2372

REPORT ON THE 93L/13E
INDUCED POLARIZATION
AND RESISTIVITY SURVEY
ON THE
LOU GROUP, SMITHERS AREA, B.C.
FOR
CANADIAN SUPERIOR EXPLORATION LTD.

BY

MARION A. GOUDIE, B.Sc.

AND

PHILIP G. HALLOF, Ph.D.

NAME AND LOCATION OF PROPERTY

LOU GROUP, SMITHERS AREA, B.C.

OMINECA MINING DIVISION, 54°N, 127°W - NW

DATE STARTED: JANUARY 13, 1970

DATE FINISHED: MARCH 20, 1970

TABLE OF CONTENTS

McPHAR GEOPHYSICS

NOTES ON THE THEORY, METHOD OF FIELD OPERATION, AND PRESENTATION OF DATA FOR THE INDUCED POLARIZATION METHOD

Induced Polarization as a geophysical measurement refers to the blocking action or polarization of metallic or electronic conductors in a medium of ionic solution conduction.

This electro-chemical phenomenon occurs wherever electrical current is passed through an area which contains metallic minerals such as base metal sulphides. Normally, when current is passed through the ground, as in resistivity measurements, all of the conduction takes place through ions present in the water content of the rock, or soil, i.e. by ionic conduction. This is because almost all minerals have a much higher specific resistivity than ground water. The group of minerals commonly described as "metallic", however, have specific resistivities much lower than ground waters. The induced polarization effect takes place at those interfaces where the mode of conduction changes from ionic in the solutions filling the interstices of the rock to electronic in the metallic minerals present in the rock.

The blocking action or induced polarization mentioned above, which depends upon the chemical energies necessary to allow the ions to give up or receive electrons from the metallic surface, increases with the time that a d. c. current is allowed to flow through the rock; i. e. as ions pile up against the metallic interface the resistance to current flow increases. Eventually, there is enough polarization in the form of excess ions at the interfaces, to appreciably reduce the amount of current flow through the metallic particle. This polarization takes place at each of the infinite number of solution-metal interfaces in a mineralized rock.

When the d. c. voltage used to create this d. c. current flow is cut off, the Coulomb forces between the charged ions forming the polarization cause them to return to their normal position. This movement of charge creates a small current flow which can be measured on the surface of the ground as a decaying potential difference.

From an alternate viewpoint it can be seen that if the direction of the current through the system is reversed repeatedly before the polarization occurs, the effective resistivity of the system as a whole will change as the frequency of the switching is changed. This is a consequence of the fact that the amount of current flowing through each metallic interface depends upon the length of time that current has been passing through it in one direction.

The values of the per cent frequency effect or F. E. are a measurement of the polarization in the rock mass. However, since the measurement of the degree of polarization is related to the apparent resistivity of the rock mass it is found that the metal factor values or M. F. are the most useful values in determining the amount of polarization present in the rock mass. The MF values are obtained by normalizing the F. E. values for varying resistivities.

The induced polarization measurement is perhaps the most powerful geophysical method for the direct detection of metallic sulphide mineralization, even when this mineralization is of very low concentration. The lower limit of volume per cent sulphide necessary to produce a recognizable IP anomaly will vary with the geometry and geologic environment of the source, and the method of executing the survey. However, sulphide mineralization of less than one per cent by volume has been detected by the IP method under proper geological conditions.

The greatest application of the IP method has been in the search for disseminated metallic sulphides of less than 20% by volume. However, it has also been used successfully in the search for massive sulphides in situations where, due to source geometry, depth of source, or low resistivity of surface layer, the EM method can not be successfully applied. The ability to differentiate ionic conductors, such as water filled shear zones, makes the IP method a useful tool in checking EM anomalies which are suspected of being due to these causes.

In normal field applications the IP method does not differentiate between the economically important metallic minerals such as chalcopyrite, chalcocite, molybdenite, galena, etc., and the other metallic minerals such as pyrite. The induced polarization effect is due to the total of all electronic conducting minerals in the rock mass. Other electronic conducting materials which can produce an IP response are magnetite, pyrolusite, graphite, and some forms of hematite.

In the field procedure, measurements on the surface are made in a way that allows the effects of lateral changes in the properties of the ground to be separated from the effects of vertical changes in the properties. Current is applied to the ground at two points in distance (X) apart. The potentials are measured at two other points (X) feet apart, in line with the current electrodes is an integer number (n) times the basic distance (X).

The measurements are made along a surveyed line, with a constant distance (nX) between the nearest current and potential electrodes. In most surveys, several traverses are made with various values of (n); i.e. (n) = 1, 2, 3, 4, etc. The kind of survey required (detailed or reconnaissance) decides the number of values of (n) used.

In plotting the results, the values of the apparent resistivity, apparent per cent frequency effect, and the apparent metal factor measured for each set of electrode positions are plotted at the intersection of grid lines, one from the center point of the current electrodes and the other from the center point of the potential electrodes. (See Figure A.) The resistivity values are plotted above the line as a mirror image of the metal factor values below. On a second line, below the metal factor values, are plotted the values of the per cent frequency effect. In some cases the values of per cent frequency effect are plotted as superscripts of the metal factor value. In this second case the frequency effect values are not contoured. The lateral displacement of a given value is determined by the location along the survey line of the center point between the current and potential electrodes. The distance of the value from the line is determined by the distance (nX) between the current and potential electrodes when the measurement was made.

The separation between sender and receiver electrodes is only one factor which determines the depth to which the ground is being sampled in any particular measurement. The plots then, when contoured, are not section maps of the electrical properties of the ground under the survey line. The interpretation of the results from any given survey must be carried out using the combined experience gained from field results, model study results and theoretical investigations. The position of the electrodes when anomalous values are measured is important in the interpretation.

In the field procedure, the interval over which the potential differences are measured is the same as the interval over which the electrodes are moved after a series of potential readings has been made. One of the advantages of the induced polarization method is that the same equipment can be used for both detailed and reconnaissance surveys merely by changing the distance (X) over which the electrodes are moved each time. In the past, intervals have been used ranging from 25 feet to 2000 feet for (X). In each case, the decision as to the distance (X) and the values of (n) to be used is largely determined by the expected size of the mineral deposit being sought, the size of the expected anomaly and the speed with which it is desired to progress.

The diagram in Figure A demonstrates the method used in plotting the results. Each value of the apparent resistivity, apparent metal factor, and apparent per cent frequency effect is plotted and identified by the position of the four electrodes when the measurement was made. It can be seen that the values measured for the larger values of (n) are plotted farther from the line indicating that the thickness of the layer of the earth that is being tested is greater than for the smaller values of (n); i. e. the depth of the measurement is increased. When the F. E. values are plotted as superscripts to the MF values the third section of data values is not presented and the F. E. values are not contoured.

The actual data plots included with the report are prepared utilizing an IBM 360/75 Computer and a Calcomp 770/763 Incremental Plotting System. The data values are calculated, plotted, and contoured according to a programme developed by McPhar Geophysics. Certain symbols have been incorporated into the programme to explain various situations in recording the data in the field.

The IP measurement is basically obtained by measuring the difference in potential or voltage (ΔV) obtained at two operating frequencies. The voltage is the product of the current through the ground and the apparent resistivity of the ground. Therefore in field situations where the current is very low due to poor electrode contact, or the apparent resistivity is very low, or a combination of the two effects; the value of (ΔV) the change in potential will be too small to be measurable. The symbol "TL" on the data plots indicates this situation.

In some situations spurious noise, either man made or natural, will render it impossible to obtain a reading. The symbol "N" on the data plots indicates a station at which it is too noisy to record a reading. If a reading can be obtained, but for reasons of noise there is some doubt as to its accuracy, the reading is bracketed in the data plot ( ).

In certain situations negative values of Apparent Frequency Effect are recorded. This may be due to the geologic environment or spurious electrical effects. The actual negative frequency effect value recorded is indicated on the data plot, however the symbol "NEG" is indicated for the corresponding value of Apparent Metal Factor. In contouring negative values the contour lines are indicated to the nearest positive value in the immediate vicinity of the negative value.

The symbol "NR" indicates that for some reason the operator did not attempt to record a reading although normal survey procedures would suggest that one was required. This may be due to inaccessible topography or other similar reasons. Any symbol other than those discussed above is unique to a particular situation and is described within the body of the report.

METHOD USED IN PLOTTING DIPOLE-DIPOLE INDUCED POLARIZATION AND RESISTIVITY RESULTS

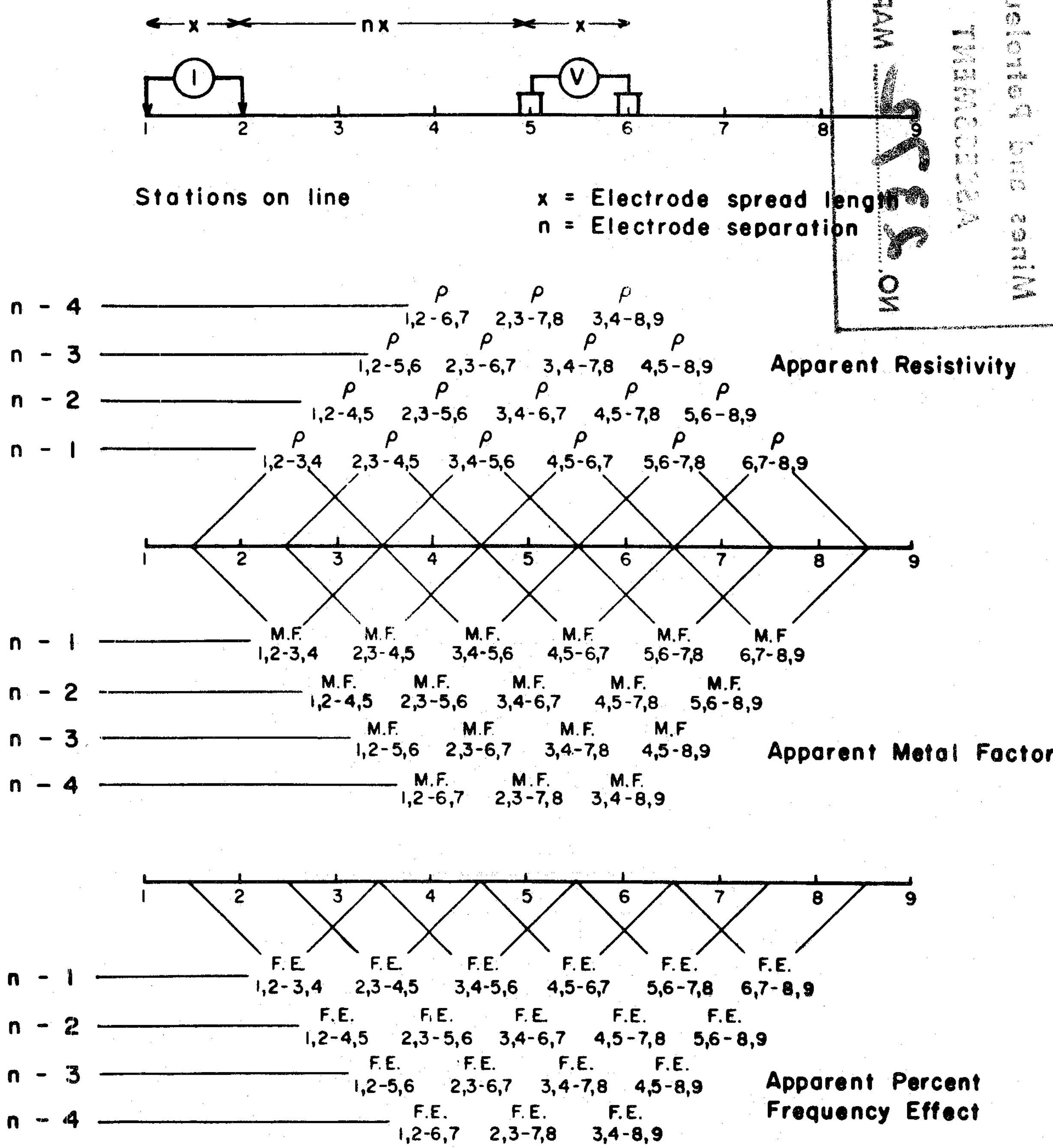


Fig. A

McPHAR GEOPHYSICS LIMITED

REPORT ON THE INDUCED POLARIZATION AND RESISTIVITY SURVEY ON THE LOU GROUP, SMITHERS AREA, B.C. FOR CANADIAN SUPERIOR EXPLORATION LTD.

