20
280	-80	-35	6	240	-50	-58
280	-60	-13	6	240	-30	-43
280	-40	0	3	240	-10	-28
280	-20	9	8	240	10	9
280	0	20	12	240	30	43
280	20	35	20	240	50	44
280	40	2	1	240	70	23
280	60	-10	-2	240	90	-4
280	80	-17	-3	240	110	-16
280	100	-14	4	240	130	-7
280	120	-11	10	200	-70	-78
280	140	0	22	200	-50	-49
240	-80	-38	0	200	-30	-36

E-W	N-S	Dip Angle	Quad	(X)	(Y)	(Z)
240	-60	-15	3	200	-10	-21
240	-40	-3	5	200	10	7
240	-20	8	6	200	30	34
240	0	17	10	200	50	46
240	20	16	9	200	70	25
240	40	0	22	200	90	-6
240	60	-10	-2	200	110	-17
240	80	-18	-1	160	-70	-48
240	100	-15	2	160	-50	-37
240	120	-9	8	160	-30	-39
240	140	-8	9	160	-10	-13
240	160	-9	11	160	10	28
200	-90	-60	2	160	30	52
200	-80	-30	4	160	50	31
200	-60	-12	2	160	70	-3
200	-40	0	3	160	90	-13
200	-20	7	7	160	110	-26
200	0	17	7	120	30	28
200	20	11	5	120	50	0
200	40	6	4	120	70	-7
200	60	-12	2	120	90	-11
200	80	-17	-1	120	110	-32
200	100	-14	3	120	130	-41
200	120	-9	8	80	-70	-56
200	140	-5	9	80	-50	-37
160	-100	-46	11	80	-30	-24
160	-80	-13	5	80	-10	22
160	-60	-12	0	80	10	43
160	-40	1	2	80	30	12
160	-20	11	2	80	50	-10
160	0	17	5	80	70	-13
160	20	8	2	80	90	-19
160	40	-8	-2	40	-70	109
160	60	-19	-3	40	-50	-26
160	80	-12	2	40	-30	-21
160	100	-12	4	40	-10	18
160	120	-6	10	40	10	34
160	140	8	20	40	30	5
120	0	5	2	40	50	-12
120	20	-11	1	40	70	-18
120	40	-19	-6	40	90	-32
120	60	-15	0	40	110	-30
120	80	-15	2	0	-50	-32
120	100	-12	6	0	-30	-17
120	120	-7	9	0	-10	-11

E-W	N-S	Dip Angle	Quad	(X)	(Y)	(Z)
120	140	12	12	0	10	16
120	160	10	18	0	30	11
80	-100	-50	8	0	50	-14
80	-80	-27	10	0	70	-34
80	-60	-12	9	0	90	-24
80	-40	-9	5	0	110	-18
80	-20	7	10	-40	-30	-70
80	0	-4	2	-40	-10	-20
80	20	-20	-2	-40	10	34
80	40	-20	-1	-40	30	28
80	60	-16	-1	-40	50	-1
80	80	-14	4	-40	70	-14
80	100	-9	6	-40	90	-25
80	120	-2	10	-40	110	-43
40	-100	112	8	-80	-30	-100
40	-80	-31	12	-80	-10	-27
40	-60	-9	10	-80	10	18
40	-40	-19	-1	-80	30	28
40	-20	5	6	-80	50	39
40	0	-12	2	-80	70	12
40	20	-20	0	-80	90	-54
40	40	-21	0	-120	10	-79
40	60	-16	1	-160	-130	-29
40	80	-13	5	-160	-110	-64
40	100	-6	8	-200	-90	-44
40	120	9	6			
40	140	2	12			
0	-80	-54	17			
0	-60	-22	8			
0	-40	-25	1			
0	-20	-19	1			
0	0	-11	4			
0	20	-22	0			
0	40	-24	0			
0	60	-20	2			
0	80	-12	6			
0	100	2	6			
0	120	-10	6			
0	140	18	24			
-40	-60	-55	16			
-40	-40	-35	3			
-40	-20	-15	6			
-40	0	-5	9			
-40	20	-25	0			
-40	40	-29	0			

E-W	N-S	Dip Angle	Quad
-40	60	-29	-1
-40	80	-24	1
-40	100	-20	4
-40	120	-8	10
-40	140	7	18
-80	-60	-88	14
-80	-40	-32	8
-80	-20	-18	8
-80	0	-2	14
-80	20	-21	3
-80	40	-17	7
-80	60	-34	0
-80	80	-43	-10
-80	100	-20	2
-80	120	-3	12
-120	-100	30	-20
-120	-80	60	-18
-120	-20	-36	12
-120	0	-25	10
-120	20	-4	22
-120	40	22	20
-160	-160	17	-14
-160	-140	27	-8
-160	-120	28	-12
-160	-100	45	-12
-160	-80	74	-6
-160	-20	-70	11
-160	0	-38	12
-200	-120	37	-8
-200	-100	43	-7
-200	-80	50	-9
-200	-60	74	-9
-200	0	-52	14

APPENDIX 4

Appendix 4 contains the raw data for the Total Field Magnetic survey over the Long Lake mine. The survey was conducted using a G-826 Proton Magnetometer rented from Exploranium Limited in Bolton, Ontario.

The data is divided by grid location (metres) and reading (gammas). The regional magnetic field of 56,000 gammas has not been subtracted from the readings. Negative grid locations represent either south or west locations.

Presentation of the raw data was produced through Lotus 1-2-3 and an add-on program called Allways, distributed by Funk Industries. Reduction of the data contouring and surfacing was produced through Surfer, a program distributed by Golden Software Inc.

LONG LAKE MINE					
TOTAL FIELD MAGNETICS					
E-W (E -ve)	N-S (S -ve)	Reading (gammas)	E-W (E -ve)	N-S (S -ve)	Reading (gammas)
335	-60	58531	240	20	54716
395	-40	56640	240	40	55109
395	-20	55219	240	60	54438
395	0	54860	240	80	56053
360	-80	56312	240	100	56844
360	-60	55343	240	120	58183
360	-40	57119	240	140	57887
360	-20	56230	240	160	57319
360	0	56479	200	-95	57017
360	20	54973	200	-80	55086
360	40	55357	200	-60	56326
360	60	55405	200	-40	56067
360	80	55685	200	-20	57360
360	100	56262	200	0	55852
360	120	57330	200	20	55140
320	-80	56238	200	40	55420
320	-60	56233	200	60	55840
320	-40	56263	200	80	56948
320	-20	55975	200	100	58554
320	0	57982	200	120	57899
320	20	54840	200	140	57107
320	40	54940	160	-100	57104
320	60	53648	160	-80	55501
320	80	55741	160	-60	56048
320	100	57186	160	-40	56811
320	120	58301	160	-20	57275
280	-80	56710	160	0	54948
280	-60	56873	160	20	55220
280	-40	56880	160	40	57770
280	-20	57702	160	60	56032
280	0	58255	160	80	56714
280	20	54856	160	100	57564
280	40	55470	160	120	58335
280	60	55626	160	140	57185
280	80	55984	120	0	55301
280	100	56533	120	20	55488
280	120	58334	120	40	55929
280	140	59003	120	60	57119
240	-80	55642	120	80	58089
240	-60	55850	120	100	58555
240	-40	55500	120	120	57696
240	-20	55025	120	140	57058

