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THE APPLICATION OF GEOPHYSICS TO DISSEMINATED SULPHIDE DEPOSITS IN BRITISH COLUMBIA

BY

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David K. Fountain graduated with a Bachelor of Applied Science degree in Engineering Physics (Geophysics Option) from the University of Toronto. He has had experience in all phases of geophysics, both ground and airborne, having carried out exploration work throughout Canada and the United States, as well as Mexico, South America, West Africa and Ireland. He has also been responsible for geophysical work carried out in Australia and the North Sea. He joined McPhar Geophysics Limited in March 1968 and is now Chief Geophysicist and Manager of the Airborne Division, as well as carrying out consulting work. He served as Chief Geophysicist of Noranda Mines Limited for four years prior to this; and prior to joining Noranda worked for the Pan American Petroleum Corporation, Spartan Airservices, and carried out geophysical contracting and consulting including work for the United Nations.

He is a member of the S.E.G., E.A.E.G., C.I.M.M., the Association of Professional Engineers of Ontario and British Columbia; and is a member and past-president of the Canadian Exploration Geophysical Society.

TABLE OF CONTENTS

ABSTRACT

The growth of the mining industry in British Columbia in recent years has been mainly due to the development of large low-grade disseminated sulphide deposits. The two problems faced by the geophysicist in the exploration for deposits of this nature are one. to detect large volumes of rock containing a low percentage content of total sulphide mineralization and two, to obtain some idea of the economic significance of the mineralization.

Although the standard geophysical methods used in the search for disseminated sulphide deposits have been successfully applied, there are some aspects of the British Columbia deposits which create additional problems for the geophysicist. As illustrated by the Brenda, Valley Copper and Lornex deposits, the lack of appreciable pyrite associated with the economic mineralization results in a low total sulphide content which in turn makes it difficult to obtain a diagnostic anomalous geophysical response even employing the Induced Polarization method. The rugged terrain and generally heavy forest growth results in high cost for the use of the more powerful geophysical methods such as Induced Polarization. However, as illustrated by results from the Babine Lake area, alteration and fracturing associated with the disseminated mineralization may lower the overall resistivity of the deposit sufficiently to allow detection using electromagnetic methods. Although limited in application, the lower cost of EM in many situations renders its use practical, especially if airborne methods can be employed.

The application of the various geophysical methods is illustrated by survey results from several properties in British Columbia.

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1. 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 disseminated sulphide deposits. A more appropriate term for these might be "open-pit bulk ore deposits" in which classification can be included the deposits of Bethlehem Copper Corporation Limited, Endako Mines Ltd., British Columbia Molybdenum Ltd., and Granisle Copper Limited, all of which are in production. Currently in various stages of development are the large-tonnage deposits of Brenda Mines Limited, Noranda's Newman Deposits, Stikine Copper Limited, Valley Copper Mines Limited, Highmont Mining Corporation Limited, Utah Construction and Mining Company, Lornex Mining Corporation Ltd., Newmont Mining Corporation and others.

The two problems faced by the geophysicist in the exploration for deposits of this nature are one, to detect large volumes of rock containing a low percentage content of total sulphide mineralization and two, to obtain some idea of the economic significance of this mineralization. The following brief case histories will illustrate how geophysics has been applied and some of the problems encountered in British Columbia.

II. THE BRENDA DEPOSIT

The history and development of the Brenda Deposit in the Okanagan Lake district near Peachland, British Columbia, typifies the recent successful exploration for, and development of, disseminated sulphide deposits in British Columbia. Scheduled to go into full production in the fall of 1969 at a planned capacity of 24,000 tons per day, Brenda has estimated

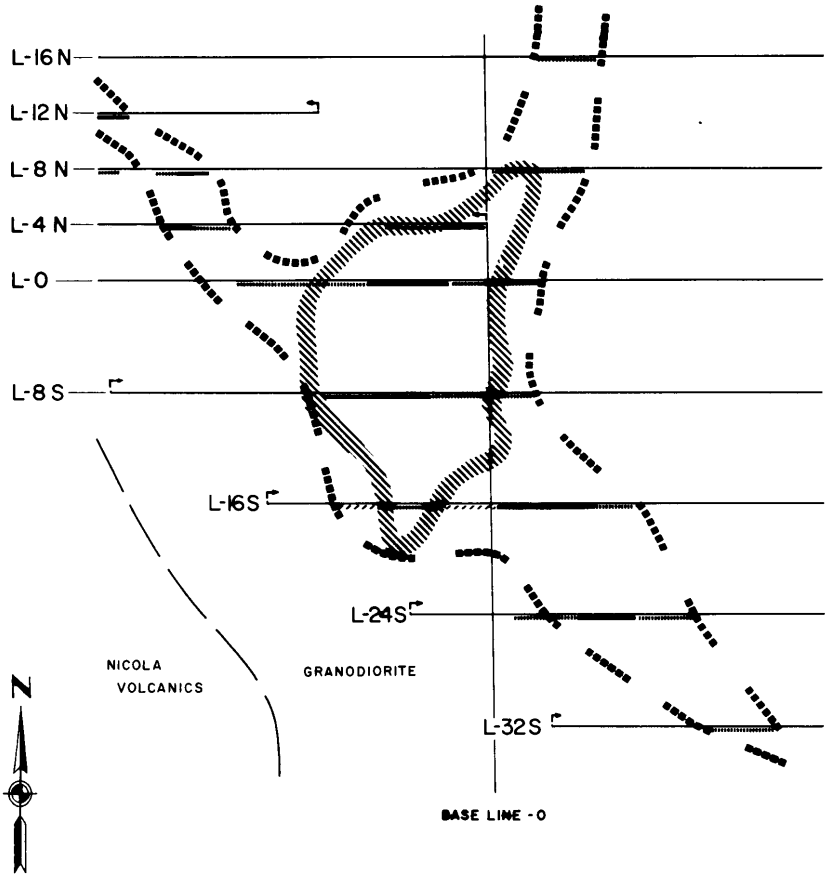
reserves of approximately 175 million tons, grading about 0.2% copper and about 0.05% molybdenum. This will make it one of the largest open pit mines in Canada, but also one of the lowest grade mines in the world. There is no question that the development of the Brenda deposit gave a great deal of impetus to the work that has led to the discovery and development of subsequent low grade sulphide deposits in B.C.

From a geophysical standpoint the significance of Brenda has been the successful application of the Induced Polarization method, and its ability 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 1-1/2% by weight and less than 1% by volume. However, this sulphide mineralization is largely restricted to chalcopyrite and molybdenite, with only minor pyrite, and is therefore of economic interest.

The presence of copper-molybdenum mineralization on the Brenda property has been known for many years, being described in Geological Survey of Canada Memoir No. 243, 1947, based upon investigations in the summer of 1944. A narrow quartz vein, well mineralized with chalcopyrite and molybdenite and occurring near the centre of the present Brenda pit, was worked for several years in the 1940's. Extensive work was carried out in 1955, 1956 and 1957 by Noranda and Kennecott which indicated widespread, low grade mineralization. Included in the 1957 programme of work was a limited IP survey which was one of the first surveys employing the variable-frequency method to be carried out in Canada. Based upon a study of the results of the 1957 IP survey which indicated a weak anomalous response from the areas of mineralization, a substantial IP programme was carried out in 1965 and 1966 as part of the re-evaluation of the Brenda Deposit.

In Figure 1 is presented a plan of the area of mineralization at Brenda. The individual IP anomalies are indicated, as well as an outline of the over-all anomalous IP zone. Superimposed on this is the approximate outline of the mineralization. It is important to note that this outline is based upon an economic cut-off and does not represent a sharp discontinuity in the presence of sulphides. It can be seen from the figure that the anomalous IP survey 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 interest.

In Figure 2 are illustrated the results of the IP survey on Line 0+00. The IP anomaly centred at 4W to 8W and extending from 4E to 18W, although weak, correlates very well with the mineralized zone. The apparent resistivities are quite uniform with a slight low correlating with the area of interest. This is indicative of the freshness of the granodiorite and lack of alteration. The anomalous Apparent Frequency Effects and Apparent Metal Factors are



BRENDA MINES I.P SURVEY

— 1965 - 1966 —

I.P ANOMALIES

DEFINITE

PROBABLE

POSSIBLE

LIMITS OF EFFECTIVE COVERAGE

GEOLOGICAL CONTACT

OUTLINE OF ANOMALOUS ZONE

OUTLINE OF MOST CONCENTRATED MINERALIZATION

SCALE

0 400 800 1200

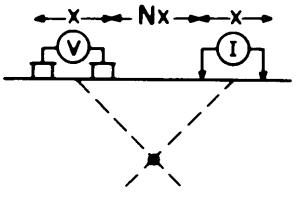
1 IN. = 400 FT.

FIG. 1

INDUCED POLARIZATION AND DRILLING RESULTS FROM BRENDA MINES PEACHLAND, B.C.

LINE - 0+00

FREQUENCIES - 0·31 & 2·5 CPS.