1. INTRODUCTION

At the request of Mr. W. Rainboth, an induced polarization and resistivity survey has been completed on the Lou Group of claims in the Smithers area of British Columbia for Canadian Superior Exploration Ltd. The property is located about 21 miles west northwest of Smithers. The centre of the property is situated in the northwest quadrant of the 1° quadrilateral whose southeast corner is at 54°N latitude and 127°W longitude in the Omineca Mining Division.

There has been continuing exploration activity in the Smithers area for disseminated sulphide deposits since early in the 1960's. Two deposits of this type are the Granisle copper deposit on McDonald Island in Babine Lake and the Newman deposit of Noranda Mines Ltd. on the Newman peninsula in Babine Lake.

The country rocks in the grid area are feldspar porphyry with associated pyroclastics; sediments are present to the northeast. Two northeast - southwest trending faults cross the property.

The induced polarization and resistivity survey was carried out to try to locate sources of metallic mineralization in the grid area. The IP survey used a McPhar variable frequency unit operating at 0.3 and 5.0 cps. Field work was performed in late January and early February, 1970, on the following claims:

Lou Group: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 28, 30, 32, 34, 36, 38, 45, 47, 48, 88, 89, 90, 91, 92, 105, 106, 107, 108, 109, 111, 132, 134, 136, 138, 140, 166, 168, 170, 172.

These claims are all located in the Omineca Mining District and are assumed to be owned or held under option by Canadian Superior Exploration Ltd.

2. PRESENTATION OF RESULTS

The induced polarization and resistivity results are shown on the following data plots in the manner described in the notes preceding this report.

Line	Electrode Intervals	Dwg.No.
12+00E	200 feet	IP 5425-1
20+00E	200 feet	IP 5425-2
28+00E	200 feet	IP 5425-3
36+00E	200 feet	IP 5425-4
44+00E	200 feet	IP 5425-5
52+00E	200 feet	IP 5425-6

Line	Electrode Intervals	Dwg. No.
60+00E	200 feet	IP 5425-7
60+00E	100 feet	IP 5425-8
68+00E	200 feet	IP 5425-9
72+00E	200 feet	IP 5425-10
76+00E	200 feet	IP 5425-11
84+00E	200 feet	IP 5425-12
92+00E	200 feet	IP 5425-13
100+00E	200 feet	IP 5425-14
108+00E	200 feet	IP 5425-15
116+00E	200 feet	IP 5425-16
124+00E	200 feet	IP 5425-17

Enclosed with this report is Dwg. I.P.P. 4612, a plan map of the grid at a scale of 1" = 400'. The definite and possible induced polarization anomalies are indicated by solid and broken bars respectively on this plan map as well as the data plots. These bars represent the surface projection of the anomalous zones as interpreted from the location of the transmitter and receiver electrodes when the anomalous values were measured.

Since the induced polarization measurement is essentially an averaging process, as are all potential methods, it is frequently difficult to exactly pinpoint the source of an anomaly. Certainly, no anomaly can be located with more accuracy than the spread length; i.e. when using 200' spreads the position of a narrow sulphide body can only be determined to lie between two stations 200' apart. In order to locate sources at some depth, larger spreads must be used, with a corresponding increase in the uncertainties of location. Therefore, while the centre of the indicated anomaly probably corresponds fairly well with source, the length of the indicated anomaly along the line should not be taken to represent the exact edges of the anomalous material.

3. DISCUSSION OF RESULTS

IP has been quite successful in outlining deposits of disseminated sulphides in British Columbia. However, the interpretation of the IP results must be approached with caution. The technical paper bound with this report illustrates this with results from two different surveys in the Smithers area. Figure 6, page 5, shows a survey where the strongest portion of the anomaly overlies an economic sulphide source. Figure 9, page 7, illustrates an anomaly where the strongest IP response is caused by a heavy concentration of pyrite and the weaker IP response represents a concentration of economic sulphides. Thus, if strong anomalies prove to be uninteresting, an area should not be abandoned before evaluating the weaker IP responses.

IP anomalies were located on all lines of the survey, forming an open-ended zone trending southwest - northeast. The central portion of this zone (Zone A_1) contains the strongest portions of the anomalies and has been tested by sixteen drill holes. A seventeenth drill hole, #A, tested a barren section of Line 128N outside the grid area. The definite portion of this zone almost pinches out on Line 20N at the contact of the more northerly of the two faults. Eastward from this point, the strong portion of the zone, now designated Zone A_2, lies to the south of the fault and may be in an entirely different geological environment. This premise should be checked with a test hole on Line 108E, with the hole collared at either 56N or at 71N and drilled at an angle to test the anomaly under the lake. If economic mineralization is present the zone is large enough to make the deposit of economic interest.

The possibility also exists that there may be a northwest - southeast trending fault crossing the grid area near the joining point of Zone A_1 and Zone A_2.

A brief summary of the drilling results has been made to try to analyze and correlate these results with the IP results.

D.D.H.	MF	Depth	Source	Host Rock
16	178 to 216	100' - 250'	pyrite	mostly tuff
15	305 278	130' - 200' 270' - 350'	pyrite .1 to 1.9 Cu	sericite rock agglomerate
14	246 approx.210	160' - 170' 50' - 60'	0.16 Cu & pyrite 0.17 Cu	tuff
13	183	150' - 160'	0.58 Cu & pyrite/ molybdenum/ chalcopyrite tennantite ?	altered agglomerate
12	112 210	90' - 100' 250'	1.16 Cu & pyrite pyrite	altered porphyry altered porphyry
11	125 approx.100	100' 180' - 190'	pyrite 0.14 Cu & pyrite	porphyry (tuff ?) pyrite-banded tuff
10	1250	120' - 210'	pyrite	pyrite-banded sericite kaolin rock

D.D.H.	MF	Depth	Source	Host Rock
9	300 ?	30' - 90'	0.13 to 0.19 Cu & pyrite	altered porphyry agglomerate
	328	90' - 180'	approx. .1 Cu & pyrite	quartz sericite rock & altered porphyry
8	300 ?	50' - 60'	0.11 Cu & pyrite	porphyry
	125	250' - 350'	pyrite, molybdenum & stibnite ?	sericite & altered porphyry
7			No IP	
6	859	189' - 352'	tennantite & red-brown mineral	sericite rock & porphyry
5	115 ?	118' - 182'	tennantite/ chalcopyrite/ molybdenum/pyrite/ red-brown mineral	kaolin sericite rock
	155	263' - 277'	tennantite & red-brown mineral	feldspar porphyry
4	300 to 700	62' - 435'	tennantite/ chalcopyrite/pyrite/ red-brown mineral	porphyry & sericite rock
3		170' - 420'	tennantite & red-brown mineral	sericite kaolin rock
2	39 to 75 ?	86' - 158'	moderate tennantite	porphyry agglomerate
	166	158' - 240'	less tennantite	altered porphyry
1	165 to 950	207' - 291'	tennantite/pyrite/ molybdenum	agglomerate
	950	291' - 308'	pyrite	

The following inferences can be drawn:

1) the strongest IP responses appear to be caused mainly by pyrite mineralization, which is probably greater in concentration than indicated in the core description;

2) pyrite accompanies almost all of the mineralization noted in the cores and consequently gives an increased IP response;

3) mineralization occurs in more than one type of host rock.

Rather a large suite of minerals has been identified from the cores, as follows: tennantite, molybdenite, chalcopyrite, sphalerite, galena, stibnite (rare), cinnabar (rare), and an unidentified red-brown mineral which seems to be fairly common throughout the cores in association with the tennantite. Tennantite is most common, followed by the red-brown mineral, then molybdenite.

Dwg. I.P.P. 4612 illustrates the division of the anomalous areas into Zone A_1 and Zone A_2, which include the definite portions of the anomalies. A fairly typical example of Zone A_1 mineralization can be found on Line 60E, where five holes were drilled. The copper values varied from less than .1% in D.D.H. #10 to .5% in D.D.H. #3. The highest MF values tested, in D.D.H. #10, had pyrite as the source. The weaker portions of the anomalies lie to the north and south of the main zones and have not been tested by drilling. It would be useful to know whether the pyrite mineralization decreases and the economic sulphide content increases in these portions of the grid. Two drill hole locations to test this possibility could be on Line 12E, with a vertical hole collared at 50N, or on Line 20E with a vertical hole collared at 32N. If this drilling is completed, and the results are of economic interest, Line 12E and Line 28E should be extended to the south to complete data over the anomalies.

4. SUMMARY

Two zones of strong anomalies were located by the survey. The western zone, Zone A_1, was extensively tested by drilling and the results indicated that wide variations in sulphide mineralization exist and that pyrite is present in varying quantities. Indeed, pyrite appears to be the major source of the strongest sections of the anomalies.

Zone A_1 is flanked to the north and south by weaker anomalies which are untested. In view of the history of the general area, it would be of interest to know the source of these weaker anomalies. Two possible drill hole locations have been suggested.

Zone A_2 lies to the south of the southwest - northeast trending fault and may lie in a different geological environment to that of Zone A_1. The zone is untested and it has been recommended that it be checked with at least one drill hole.

McPHAR GEOPHYSICS LIMITED

Marion A. Goudie,
Geologist.

Philip G. Hallof,
Geophysicist.