E-W (E -ve)	N-S (S -ve)	Reading (gammas)	E-W (E -ve)	N-S (S -ve)	Reading (gammas)
240	0	55645	120	160	57500
80	-100	56156	-40	0	56144
80	-80	56935	-40	20	56970
80	-60	56227	-40	40	59040
80	-40	58393	-40	60	59160
80	-20	55963	-40	80	59910
80	0	55545	-40	100	60820
80	20	56350	-40	120	57920
80	40	57688	-40	140	56792
80	60	57947	-80	-135	57375
80	80	57512	-80	-120	57766
80	100	58045	-80	-100	57080
80	120	57770	-80	-80	57055
40	-115	56660	-80	-60	56745
40	-100	56391	-80	-40	55535
40	-80	56519	-80	-20	55910
40	-60	56512	-80	0	56284
40	-40	57530	-80	20	57388
40	-20	55507	-80	40	58188
40	0	55713	-80	60	56630
40	20	57739	-80	80	57206
40	40	59460	-80	100	57970
40	60	58578	-80	120	56277
40	80	57605	-80	140	58460
40	100	57563	-120	-120	57610
40	120	57800	-120	-100	58050
40	140	57825	-120	-80	56210
0	-120	57180	-120	-60	56370
0	-100	58385	-120	-40	55863
0	-80	54380	-120	-20	56050
0	-60	57000	-120	0	56665
0	-40	57093	-120	20	57850
0	-20	55545	-120	40	58110
0	0	56065	-160	-160	56900
0	20	57750	-160	-155	56918
0	40	58326	-160	-140	57244
0	60	58117	-160	-120	57800
0	80	57756	-160	-100	56073
0	100	57635	-160	-80	56296
0	120	58177	-160	-60	56040
0	140	56106	-160	-40	56186
-40	-120	56835	-160	-20	56601
-40	-100	57700	-160	0	58463
-40	-80	57609	-200	-120	55840
-40	-60	57780	-200	-100	56088

E-W (E -ve)	N-S (S -ve)	Reading (gammas)	E-W (E -ve)	N-S (S -ve)	Reading (gammas)
-40	-40	56015			
-40	-20	55903			
-200	-80	56080			
-200	-60	55971			
-200	-40	56218			
-200	-20	56940			
-200	0	57550			
Baseline Profile					
-200	0	57550	120	0	55301
-180	0	58216	140	0	55366
-160	0	58463	160	0	54948
-140	0	56961	180	0	55384
-120	0	56665	200	0	55852
-100	0	55598	220	0	55677
-80	0	56284	240	0	55645
-60	0	56345	260	0	55220
-40	0	56144	280	0	58255
-20	0	56188	300	0	56883
0	0	56065	320	0	57982
20	0	56511	340	0	56475
40	0	55713	360	0	57982
60	0	55713	380	0	56397
80	0	55545	395	0	56479
100	0	55532			

APPENDIX 5

Appendix 5 contains the raw data from the Self-Potential (SP) survey over the Long Lake mine. The survey was conducted using a RSP-6 D.C. Resistivity and Self-Potential Unit available at Carleton University in Ottawa, Ontario. A survey with increased spacing and a reference station at 0+80E, 1+20N was performed.

The data is divided by grid location (metres) and reading (millivolts). Negative grid locations represent either south or west grid locations.

Presentation of the raw data was produced through Lotus 1-2-3 and an add-on program called Allways, distributed by Funk Industries. Reduction of the data caontouring and surfacing was produced through Surfer, a program distributed by Golden Software Inc.

LONG LAKE MINE SELF-POTENTIAL SURVEY

Grid			Grid		
E-W (metres)	N-S (metres)	Reading (millivolts)	E-W (metres)	N-S (metres)	Reading (millivolts)
360	-80	-50	240	80	-37
360	-60	-53	240	100	-39
360	-40	-45	240	120	-21
360	-20	-38	200	-80	-23
360	0	-35	200	-60	-28
360	20	-33	200	-40	-26
360	40	-40	200	-20	-48
360	60	-56	200	0	-62
360	80	-40	200	20	50
360	100	-49	200	40	-39
360	120	-32	200	60	-40
320	-80	-34	200	80	-35
320	-60	-48	200	100	-24
320	-40	-49	200	120	-15
320	-20	-47	160	-100	-40
320	0	-48	160	-80	-35
320	20	-40	160	-60	-26
320	40	-44	160	-40	-28
320	60	-141	160	-20	-33
320	80	-57	160	0	-37
320	100	-51	160	20	-41
320	120	-8	160	40	-62
280	-80	-34	160	60	-52
280	-60	-38	160	80	-35
280	-40	-38	160	100	-22
280	-20	-40	160	120	-13
280	0	-37	120	0	-63
280	20	-46	120	20	-31
280	40	-44	120	40	-56
280	60	-42	120	60	-37
280	80	-35	120	80	-27
280	100	-37	120	100	-26
280	120	-16	120	120	-18
240	-80	-25	80	-100	-28
240	-60	-30	80	-80	-28
240	-40	-30	80	-60	-60
240	-20	-42	80	-40	-43
240	0	-59	80	-20	-29
240	20	-62	80	0	-29
240	40	-79	80	20	-15
240	60	-55	80	40	-39

W-E (metres)	N-S (metres)	Reading (millivolts)	W-E (metres)	N-S (metres)	Reading (millivolts)
80	60	-31	-80	20	-17
80	80	-45	-80	40	-29
80	100	-24	-80	60	-18
40	-100	-19	-80	80	-12
40	-80	-23	-80	100	-25
40	-60	-26	-80	120	-14
40	-40	-25	-120	-120	-40
40	-20	-31	-120	-100	-49
40	0	-36	-120	-80	54
40	20	-18	-120	-60	-58
40	40	-20	-120	-40	-50
40	60	-21	-120	-20	-31
40	80	-7	-120	0	-31
40	100	7	-160	-160	-49
40	120	-11	-160	-140	-37
0	-100	8	-160	-120	-33
0	-80	-2	-160	-100	-46
0	-60	8	-160	-80	-39
0	-40	0	-160	-60	-34
0	-20	-3	-160	-40	-51
0	0	-3	-160	-20	-46
0	20	19	-160	0	-31
0	40	12	-200	-120	-54
0	60	6	-200	-100	-40
0	80	13	-200	-80	-55
0	100	17	-200	-60	-44
0	120	3	-200	-40	-14
-40	-100	-16	-200	-20	-52
-40	-80	-12	-200	0	-13
-40	-60	-8			
-40	-40	-22			
-40	-20	-26			
-40	0	-39			
-40	20	15			
-40	40	12			
-40	60	-13			
-40	80	5			
-40	100	9			
-40	120	-10			
-80	-100	-25			
-80	-80	-37			
-80	-60	-49			
-80	-40	-57			
-80	-20	-45			
-80	0	-43			

APPENDIX 6

Appendix 6 contains the raw data from the Max-Min Horizontal Loop Data Electro-Magnetic (HLEM) survey at five different frequencies (222, 444, 888, 1777, 3555 mhz). The survey was carried out using an Apex Maxmin II portable HLEM rented from Terraform Limited (Geoterrex) in Ottawa. Using a 100 metre spacing between transmitter and reciever at 20 metre stations along north-south lines and 40 metres between the north-south grid lines, an area bounded by 0+40W to 3+60E and 0+00 to 1+60 N was covered. Readings were not taken on Line 1+20E. The data is divided by grid location (metres), in-phase (% Dip), quadrature (%).