X EQUALS 400 FEET

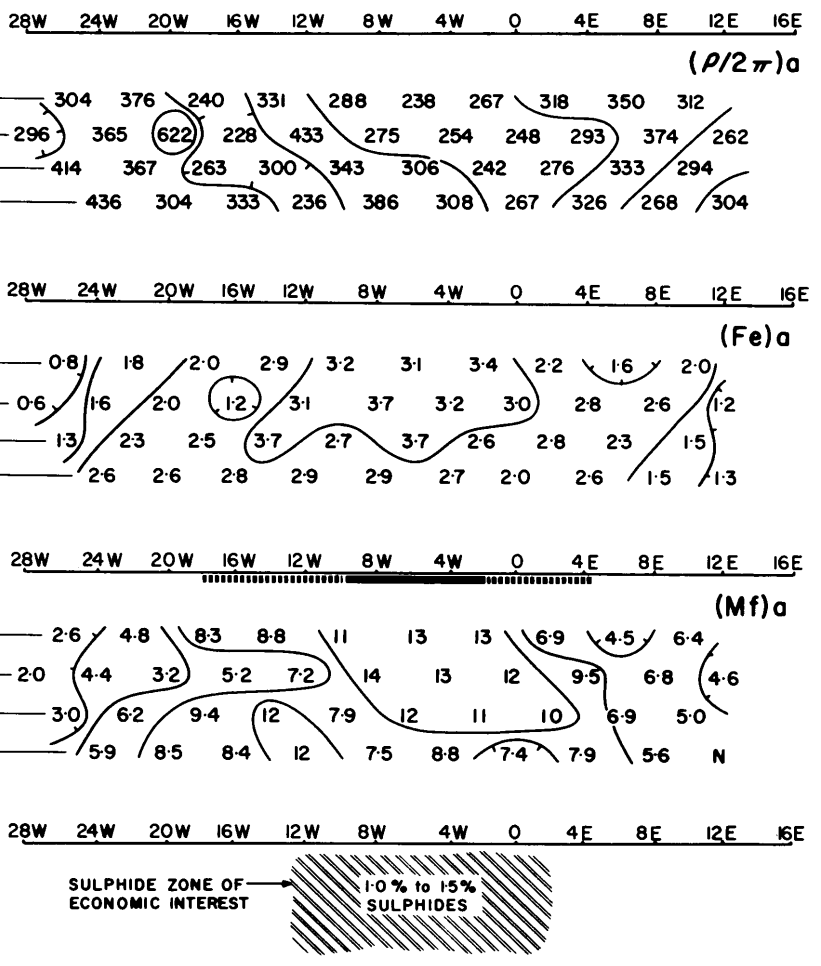


FIG. 2

low in magnitude with values of about three for the former and about ten for the latter being significant.

The results of the IP survey on Line 8S across the mineralized zone are presented in Figure 3. Again the IP anomaly correlates very well with the zone of concentrated sulphides. The edge of the anomaly is quite sharp on the west side, but less distinct to the east suggesting a more gradual decrease in sulphide mineralization in this direction.

The frequencies employed for the survey data presented in Figure 2 for Line 0+00 were 0.31 Hz and 2.5 Hz while for most of the data in Figure 3, for Line 8S they were 0.31 Hz and 5.0 Hz. This would account for the generally higher values of Apparent Frequency Effect and Apparent Metal Factor obtained on Line 8S. It is also interesting to note that the data on Line 8S to the west of station 0, i.e., the diagonal line of Apparent Frequency Effects 3.5, 3.0, 3.2, 3.0, and to the west, was obtained employing frequencies of 0.31 Hz and 5.0 Hz; while the data to the east, i.e., the diagonal line of Apparent Frequency Effects 3.0, 3.0, 3.0, 5.0 and to the east, was obtained employing frequencies of 0.31 Hz and 2.5 Hz. This change of frequency interval would partially account for the lack of uniformity of anomalous values across the mineralized zone.

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 immediate area, however, has shown that the overall background IP response in the area of the Nicola Volcanic rocks to the west, 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 the latter environment. The source of these anomalous effects is primarily pyrite and magnetite.

In the Brenda deposit itself, the lack of pyrite with the economic mineralization results in an anomalous IP response of relatively low magnitude. However, this has also resulted in increased application of IP results in planning the drill programme since the strongest anomalous response represents the greatest concentration of economic mineralization. Contouring of the IP data in plan form was an effective form of presentation in this situation.

Geochemical programmes, both silt and soil sampling, were also carried out on the Brenda property. Figure 4 shows the outlines of the concentrated mineralization, the IP anomaly and the soil geochemical anomaly. As seen in the figure there is good correlation between the IP and geochemical results

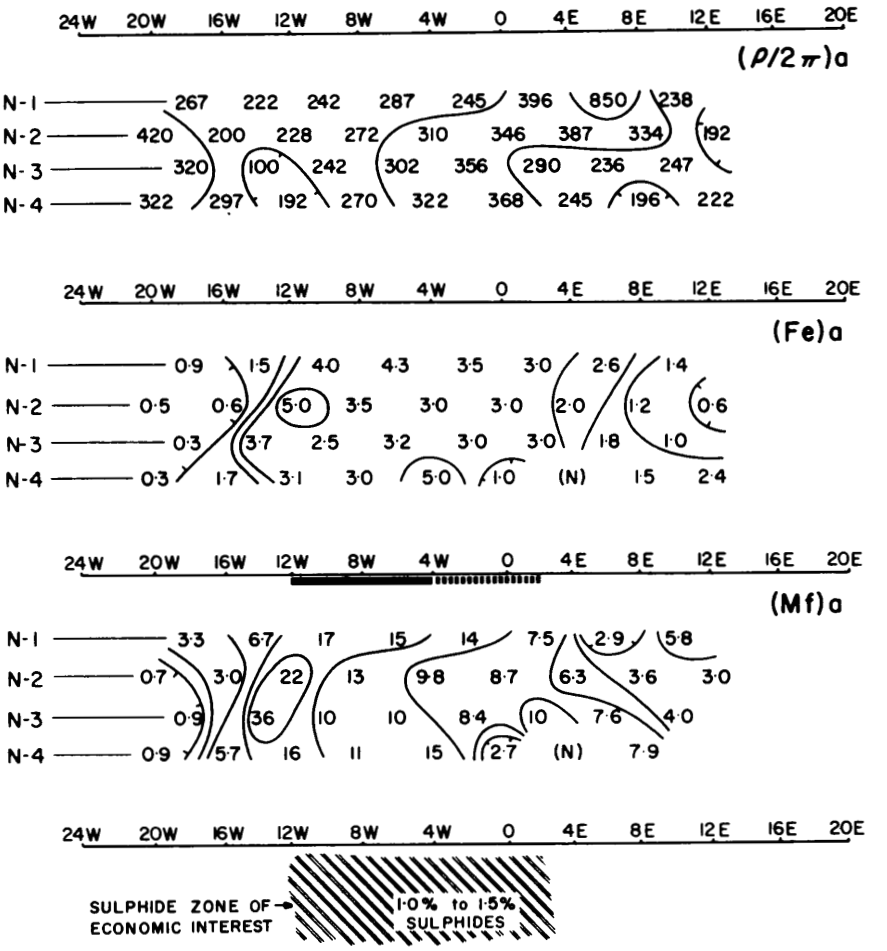
INDUCED POLARIZATION

AND

DRILLING RESULTS

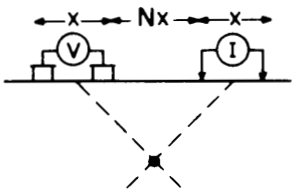
FROM

BRENDA MINES
PEACHLAND, B.C.



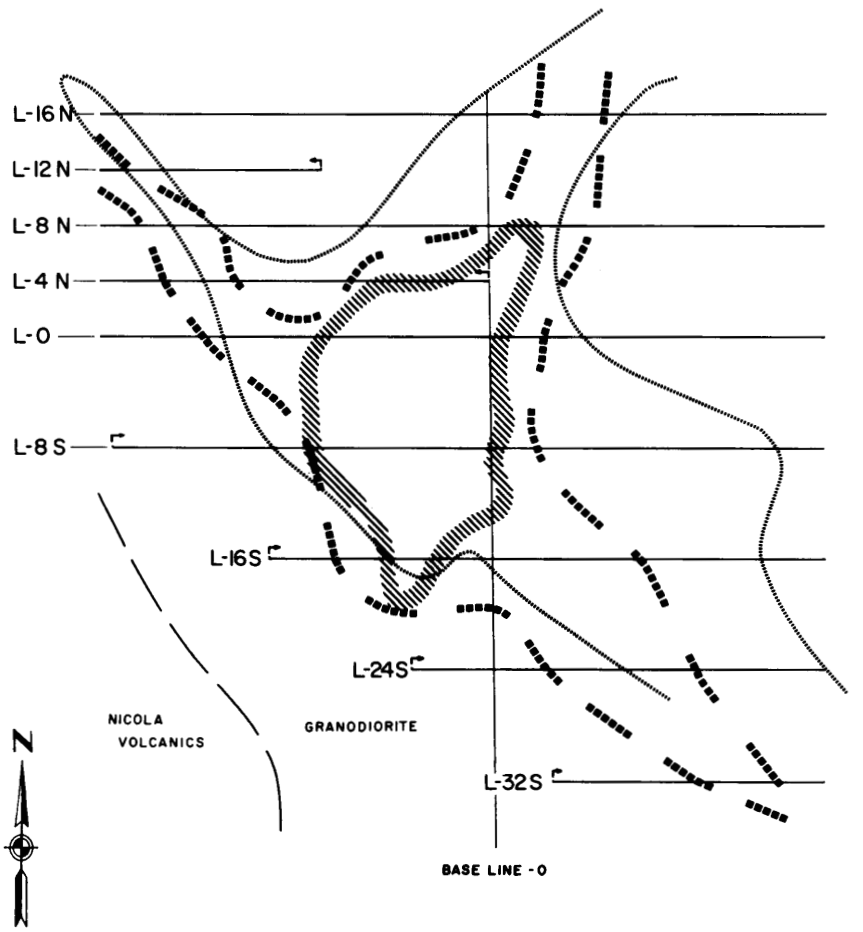
LINE - 8 S

FREQUENCIES - 0·31 & 5·0 CPS



X EQUALS 400 FEET

FIG. 3



BRENDA MINES

I.P. – GEOCHEMICAL COMPARISON

OUTLINE OF I.P. ANOMALOUS ZONE

OUTLINE OF CONCENTRATED MINERALIZATION

OUTLINE OF GEOCHEMICAL SOIL ANOMALY

GEOLOGICAL CONTACT

LIMITS OF EFFECTIVE COVERAGE

SCALE

0 400 800 1200

1 IN. = 400 FT.

FIG. 4

III. THE HIGHLAND VALLEY AREA

One of the most significant steps in the recent trend to exploration for large low-grade mineral deposits in British Columbia has been the successful and profitable operation at Bethlehem Copper Corporation Limited in the Highland Valley, which, since 1963, has become the province's largest single producer of copper.

