Department of Mines and Petroleum Resources
ASSESSMENT REPORT
NO. 3265 MAP

3265

REPORT ON THE INDUCED POLARIZATION AND RESISTIVITY SURVEY ON THE J.K. CLAIM GROUP, TOODOGGONE RIVER AREA, OMINECA MINING DIVISION, B.C. FOR CORDILLERAN ENGINEERING LIMITED

94E/7E

BY

MARION A. GOUDIE, B.Sc.

AND

PHILIP G. HALLOF, Ph.D.

NAME AND LOCATION OF PROPERTY:

J.K. CLAIM GROUP, TOODOGGONE RIVER AREA

OMINECA MINING DIVISION, B.C. 57°N, 126°W - SW

DATE STARTED: JULY 10, 1971

DATE FINISHED: JULY 20, 1971

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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 noisey 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

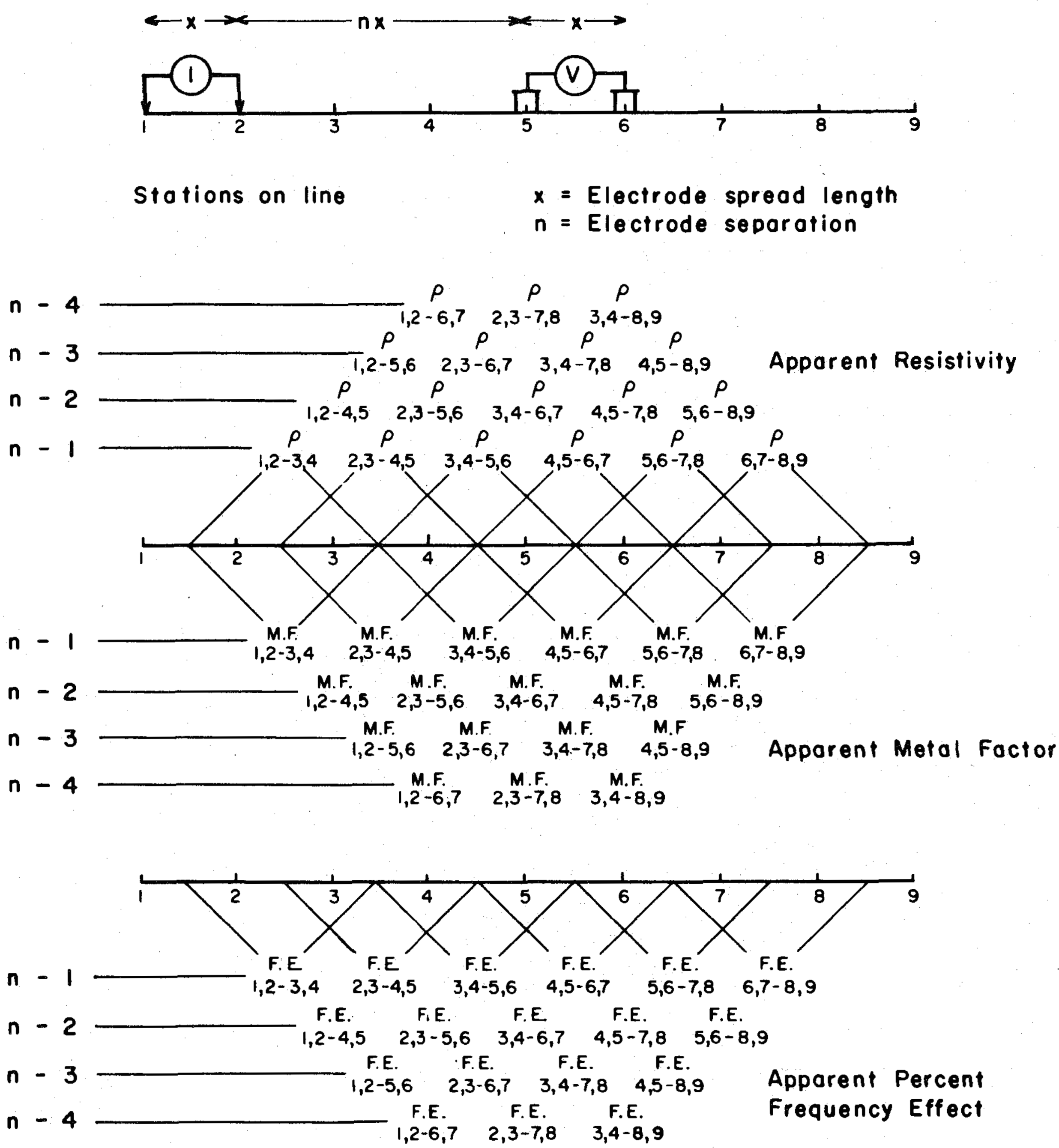

Fig. A

McPHAR GEOPHYSICS LIMITED

REPORT ON THE INDUCED POLARIZATION AND RESISTIVITY SURVEY ON THE J.K. CLAIM GROUP, TOODOGGONE RIVER AREA, OMINECA MINING DIVISION, BRITISH COLUMBIA FOR CORDILLERAN ENGINEERING LIMITED

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1. INTRODUCTION

At the request of Mr. A.F. Reeve, President of the company, an Induced Polarization and Resistivity Survey has been complted on the J.K. Claim Group, Toodoggone River area, Omineca Mining Division, British Columbia. The claims, which are accessible by air, are located in the southwest quadrant of the 1° quadrilateral whose southeast corner is situated at 57°N and 126°W.

The J.K. property is underlain by andesite, feldspar and augite porphyry volcanic flow rocks of Triassic age. These rocks have been cut by Jurassic syenite-monzonite intrusives. These units have been altered by the introduction of pyrite, epidote, chlorite and locally intense fracturing. Minor occurrences of chalcopyrite, sphalerite, galena and hematite have been found in the volcanic rocks. Geochemical samples were analyzed for copper, zinc, molybdenum and manganese.

The survey was carried out to investigate an EM conductor which is coincident with a very extensive copper geochemical anomaly on the flank of a sharply positive magnetic feature.

The claim group was surveyed in July, 1971, using a McPhar P660 high power variable frequency IP unit over the following claims:

J.K. Claims - 17, 19, 21, 18, 20,22, 29, 31, 33

These claims are assumed to be owned or held under option by Cordilleran Engineering Limited.