Presentation of the raw data was produced through Lotus 1-2-3 and an add-on program called Allways distributed by Funk Industries. Reduction of the data by contouring and surfacing was produced through Surfer, a program distributed by Golden Software Inc.

LONG LAKE MINE **MAX-MIN E-M SURVEY**

222 MHZ

Grid Location (m)	Readings		Grid Location (m)	Readings	
LINE	% Dip	Quadrature	LINE	% Dip	Quadrature
3+60E			2+80E		
-160	0	0	-160	0	0
-140	0	0	-140	0	0
-120	0	0	-120	0	0
-100	0	0	-100	0	0
-80	0	0	-80	0	0
-60	0	0	-60	0	0
-40	0	0	-40	0	0
-20	0	0	-20	0	0
0	0	0	0	0	0
20	1.5	0	20	-8	0
40	-2	0	40	-3	-1
60	-2.5	-0.5	60	-5	-1
80	-3	-1	80	-5	-1
100	-4	-1	100	-4	-1
120	-10	-1	120	-9	-1
140	0	0	140	0	0
160	0	0	160	0	0

LINE

3+20E

-160	0	0
-140	0	0
-120	0	0
-100	0	0
-80	0	0
-60	0	0
-40	0	0
-20	0	0
0	0	0
20	-3	0
40	0	0
60	-8	1
80	-5	-1
100	-6	-1
120	-8	-1
140	0	0
160	0	0

LINE

240E

-160	0	0
-140	0	0
-120	0	0
-100	0	0
-80	0	0
-60	0	0
-40	0	0
-20	0	0
0	0	0
20	-10	0
40	-6	0
60	-3	-1
80	-3	-1
100	-2	-1
120	-3	-1
140	-6	0
160	0	0

Grid			Grid		
Location (m)	Readings		Location (m)	Readings	
	% Dip	Quadrature		% Dip	Quadrature
LINE 2+00E			LINE 0+80E		
-160	0	0	-160	0	0
-140	0	0	-140	0	0
-120	0	0	-120	0	0
-100	0	0	-100	0	0
-80	0	0	-80	0	0
-60	0	0	-60	0	0
-40	0	0	-40	0	0
-20	0	0	-20	0	0
0	0	0	0	0	0
20	-5	0	20	-5	0
40	-7	0	40	-8	-1
60	-5	0	60	-3	-1
80	-3	-1	80	-3	-1
100	-2	-1	100	-4	-1
120	2	-1	120	-1	-1
140	0	0	140	0	0
160	0	0	160	0	0
LINE 1+60E			LINE 0+40E		
-160	0	0	-160	0	0
-140	0	0	-140	0	0
-120	0	0	-120	0	0
-100	0	0	-100	0	0
-80	0	0	-80	0	0
-60	0	0	-60	0	0
-40	0	0	-40	0	0
-20	0	0	-20	0	0
0	0	0	0	-8	0
20	-6	0	20	-6	0
40	-8	1	40	-4	-1
60	-5	-1	60	-4	0
80	-6	-1	80	-5	-1
100	-6	-1	100	-4	-1
120	-7	-1	120	-1	-1
140	-1	-1	140	-1	-1
160	0	0	160	0	0

Grid			Grid		
Readings			Readings		
Location	% Dip	Quadrature	Location	% Dip	Quadrature
(m)			(m)		
LINE			LINE		
0+00			0+40W		
-160	0	0	-160	0	0
-140	0	0	-140	0	0
-120	0	0	-120	0	0
-100	0	0	-100	0	0
-80	0	0	-80	0	0
-60	0	0	-60	0	0
-40	0	0	-40	0	0
-20	0	0	-20	0	0
0	0	0	0	0	0
20	-8	0	20	0	0
40	-6	-1	30	-5	0
60	-6	-1	50	-6	0
80	-5	0	80	-5	-1
100	-6	0	100	-5	-1
120	2	0	120	3	0
140	-2	0	140	-5	0
160	0	0	160	0	0

NOTE A combined zero quadrature and % dip denotes no reading taken at that location.

LONG LAKE MINE **MAX-MIN E-M SURVEY**

444 MHZ

Grid Location (m)	Readings		Grid Location (m)	Readings	
LINE	% Dip	Quadrature	LINE	% Dip	Quadrature
3+60E			2+80E		
-160	0	0	-160	0	0
-140	0	0	-140	0	0
-120	0	0	-120	0	0
-100	0	0	-100	0	0
-80	0	0	-80	0	0
-60	0	0	-60	0	0
-40	0	0	-40	0	0
-20	0	0	-20	0	0
0	0	0	0	0	0
20	2	1.5	20	-8	1
40	-2	0	40	-3	0
60	-2	-0.5	60	-5	0
80	-3	-0.5	80	-5	-1
100	-4	-1	100	-5	-1
120	-10	-1	120	-9	-1
140	0	0	140	0	0
160	0	0	160	0	0

Grid Location (m)	Readings		Grid Location (m)	Readings	
LINE	% Dip	Quadrature	LINE	% Dip	Quadrature
3+20E			240E		
-160	0	0	-160	0	0
-140	0	0	-140	0	0
-120	0	0	-120	0	0
-100	0	0	-100	0	0
-80	0	0	-80	0	0
-60	0	0	-60	0	0
-40	0	0	-40	0	0
-20	0	0	-20	0	0
0	0	0	0	0	0
20	-3	0	20	-10	1
40	0	1	40	-6	0
60	-7	0	60	-3	0
80	-5	-1	80	-3	-1
100	-6	-1	100	-3	-1
120	-8	-1	120	-4	0
140	0	0	140	-6	0
160	0	0	160	0	0

Grid Location (m)	Readings		Grid Location (m)	Readings	
LINE	% Dip	Quadrature	LINE	% Dip	Quadrature
2+00E			0+80E		
-160	0	0	-160	0	0
-140	0	0	-140	0	0
-120	0	0	-120	0	0
-100	0	0	-100	0	0
-80	0	0	-80	0	0
-60	0	0	-60	0	0
-40	0	0	-40	0	0
-20	0	0	-20	0	0
0	0	0	0	0	0
20	-5	2	20	-5	0
40	-7	1	40	-8	0
60	-5	0	60	-4	0
80	-2	0	80	-4	0
100	-2	0	100	-5	0
120	1	0	120	-2	0
140	0	0	140	0	0
160	0	0	160	0	0
LINE 1+60E			LINE 0+40E		
-160	0	0	-160	0	0
-140	0	0	-140	0	0
-120	0	0	-120	0	0
-100	0	0	-100	0	0
-80	0	0	-80	0	0
-60	0	0	-60	0	0
-40	0	0	-40	0	0
-20	0	0	-20	0	0
0	0	0	0	-8	1
20	-6	0	20	-6	0
40	-8	0	40	-5	0
60	-5	0	60	-4	0
80	-6	0	80	-5	0
100	-6	0	100	-4	0
120	-6	0	120	-1	0
140	-1	0	140	1	0
160	0	0	160	0	0