However, now Bethlehem is to be joined by two other large developments both in the Highland Valley, Valley Copper lying about 2 miles to the southwest and Lornex Mining Corporation about 4 miles to the south. The relative positions of these deposits are indicated on the aeromagnetic survey map of the area in Figure 5. The aeromagnetic data forms part of the Federal-Provincial survey and was flown by Lockwood Survey Corporation. The flight line interval is 1/2 mile with a survey altitude of 1000 feet. The Bethsaida Granite or Granodiorite within the Guichon Batholith is outlined by a well defined magnetic low, the limits of which are shaded in red in the figure. The deposits of Valley Copper, Lornex and Highmont Mining all lie on the northeast flank of this magnetic feature. Some geologists have postulated an approximate north-south structure as indicated in the figure which would tie in the former deposits with Bethlehem and the Krain and Trojan deposits to the north. I do not wish to become involved in a geologic discussion here, however, the magnetic data does illustrate the usefulness of systematically flown regional airborne geophysical surveys as an aid to understanding and mapping the geology.

The Highland Valley disseminated sulphide deposits are characterized by their overall low metallic sulphide content. As in the case of Brenda, there are only minor amounts of pyrite associated with the deposits resulting in a total sulphide content of 1% to 3% as opposed to the 5% to 10% normally encountered in the typical disseminated deposits of the Southwest United States. This has caused some companies whose geophysical interpretation is based upon criteria established in the Southwest to disregard weak IP responses in the Highland Valley area which subsequently proved to be of economic significance. In fact, there is some concern amongst geophysicists as to our ability to obtain a diagnostic geophysical anomalous response, even employing IP, from the extremely low sulphide concentrations that are now being considered of economic significance.

In Figure 6 are illustrated the results of an IP survey on Section 15N, looking north, across the centre of the Lornex orebody. The total sulphide content, primarily chalcopyrite and bornite with minor pyrite and molybdenite, is 1-1/2% to 2%. The announced reserves of mineable ore are calculated at 300 million tons averaging 0.427% copper and 0.04% molybdenum. The IP survey data illustrated are from a survey carried out by the geophysical staff of Rio Tinto Canadian Exploration employing a Seigel Mark IV time domain IP unit and the three electrode array; utilizing a = 200 feet, a = 400 feet,

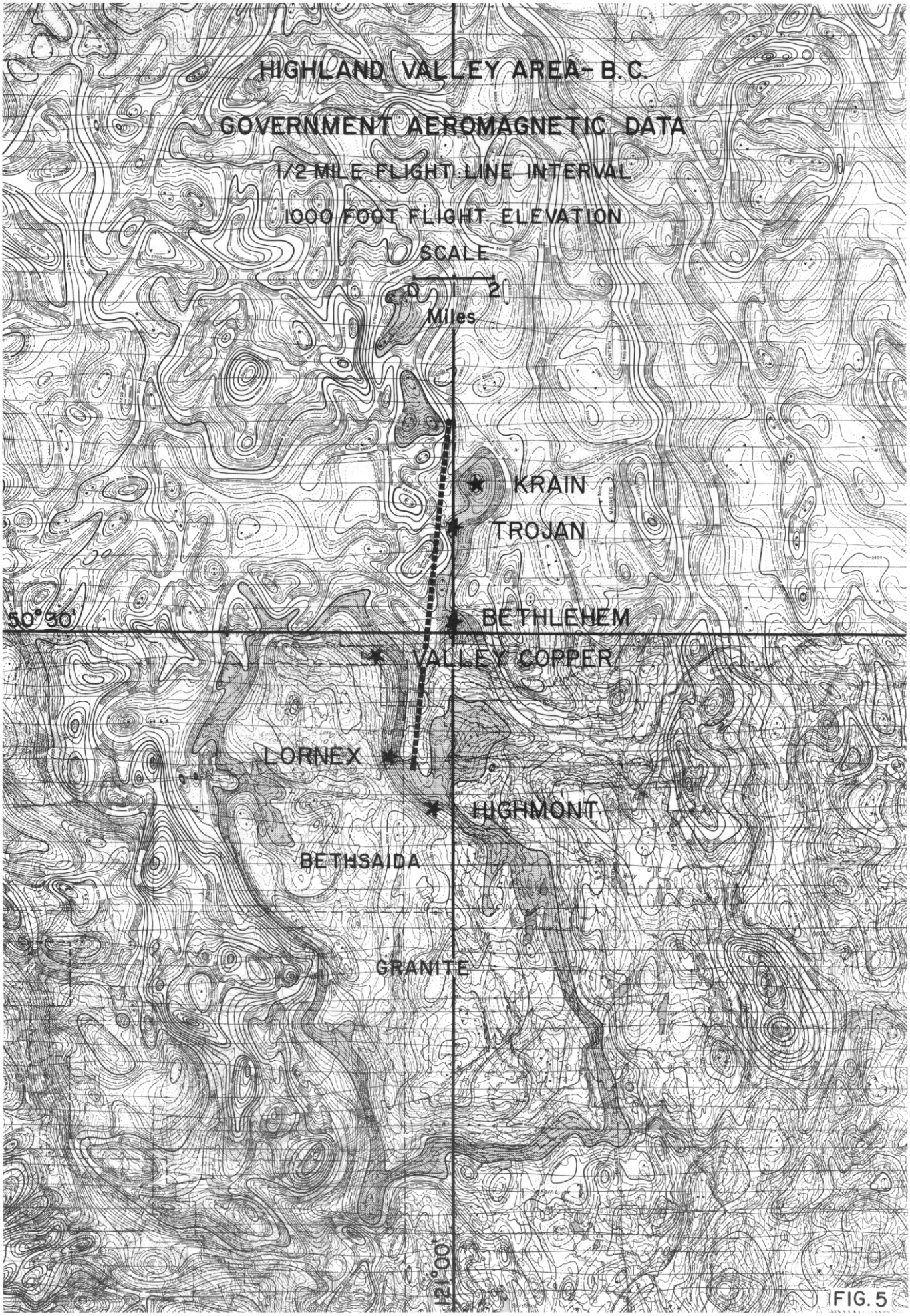

HIGHLAND VALLEY AREA - B.C.
GOVERNMENT AEROMAGNETIC DATA
1/2 MILE FLIGHT LINE INTERVAL
1000 FOOT FLIGHT ELEVATION
SCALE
0
2
Miles
KRAIN
TROJAN
BETHLEHEM
VALLEY COPPER
LORNEX
HIGHMONT
BETHSAIDA
GRANITE
50° 30'
120° 15'

FIG. 5

and a = 800 feet. The survey data is indicated in profile form in the figure with the Apparent Chargeability in milliseconds at the top, the Apparent Resistivity in ohm metres in the middle and the geologic section indicating the mineralized zone at the bottom. The Apparent Resistivity values are quite uniform for all three values of "a". However, there is a general decrease in values with the increasing thickness of overburden to the west. For a = 200 feet a distinct low magnitude chargeability anomaly is indicated centred at about 10, 100E and falling off gradually to the west as the thickness of overburden increases beyond 75 feet. For a = 400 feet a distinct chargeability anomaly is indicated as starting at about 10, 200E and extending to 8, 500E. The magnitude of the anomaly decreases to the west as the thickness of overburden increases beyond 150 feet. However, there is still above-background response where the depth to bedrock is about 250 feet. Employing a = 800 feet the eastern edge of the anomaly is not as distinct, however, the western portion is not as affected by the increasing thickness of overburden and the response actually increases to a peak at about 9, 000E. It can be seen from the geologic section that there is a differentiation between the less than 0. 5% copper and the greater than 0. 5% copper with the latter lying along the west side of the ore zone. The increase in sulphide mineralization in the west portion of the zone somewhat counter balances the effect of increased overburden, thereby helping to increase the larger spacing Apparent Chargeability responses in this region.