Dated: May 5, 1970

ASSESSMENT DETAILS

PROPERTY: Lou Claim Group		MINING DIVISION: Omineca
SPONSOR: Canadian Superior Exploration Ltd.		PROVINCE: British Columbia
LOCATION: Smithers Area		DATE STARTED: January 13 - February 10, 1970
TYPE OF SURVEY: Induced Polarization		
OPERATING MAN DAYS:	62	DATE FINISHED: March 8 - March 20, 1970
EQUIVALENT 8 HR. MAN DAYS:	93	
CONSULTING MAN DAYS:	6	NUMBER OF STATIONS: 488
DRAUGHTING MAN DAYS:	21	NUMBER OF READINGS: 4640
TOTAL MAN DAYS:	120	MILES OF LINE SURVEYED: 16

CONSULTANTS:

Marion A. Goudie, 739 Military Trail, West Hills, Ontario.
Philip G. Hallof, 5 Minorca Place, Don Mills, Ontario.

FIELD TECHNICIANS:

A. Walcer, 78 Braemar Drive, Apt. 711, Bramalea, Ontario.
W. McDowall, 948 Piermond Avenue, Richmond, B.C.
Plus 2 helpers supplied by client.

DRAUGHTSMEN:

D. Holmes, 1053 Don Mills Road, Apt. 101, Don Mills, Ontario.
N. Lade, 1355 Lakefield Street, Oshawa, Ontario.
J. Duffy, 7 Waddington Crescent, Willowdale, Ontario.

McPHAR GEOPHYSICS LIMITED

Marion A. Goudie

Marion A. Goudie,
Geologist.

Dated: May 5, 1970

CERTIFICATE

I, Marion A. Goudie, of the City of Toronto, Province of Ontario, do hereby certify that:

1. I am a Geologist residing at 739 Military Trail, West Hill, Ontario.

2. I am a graduate of the University of Western Ontario with a B.Sc. Degree (1950) in Honours Geology.

3. I am a member of the Geological Society of America.

4. I have been practising my profession for 20 years.

5. I have no direct or indirect interest, nor do I expect to receive any interest directly or indirectly, in the property or securities of Canadian Superior Exploration Ltd. or any affiliate.

6. The statements made in this report are based on a study of published geological literature and unpublished private reports.

7. Permission is granted to use in whole or in part for assessment and qualification requirements but not for advertising purposes.

Dated at Toronto

This 5th day of May 1970.

Marion A. Goudie

Marion A. Goudie, B.Sc.

CERTIFICATE

I, Philip George Hallof, of the City of Toronto, Province of Ontario, do hereby certify that:

1. I am a geophysicist residing at 5 Minorca Place, Don Mills, (Toronto) Ontario.

2. I am a graduate of the Massachusetts Institute of Technology with a B.Sc. Degree (1952) in Geology and Geophysics, and a Ph.D. Degree (1957) in Geophysics.

3. I am a member of the Society of Exploration Geophysicists and the European Association of the Exploration Geophysicists.

4. I have been practising my profession for ten years.

5. I have no direct or indirect interest, nor do I expect to receive any interest directly or indirectly, in the property or securities of Canadian Superior Exploration Ltd. or any affiliate.

6. The statements made in this report are based on a study of published geological literature and unpublished private reports.

7. Permission is granted to use in whole or in part for assessment and qualification requirements but not for advertising purposes.

Dated at Toronto

This 5th day of May 1970.

Philip G. Hallof, Ph.D.

PROFESSIONAL ENGINEER
PROVINCE OF ONTARIO

Expiry Date: February 28, 1971

STATEMENT OF COST

Canadian Superior Explorations - Lou Group

Crew (2 Men)

17	days Operating	@ $240.00/day	4,080.00
8 1/2	days Operating	@ $230.00/day	1,955.00
3 1/2	days Travel)		
4 1/2	days Preparation)		
6 1/2	days Standby)	15 1/2 days @ $ 85.00/day	1,317.50
1	day Bad Weather)		

Expenses

Transportation - Air	88.40	
Transportation - Bus	7.33	
Freight & Brokerage	486.00	
Taxis	5.63	
Meals & Accommodation	3.84	
Telephone & Telegraph	23.10	
Supplies	51.12	
Mileage	3.90	
	669.32	
Plus 10% Service Charge	66.93	
		736.25
		$8,088.75

McPHAR GEOPHYSICS LIMITED

Marion A. Goudie

Marion A. Goudie,
Geologist

Dated: May 5, 1970

DWG. NO.- I.P.-5425-1

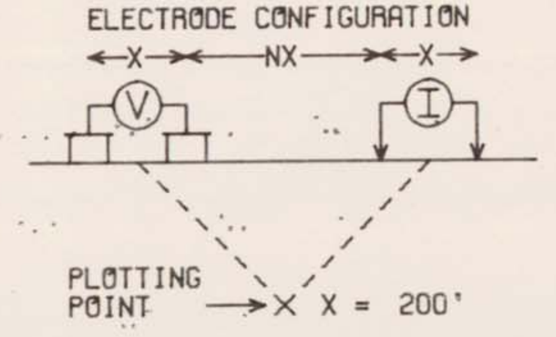
CANADIAN SUPERIOR EXPLORATION LTD.

LOU GROUP, SMITHERS AREA

OMINECA M.D., B.C.

LINE NO.- 12E

ELECTRODE CONFIGURATION



PLOTTING POINT → X X = 200'

SURFACE PROJECTION OF ANOMALOUS ZONES

DEFINITE
PROBABLE
POSSIBLE

FREQUENCIES: 0.31-5.0 CPS

DATE SURVEYED: FEB 1970

APPROVED:

NOTE: CONTOURS AT LOGARITHMIC INTERVALS 1.-1.5-2.-3.-5.-7.5-10

DATE: 5/3/70

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — PHILIP G. HALLOF

Expiry Date: February 25, 1971

2372

McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY

NOTE: THIS PLOT WAS PRODUCED WITH AN IBM 360/75 COMPUTER AND A CALCOMP PLOTTER

DWG. NO.- I.P.-5425-2

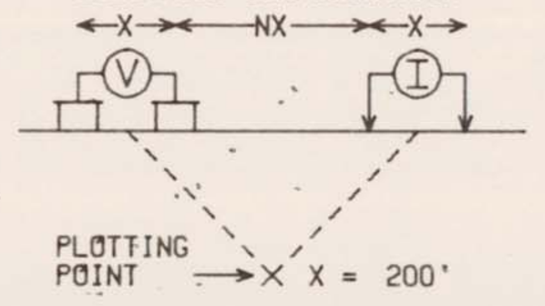
CANADIAN SUPERIOR EXPLORATION LTD.

LOU GROUP, SMITHERS AREA

OMINECA M.D., B.C.

LINE NO.- 20E

ELECTRODE CONFIGURATION



SURFACE PROJECTION OF ANOMALOUS ZONES

DEFINITE

PROBABLE

POSSIBLE

FREQUENCIES: 0.31-5.0 CPS

DATE SURVEYED: FEB 1970

APPROVED:

DATE:

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — PHILIP G. HALLOF

Expiry Date: February 25, 1971

NOTE: CONTOURS AT LOGARITHMIC INTERVALS 1.-1.5-2.-3.-5.-7.5-10

2372

McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY

NOTE: THIS PLOT WAS PRODUCED WITH AN IBM 360/75 COMPUTER AND A CALCOMP PLOTTER

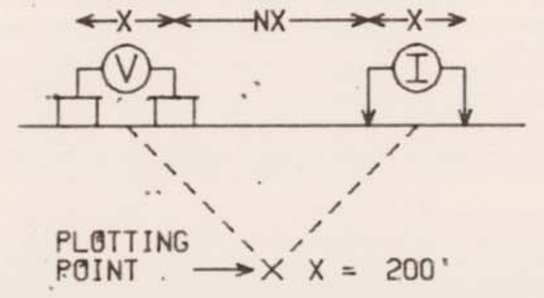
DWG. NO.- I.P.-5425 - 3

CANADIAN SUPERIOR EXPLORATION LTD.

LOU GROUP, SMITHERS AREA
OMINECA M.D., B.C.

LINE NO.- 28E

ELECTRODE CONFIGURATION



SURFACE PROJECTION OF ANOMALOUS ZONES

DEFINITE
PROBABLE
POSSIBLE

FREQUENCIES: 0.31-5.0 CPS

DATE SURVEYED: FEB 1970

APPROVED:

NOTE: CONTOURS AT LOGARITHMIC INTERVALS 1.-1.5-2.-3.-5.-7.5-10

DATE: 5/5/70

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA HALLOF

Expiry Date: February 25, 1971

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McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY

NOTE: THIS PLOT WAS PRODUCED WITH AN IBM 360/75 COMPUTER AND A CALCOMP PLOTTER

DWG. NO.- I.P.-5425-4

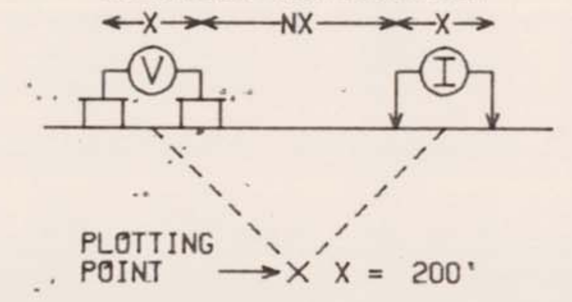
CANADIAN SUPERIOR EXPLORATION LTD.

LOU GROUP, SMITHERS AREA

OMINECA M.D., B.C.

LINE NO.- 36E

ELECTRODE CONFIGURATION



SURFACE PROJECTION OF ANOMALOUS ZONES

DEFINITE
PROBABLE
POSSIBLE

FREQUENCIES: 0.31-5.0 CPS

DATE SURVEYED: FEB 1970

APPROVED:

NOTE: CONTOURS AT LOGARITHMIC INTERVALS 1.-1.5-2.-3.-5.-7.5-10

DATE:

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
PHILIP G. HALLOF

Expiry Date: February 28, 1971

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McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY

NOTE: THIS PLOT WAS PRODUCED WITH AN IBM 360/75 COMPUTER AND A CALCOMP PLOTTER

DWG. NO.- I.P.-5425-5

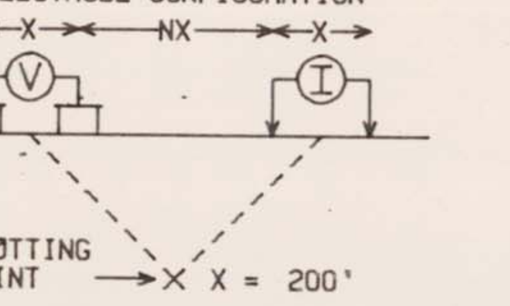
CANADIAN SUPERIOR EXPLORATION LTD.

LOU GROUP, SMITHERS AREA

OMINECA M.D., B.C.