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.
2400N	300 feet	IP 5828-1
1600N	300 feet	IP 5828-2
1150N	300 feet	IP 5828-3
700N	300 feet	IP 5828-4
350N	300 feet	IP 5828-5
0	300 feet	IP 5828-6
450S	300 feet	IP 5828-7

Also enclosed with this report is Dwg. I.P.P. 2878, a plan map of the J.K. Claim Group Grid at a scale of 1" = 400'. The definite, probable and possible Induced Polarization anomalies are indicated by bars, in the manner shown on the legend, on this plan map as well as on 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 electrode interval length; i.e. when using 400' electrode intervals the position of a narrow sulphide body can only be determined to lie between two stations 400' apart. In order to definitely locate, and fully evaluate, a narrow, shallow source it is necessary to use shorter electrode intervals. In order to locate sources at some depth, larger electrode intervals 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

The porphyry copper deposits of the Southwestern United States are characterized by concentrations of up to 6% pyrite. This type of deposit in British Columbia does not have large amounts of pyrite associated with the sulphide mineralization, thus, the concentration of metallic mineralization is weaker and is reflected by weak anomalies. This is illustrated in the paper entitled "The Application of the Induced Polarisation Method at Brenda Mines, British Columbia" which is bound with this report. Figure 2, page 2, of that paper shows an IP line over the Brenda ore body where the Metal Factor values are between 10 and 14 and the resistivities are moderate. This line could be compared to Line 0 on the J.K. Claims.

The IP results on each line are very similar. The anomalies are broad and weak. The top of the source is, in general, shallow, lying at a depth of less than 150'. The source of the anomalies appears to be disseminated mineralization, with irregular concentrations within the disseminated material. A typical line is Line 0, which is described below.

Line 0

A broad anomaly extends from 4E to 15E. The anomaly is weak and indefinite except from 9E to 12E, where it is probable. The top of the source lies at a depth of less than one electrode interval and some depth extent is indicated.