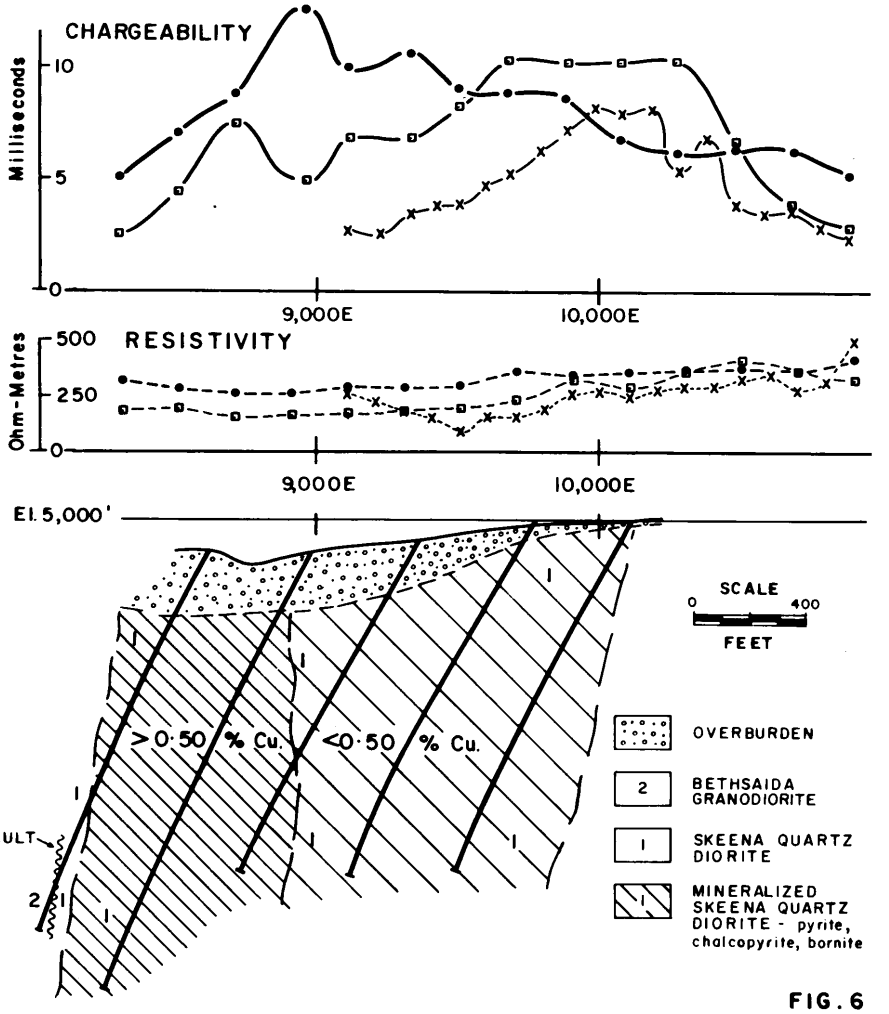
Although an example is not available, it is understood that the anomalous IP response over the deposit of Valley Copper Mines Limited has values of Apparent Frequency Effect, Apparent Resistivity, and Apparent Metal Factor almost the same as those shown earlier for the Brenda deposit. Recent figures for Valley Copper indicate a potential of 600, 000 tons per vertical foot of average grade 0. 4% copper or better for a total tonnage of about 900 million tons. In both the case of Lornex and Valley Copper, the mineralization is more deeply buried than at Brenda, so that although a higher percentage total sulphide content is present the measured apparent IP response is of the same order of magnitude.

IV. THE PRINCETON AREA

Straddling the Hope-Princeton Highway approximately 10 miles from the city of Princeton, Newmont Mining Corporation of Canada is developing disseminated sulphide deposits based upon redevelopment of the old Copper Mountain workings and the new Ingerbelle discovery. In Figure 7 are presented the results of a representative line of IP data across the Ingerbelle Property which is typical of the response obtained. The survey work was carried out by Seigel Associates Limited employing a Seigel Mark IV time domain IP unit. The chargeability values should be doubled to compare with results from the newer Newmont type receiver. The equispaced three electrode array was employed with a = 200 feet and a = 400 feet. The data is presented in profile form with Apparent Chargeability in milliseconds at

INDUCED POLARIZATION and GEOLOGIC DATA from LORNEX MINING CORP. B.C.

SECTION 15N LOOKING NORTH



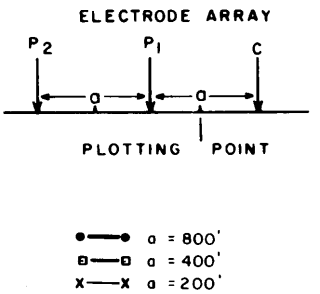
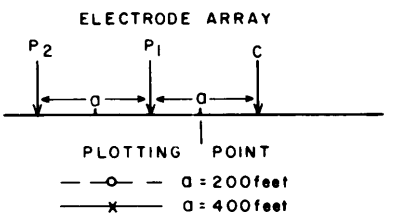
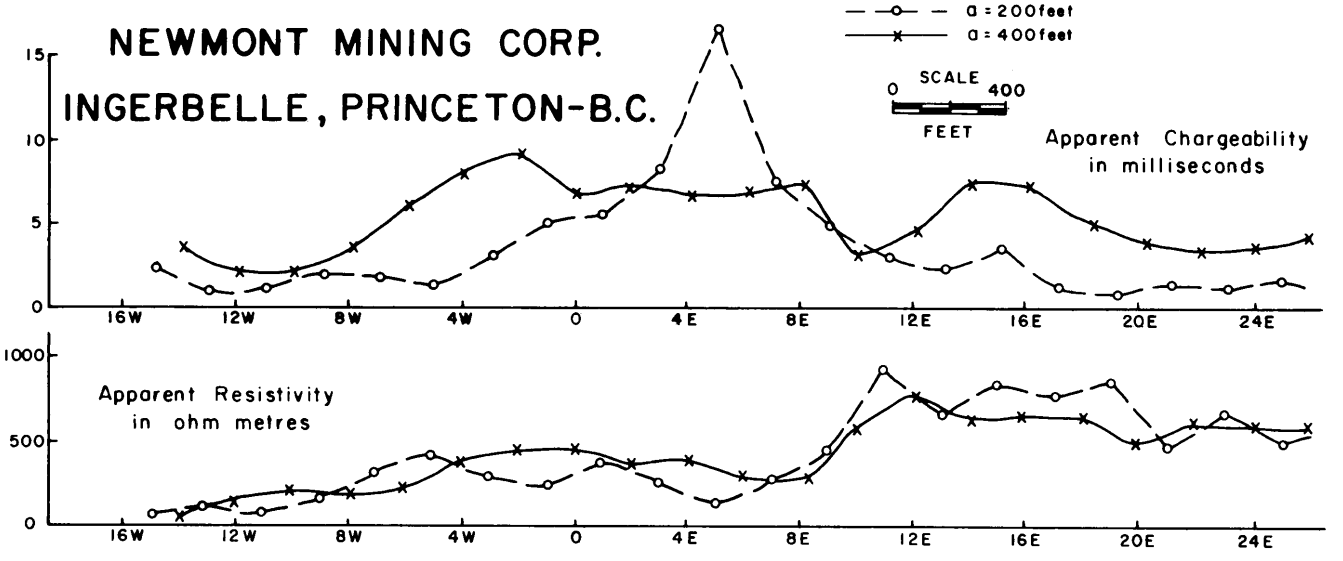


FIG. 6

INDUCED POLARIZATION and GEOLOGIC DATA

NEWMONT MINING CORP. INGERBELLE, PRINCETON-B.C.





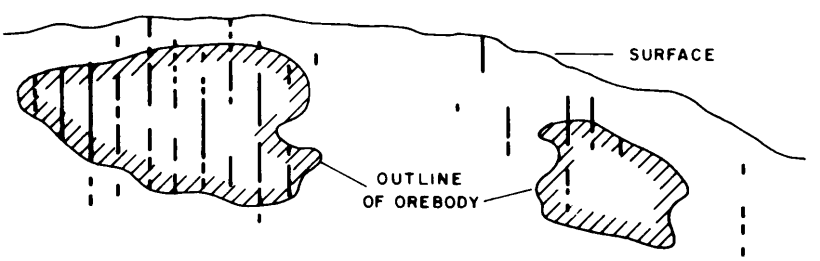


FIG. 7

the top, the Apparent Resistivity in ohm-metres in the middle and a geologic section at the bottom. The two orebodies are outlined and the lines indicate diamond drill hole intersections of greater than 0.3% copper. The country rock is dominately intermediate volcanics with minor pyroclastics. Only the copper zones have been indicated, however, these economic zones occur within a large area of 3% and up disseminated pyrite mineralization. There is no significant increase in total sulphide content in the copper zones and in fact it is more common to have much less total sulphides by volume within these zones. However, a close geographic association does exist between the pyrite and chalcopyrite. Therefore the IP survey area, although not outlining specifically the economic mineralization, has indicated the general areas of interest.

In the data presented in Figure 7 the Apparent Resistivity values for both a = 200 feet and a = 400 feet are quite uniform being somewhat higher on the eastern end of the line and falling off gradually to the west. For a = 200 feet above background Apparent Chargeability response occurs from 2W to about 10E. The sharp strong anomalous response centred at about 5E is due to a narrow shallow zone of up to 5% pyrite. The a = 400 feet Apparent Chargeability data is more representative indicating above background response from 8W to about 18E. There is no significant increase in IP response over the two copper zones, with a chargeability low associated with the eastern zone.

V. THE SMITHERS - BABINE LAKE AREA

Since the early 1960's there has been continuing exploration activity in the Smither's area for disseminated sulphide deposits. A large percentage of this activity has been centred in the Babine Lake area to the north and east of the town of Smithers. In November 1966 production started at Granisle Copper Limited on McDonald Island in Babine Lake; grade of the deposit being 0.53% copper.