LINE NO.- 44E

ELECTRODE CONFIGURATION



SURFACE PROJECTION OF ANOMALOUS ZONES

DEFINITE
PROBABLE
POSSIBLE

FREQUENCIES: 0.31-5.0 CPS

DATE SURVEYED: FEB 1970

APPROVED:

DATE: 3/5/70

PROFESSIONAL ENGINEER, PROVINCE OF BRITISH COLUMBIA, PHILIP G. HALLOF

Expiry Date: February 25, 1971

NOTE: CONTOURS AT LOGARITHMIC INTERVALS 1.-1.5-2.-3.-5.-7.5-10

2372

McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY

NOTE: THIS PLOT WAS PRODUCED WITH AN IBM 360/75 COMPUTER AND A CALCOMP PLOTTER

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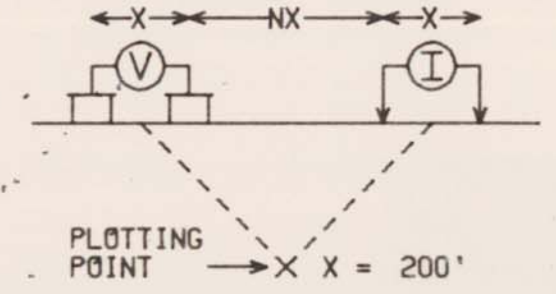
CANADIAN SUPERIOR EXPLORATION LTD.

LOU GROUP, SMITHERS AREA
OMINECA M.D., B.C.

LINE NO.- 52E

ELECTRODE CONFIGURATION



SURFACE PROJECTION OF ANOMALOUS ZONES

DEFINITE
PROBABLE
POSSIBLE

FREQUENCIES: 0.31-5.0 CPS

DATE SURVEYED: JAN 1970

APPROVED:

DATE:

NOTE: CONTOURS AT LOGARITHMIC INTERVALS 1.-1.5-2.-3.-5.-7.5-10

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — PHILIP G. HALLOF

Expiry Date: February 25, 1971

2372

McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY

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CANADIAN SUPERIOR EXPLORATION LTD.

LOU GROUP, SMITHERS AREA
OMINECA M.D., B.C.

LINE NO.- 60E

ELECTRODE CONFIGURATION

PLOTTING POINT X = 200'

SURFACE PROJECTION OF ANOMALOUS ZONES
DEFINITE
PROBABLE
POSSIBLE

FREQUENCIES: 0.31-5.0 CPS

DATE SURVEYED: JAN 1970

APPROVED

NOTE: CONTOURS AT LOGARITHMIC INTERVALS 1.-1.5-2.-3.-5.-7.5-10

DATE:

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — P. HALLOF

Expiry Date: February 25, 1973

2372

McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY

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CANADIAN SUPERIOR EXPLORATION LTD.

LOU GROUP, SMITHERS AREA
OMINECA M.D., B.C.

LINE NO.- 60E

ELECTRODE CONFIGURATION

X — NX — X

PLOTTING POINT X = 100'

SURFACE PROJECTION OF ANOMALOUS ZONES
DEFINITE
PROBABLE
POSSIBLE

FREQUENCIES: 0.31-5.0 CPS

DATE SURVEYED: MAR 1970

APPROVED:

NOTE: CONTOURS AT LOGARITHMIC INTERVALS 1.-1.5-2.-3.-5.-7.5-10

DATE:

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — PHILIP G. HALLOF

Expiry Date: February 25, 1971

2372

McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY

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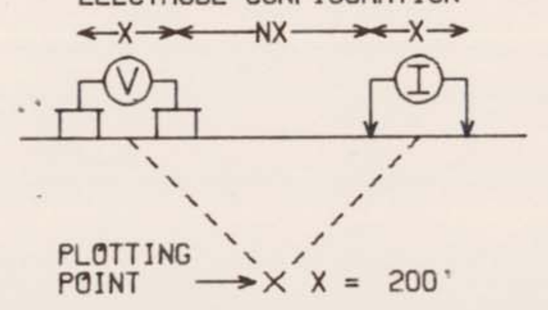
LINE NO.- 68E



SURFACE PROJECTION OF ANOMALOUS ZONES

DEFINITE
PROBABLE
POSSIBLE

FREQUENCIES: 0.31-5.0 CPS

DATE SURVEYED: JAN 1970

APPROVED:

NOTE: CONTOURS AT LOGARITHMIC INTERVALS 1.-1.5-2.-3.-5.-7.5-10

DATE:

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — PHILIP G. HALLOF — 3/5/70

Expiry Date: February 25, 1971

2372

McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY

NOTE: THIS PLOT WAS PRODUCED WITH AN IBM 360/75 COMPUTER AND A CALCOMP PLOTTER

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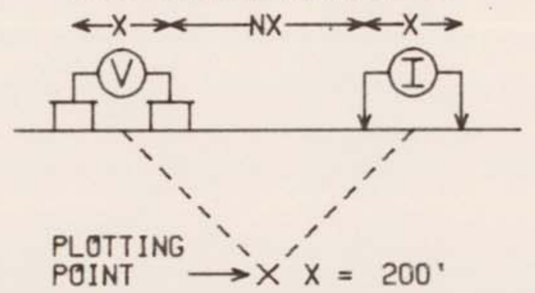
LOU GROUP, SMITHERS AREA

OMINECA M.D., B.C.

LINE NO. 72E

ELECTRODE CONFIGURATION



SURFACE PROJECTION OF ANOMALOUS ZONES

DEFINITE

PROBABLE

POSSIBLE

FREQUENCIES: 0.31-5.0 CPS

DATE SURVEYED: MAR 1970

APPROVED:

DATE:

NOTE: CONTOURS AT LOGARITHMIC INTERVALS 1.-1.5-2.-3.-5.-7.5-10

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA PHILIP G. HALLOF

Expiry Date: February 25, 1971

2372

McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY

NOTE: THIS PLOT WAS PRODUCED WITH AN IBM 360/75 COMPUTER AND A CALCOMP PLOTTER

DWG. NO.- I.P.-5425-11

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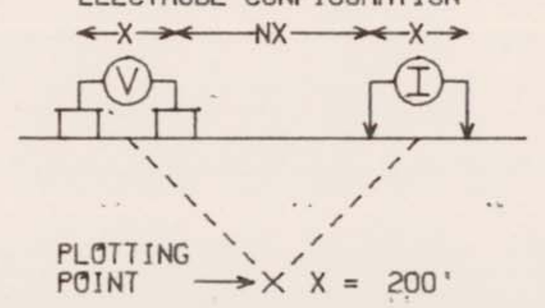
LOU GROUP, SMITHERS AREA

OMINECA M.D., B.C.

LINE NO.- 76E



SURFACE PROJECTION OF ANOMALOUS ZONES

DEFINITE ▬▬▬

PROBABLE ||||||||||

POSSIBLE / / / / /

FREQUENCIES: 0.31-5.0 CPS

DATE SURVEYED: JAN 1970

APPROVED:

DATE:

NOTE: CONTOURS AT LOGARITHMIC INTERVALS 1.-1.5-2.-3.-5.-7.5-10

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Expiry Date: February 25, 1971

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McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY

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DWG. NO.- I.P.-5425-12

CANADIAN SUPERIOR EXPLORATION LTD.

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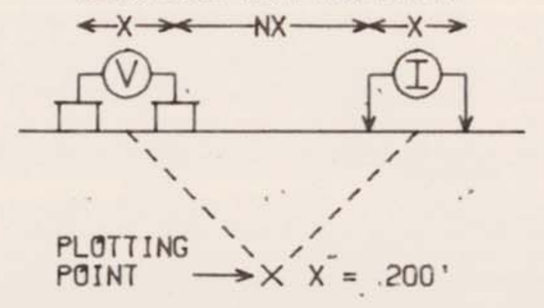
OMINECA M.D., B.C.

LINE NO.- 84E

ELECTRODE CONFIGURATION



SURFACE PROJECTION OF ANOMALOUS ZONES

DEFINITE ▬▬▬

PROBABLE ||||||||||||

POSSIBLE / / / / /

FREQUENCIES: 0.31-5.0 CPS

DATE SURVEYED: JAN 1970

APPROVED:

NOTE: CONTOURS AT LOGARITHMIC INTERVALS 1.-1.5-2.-3.-5.-7.5-10

DATE: 5/5/70

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA PHILIP G. HALLOF

Expiry Date February 25, 1971

2372

McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY

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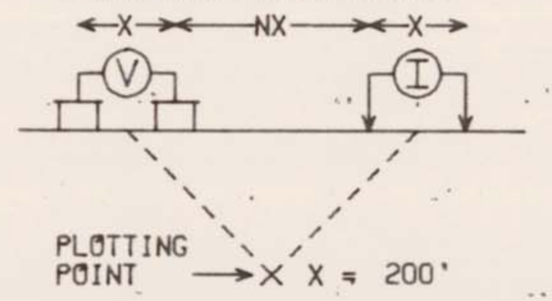
CANADIAN SUPERIOR EXPLORATION LTD.

LOU GROUP, SMITHERS AREA

OMINECA M.D., B.C.

LINE NO.- 92E

ELECTRODE CONFIGURATION



SURFACE PROJECTION OF ANOMALOUS ZONES

DEFINITE
PROBABLE
POSSIBLE

FREQUENCIES: 0.31-5.0 CPS

DATE SURVEYED: FEB 1970

APPROVED:

DATE:

NOTE: CONTOURS AT LOGARITHMIC INTERVALS 1.-1.5-2.-3.-5.-7.5-10

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA ... HALLOF

Expiry Date: February 25, 1971

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McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY

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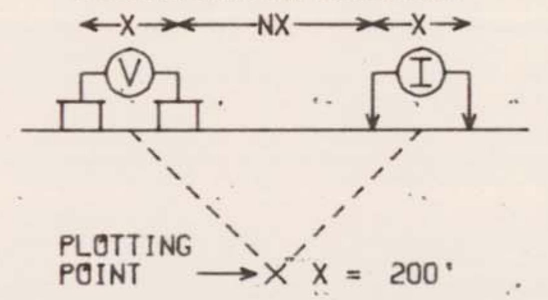
CANADIAN SUPERIOR EXPLORATION LTD.

LOU GROUP, SMITHERS AREA

OMINECA M.D., B.C.

LINE NO.- 100E



SURFACE PROJECTION OF ANOMALOUS ZONES

DEFINITE
PROBABLE
POSSIBLE

FREQUENCIES: 0.31-5.0 CPS

DATE SURVEYED: FEB 1970

APPROVED:

DATE:

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
PHILIP G. HALLOF

Expiry Date: February 25, 1971

NOTE: CONTOURS AT LOGARITHMIC INTERVALS 1.-1.5-2.-3.-5.-7.5-10

2372

McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY

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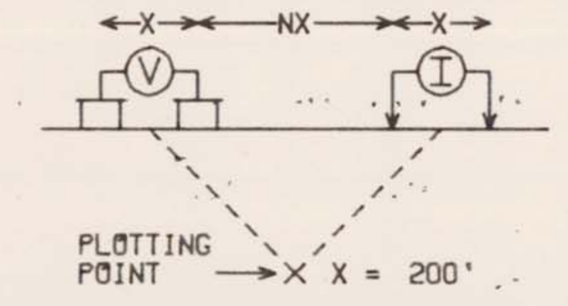
LOU GROUP, SMITHERS AREA

OMINECA M.D., B.C.