4. CONCLUSIONS AND RECOMMENDATIONS

It is not known where the EM and magnetic features are located, so it is not possible to correlate the over-all geophysical results. The IP survey has outlined an open-ended anomalous zone trending north-south. The IP anomalies are weak, but they can represent mineralization of economic importance, depending upon which minerals constitute the source of the anomalies.

If the results are of interest, it is recommended that one or more of the IP lines be surveyed with shorter electrode intervals to better locate and define the source so that a drill test can be planned.

McPHAR GEOPHYSICS LIMITED

Marion A. Goudie per N.L.

Marion A. Goudie,
Geologist.

Philip G. Hallof

Philip G. Hallof,
Geophysicist.

PROFESSIONAL ENGINEER PROVINCE OF ... PHILIP G. HALLOF

Dated: August 20, 1971

Expiry Date: February 26, 1972

ASSESSMENT DETAILS

PROPERTY: J.K. Claim Group

MINING DIVISION: Omineca

SPONSOR: Cordilleran Engineering Limited

PROVINCE: British Columbia

LOCATION: Toodoggone River Area

TYPE OF SURVEY: Induced Polarization

OPERATING MAN DAYS:	8	DATE STARTED:	July 10, 1971
EQUIVALENT 8 HR. MAN DAYS:	12	DATE FINISHED:	July 20, 1971
CONSULTING MAN DAYS:	3	NUMBER OF STATIONS:	72
DRAUGHTING MAN DAYS:	3	NUMBER OF READINGS:	459
TOTAL MAN DAYS:	18	MILES OF LINE SURVEYED:	3.7

CONSULTANTS:
Marion A. Goudie, 739 Military Trail, West Hill, Ontario.
Philip G. Hallof, 11 Barnwood Court, Don Mills, Ontario.

FIELD TECHNICIANS:
D. Broswick, c/o McPhar Geophysics Ltd., Suite 811, 837 West Hastings St. Vancouver, B.C.
M. McDonald, 6135 Bow Crescent, N.W. Calgary, Alberta.
Plus 2 Helpers: supplied by client

DRAUGHTSMEN:
B. Marr, 19 Kenewen Court, Toronto 16, Ontario.
P. Thompson, 9 Chipping Road, Don Mills, Ontario.

McPHAR GEOPHYSICS LIMITED

Marion A. Goudie

Marion A. Goudie, Reg. N.L.
Geologist.

Dated: August 20, 1971

STATEMENT OF COST

J.K. Claim Group

Toodoggone River Area

Cordilleran Engineering Limited

Crew (2 men) - D. Broswick - Murray McDonald

2 days Operating		@ $265.00/day	$ 530.00
1½ days Electrode Preparation)			
1½ days Travel)	5½	@ $100.00/day	550.00
½ day Organization)			
2 days Standby)			
			1,080.00

Expenses

Meals and Accommodation	$16.55	
Transportation - Smithers - Kamloops	53.00	
		69.55
		$1,149.55

McPHAR GEOPHYSICS LIMITED

Marion A. Goudie

Marion A. Goudie, Per N.L.
Geologist.

Dated: August 20, 1971

Declared before me at the City of Vancouver, in the Province of British Columbia, this 7th day of Sept 1971, A.D.

M. A. Sanguinetti

G. P. Phillips

A Commissioner for taking Affidavits within British Columbia or
A Notary Public in and for the Province of British Columbia.

Sub-mining Recorder

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 year.

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 Cordilleran Engineering Limited 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 nor for advertising purposes.

Dated at Toronto

This 20th day of August 1971

Marion A. Goudie

Marion A. Goudie, B.Sc. Rec. N.L.

CERTIFICATE

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

1. I am a geophysicist residing at 11 Barnwood Court, Don Mills, (Toronto) Ontario.

2. I am a graduate of the Massachusetts Institute of Technology with 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 am a Professional Geophysicist, registered in the Province of Ontario, the Province of British Columbia and the State of Arizona.

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This 20th day of August 1971

PROFESSIONAL PROVINCE PHILIP G. HALLOF ENGINEER

Philip G. Hallof, Ph.D.