To the north of Granisle and located on the Newman Peninsula, the Newman Deposit of Noranda Mines Limited is quite unique from a geophysical standpoint. Although it is classified as a disseminated sulphide deposit, grade of copper being of the order of 0.5%, it was diamond drilling based upon combined Self Potential and Electromagnetic anomalies which led to its discovery. In Figure 8 are the results of the Electromagnetic Survey on Line 22N and Line 24N across the Newman deposit. The survey was carried out employing the JEM or Crone "Shootback" method, which is an in-line, dip-angle-measurement, transceiver method developed by Noranda Mines Limited and Crone Geophysics. 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. 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.

From the ratios between the 480 Hz response and the 1800 Hz response it can be seen that the source has a poor conductivity, of a nature which is normally associated with conductive overburden. In the lower part of Figure 8 are the results of the electromagnetic survey on Line 70N. The anomaly is similar to that obtained on Line 24N over the sulphide zone. However, drilling indicated the source of this anomaly to be 150 feet of clay, the conductivity being about the same as that of the sulphides on Line 22N and Line 24N.

For those who are not familar with the "Shootback" method, Figure 9 illustrates typical results across a vertical, narrow, massive sulphide conductor. This is the ideal type of EM anomaly source and produces the most diagnostic anomaly pattern.

Subsequent to the discovery, the IP method has been employed in the area of the Newman Deposit. The IP survey work has outlined large zones of sulphide mineralization which were not detected by the electromagnetic method, either due to masking by depth of overburden or insufficient resistivity contrast. These results have changed the overall geologic 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. However, the IP work has not as yet led to the discovery of more ore.

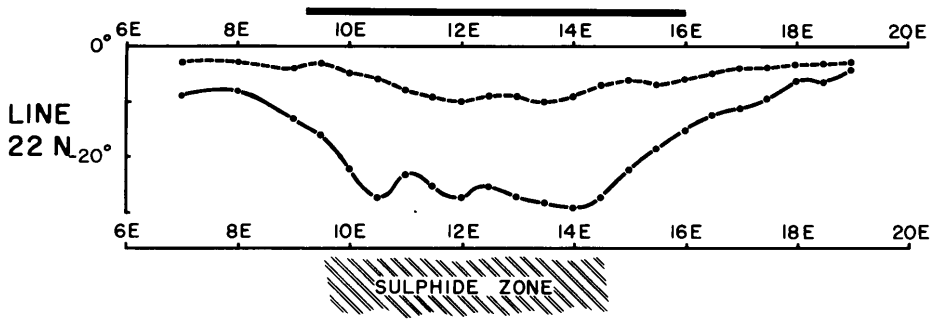
The initial IP work was carried out in 1964 by Canadian Aero Mineral Surveys employing time-domain IP equipment. The results of the survey on Line 20N and Line 24N are indicated in Figure 10. The survey was carried out using the three electrode array with a value of a = 200 feet. On both lines there is a distinctly anomalous IP response over the economic sulphide zone and the uneconomic sulphides, mainly pyrite, to the west. Apparent Chargeability values of 30 to 50 milliseconds are indicated over the mineralized zone. The sharp fall-off in values of Apparent Resistivity are indicative of the alteration and fracturing associated with the economic mineralization.

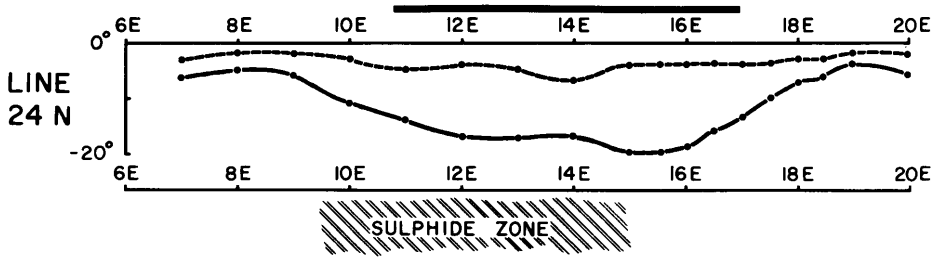
In 1966 further IP surveying was carried out employing the variable-frequency IP method. The results of a survey on Line 22N employing 200 foot dipoles and frequencies of 0.31 Hz and 5.0 Hz are indicated in Figure 11. A very strong and distinct IP anomaly is indicated across the economic sulphide zone. Again the very low values of Apparent Resistivity down to 2.6 ohm feet/2π , indicate the alteration and fracturing, and resultant increased porosity, associated with the economic mineralization. To the west, the IP anomaly is still quite strong over the zone of uneconomic mineralization.

COMPARISON OF

ELECTROMAGNETIC ANOMALIES FROM NEWMAN PENINSULA B.C.

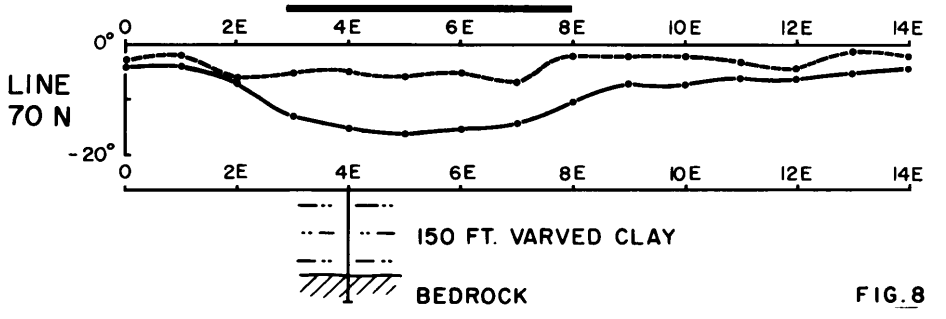
J.E.M.
SHOOTBACK METHOD





FREQUENCIES —•— 1800 C.P.S.
---•--- 480 C.P.S.

ANOMALOUS E.M. RESPONSE

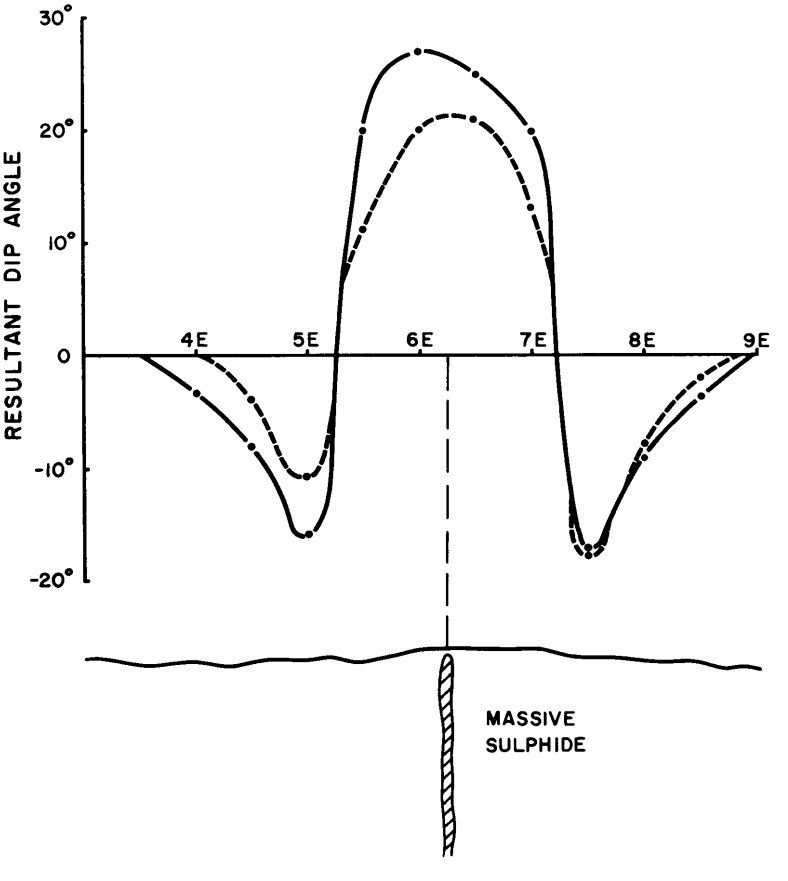


COIL SPACING 200 FEET

FIG. 8

ELECTROMAGNETIC RESPONSE FROM NARROW VERTICAL MASSIVE SULPHIDE CONDUCTOR

SHOOTBACK METHOD



FREQUENCIES —•— 1800 C.P.S.
—•— 480 C.P.S.

COIL SPACING 200 FEET

FIG. 9

INDUCED POLARIZATION and GEOLOGIC DATA

NEWMAN PENINSULA, B.C.