LINE NO.- 108E

ELECTRODE CONFIGURATION



SURFACE PROJECTION OF ANOMALOUS ZONES

DEFINITE
PROBABLE
POSSIBLE

FREQUENCIES: 0.31-5.0 CPS

DATE SURVEYED: FEB 1970

APPROVED:

NOTE: CONTOURS AT LOGARITHMIC INTERVALS 1.-1.5-2.-3.-5.-7.5-10

DATE:

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA PHILIP G. HALLOF

Expiry Date: February 25, 1971

2372

McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY

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LOU GROUP, SMITHERS AREA

OMINECA M.D., B.C.

LINE NO.- 116E

ELECTRODE CONFIGURATION

X — NX — X

PLOTTING POINT

X = 200'

SURFACE PROJECTION OF ANOMALOUS ZONES

DEFINITE

PROBABLE

POSSIBLE

FREQUENCIES: 0.31-5.0 CPS

DATE SURVEYED: MAR 1970

APPROVED:

DATE:

NOTE: CONTOURS AT LOGARITHMIC INTERVALS 1.-1.5-2.-3.-5.-7.5-10

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — P. G. HALLOF

Expiry Date: February 25, 1971

2372

McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY

NOTE: THIS PLOT WAS PRODUCED WITH AN IBM 360/75 COMPUTER AND A CALCOMP PLOTTER

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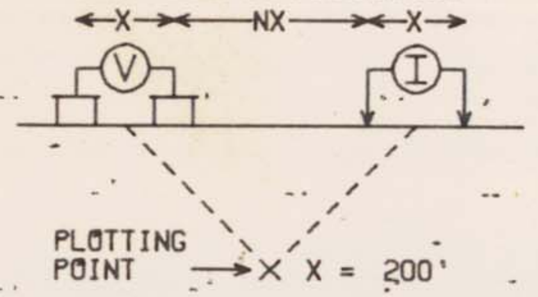
CANADIAN SUPERIOR EXPLORATION LTD.

LOU GROUP, SMITHERS AREA
OMINECA M.D., B.C.

LINE NO.- 124E

ELECTRODE CONFIGURATION



SURFACE PROJECTION OF ANOMALOUS ZONES

DEFINITE ▬▬▬
PROBABLE ┅┅┅
POSSIBLE ////

FREQUENCIES: 0.31-5.0 CPS

DATE SURVEYED: MAR 1970

APPROVED

NOTE: CONTOURS AT LOGARITHMIC INTERVALS 1.-1.5-2.-3.-5.-7.5-10

DATE

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — PHILIP G. HALLOF

Expiry Date: February 25, 1971

2372

McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY

NOTE: THIS PLOT WAS PRODUCED WITH AN IBM 360/75 COMPUTER AND A CALCOMP PLOTTER

Geophysics Applied to the Exploration and Development of Copper and Molybdenum Deposits In British Columbia

DAVID K. FOUNTAIN, Chief Geophysicist,
McPhar Geophysics Incorporated.
Formerly Geophysicist, Noranda Mines Ltd.

DAVID K. FOUNTAIN graduated with a B.A.Sc. degree in engineering physics (geophysics option) from the University of Toronto. He has had experience in all phases of geophysics, both ground and airborne, carrying out exploration work throughout Canada as well as in the United States, Mexico, South America, West Africa and Ireland. He joined McPhar Geophysics in March, 1968 from Noranda Mines Limited, where he had been geophysicist since 1964. Prior to this, he had worked for Pan American Petroleum, and had carried out geophysical contracting and consulting, including work for the United Nations.

THE PAPER WAS PRESENTED: at the 70th Annual General Meeting of the Institute, Vancouver, April, 1968. It will appear in the C.I.M. Transactions for 1968.

KEYWORDS IN THIS PAPER: Copper deposits, Molybdenum deposits, Geophysical exploration, Gravity methods, Radiometric methods, Electrical methods, Self Potential methods, Electromagnetic methods, Resistivity methods, Induced polarization, Magnetic methods, Brenda Mines, Newman Peninsula, Babine lake.

ABSTRACT

The growth of the mining industry in British Columbia in the last ten years has been largely the result of the development of large low-grade copper and molybdenum deposits. There are two problems which must be solved in the search for mineral deposits of this type. It is necessary to detect large volumes of rock containing a low percentage of total sulphide mineralization and, secondly, to get some idea of the economic significance of this mineralization.

The standard geophysical exploration techniques available have a varying degree of application in the search for disseminated sulphide deposits. The electrical methods, and the induced polarization method in particular, are the most successful direct methods, and magnetic methods have indirect application in most situations. This is illustrated by geophysical survey results from several properties in British Columbia.

INTRODUCTION

WITHIN THE LAST TEN YEARS, there has been a tremendous growth in the mining industry of British Columbia. This growth has been largely the result of the discovery and, more important, the successful development of copper and molybdenum deposits. These two metals combined have supplanted lead and zinc in highest value of current production. This paper will attempt to outline how geophysics has been, and can be, applied to the exploration for, and development of, copper and molybdenum deposits in British Columbia. In discussing this, the application to property situations will be covered in more detail than the regional applications.

TYPE OF MINERAL DEPOSIT

Perhaps the most significant step in the emergence of copper and molybdenum as the leaders in British Columbia mineral production has been the demonstration, at Bethlehem Copper Corp. Ltd., of the successful and profitable development and production from large low-grade mineral deposits. The more recent successes at Endako Mines Ltd. and British Columbia Molybdenum Ltd. have firmly established the policy of looking for these large low-grade deposits in British Columbia. Currently in various stages of development are the large-tonnage deposits of Brenda Mines Limited, Noranda's Newman Peninsula deposit, Lornex Mines, Stikine Copper Ltd., and others.

The question is how, and with what degree of success, can geophysics be applied to the exploration and development of these types of deposits. There is really no all-inclusive term to describe them. "Low grade" carries a poor connotation; "porphyry copper" is not always correct in a true geological sense; and "disseminated" can include a broad range of varying modes of sulphide dispersion. The typical deposit contains mineralization having less than 1 per cent copper or the equivalent value in molybdenum or copper-molybdenum. Therefore, to be economical it must be very large or in such a form that it can be mined very cheaply. "Open-pit bulk ore" might be the best description of these deposits, although even this term is not always correct.

In the search for mineral deposits of this type, there are two problems to which solutions are required. First, it is necessary to have a reasonably reliable technique for detecting the presence of volumes of rock containing a low percentage of total sulphide mineralization. Second, it is desirable to determine the probability of this sulphide mineralization being of economic significance. As it turns out, the second problem is the more difficult.

GEOPHYSICAL METHODS AVAILABLE

For the purpose of our discussion, we will consider that the type of deposit we are looking for contains "sulphide mineralization scattered as specks and veinlets through the rock and constituting not over 20 per cent of the total volume." This is the definition for disseminated sulphide as given in the *AGI Glossary, 1951.* Economics put the lower limit of mineralization as being about 0.5 per cent by volume. The per cent sulphide by volume is a more meaningful geophysical criterion than the more common classification of per cent sulphide by weight. In the case of sulphide mineralization, volume per cent is less than weight per cent. For example, 1 per cent chalcopyrite by weight equals approximately 0.65 per cent by volume.

The standard geophysical exploration techniques available have a varying degree of application in the search for the disseminated copper-molybdenum deposits being considered. In this regard, it should be stressed that the high cost of property access and the short summer field season in British Columbia require that the most diagnostic exploration procedures and techniques be applied. The cost of returning to a property to carry out another survey will often be greater than the extra expense of doing a thorough job the first time. In *Figure 1,* the various methods available are listed, along with the physical property measured and the degree of application.

GRAVITY METHOD

Although useful in some cases as a regional or indirect tool, the gravity method is generally of little direct help in evaluating disseminated sulphide deposits. Due to the small amount of sulphide mineralization present, the density contrast between mineralized rock and unmineralized rock is relatively small. Therefore, great accuracy of elevation control and topographic correction would be required in the gravity survey; and, from a practical standpoint, this density contrast can be considered to be undetectable. As a further problem, the density of the host rock in the mineralized area may be reduced by fracturing and alteration, and a leached or oxidized zone overlying the sulphide zone would be expected to have a low density. The combination of the above factors makes the useful application of the gravity method difficult.

METHOD	PHYSICAL PROPERTY MEASURED	DEGREE OF APPLICATION
GRAVITY METHOD	DENSITY CONTRAST	LITTLE DIRECT APPLICATION SOME USE AS REGIONAL INDIRECT TOOL
RADIOMETRIC METHOD	RADIOACTIVITY	SOME USE AS REGIONAL INDIRECT TOOL
ELECTRICAL METHODS		
S. P.	SELF POTENTIAL	USEFUL DIRECT TOOL UNDER SOME CONDITIONS
ELECTROMAGNETIC	ELECTRICAL CONDUCTIVITY	USEFUL DIRECT TOOL IN LIMITED SITUATIONS SOME USE REGIONALLY
RESISTIVITY	ELECTRICAL CONDUCTIVITY	DIRECT APPLICATION IN LIMITED SITUATIONS
INDUCED POLARIZATION	ELECTRICAL POLARIZATION	USEFUL DIRECT TOOL IN MOST SITUATIONS
MAGNETIC METHOD	MAGNETIC SUSCEPTIBILITY	USEFUL DIRECT TOOL IN SOME SITUATIONS INDIRECT APPLICATION IN MOST SITUATIONS

Figure 1.—Geophysical Methods Available and Application to Disseminated Sulphide Deposits.

RADIOMETRIC METHODS

Some use has been made of radiometric methods to map the potassium concentration associated with the alteration patterns of disseminated sulphide deposits. This has been mainly carried out in conjunction with other geophysical methods as a regional reconnaissance tool. It has not, to the author's knowledge, been applied extensively on the ground, especially in British Columbia.

ELECTRICAL METHODS

The most definitive physical properties of a disseminated sulphide deposit are its electrical characteristics. The metallic sulphide minerals themselves are highly conductive, conduct electronically and therefore are polarizable, and, if in a suitable geologic environment, undergo oxidation and may develop self potential. These properties would suggest the application of several standard geophysical methods: electromagnetic, both passive and active induced polarization; resistivity; and self potential.

Self Potential Method

Under proper conditions, the self potential method is a useful direct tool in the search for disseminated sulphides. However, the simplicity of the equipment and field technique of the SP method is offset by the complexity of the electrochemical and theoretical considerations involved. Suffice it to say that many SP anomalies are due to non-sulphide and the absence of an anomaly does not preclude the presence of sulphide mineralization.

A self potential anomaly, however, was indicated over Noranda's Newman deposit, and drilling based on the combined SP and EM anomalies led to its discovery.