Grid	Readings		Grid	Readings	
Location	% Dip	Quadrature	Location	% Dip	Quadrature
(m)			(m)		
LINE			LINE		
0+00			0+40W		
-160	0	0	-160	0	0
-140	0	0	-140	0	0
-120	0	0	-120	0	0
-100	0	0	-100	0	0
-80	0	0	-80	0	0
-60	0	0	-60	0	0
-40	0	0	-40	0	0
-20	0	0	-20	0	0
0	0	2	0	0	0
20	-8	0	20	0	0
40	-6	0	30	-3	1
60	-6	0	50	-6	0
80	-6	0	80	-6	0
100	-6	0	100	-5	0
120	2	0	120	3	2
140	-2	0	140	-5	0
160	0	0	160	0	0

LONG LAKE MINE **MAX-MIN E-M SURVEY**

888 MHZ

Grid Location (m) LINE	Readings		Grid Location (m) LINE	Readings	
	% Dip	Quadrature		% Dip	Quadrature
3+60E			2+80E		
-160	0	0	-160	0	0
-140	0	0	-140	0	0
-120	0	0	-120	0	0
-100	0	0	-100	0	0
-80	0	0	-80	0	0
-60	0	0	-60	0	0
-40	0	0	-40	0	0
-20	0	0	-20	0	0
0	0	0	0	0	0
20	3	2	20	-7	2
40	-2.5	5	40	-3	0
60	-2	0	60	-6	-1
80	-4	-1	80	-6	-2
100	-4	-1.5	100	-5	-1
120	-11	-2	120	-9	-1
140	0	0	140	0	0
160	0	0	160	0	0
LINE 3+20E			LINE 240E		
-160	0	0	-160	0	0
-140	0	0	-140	0	0
-120	0	0	-120	0	0
-100	0	0	-100	0	0
-80	0	0	-80	0	0
-60	0	0	-60	0	0
-40	0	0	-40	0	0
-20	0	0	-20	0	0
0	0	0	0	0	0
20	-3	2	20	-10	1
40	0	1	40	-7	0
60	-7	-1	60	-3	0
80	-6	-1	80	-3	-1
100	-6	-1	100	-3	-1
120	-8	-2	120	-4	-1
140	0	0	140	-6	0
160	0	0	160	0	0

Grid Location (m)	Readings		Grid Location (m)	Readings	
LINE	% Dip	Quadrature	LINE	% Dip	Quadrature
2+00E			0+80E		
-160	0	0	-160	0	0
-140	0	0	-140	0	0
-120	0	0	-120	0	0
-100	0	0	-100	0	0
-80	0	0	-80	0	0
-60	0	0	-60	0	0
-40	0	0	-40	0	0
-20	0	0	-20	0	0
0	0	0	0	0	0
20	-6	1	20	-5	0
40	-7	0	40	-8	0
60	-5	-1	60	-4	0
80	-3	-1	80	-4	0
100	-2	-1	100	-5	0
120	1	0	120	-2	-1
140	0	0	140	0	0
160	0	0	160	0	0
LINE 1+60E			LINE 0+40E		
-160	0	0	-160	0	0
-140	0	0	-140	0	0
-120	0	0	-120	0	0
-100	0	0	-100	0	0
-80	0	0	-80	0	0
-60	0	0	-60	0	0
-40	0	0	-40	0	0
-20	0	0	-20	0	0
0	0	0	0	-7	0
20	-6	1	20	-5	0
40	-8	0	40	-4	0
60	-5	-1	60	-4	0
80	-6	-1	80	-5	0
100	-7	-1	100	-4	0
120	-7	0	120	-1	0
140	-1	1	140	1	1
160	0	0	160	0	0

Grid	Readings		Grid	Readings	
Location	% Dip	Quadrature	Location	% Dip	Quadrature
(m)			(m)		
LINE			LINE		
0+00			0+40W		
-160	0	0	-160	0	0
-140	0	0	-140	0	0
-120	0	0	-120	0	0
-100	0	0	-100	0	0
-80	0	0	-80	0	0
-60	0	0	-60	0	0
-40	0	0	-40	0	0
-20	0	0	-20	0	0
0	0	2	0	0	0
20	-7	0	20	0	0
40	-6	0	30	-3	1
60	-6	0	50	-5	0
80	-6	0	80	-5	0
100	-7	1	100	-5	1
120	2	0	120	3	4
140	-2	1	140	-5	1
160	0	0	160	0	0

NOTE A combined zero quadrature and % dip denotes no reading taken at that location.

LONG LAKE MINE **MAX-MIN E-M SURVEY**

1777 MHZ

Grid	Readings		Grid	Readings	
Location	% Dip	Quadrature	Location	% Dip	Quadrature
(m)			(m)		
LINE			LINE		
3+60E			2+80E		
-160	0	0	-160	0	0
-140	0	0	-140	0	0
-120	0	0	-120	0	0
-100	0	0	-100	0	0
-80	0	0	-80	0	0
-60	0	0	-60	0	0
-40	0	0	-40	0	0
-20	0	0	-20	0	0
0	0	0	0	0	0
20	3	4	20	-7	-3
40	-2	0	40	-3	-3
60	-2	-2	60	-6	-3
80	-4	-3	80	-6	-2
100	-5	-3	100	-6	0
120	-11	2	120	-10	3
140	0	0	140	0	0
160	0	0	160	0	0

LINE			LINE		
3+20E			240E		
-160	0	0	-160	0	0
-140	0	0	-140	0	0
-120	0	0	-120	0	0
-100	0	0	-100	0	0
-80	0	0	-80	0	0
-60	0	0	-60	0	0
-40	0	0	-40	0	0
-20	0	0	-20	0	0
0	0	0	0	0	0
20	-2	3	20	-9	2
40	0	0	40	-6	0
60	-7	-1	60	-3	-1
80	-6	-3	80	-4	-2
100	-6	-3	100	-3	-2
120	-9	-3	120	-4	-4
140	0	0	140	-6	0
160	0	0	160	0	0

Grid Location (m)	Readings		Grid Location (m)	Readings	
LINE	% Dip	Quadrature	LINE	% Dip	Quadrature
2+00E			0+80E		
-160	0	0	-160	0	0
-140	0	0	-140	0	0
-120	0	0	-120	0	0
-100	0	0	-100	0	0
-80	0	0	-80	0	0
-60	0	0	-60	0	0
-40	0	0	-40	0	0
-20	0	0	-20	0	0
0	0	0	0	0	0
20	-5	2	20	-6	0
40	-7	1	40	-8	-1
60	-5	-1	60	-4	1
80	-5	-2	80	-4	-1
100	-3	-2	100	-5	-1
120	1	-1	120	-2	1
140	0	0	140	0	0
160	0	0	160	0	0
LINE 1+60E			LINE 0+40E		
-160	0	0	-160	0	0
-140	0	0	-140	0	0
-120	0	0	-120	0	0
-100	0	0	-100	0	0
-80	0	0	-80	0	0
-60	0	0	-60	0	0
-40	0	0	-40	0	0
-20	0	0	-20	0	0
0	0	0	0	-7	1
20	-6	1	20	-5	-1
40	-8	0	40	-4	-1
60	-6	-2	60	-4	-1
80	-6	-2	80	-5	-1
100	-7	-2	100	-5	0
120	-7	-1	120	-2	0
140	-1	1	140	1	1
160	0	0	160	0	0

Grid Location (m) LINE	Readings		Grid Location (m) LINE	Readings	
	% Dip	Quadrature		% Dip	Quadrature
0+00			0+40W		
-160	0	0	-160	0	0
-140	0	0	-140	0	0
-120	0	0	-120	0	0
-100	0	0	-100	0	0
-80	0	0	-80	0	0
-60	0	0	-60	0	0
-40	0	0	-40	0	0
-20	0	0	-20	0	0
0	2	2	0	0	0
20	-7	-1	20	0	0
40	-6	0	30	-3	1
60	-6	-1	50	-5	0
80	-6	0	80	-5	0
100	-7	1	100	-5	1
120	2	0	120	3	4
140	-2	1	140	-5	1
160	0	0	160	0	0

NOTE A combined zero quadrature and % dip denotes no reading taken at that location.