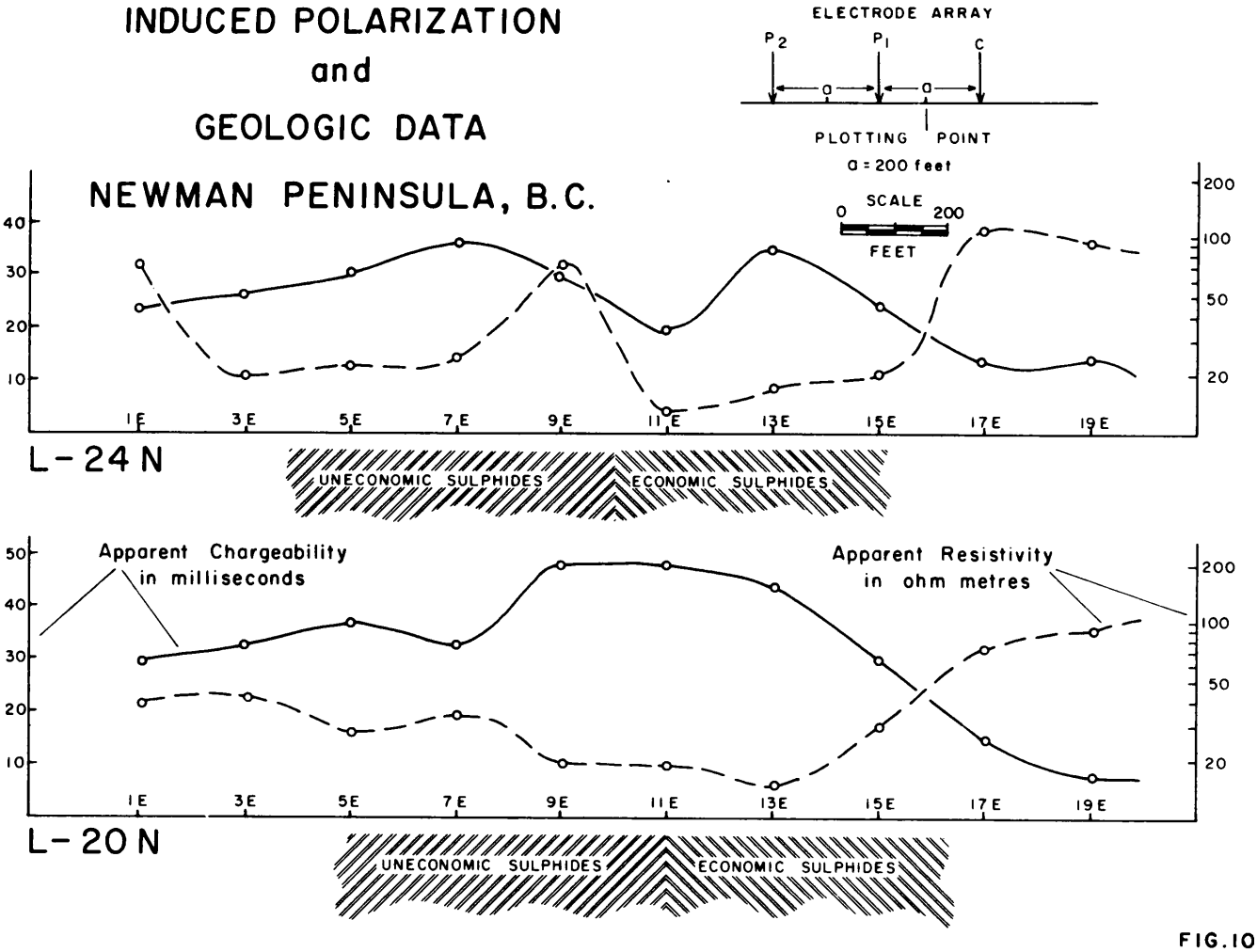
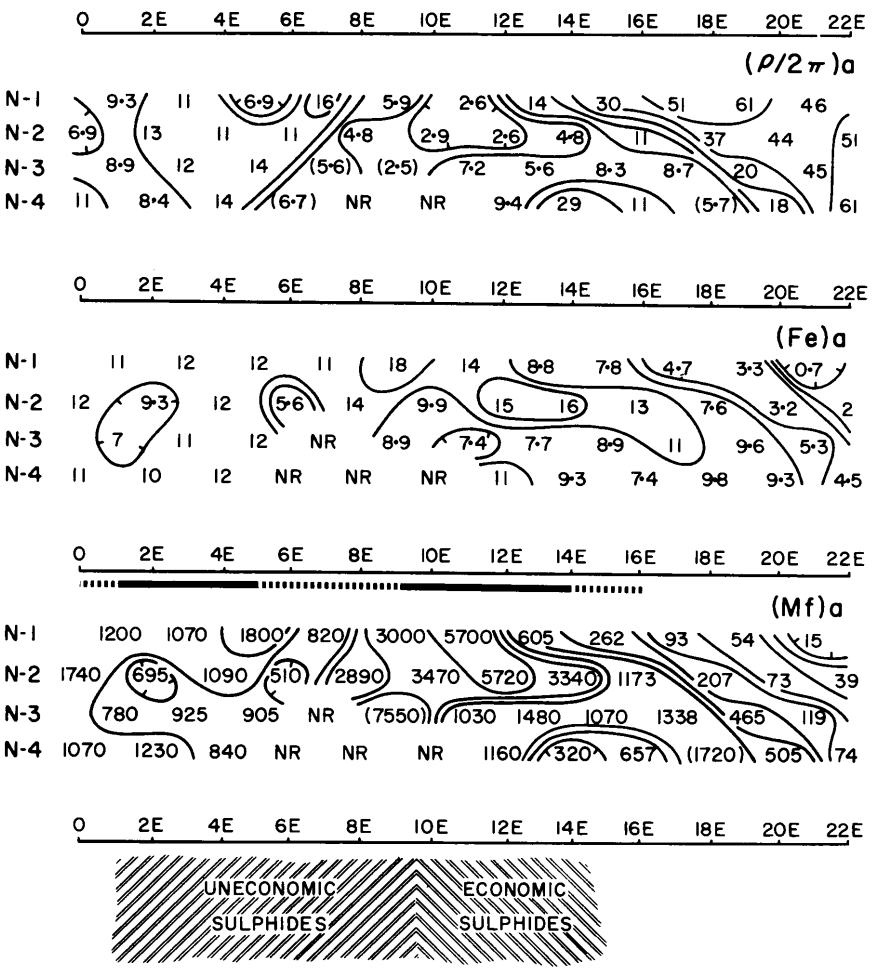


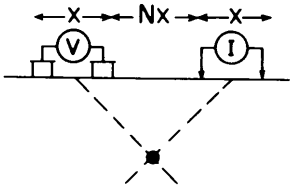
FIG. 10

INDUCED POLARIZATION AND DRILLING RESULTS FROM NEWMAN PENINSULA B.C.



LINE - 22 N

FREQUENCIES - 0·31 & 5·0 CPS.



X EQUALS 200 FEET

FIG. 11

Although the lines are somewhat displaced and the boundaries of the mineralized areas are not exact, there is good correlation between the results from the two types of IP surveys. The low resistivities measured also indicate why the electromagnetic method was successful.

The plan illustrated in Figure 12 is from another property in the Babine Lake area. 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 overall high IP response. The zone of strong IP anomalies 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. The contour values are in gammas and represent the variation of the vertical magnetic field. 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 programme. Detailed geologic study of the core indicated the mineral association which caused the magnetic anomalies, however, this association was not assumed prior to drilling the magnetic highs.

VI. THE GALORE CREEK COPPER DEPOSITS

The Galore Creek copper deposits being developed by Stikine Copper Limited are situated in the Stikine River district, 640 miles northwest of Vancouver. The ten deposits are distributed over an area 3.5 x 2 miles and through an elevation range of 4,000 feet. They share many of the features common to both the porphyry copper type of mineralization and pyrometasomatic deposits. Both geochemical and geophysical methods were used in the exploration and development of these deposits. The main geophysical methods employed were magnetics and induced polarization.

Both airborne (helicopter) and ground magnetometer surveys were carried out. The magnetic results, although not being a direct indicator, did assist with interpreting the geology. In particular the magnetic data indicated the N20^{O}E trend which is one of the most striking features shared by many of the deposits.

The IP method proved very useful as a direct indicator although in many cases the stronger IP anomalies were due to disseminated pyrite. In Figure 13 are presented the IP and magnetic data and the approximate geologic section for Line 200N. In the lower portion of the figure is the schematic geologic section. The ore zone, consisting of pyrite, chalcopyrite and bornite for a total sulphide content of greater than 5%, occurs in intermediate and dark syenite porphyry and is centred between 180E and 185E. The boundaries of the ore in the figure are only approximate and in actual fact there are barren