Expiry Date: February 29, 1972

The Application of the Induced Polarization Method at Brenda Mines, British Columbia

D. K. FOUNTAIN, Geophysicist,
Noranda Exploration Company, Ltd.,
Toronto, Ont.

ABSTRACT

High metal prices and advanced technology in open-pit mining methods have resulted in considerable interest in the development of large, low-grade mineral deposits. Brenda Mines Limited is presently testing such a deposit of copper-molybdenum mineralization near Penticton, British Columbia.

The mineralization of economic interest at Brenda has a total metallic sulphide content of between 1 and 1.5 per cent. This sulphide content approaches the limits of detectability of standard geophysical methods. However, due to a favourable geological environment, it has been possible to utilize the Induced Polarization Method to outline the mineralization at the Brenda property.

DAVID K. FOUNTAIN graduated with a B.A.Sc. degree in engineering physics (geophysics option) at 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, West Africa and Ireland. Prior to joining Noranda Mines Limited in 1964 as geophysicist, he worked with Pan American Petroleum Corporation, and did some geophysical contracting, including work for the United Nations.

THE PAPER WAS PRESENTED at the 69th Annual General Meeting of the Institute, Ottawa, 1967. It will appear in the 1968 Transactions.

KEYWORDS IN THIS PAPER: Induced polarization method, Geophysical prospecting, Brenda Mines Ltd., Copper, Molybdenum, Mine geology.

Introduction

THE INDUCED POLARIZATION Method of geophysical surveying was originally developed as a tool to detect disseminated metallic sulphide mineralization. When electronic-conducting sulphide minerals are present within ionic-conducting rock materials, the ground is polarizable and the I.P. method can be applied. The lower limit of volume per cent sulphide necessary to produce a recognizable I.P. 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, provides a fairly good "rule of thumb" for this lower limit.

In recent years, higher metal prices and advanced technology in mining methods have resulted in exploration for, and the re-evaluation of, metallic sulphide deposits containing grades of mineralization too low to be of economic interest ten years ago. In many cases, the concentration of mineralization involved approaches the limits of detectability by geophysical methods.

At the present time, Brenda Mines Limited is testing such a deposit of copper-molybdenum mineralization near Penticton, British Columbia. 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.

History and Geology of the Brenda Property

The property of Brenda Mines Limited is located in the Osoyoos Mining Division, approximately 14 miles northwest of Peachland, British Columbia. The presence of copper-molybdenum mineralization on the property has been known for many years. It is referred to in Memoir 243 of the Mines and Geology Branch of the Canada Department of Mines and Resources (1947). Work was also carried out in 1955, 1956 and 1957 which indicated widespread mineralization.

The mineralized area of interest at Brenda lies within a granodiorite host rock. The contact between the granodiorite and the Nicola volcanics lies approximately 2,000 feet to the west. The copper-molybdenum metals are present for the most part as chalcopyrite and molybdenite. The total metallic sulphide mineralization is largely restricted to the above-mentioned chalcopyrite and molybdenite, with minor pyrite and some very minor pyrrhotite. The chalcopyrite and molybdenite occur almost entirely in association with quartz and potassium feldspar as fracture fillings, and very little mineralization has invaded or been disseminated in the host rock. The oxidation is shallow, with no evidence of extensive alteration, weathering or breakdown of sulphide minerals.

The granodiorite itself is very fresh, with alteration restricted to the walls of fractures or faults. The three principal strike directions of these fractures are approximately north, N 60°E and N 50°W. The concentration of mineralization is largely a function of the fracture density.

Induced Polarization Surveys

A limited induced polarization survey was carried out on the Brenda property in 1957. On the basis of the results of this work, a more complete survey was carried out