Electromagnetic Methods

In general, the basic problem in utilizing electromagnetic methods in the search for disseminated sulphide deposits is that a sulphide content of up to 20 per cent in a truly disseminated form does not have a pronounced resistivity contrast and therefore does not have an anomalous electromagnetic response in the normal frequency ranges employed. However, the sulphide particles in a disseminated deposit generally are not uniformly distributed, but usually are preferentially oriented along veinlets and fractures and may be electrically continuous. As a result, they behave electrically as though more sulphides were present. In addition, the alteration and fracturing frequently associated with mineralization as a rule tends to lower the over-all resistivity of the deposit. It is seen, therefore, that electromagnetic methods can, in some cases, be applied.

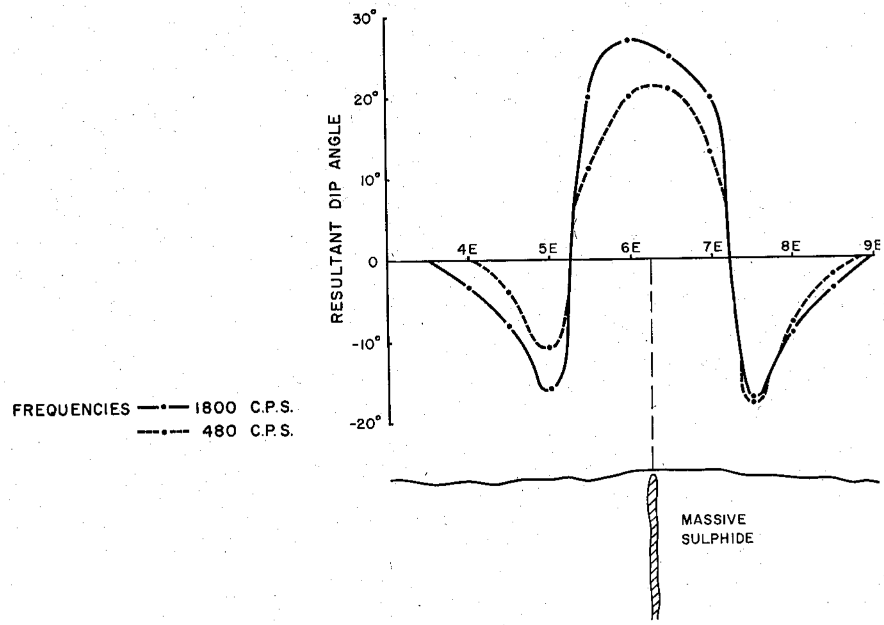


Figure 3.—Electromagnetic Response from a Narrow, Vertical Massive Sulphide Conductor — Shootback Method.
(coil spacing, 200 ft)

The majority of the standard EM systems were designed for the purpose of detecting steeply dipping massive sulphides. The coil configuration and frequencies employed were chosen to bias against the detection of flat-lying, poor conductivity sources, the conductive overburden of the Canadian Shield, but also the characteristics of the disseminated sulphide deposits being sought in British Columbia.

In *Figure 2* are the results of an electromagnetic survey on Line 22N and Line 24N across Noranda Mines' Newman deposit on the Newman peninsula of Babine lake. The EM survey was carried out employing the JEM "Shootback" method, which is an in-line, dip-a n g l e-measurement, transceiver method developed by the staff of Noranda Mines Limited. The large negative angles over the sulphide zone on Line 24N and Line 22N are typical of the response of a conductive source of greater width than the coil separation, which in this case is 200 feet. It was diamond drilling of electromagnetic anomalies of this type which led to the discovery of the Newman deposit.

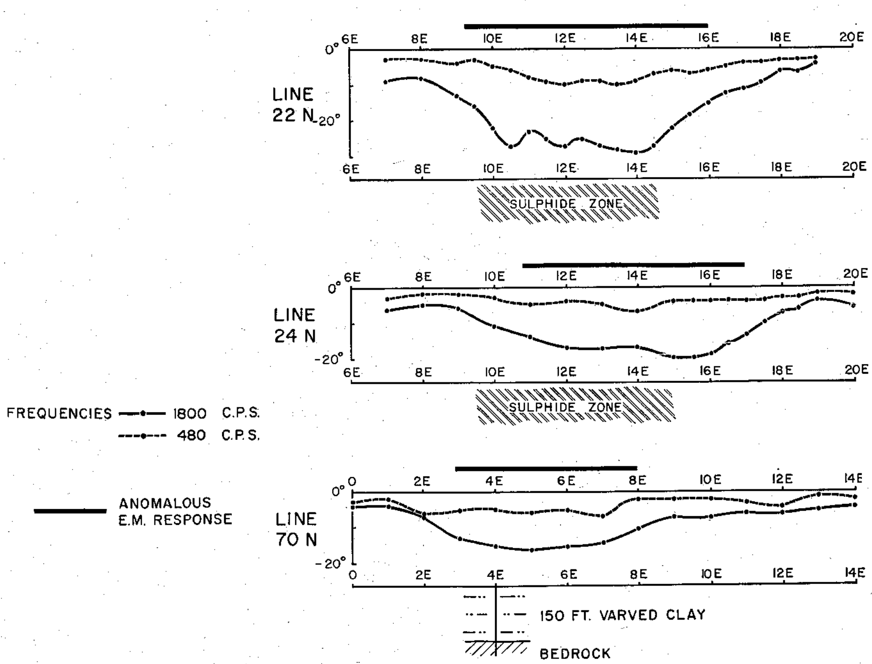


Figure 2.—Comparison of Electromagnetic Anomalies from Newman Peninsula, B.C. — J.E.M. Shootback Method.
(coil spacing, 200 ft)

The combination of fracturing, alteration and the fact that the mineralization at Newman is, in many cases, interconnected along fractures produced a sufficiently low resistivity to be detectable by the electromagnetic method. However, it can be seen from the ratio between the 480-cycle-per-second response and the 1,800-cycle-per-second response that the source is a poor conductor and in the Shield would likely be interpreted as conductive overburden and consequently disregarded.

In the lower part of the figure are the results of the EM survey on Line 70N. The anomaly is similar to that obtained on Line 24N over the sulphide zone. However, drilling indicated the source of the anomaly to be 150 feet of clay, the conductivity being about the same as that of the sulphides on Line 22N and Line 24N.

By way of comparison with the results over Newman, *Figure 3* illustrates typical results employing the Noranda "Shootback" EM method across a vertical massive sulphide zone. This is the type of situation the method was designed for and produces the most diagnostic anomaly. Increasing the frequencies employed in the electromagnetic systems in order to detect the poorer conductivity of disseminated sulphides results in greater susceptibility to clay beds, shear zones and other spurious electrolytic conductors. This is the basic problem encountered with the various methods employing VLF radio signals, the frequencies of which are 4 to 10 times those of of the standard EM methods. It should be noted that no discernible anomaly was indicated over the Newman deposit using a VLF system.

The use of electromagnetic methods, including VLF and AFMAG, has met with some success in mapping structures; however, the inherent problems mentioned above exist in their use to detect disseminated sulphides directly.

Resistivity Methods

In general, the same basic problems are encountered with the resistivity methods as with the electromagnetic method; namely, that the resistivity contrast in disseminated sulphide deposits is small, if in fact there is a contrast, and that resistivity variations of this same order can be expected from variations in rock types and other non-sulphide sources. Examples of this will be shown later.

Induced Polarization Method

The most diagnostic electrical property of disseminated sulphide deposits is the result of the mode of electrical conduction through them. When electronic conducting sulphide minerals are present within ionic conducting rock materials, the ground is polarizable and the induced polarization method can be applied. The lower limit of volume per cent sulphide necessary to produce a recognizable IP anomaly will vary with the geometry and geologic environment of the source, and the method of executing the survey. However, a rough figure of between 0.5 and 2.0 per cent metallic sulphide by volume, under most conditions, is a pretty good "rule of thumb" for this lower limit.

The successful application of the induced polarization method at Brenda Mines near Peachland, British Columbia, is a good example of the ability of the method to detect very low concentrations of metallic sulphide mineralization if the proper geological conditions exist. At Brenda, the total metallic sulphide content of the deposit is between 1 and 1.5 per cent by weight and less than 1 per cent by volume. However, this sulphide mineralization is largely restricted to chalcopyrite and molybdenite, with minor pyrite, and is therefore of economic interest. In *Figure 4* are illustrated the results of the IP survey on Line 0+00. The IP anomaly centered at 4W to 8W and extending from 4E to 18W, although weak, correlates very well with the mineralized zone. The resistivities are quite uniform, with a slight low correlating with the area of interest. The resistivity contrasts alone would not be diagnostic enough to outline the mineralized zone, especially when the normal resistivity variations throughout the survey area are considered.

In *Figure 5* is presented a plan of the area of the zone of mineralization at Brenda. The individual IP anomalies are indicated, as well as an outline of the over-all anomalous IP zone. It can be seen that this anomalous zone fits very closely to the outline of the economic mineralization. Sulphide mineralization does correlate with the northeast, northwest and southeast extensions of the IP zone, but it is not of current economic significance.

At Brenda, the granodiorite host rock has a uniform and low background IP response, permitting the detection of the weak anomalous response. Experience in the area, however, has shown that the over-all background IP response in the area of the volcanic rocks, and especially in the region of the contact between the volcanics and granodiorite, is so high that it would not be possible to detect the weak Brenda anomaly were it in this latter environment. The source of these anomalous effects is primarily pyrite and magnetite.

In normal field applications, the IP method does not differentiate between pyrite and the economically important metallic sulphides such as chalcopyrite and molybdenite. At Brenda, the lack of pyrite with the mineralization of economic interest results in IP anomalies of relatively small magnitude. However, there has been increased application of IP results in planning the drill program, as the strongest anomalies represent the greatest concentration of mineralization of economic interest.

Figure 6 presents the results of the induced polarization and resistivity survey on Line 22N across the Newman deposit. This is the same line for which the EM survey results were indicated in *Figure 2*. A very strong and distinct IP anomaly is indicated across the economic sulphide zone. The very low resistivities over this zone, down to an apparent resistivity of 2.6 ohm-feet/2π, indicate the alteration and fracturing, and resultant increased porosity, associated with the economic mineralization. This low resistivity also indicates why

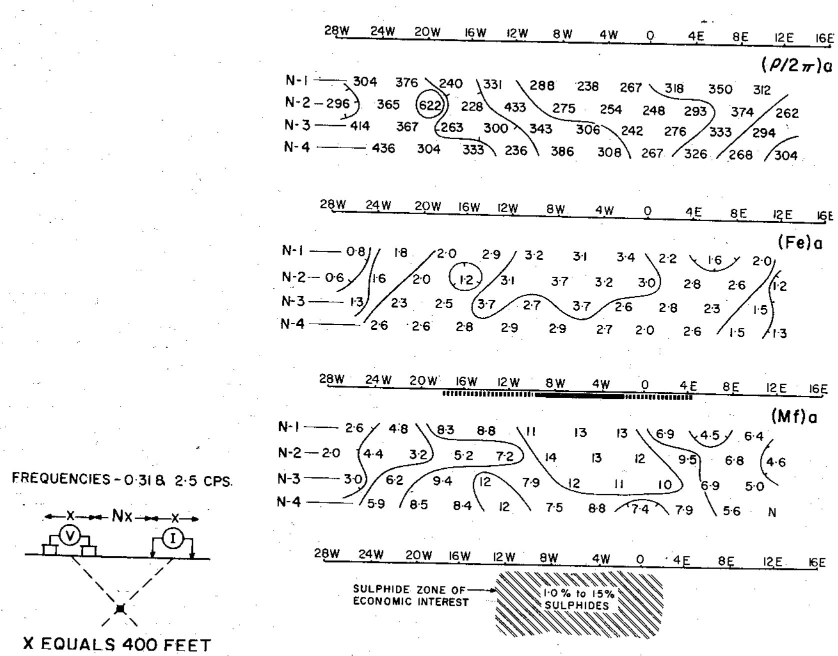


Figure 4.—Induced Polarization and Drilling Results from Brenda Mines, Peachland, B.C. — Line 0+00.