LONG LAKE MINE **MAX-MIN E-M SURVEY**

3555 MHZ

Grid Location (m) LINE	Readings		Grid Location (m) LINE	Readings	
	% Dip	Quadrature		% Dip	Quadrature
3+60E			2+80E		
-160	0	0	-160	0	0
-140	0	0	-140	0	0
-120	0	0	-120	0	0
-100	0	0	-100	0	0
-80	0	0	-80	0	0
-60	0	0	-60	0	0
-40	0	0	-40	0	0
-20	0	0	-20	0	0
0	0	0	0	0	0
20	4	6	20	-6	4
40	-1.5	-0.5	40	-2	-1
60	-1	-2	60	-6	-3
80	-4	-5	80	-7	-5
100	-5	-6	100	-6	-5
120	-9	-2	120	-10	-6
140	0	0	140	0	0
160	0	0	160	0	0
LINE 3+20E			LINE 240E		
-160	0	0	-160	0	0
-140	0	0	-140	0	0
-120	0	0	-120	0	0
-100	0	0	-100	0	0
-80	0	0	-80	0	0
-60	0	0	-60	0	0
-40	0	0	-40	0	0
-20	0	0	-20	0	0
0	0	0	0	0	0
20	-1	5	20	-8	2
40	1.5	0	40	-8	-1
60	-5	-2	60	-3	-3
80	-5	-5	80	-3	-4
100	-5	-6	100	-2	-5
120	-8	-7	120	-4	-3
140	0	0	140	-5	-1
160	0	0	160	0	0

Grid			Grid		
Location (m)	Readings		Location (m)	Readings	
	% Dip	Quadrature		% Dip	Quadrature
LINE			LINE		
2+00E			0+80E		
-160	0	0	-160	0	0
-140	0	0	-140	0	0
-120	0	0	-120	0	0
-100	0	0	-100	0	0
-80	0	0	-80	0	0
-60	0	0	-60	0	0
-40	0	0	-40	0	0
-20	0	0	-20	0	0
0	0	0	0	0	0
20	-5	2	20	-4	-2
40	-6	0	40	-7	-2
60	-6	-2	60	3	-2
80	-3	-4	80	-5	-3
100	-3	-3	100	-5	-2
120	1	-3	120	-3	1
140	-2	-1	140	0	0
160	0	0	160	0	0
LINE			LINE		
1+60E			0+40E		
-160	0	0	-160	0	0
-140	0	0	-140	0	0
-120	0	0	-120	0	0
-100	0	0	-100	0	0
-80	0	0	-80	0	0
-60	0	0	-60	0	0
-40	0	0	-40	0	0
-20	0	0	-20	0	0
0	0	0	0	-6	0
20	-5	1	20	-4	-2
40	-7	-1	40	-3	-3
60	-5	-3	60	-3	-2
80	-6	-4	80	-4	-3
100	-6	-4	100	-3	0
120	-7	-2	120	-1	0
140	1	1	140	2	1
160	0	0	160	0	0

Grid Location (m)	Readings		Grid Location (m)	Readings	
LINE	% Dip	Quadrature	LINE	% Dip	Quadrature
0+00			0+40W		
-160	0	0	-160	0	0
-140	0	0	-140	0	0
-120	0	0	-120	0	0
-100	0	0	-100	0	0
-80	0	0	-80	0	0
-60	0	0	-60	0	0
-40	0	0	-40	0	0
-20	0	0	-20	0	0
0	3	1	0	0	0
20	-7	-3	20	0	0
40	-5	-1	30	0	0
60	-6	-2	50	-4	-1
80	-5	-1	80	-5	-1
100	-7	2	100	-3	0
120	2	0	120	9	9
140	-2	2	140	-5	3
160	0	0	160	0	0

NOTE A combined zero quadrature and % dip denotes no reading taken at that location.

APPENDIX 7

Appendix 7 contains the geophysical contour maps and the geology and geography maps of the Long Lake mine property as foldout lay-overs for comparison. The geology and geography maps have been scaled to match the geophysical contour maps.

VLF Fraser Filtered Map

Total Field Magnetics Map

Self-Potential Survey (20 mv contour)

Self Potential Map

Horizontal Loop Electro-Magnetics

222 Hz

Horizontal Loop Electro-Magnetics
444 Hz Map

Horizontal Loop Electro-Magnetics
888 Hz Map

Horizontal Loop Electro-Magnetics
1777 Hz Map

Horizontal Loop Electro-Magnetics
3555 Hz Map

Geology Map

3

of/de

3

PM-1 3½"x4" PHOTOGRAPHIC MICROCOPY TARGET
NBS 1010a ANSI/ISO #2 EQUIVALENT

PRECISIONSM RESOLUTION TARGETS

PIONEERS IN METHYLENE BLUE TESTING SINCE 1974

15600 COUNTY ROAD 6 BURNHAMME MINN 55301 USA
TEL: 612 435 7887 FAX: 612 435 7887 TLE: 612 435 7887

Geography Map

Geography Map

APPENDIX 8

Appendix 8 contains the raw data from the VLF (Very Low Frequency) survey performed by Sands Mineral Corporation (1987) over the Ore Chimney Mine. Although, Sands Minerals Corporation appears to have somehow compensated for the effect of the powerline in their presentation, no compensation is presented in these data.

The data is divided by grid location (feet), Dip Angle (% Dip), and Quadrature (%). Fraser Filtering which allows contouring of VLF data is included in Appendix B.2.1 where X and Y are the grid coordinates and Z is the filtered reading at that node. Negative grid locations represent south and west locations.

Presentation of the raw data was produced through Lotus 1-2-3 and an add-on program called Always, distributed by Funk Industries. Reduction of the data contouring and surfacing was produced through Surfer, a program distributed by Golden Software Inc.