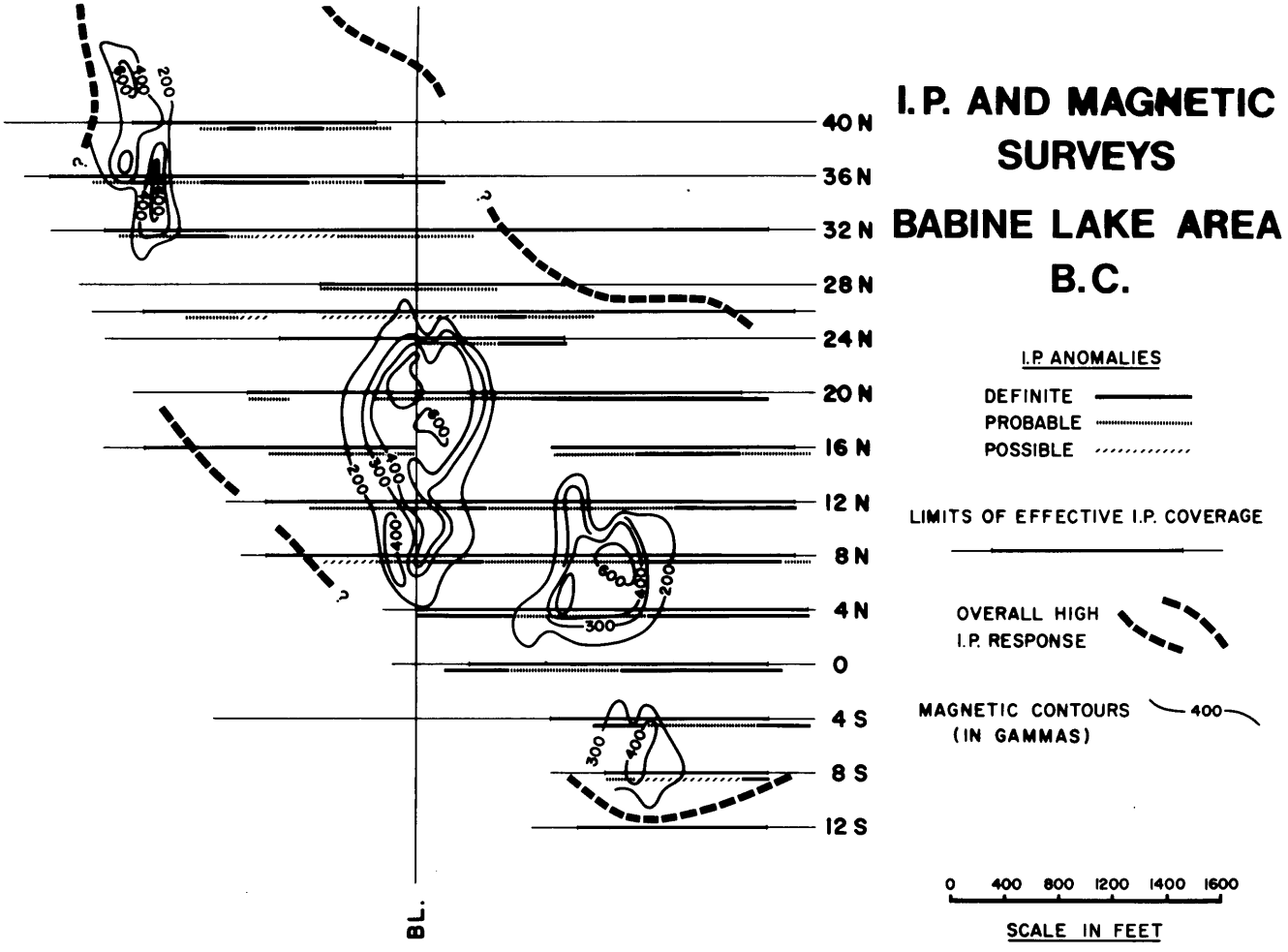


FIG. 12

Geophysical Data & Geologic Section

STIKINE COPPER LTD.

GALORE CREEK AREA, BRITISH COLUMBIA.

LINE - 200 N

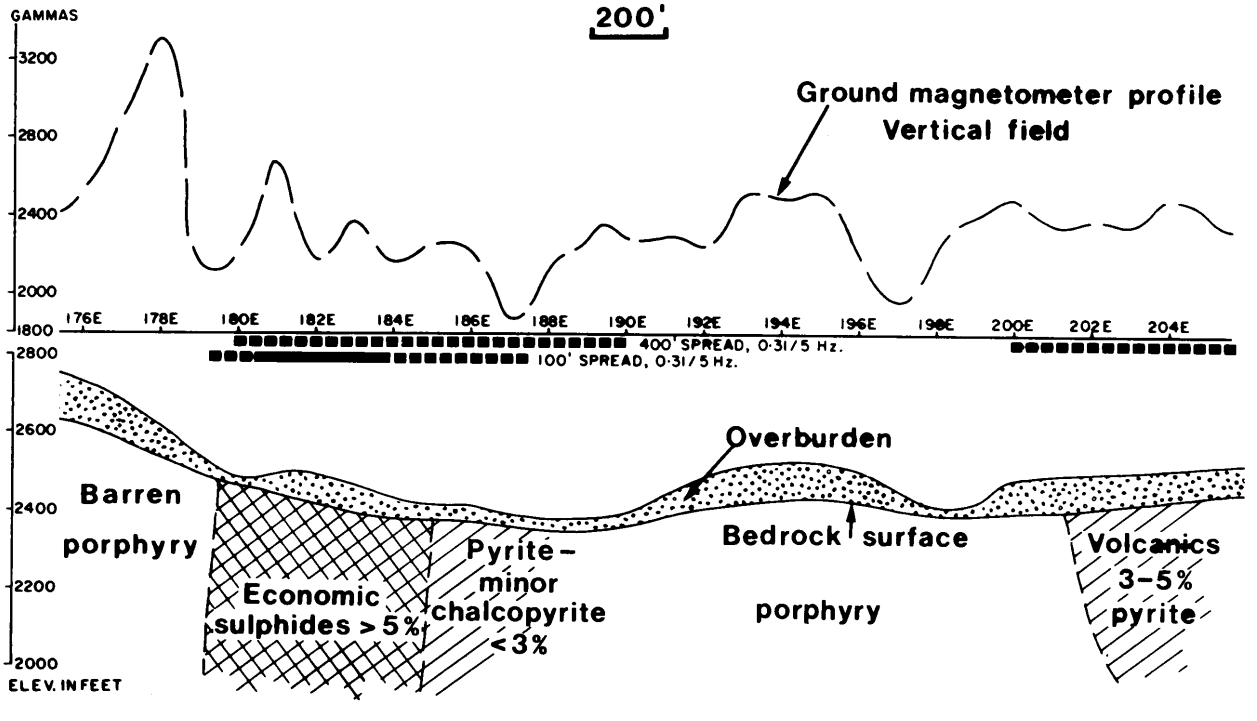


FIG. 13

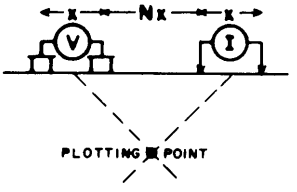
dikes within the mineralized zone. To the west of the ore zone boundary occurs fine grained, barren syenite porphyry, while to the east there is a narrow zone of pyrite and minor chalcopyrite, less than 3% total sulphide. The rocks between this mineralized zone and the metamorphosed volcanics to the east are a dark syenite porphyry. The volcanics starting about 201E and extending to the east contain between 3 - 5% pyrite. This section is by no means detailed, however, it does indicate the major features of geophysical significance. In the upper portion of the figure is a profile of the relative vertical magnetic field in gammas as obtained from the ground magnetometer survey. The magnetic data indicates that it was of little use as a direct indicator of the sulphide mineralization, although as mentioned previously it did assist with the geologic interpretation.

Beneath the magnetic data, the anomalous IP responses obtained on lines approximately along the section are indicated. The IP data was obtained in different years and employing different frequencies and dipole sizes. The initial survey work was carried out in July 1961 employing 400 foot dipoles, four dipole separations (n = 1, 2, 3, 4) and frequencies of 0.31 Hz and 5.0 Hz. The IP anomalies indicated by this data are shown at the top of the figure in the form of solid or dashed lines depending upon the distinctiveness of the anomalous response. The actual IP results obtained employing the 400 foot dipoles are indicated in Figure 14. With the 400 foot dipoles a complex anomaly is indicated from 180E to 190E which correlates with the ore mineralization and the associated pyrite to the east. A second irregular anomaly pattern, extending from 200E to at least 210E, correlates with the pyrite in the metamorphosed volcanics. In Figure 15 are presented the IP survey results in the area of the ore zone obtained using 400 foot dipoles and frequencies of DC and 5.0 Hz. There is excellent correlation between the Apparent Resistivity values obtained in both surveys and the increase in magnitude of the Apparent Frequency Effect is of an amount to be expected from the increased frequency separation.

In July 1962 the same line was surveyed utilizing 100 foot dipoles and frequencies of 0.31 Hz and 5.0 Hz. The IP anomalies indicated by this data are shown in Figure 13 just below the anomalies for the 400 foot data. The survey did not extend far enough to the east to cover the pyrite mineralization within the volcanics. The actual IP data obtained employing the 100 foot dipoles is indicated in Figure 16. There is a distinct anomaly indicated between 179+50E and 184+50E which correlates with the ore mineralization. Weaker anomalous response occurs from 184+50E to 187+50E which would correlate with the less than 3% sulphide mineralization lying to the east of the ore zone. As mentioned above, the survey line did not extend far enough to the east to traverse the pyrite in the volcanic rocks starting at 202E.

INDUCED POLARIZATION and GEOLOGIC DATA from STIKINE COPPER LTD. Galore Creek area, B.C.