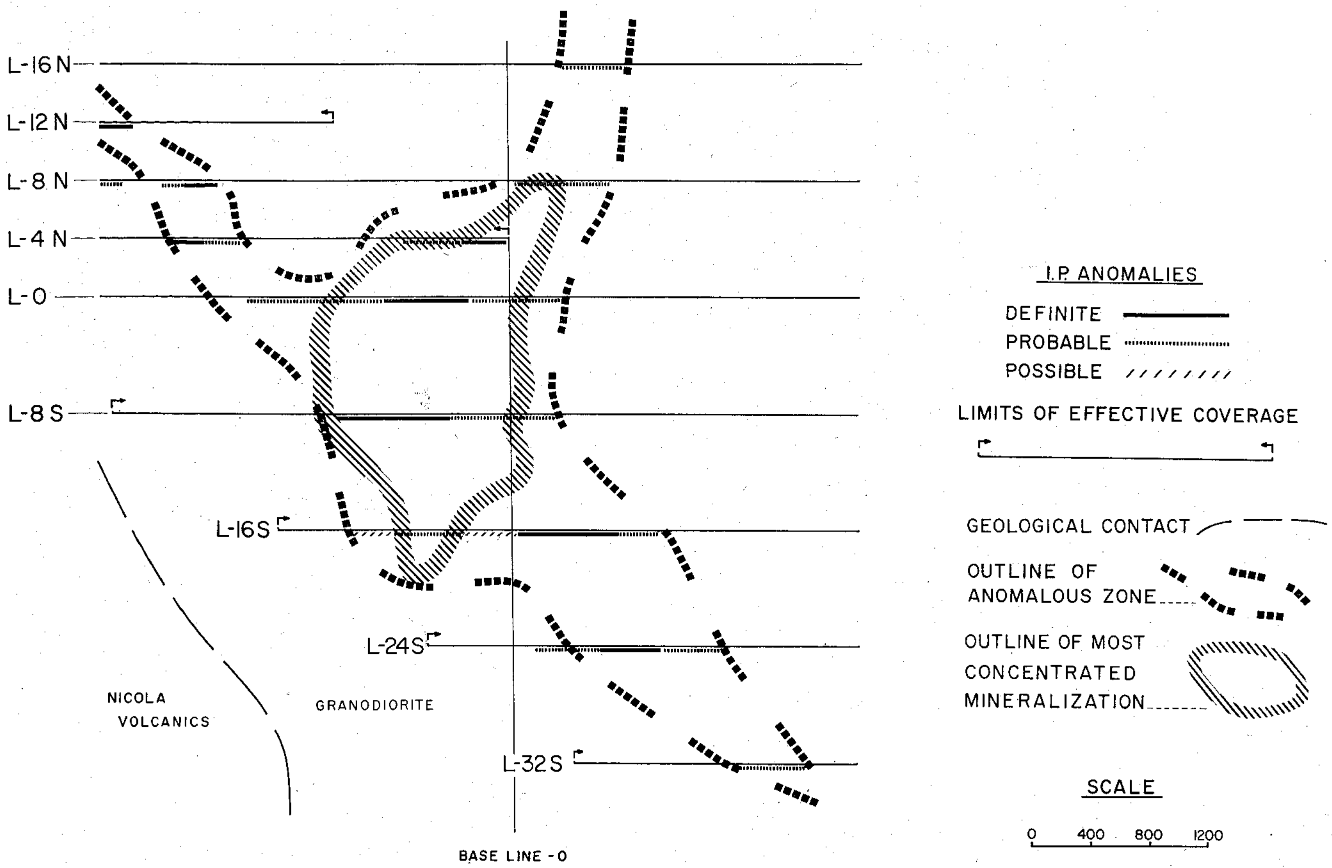


Figure 5.—Brenda Mines I.P. Survey — 1965-66.

the electromagnetic method was successful. West of the economic sulphide zone, the IP anomaly is still quite strong and drilling has indicated uneconomic sulphide mineralization, mainly pyrite.

The IP survey of the area of the Newman deposit has outlined large zones of sulphide mineralization which were not detected by the electromagnetic survey, either due to masking by overburden or insufficient resistivity contrast. These results have changed the picture from one of an isolated zone of economic sulphide mineralization to one of a large area of sulphide mineralization, mainly pyrite, in which occur isolated areas where sufficient copper mineralization is present with the pyrite to be of economic significance. We are faced with the second of our two problems; namely, the ability to separate economic metallic sulphide mineralization from uneconomic sulphide mineralization.

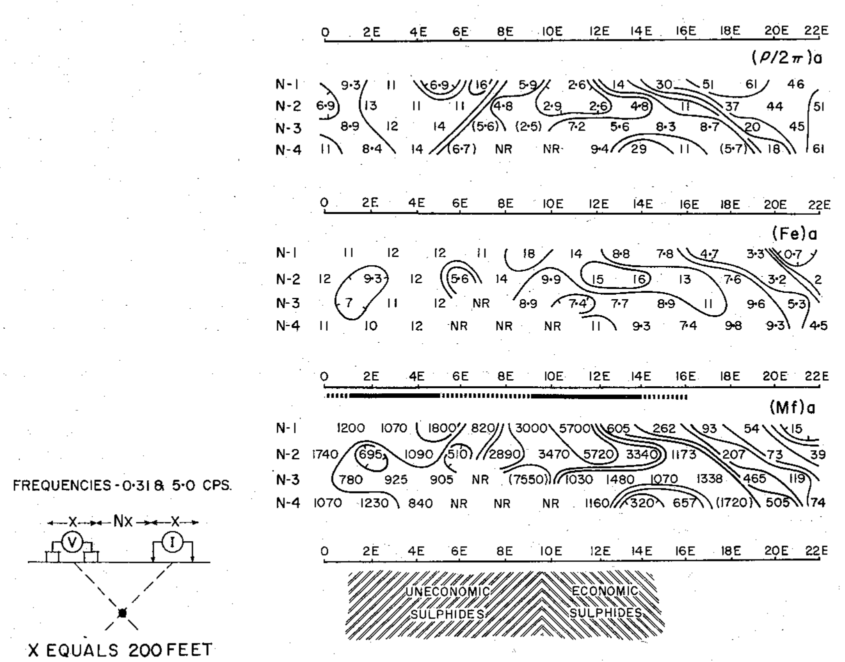


Figure 6.—Induced Polarization and Drilling Results from Newman Peninsula, B.C. — Line 22N.

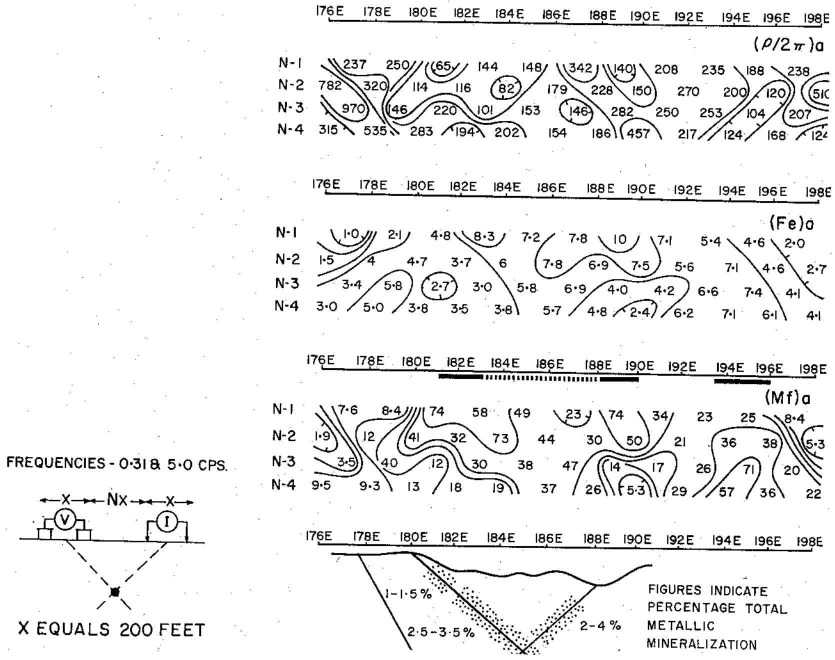


Figure 7.—Induced Polarization and Drilling Results from a Zone of Disseminated Mineralization in Northwestern B.C.

Figure 7 illustrates the IP survey results from an area in northwestern British Columbia. They form part of a large survey carried out in the area. The figures on the drill holes indicate percentage of total metallic mineralization. As the mineralization contains chalcopyrite and bornite, it is considered to be of economic significance. The IP survey in the area located stronger anomalies, but in general it was found that the largest and strongest anomalies were caused by disseminated pyrite. The copper mineralization is generally associated with the well-defined IP anomalies of weak to moderate intensity.

The IP survey results illustrated in *Figure 8* are from a property in the Babine Lake area of British Columbia. As a result of a regional geochemical stream sediment survey, followed up by prospecting and limited diamond drilling, copper mineralization of possible economic interest was discovered. An IP survey of the area was carried out and outlined a large area of over-all high IP response within which occurred zones of very strong IP anomalies and intermediate-strength IP anomalies. This was interpreted to represent a large area of sulphide mineralization within which occurred zones of increased concentration of mineralization.

Figure 8 is a section of Line 32N, which crosses the edge of this area of high background IP response. There is a distinct fall-off of IP response to the east of 6E on the line. The apparent resistivities are generally quite uniform along the line and it is not possible to detect any change in the apparent resistivity values that would correlate with the sharp drop-off in IP response.

Diamond drilling on this same property has indicated that the strongest IP anomalies are due to heavy pyrite mineralization and that the economically significant concentration of chalcopyrite mineralization is associated with the more moderate IP response, indicating a smaller total sulphide content. This is illustrated in *Figure 9*, which shows a portion of the IP survey results from Line 12N. The stronger anomaly to the east is due to heavy pyrite mineralization, and the economic mineralization is associated with the more moderate IP response to the west.