ORE CHIMNEY MINE
VLF (Very Low Frequency) DATA

VLF PROFILES**VLF FILTERED DATA***(Grid Locations in feet)**(Fraser Filtering)*

E-W	N-S	Dip Angle	Quad	(X)	(Y)	(Z)
1000	250	-4	9	1000	175	-8
1000	200	-5	10	1000	125	-5
1000	150	-8	10	1000	75	-2
1000	100	-9	10	1000	25	-4
1000	50	-9	12	1000	-25	-7
1000	0	-10	12	1000	-75	-7
1000	-50	-12	14	1000	-125	-7
1000	-100	-14	14	1000	-175	-9
1000	-150	-15	16	1000	-225	-11
1000	-200	-18	18	1000	-275	-13
1000	-250	-20	19	1000	-325	-18
1000	-300	-24	24	1000	-375	-34
1000	-350	-27	28	800	175	-2
1000	-400	-35	34	800	125	-3
1000	-450	-50	43	800	75	-5
800	250	-5	8	800	25	-6
800	200	-6	10	800	-25	-5
800	150	-6	10	800	-75	-4
800	100	-7	12	800	-125	-5
800	50	-8	12	800	-175	-8
800	0	-10	12	800	-225	-9
800	-50	-11	12	800	-275	-8
800	-100	-12	13	800	-325	-11
800	-150	-13	18	600	175	-3
800	-200	-15	18	600	125	-3
800	-250	-18	21	600	75	-5
800	-300	-19	24	600	25	-3
800	-350	-22	28	600	-25	-2
800	-400	-26	32	600	-75	-6
600	250	-3	8	600	-125	-6
600	200	-4	9	600	-175	-4
600	150	-5	9	600	-225	-5
600	100	-5	11	600	-275	-5
600	50	-7	12	400	175	-1
600	0	-8	13	400	125	0
600	-50	-7	13	400	75	-33
600	-100	-10	13	400	25	-36
600	-150	-12	15	400	-25	26
600	-200	-12	18	400	-75	-44
600	-250	-13	22	400	-125	-78
600	-320	-15	24	400	-175	60

E-W	N-S	Dip Angle	Quad	(X)	(Y)	(Z)
600	-350	-15	28	400	-225	61
400	250	0	11	400	-275	-7
400	200	0	12	400	-325	-7
400	150	-1	12	400	-375	-16
400	100	0	12	200	175	7
400	50	-1	14	200	125	2
400	0	-3	15	200	75	3
400	-50	-4	18	200	25	-4
400	-100	-4	19	200	-25	-14
400	-150	-7	21	200	-75	-10
400	-200	-9	22	200	-125	-3
400	-250	-12	24	200	-175	-11
400	-300	-13	28	200	-225	-26
400	-350	-15	31	200	-275	-23
400	-400	-17	36	200	-325	-7
400	-450	-27	40	200	-375	-5
200	250	8	14	0	175	-7
200	200	12	16	0	125	-2
200	150	14	20	0	75	5
200	100	13	21	0	25	9
200	50	15	24	0	-25	7
200	0	15	24	0	-75	0
200	-50	9	20	0	-125	-6
200	-100	7	19	0	-175	-16
200	-150	7	22	0	-225	-17
200	-200	6	26	0	-275	23
200	-250	-3	26	0	-325	40
200	-300	-10	28	0	-375	-6
200	-350	-10	34	0	-425	-33
200	-400	-10	38	-200	175	-2
200	-450	-15	44	-200	125	-3
0	250	-18	0	-200	75	-4
0	200	-21	-2	-200	25	-4
0	150	-22	-1	-200	-25	-5
0	100	-24	0	-200	-75	-8
0	50	-21	2	-200	-125	-13
0	0	-20	6	-200	-175	-22
0	-50	-16	10	-200	-225	19
0	-100	-18	10	-200	-275	71
0	-150	-18	13	-200	-325	34
0	-200	-22	13	-200	-375	9
0	-250	-30	12	-400	175	-2
0	-300	-27	16	-400	125	-4
0	-350	-2	35	-400	75	-4
0	-400	-15	34	-400	25	-3
0	-450	-20	34	-400	-25	-7
0	-500	-30	45	-400	-75	-12
-200	250	-12	8	-400	-125	-20

E-W	N-S	Dip Angle	Quad	(X)	(Y)	(Z)
-200	200	-13	7	-400	-175	-6
-200	150	-13	7	-400	-225	35
-200	100	-14	8	-400	-275	40
-200	50	-15	8	-400	-325	1
-200	0	-16	9	-400	-375	-29
-200	-50	-17	9	-400	-425	-28
-200	-100	-19	10	-600	175	-4
-200	-150	-22	10	-600	125	-4
-200	-200	-27	8	-600	75	-3
-200	-250	-36	5	-600	25	-4
-200	-300	6	22	-600	-25	-9
-200	-350	2	33	-600	-75	-10
-200	-400	2	44	-600	-125	-6
-200	-450	15	45	-600	-175	3
-400	250	-7	8	-600	-225	12
-400	200	-9	8	-600	-275	7
-400	150	-8	9	-600	-325	-2
-400	100	-10	10	-600	-375	-8
-400	50	-11	12	-600	-425	-25
-400	0	-11	11	-800	175	-4
-400	-50	-13	12	-800	125	-4
-400	-100	-16	11	-800	75	-5
-400	-150	-20	11	-800	25	-6
-400	-200	-29	5	-800	-25	-7
-400	-250	-13	15	-800	-75	-8
-400	-300	-1	28	-800	-125	-9
-400	-350	-1	36	-800	-175	6
-400	-400	-12	36	-800	-225	20
-400	-450	-19	41	-800	-275	-1
-400	-500	-22	45	-800	-325	-16
-600	250	-3	10	-800	-375	-11
-600	200	-5	10	-800	-425	-15
-600	150	-5	10	-1000	175	-2
-600	100	-7	11	-1000	125	-4
-600	50	-7	11	-1000	75	-3
-600	0	-8	12	-1000	25	-3
-600	-50	-10	12	-1000	-25	-4
-600	-100	-14	12	-1000	-75	-5
-600	-150	-14	14	-1000	-125	-1
-600	-200	-16	14	-1000	-175	10
-600	-250	-9	18	-1000	-225	7
-600	-300	-9	23	-1000	-275	-9
-600	-350	-9	28	-1000	-325	-16
-600	-400	-11	32			
-600	-450	-15	38			
-600	-500	-30	45			
-800	250	0	12			
-800	200	0	12			

E-W	N-S	Dip Angle	Quad
-800	150	-2	12
-800	100	-2	12
-800	50	-4	13
-800	0	-5	12
-800	-50	-7	14
-800	-100	-9	14
-800	-150	-11	14
-800	-200	-14	14
-800	-250	0	25
-800	-300	-5	24
-800	-350	-10	28
-800	-400	-11	32
-800	-450	-15	39
-800	-500	-21	45
-1000	250	-1	10
-1000	200	0	10
-1000	150	-1	10
-1000	100	-2	11
-1000	50	-3	13
-1000	0	-3	12
-1000	-50	-5	14
-1000	-100	-5	14
-1000	-150	-8	15
-1000	-200	-3	17
-1000	-250	0	21
-1000	-300	-4	24
-1000	-350	-8	26
-1000	-400	-12	30

**Data taken from a
SANDS MINERALS CO. P.
survey (1987).*

APPENDIX 9

Appendix 9 contains the raw data for the Total Field Magnetic survey. The data is divided by grid location (feet) and reading (gammas). Data for Lines 600W, 800W, and 1000W were obtained from the Sands Mineral Corporation survey. Negative grid locations represent either south or west locations. In places there are two or more at one station. This was done to test the consistency of anomalously high readings. The computer program averaged readings at the same location.

Presentation of the raw data was produced through Lotus 1-2-3 and an add-on program called Allways, distributed by Funk Industries. Reduction of the data contouring and surfacing was produced through Surfer, a program distributed by Golden Software Inc.