Line-200N



FREQUENCIES - 0.31 & 5.0 Hz

X EQUALS 400 FEET

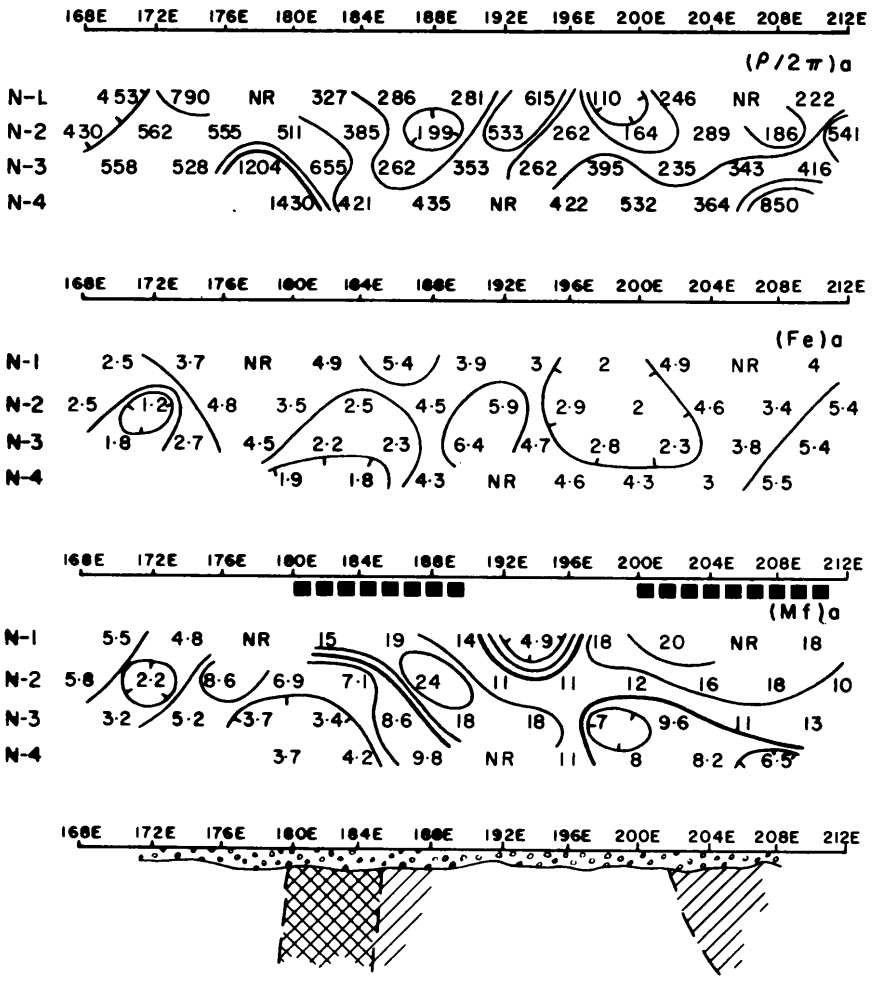
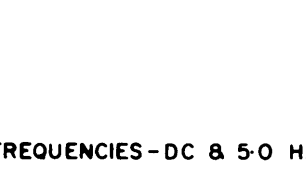


FIG. 14

INDUCED POLARIZATION and GEOLOGIC DATA from STIKINE COPPER LTD. Galore Creek area, B.C.

Line-200N



FREQUENCIES - DC & 5.0 Hz

X EQUALS 400 FEET

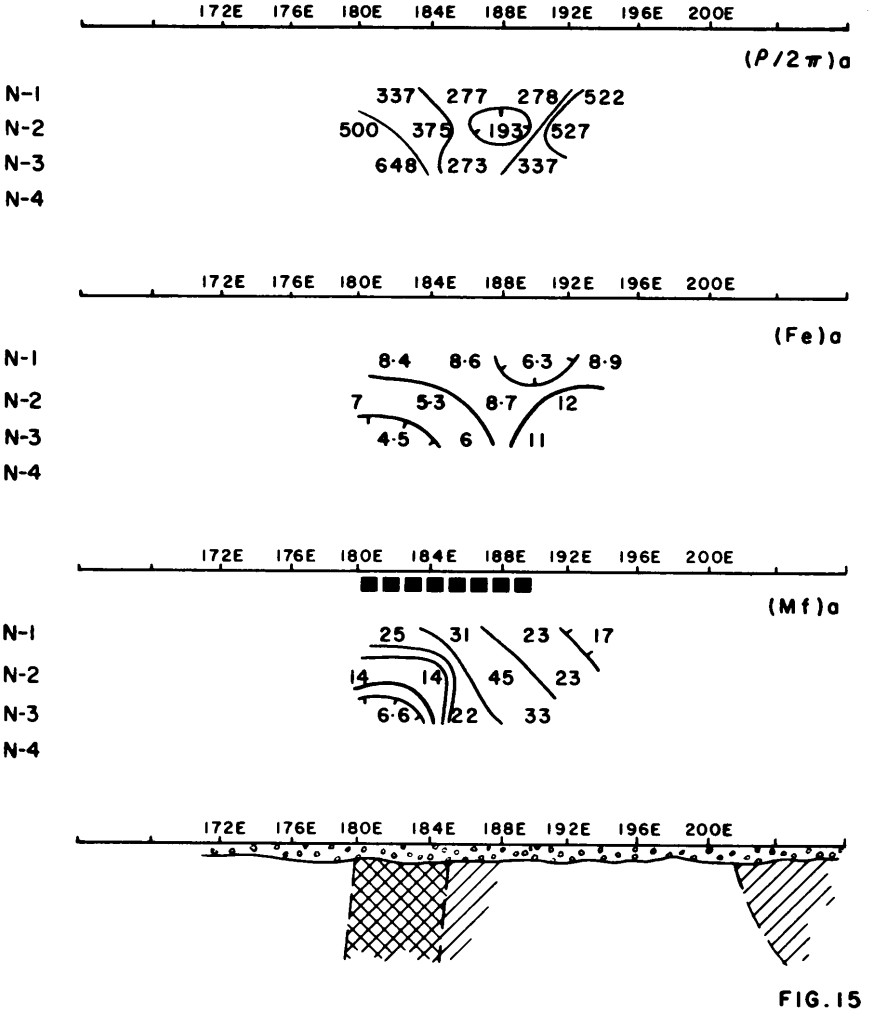
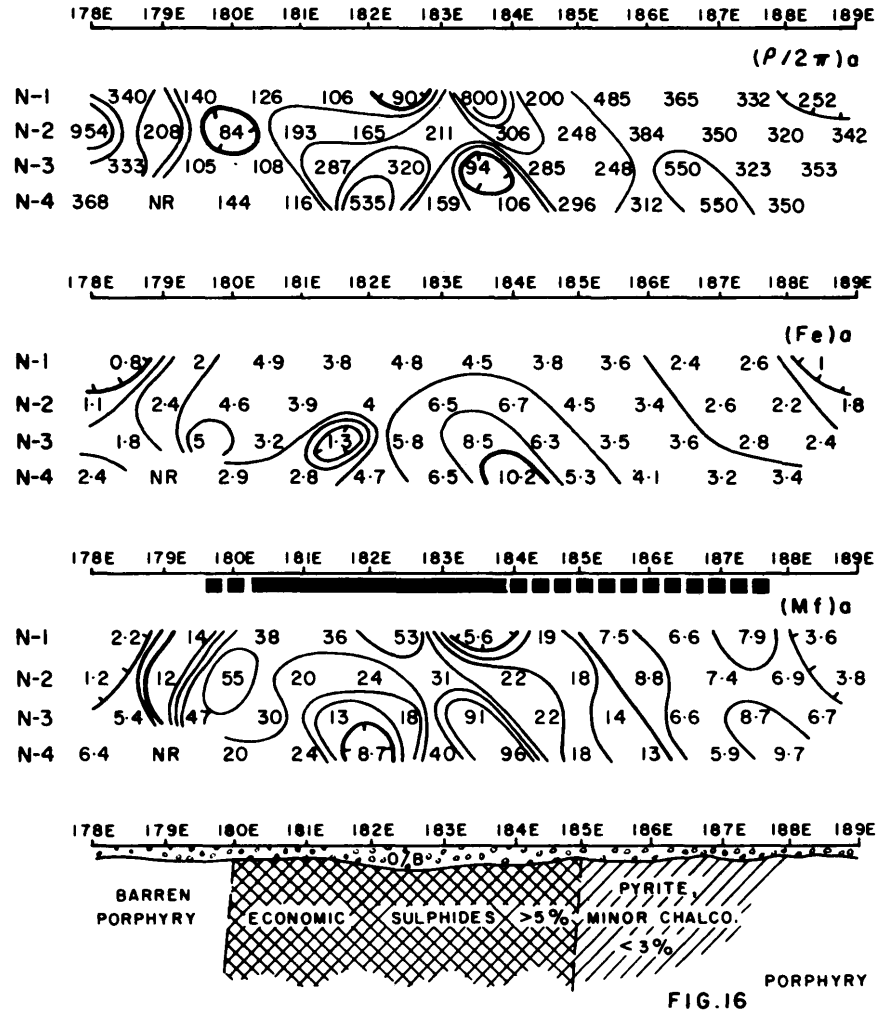


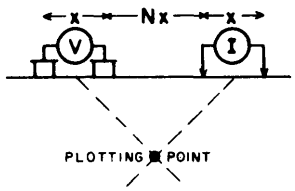
FIG. 15

INDUCED POLARIZATION
and
GEOLOGIC DATA
from
STIKINE COPPER LTD.
Galore Creek area, B.C.

Line-200N



FREQUENCIES - 0·31 & 5·0 Hz



X EQUALS 100 FEET

FIG. 16

VII. SUMMARY

The preceding case histories from various areas in British Columbia have indicated the usefulness of geophysics in the search for disseminated sulphide deposits in the province. No attempt has been made to cover all the disseminated sulphide deposits nor to give a detailed case history of the deposits considered. A paper in itself could be prepared on the use of geophysics for regional exploration utilizing airborne magnetic and radiometric methods.

However, it is felt that the cases from the Brenda Deposit, Highland Valley Area, Princeton Area, Smithers-Babine Lake Area, and Galore Creek Area give a representative cross-section of the various types of situations encountered in British Columbia. As information becomes available, fuller descriptions should be given of the use of geophysics at Valley Copper Mines Limited, Utah Construction's Vancouver Island deposit, which is scheduled for production in 1971 with announced reserves of approximately 280 million tons grading 0.52% copper and 0.029% molybdenum sulphide, and the recent development of Gibralter Mines Limited north of Williams Lake.

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