MAGNETIC METHODS

Except where magnetite or pyrrhotite is associated with the copper-molybdenum mineralization, and this is not common, magnetic surveying is usually not successful as a direct exploration approach for the type of situation we are dealing with. However, magnetics are of great value when closely coordinated with, and used in conjunction with, the geological knowledge of the situation. In general, there is usually some "redistribution" of magnetite at the time of mineralization. In some cases, magnetite appears to have been destroyed by the alteration accompanying mineralization, resulting in low magnetic anomalies; in other cases additional magnetite may be introduced, resulting in magnetic high anomalies. Unfortunately, the magnitude of these magnetic anomalies is usually about the same as would be expected from several other geologic conditions, and therefore the magnetic results are commonly only of use when other supporting evidence is available.

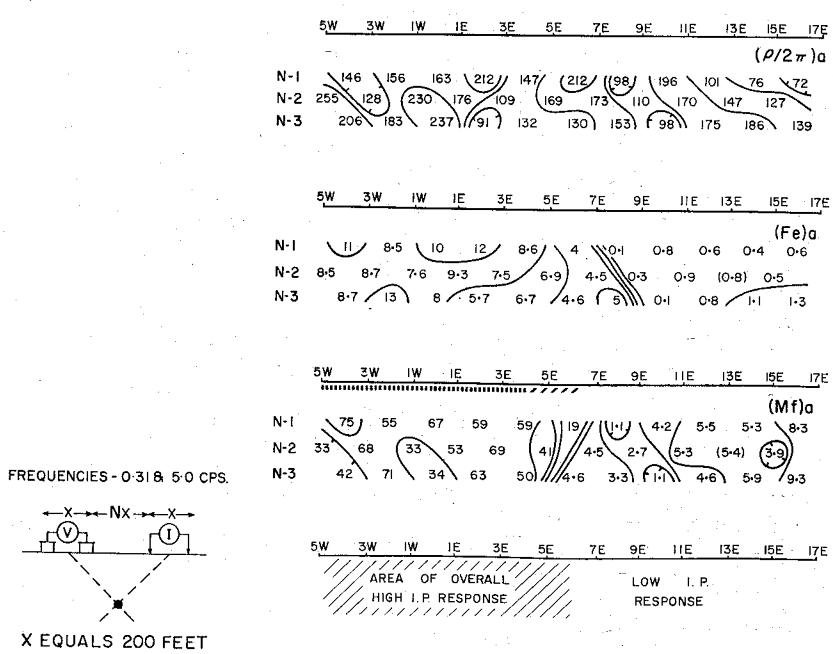


Figure 8.—Induced Polarization and Drilling Results from the Babine Lake Area, B.C. — Line 32N.

The most obvious exception to the above general statement is the case of the Craigmont mine, which does not really fit into the classification of the deposits being considered here. The discovery of this deposit was due to the drilling of a coincident magnetic and geochemical anomaly. Due to the direct association of magnetite with the chalcopyrite ore, the magnetic contours clearly reflect the position of the ore. However, even in this case it was found that a regional airborne magnetic survey indicated several similar magnetic anomalies which were due to geological variations and did not represent potential orebodies.

Figure 10 is a plan of the property in the Babine Lake area, discussed earlier in conjunction with *Figure 8* and *Figure 9*. The zone of over-all high background IP response is indicated, as well as the stronger anomalies lying within the zone. The zone of strong IP ano-

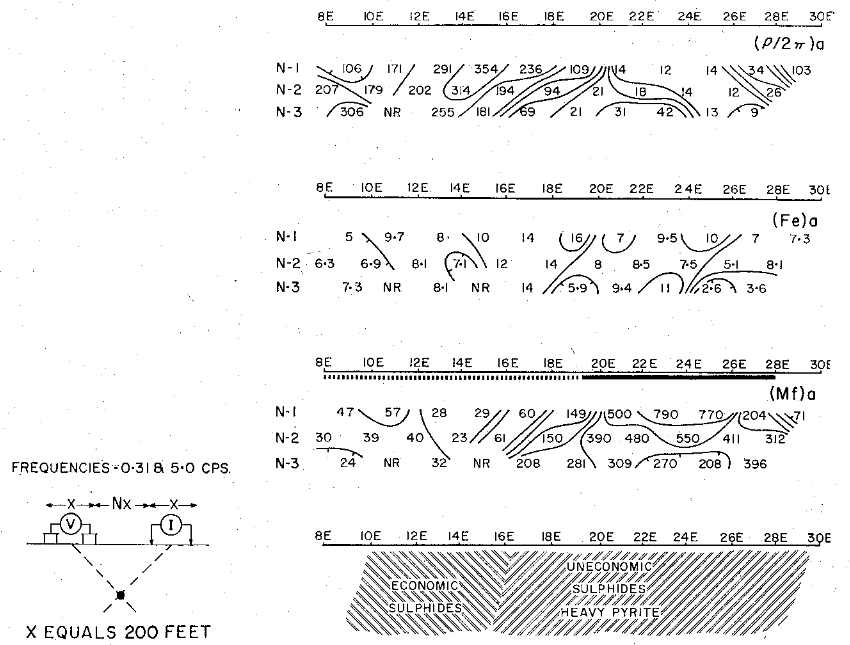


Figure 9.—Induced Polarization and Drilling Results from the Babine Lake Area, B.C. — Line 12N.

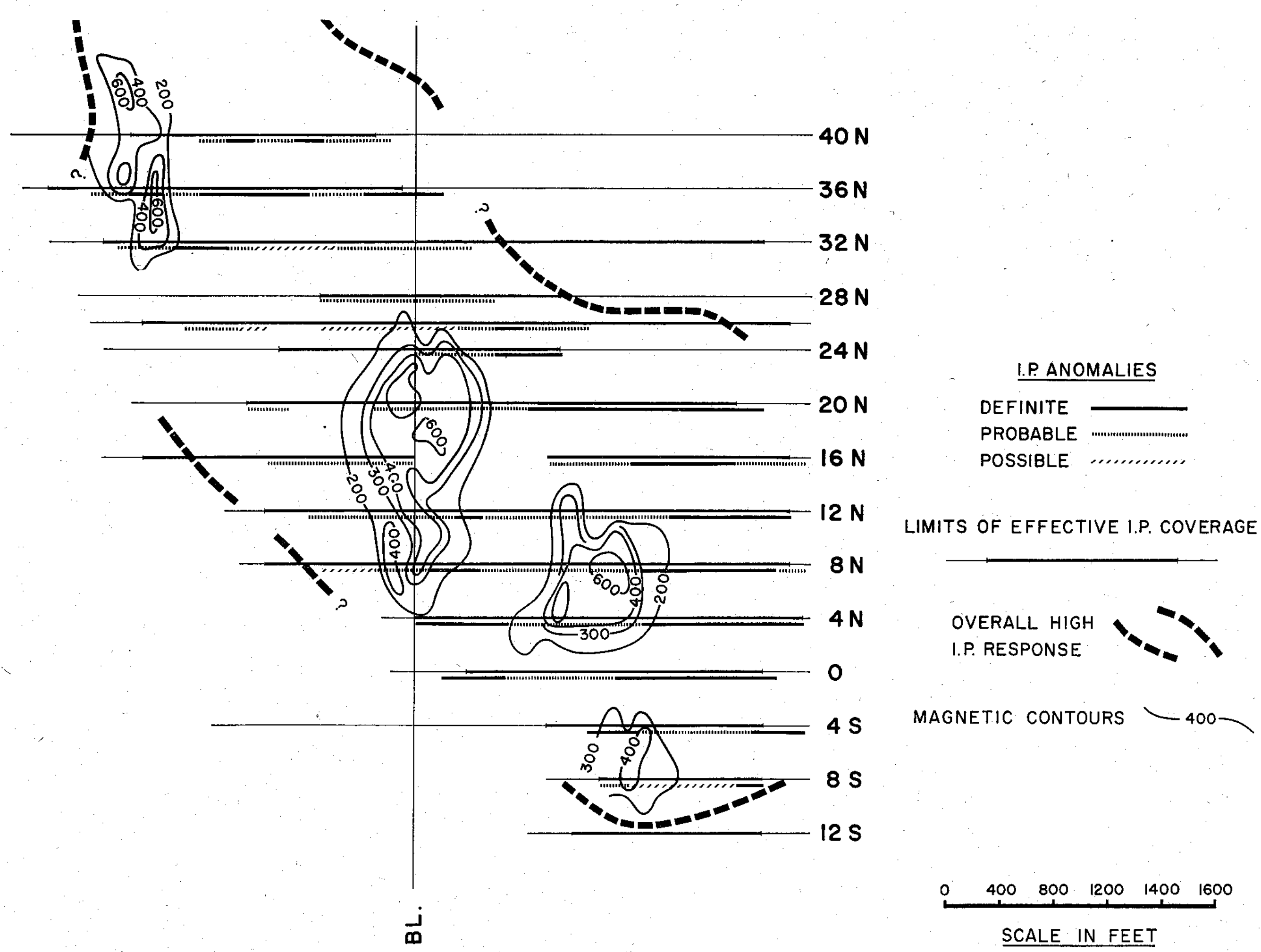


Figure 10.—I.P. and Magnetic Surveys, Babine Lake Area, B.C.

malies on the east side of the map-area is due to heavy pyrite mineralization. Superimposed upon the IP results are the contoured results of a ground magnetometer survey. It was inferred from early drilling results that the magnetic anomalies quite effectively outlined the areas of concentrated chalcopyrite mineralization within the large mineralized area, and this became the basis for planning the drill program.

Magnetic anomalies of this same magnitude are common within the area, and magnetics could not be considered as a sole exploration approach. However, when combined with other information, in this case IP and geochemical results, the magnetic survey results were very useful.

SUMMARY

The preceding comments and examples have indicated that no one geophysical method can solve the problem of detecting large volumes of rock containing a low percentage of total sulphide mineralization and also give some idea of the economic significance of this mineralization. The electrical methods, and more particularly the induced polarization method, have proved very successful in the direct detection of even very low percentages of sulphide mineralization. However, in normal field procedure they cannot differentiate between the uneconomic sulphides, such as pyrite, and the economic sulphides — chalcopyrite and molybdenite. The magnetic method has proved useful as an indirect application in several situations.

The successful search for disseminated copper and molybdenum deposits in British Columbia requires the application of both direct and indirect geophysical methods in close conjunction with geological and geochemical information.

ACKNOWLEDGMENTS

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McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY

PLAN MAP

SURFACE PROJECTION OF ANOMALOUS ZONES

DEFINITE
PROBABLE
POSSIBLE

Number at the end of anomaly indicates spread used.

CANADIAN SUPERIOR EXPLORATION LTD.

LOU GROUP, SMITHERS AREA, OMINECA M.D., B.C.

SCALE

ONE INCH EQUALS FOUR HUNDRED FEET

DEFINITE ANOMALOUS ZONE

LESS DEFINITE ANOMALOUS ZONE

DRAWN: D.N.H.
DATE: APRIL 1970
APPROVED:

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
PHILIP G. HALLOF
5/5/70
Expiry Date: February 25, 1971

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