ORE CHIMNEY MINE **Total Field Magnetics**

Grid			Grid		
E-W (feet)	N-S (feet)	Reading (gammas)	E-W (feet)	N-S (feet)	Reading (gammas)
-500	100	1102	-400	-850	1057
-500	50	1043	-300	100	1074
-500	0	1087	-300	50	1095
-500	-50	937	-300	0	1035
-500	-100	878	-300	-50	1113
-500	-150	1550	-300	-100	1110
-500	-200	1553	-300	-150	1864
-500	-250	1098	-300	-200	1905
-500	-300	960	-300	-250	985
-500	-350	945	-300	-300	964
-500	-400	1058	-300	-350	874
-400	100	1109	-300	-400	1075
-400	50	1050	-300	-400	1322
-400	0	1003	-306	-422	928
-400	-50	955	-312	-444	696
-100	-100	82	-319	-466	684
-400	-150	1465	-325	-488	644
-400	-200	1750	-331	-510	736
-400	-250	1025	-337	-533	677
-400	-300	943	-344	-554	676
-400	-350	932	-350	-577	915
-400	-400	920	-356	-599	162
-400	-400	1318	-363	-620	943
-400	-425	1036	-369	-643	985
-400	-450	614	-300	-675	1068
-400	-475	685	-300	-700	1135
-400	-500	656	-300	-725	1032
-400	-525	600	-300	-750	1049
-400	-550	809	-300	-775	1046
-400	-575	958	-300	-800	1268
-400	-600	1019	-300	-825	2620
-400	-620	1124	-300	-850	2314
-400	-640	2313	-300	-875	1147
-400	-660	1508	-300	-900	1318
-400	-680	1221	-200	100	1031
-400	-700	1127	-200	50	1061
-400	-725	1666	-200	0	1044
-400	-750	1140	-200	-50	1077
-400	-775	1107	-200	-100	1112
-400	-800	1304	-200	-150	1193

Grid			Grid		
E-W (feet)	N-S (feet)	Reading (gammas)	E-W (feet)	N-S (feet)	Reading (gammas)
-400	-825	1818	-200	-200	2006
-200	-250	1180	-100	-725	1015
-200	-300	1023	-100	-750	949
-200	-350	1115	-100	-775	954
-200	-400	927	-100	-800	928
-200	-400	906	0	100	935
-200	-429	1357	0	50	875
-200	-457	1036	0	0	901
-200	-486	632	0	0	882
-200	-514	553	0	-25	777
-200	-543	499	0	-50	832
-200	-571	515	0	-75	823
-200	-600	742	0	-100	1114
-200	-629	890	0	-125	2261
-200	-657	1347	0	-150	2477
-200	-685	977	0	-150	2483
-200	-714	992	0	-175	2436
-200	-743	976	0	-200	2573
-200	-772	1000	0	-200	2603
-200	-800	1025	0	-225	2878
-200	-828	993	0	-250	4435
-100	100	846	0	-250	4390
-100	50	871	0	-275	2671
-100	0	1023	0	-300	1743
-100	-50	964	0	-300	1683
-100	-100	974	0	-325	1369
-100	-150	1050	0	-350	1281
-100	-200	2208	0	-350	1205
-100	-250	3185	0	-375	1112
-100	-300	1895	0	-400	1190
-100	-350	1165	0	-400	1113
-100	-400	942	0	-450	1457
-100	-450	968	0	-400	1018
-100	-400	898	0	-425	666
-100	-425	999	0	-450	1397
-100	-450	543	0	-475	1226
-100	-475	883	0	-500	814
-100	-500	700	0	-525	656
-100	-525	676	0	-550	669
-100	-550	664	0	-575	680
-100	-575	513	0	-600	178
-100	-600	684	0	-625	790
-100	-625	841	0	-650	831
-100	-650	880	0	-675	873

Grid			Grid		
E-W (feet)	N-S (feet)	Reading (gammas)	E-W (feet)	N-S (feet)	Reading (gammas)
-100	-675	897	0	-700	918
-100	-700	1145	0	-725	938
0	-750	886	100	-200	3761
0	-775	787	100	-200	4083
0	-800	762	100	-220	4428
0	-825	882	100	-220	3948
0	-850	897	100	-240	5750
0	-875	927	100	-240	4515
50	0	701	100	-260	3557
50	-25	657	100	-260	5430
50	-50	554	100	-270	3691
50	-75	693	100	-270	2412
50	-100	1575	100	-300	1969
50	-25	1629	100	-300	2526
50	-150	2943	100	-320	1511
50	-175	4430	100	-320	489
50	-200	4804	100	-400	1254
50	-225	6324	100	-425	1325
50	-250	5190	100	-450	1057
50	-275	3431	100	-475	1296
50	-300	2200	100	-500	1080
50	-325	1900	100	-525	745
50	-350	1231	100	-550	705
50	-375	1178	100	-575	556
50	-400	1128	100	-600	704
100	100	770	100	-625	1787
100	50	763	100	-725	717
100	0	711	100	-750	661
100	0	657	100	-775	932
100	0	682	100	-800	1123
100	-40	586	100	-825	678
100	-40	530	100	-850	629
100	-40	610	100	-875	711
100	-85	753	100	-900	335
100	-85	902	100	-925	904
100	-85	819	100	-950	904
100	-100	955	150	0	682
100	-100	1053	150	-25	648
100	-115	986	150	-50	742
100	-115	1037	150	-75	589
100	-115	1460	150	-100	1233
100	-135	1830	150	-125	2199
100	-135	1804	150	-150	4007
100	-155	1920	150	-175	3679

Grid			Grid		
E-W (feet)	N-S (feet)	Reading (gammas)	E-W (feet)	N-S (feet)	Reading (gammas)
100	-155	3762	150	-200	5063
100	-175	3769	150	-225	2894
100	-175	1360	150	-250	4370
150	-275	3408	200	-575	512
150	-300	2759	200	-600	832
150	-325	2310	250	0	765
150	-350	1736	250	-50	603
150	-375	1497	250	-100	2040
150	-400	1331	250	-150	2580
150	-400	1164	250	-200	1797
150	-425	1191	250	-250	3261
150	-450	1149	250	-300	2689
150	-475	1150	250	-350	1996
150	-500	1205	250	-380	1515
150	-525	1142	250	-415	1431
150	-550	753	250	-435	1294
150	-575	730	250	-455	1210
200	100	907	250	-475	1138
200	50	871	250	-500	1248
200	0	748	250	-525	1202
200	0	762	250	-545	396
200	-25	650	250	-560	699
200	-50	565	250	-580	1010
200	-50	562	250	-600	1180
200	-75	672	250	-400	1568
200	-100	1603	300	100	809
200	-100	1707	300	50	753
200	-125	3432	300	0	669
200	-125	3469	300	0	628
200	-150	3705	300	0	759
200	-150	3663	300	-25	700
200	-175	3310	300	-50	612
200	-200	2860	300	-50	573
200	-225	3173	300	-50	539
200	-250	3288	300	-75	600
200	-275	2877	300	-100	3200
200	-300	2451	300	-125	4880
200	-325	2358	300	-150	2458
200	-350	1973	300	-150	2431
200	-375	1543	300	-175	1827
200	-400	1471	300	-200	1636
200	-400	1418	300	-200	1620
200	-425	1383	300	-225	1521
200	-450	1187	300	-250	1681

Grid			Grid		
E-W (feet)	N-S (feet)	Reading (gammas)	E-W (feet)	N-S (feet)	Reading (gammas)
200	-475	1123	300	-250	1655
200	-500	1360	300	-275	1500
200	-525	1158	300	-300	2743
200	-550	692	300	-300	2800
300	-325	2626	350	-600	1143
300	-350	2883	350	-625	967
300	-350	2767	350	-650	1771
300	-375	3294	400	0	1145
300	-400	1925	400	0	1175
300	-400	1944	400	-25	988
300	-375	3104	400	-50	786
300	-395	1862	400	-50	705
300	-415	1316	400	-75	866
300	-435	1262	400	-100	805
300	-455	1208	400	-100	797
300	-475	1068	400	-125	5727
300	-495	1088	400	-150	1950
300	-515	1216	400	-150	2351
300	-535	1122	400	-175	1725
300	-555	1053	400	-200	1588
300	-575	935	400	-200	1622
300	-595	676	400	-225	1542
300	-615	1700	400	-250	1489
350	0	775	400	-250	1456
350	-25	933	400	-275	1424
350	-50	765	400	-300	1395
350	-75	1420	400	-300	1386
350	-100	4811	400	-325	1435
350	-125	2674	400	-350	1589
350	-150	1748	400	-375	1508
350	-175	1642	400	-400	1645
350	-200	1592	400	-400	1627
350	-225	1571	400	-375	1747
350	-250	1535	400	-400	1460
350	-275	1511	400	-425	1275
350	-300	1529	400	-450	1213
350	-325	1775	400	-475	1208
350	-350	312	400	-500	1180
350	-375	2748	400	-525	1122
350	-400	1608	400	-550	1087
350	-375	1839	400	-575	1016
350	-400	1434	400	-600	1120
350	-425	1330	400	-625	1093
350	-450	1278	400	-650	1751

Grid			Grid		
E-W (feet)	N-S (feet)	Reading (gammas)	E-W (feet)	N-S (feet)	Reading (gammas)
350	-475	1240	400	-675	785
350	-500	1177	450	-375	1518
350	-525	1088	450	-400	1467
350	-550	1402	450	-420	1336
350	-575	1291	450	-440	1168
450	-465	5491	500	50	3327
450	-480	1243	500	0	1766
450	-515	1216	500	-50	1646
450	-530	1161	500	-100	1385
450	-560	1049	500	-150	3140
450	-575	986	500	-200	1786
450	-600	1188	500	-250	1460
450	-620	1208	500	-300	901
450	-635	994	500	-350	774
450	-655	972	500	-400	1578
450	-675	645	550	0	1329
450	0	1328	555	-25	1433
452	-19	1169	558	-45	1315
454	-38	1111	560	-60	1512
456	-58	1047	563	-110	2003
458	-80	1085	565	-120	2164
460	-90	1026	569	-155	1986
462	-115	1799	571	-177	1833
464	-135	3463	575	-201	1723
465	-151	2386	578	-215	1547
467	-173	1821	580	-235	1443
469	-192	1661	585	-251	1220
471	-211	1602	588	-275	1178
473	-230	1502	590	-295	932
475	-250	1400	594	-326	532
477	-273	1174	598	-350	665
480	-295	1056	600	100	1255
482	-318	590	600	50	1335
484	-341	1268	600	0	1499
486	-364	1369	600	0	1480
489	-386	1550	600	-25	1660
491	-406	1230	600	-50	1564
493	-432	1538	600	-50	1560
495	-455	1187	600	-75	1577
497	-477	1154	600	-90	1658
500	-500	1241	600	-90	1687
503	-525	1147	600	-115	1894
506	-550	1069	600	-125	2255
509	-575	1053	600	-135	1942

Grid			Grid		
E-W (feet)	N-S (feet)	Reading (gammas)	E-W (feet)	N-S (feet)	Reading (gammas)
512	-600	1093	600	-150	3346
515	-625	1061	600	-160	2950
518	-630	698	600	-180	2562
521	-650	501	600	-180	2654
524	-675	335	600	-200	2248
500	100	3902	600	-225	1885
600	-225	1859	650	-625	953
600	-250	1600	650	-650	1119
600	-275	1337	700	100	1852
600	-275	1327	700	50	1175
600	-300	1017	700	0	1219
600	-325	987	700	0	1730
600	-325	972	700	-25	1189
600	-350	306	700	-50	1436
600	-365	997	700	-50	1616
600	-390	1357	700	-70	3520
600	-420	1230	700	-85	4162
600	-440	1058	700	-95	4515
600	-465	1030	700	-100	3408
600	-485	1091	700	-100	3237
600	-510	1095	700	-120	2302
600	-535	665	700	-135	1901
600	-560	1225	700	-150	2807
600	-580	1087	700	-150	2299
600	-605	765	700	-170	2977
600	-630	820	700	-180	2583
650	0	1668	700	-195	2303
650	-25	1880	700	-200	1961
650	-50	4377	700	-200	1967
650	-75	2170	700	-225	1703
650	-100	1878	700	-250	1434
650	-125	2204	700	-250	1391
650	-150	1300	700	-300	1026
650	-175	4287	700	-300	966
650	-200	2320	700	-350	718
650	-225	1925	700	-350	705
650	-250	1445	700	-400	402
650	-275	1146	700	-400	434
650	-300	1129	700	-400	249
650	-325	1042	700	-410	443
650	-350	682	700	-425	960
650	-375	675	700	-438	1051
650	-400	985	700	-450	1174
650	-425	713	700	-480	1067

Grid			Grid		
E-W (feet)	N-S (feet)	Reading (gammas)	E-W (feet)	N-S (feet)	Reading (gammas)
650	-450	977	800	-450	859
650	-475	1160	800	-475	962
650	-500	1010	800	-500	1151
650	-525	100	800	-525	994
650	-550	940	800	-550	983
650	-575	955	800	-575	900
650	-600	1035	900	100	1217
750	-75	1762	900	50	1160
750	-100	1052	700	-510	1044
750	-125	1220	700	-525	1047
750	-150	1998	700	-550	1050
750	163	1661	700	-575	1068
750	-175	9778	750	0	1010
750	188	2888	750	-25	1112
750	-200	2363	750	-50	899
750	-225	1830	900	0	1129
750	-250	1630	900	-50	1383
750	-275	1183	900	-100	1416
750	-300	996	900	-150	1512
750	-325	798	900	-200	3423
750	-350	776	900	-250	3182
750	-375	529	900	-300	1683
750	-400	446	900	-350	887
750	-425	725	900	-400	995
750	-450	726	1000	100	1857
750	-475	1001	1000	50	411
750	-500	1075	1000	0	1174
750	-525	994	1000	-50	1005
750	-550	1013	1000	-100	929
750	-575	931	1000	-150	1190
750	-600	986	1000	-200	922
800	100	1076	1000	-250	3157
800	50	1136	1000	-300	1616
800	0	1257	1000	-350	937
800	-50	1245	1000	-400	960
800	-100	1205			
800	-150	2814			
800	-200	3644			
800	-250	1891			
800	-300	1129			
800	-350	809			
800	-400	946			
800	-400	839			
800	-425	720			

APPENDIX 10

Appendix B.3 contains the geophysical contour maps and the geology map of the Ore Chimney Mine property as foldout lay-overs for comparison. The geology map, even though it is metric, has been scaled and rotated to match the geophysical contour maps.

VLF Fraser Filtered Map

1000
800
600
400
200
0
200
400
600
800
1000
SW
NE
Feet

VLF Fraser Filtered Map

VLF Quadrature Map

Total Field Magnetism Map

Geology and Geography Map

END

24/1 2/92

FIN