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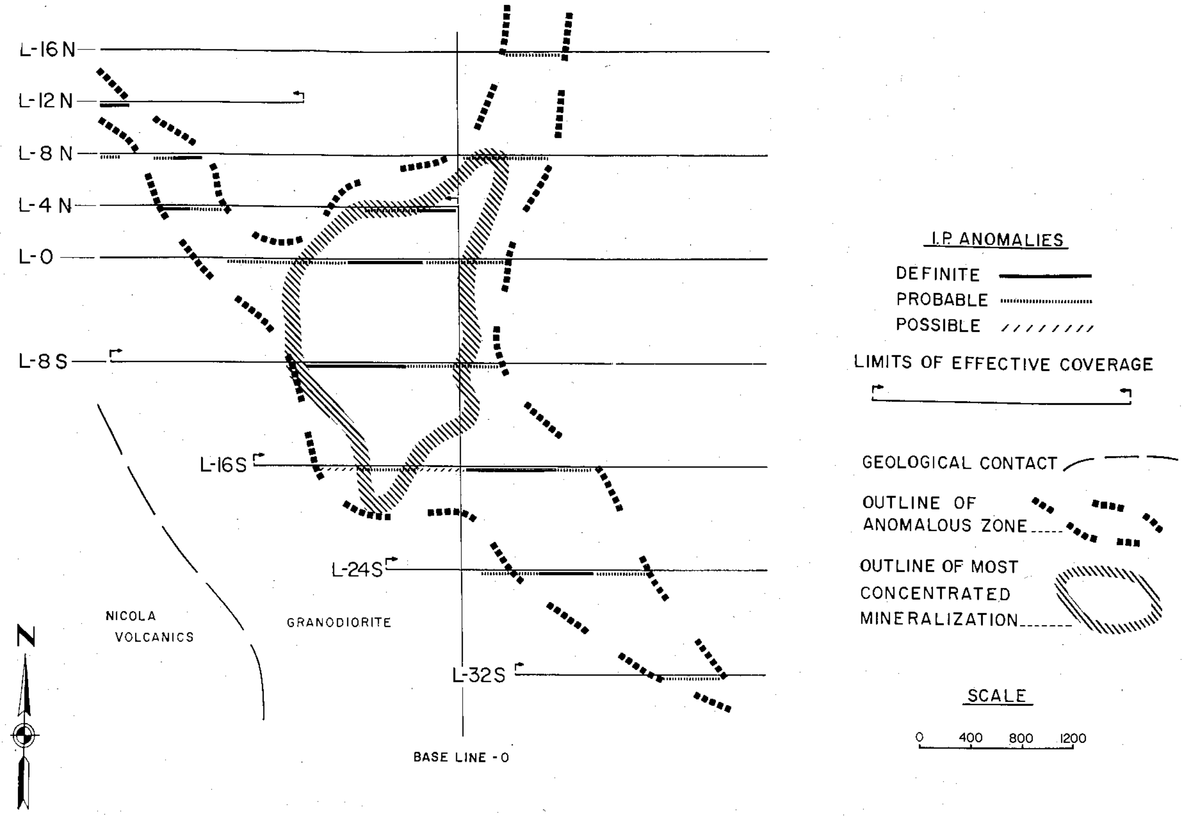

Figure 1.—I.P. Survey at Brenda Mines, 1965-1966.

during 1965 and 1966 as part of a program to re-evaluate the property. The survey, in both cases, was carried out under contract by McPhar Geophysics, employing the variable-frequency method of measuring the I.P. response.

The 1957 survey was one of the first I.P. surveys employing the variable-frequency method to be carried out in Canada. Since that time, substantial advances have been made in instrument development, especially in regard to instrument drift, proper choice of frequencies, power and the general reliability of measurement of the I.P. effect. In spite of the limitations of the older I.P. equipment, a study of the results of the 1957 survey indicated a weak response from the areas of mineralization. This response is diagnostic, due to the over-all low I.P. background of the granodiorite. The low total sulphide content of the deposit would give, at best, a weak I.P. response, and therefore these weak anomalies are considered significant.

On the basis of this, a substantial I.P. program was planned for 1965 and 1966. This work employed the dipole-dipole electrode configuration, with electrode dipoles of 400 feet, and involved reading four dipole separations. The choice of the 400-foot electrode dipoles was based on the fact that mineralization of the over-all grade of that at Brenda would have to occur in large volumes to be of economic interest. This electrode separation would measure the I.P. response from the metallic sulphides contained in a 400-foot section along the line, as well as giving a response from depth. It should be noted here, however, that the use of large electrode dipoles will be biased against detecting narrow sources, even if they are of more concentrated mineralization.

Discussion of I.P. Results

The results of the induced polarization survey in the main mineralized zone are indicated in *Figure 1*, a plan map of the area. The vertical projections of the I.P. anomalies are indicated by solid or dashed

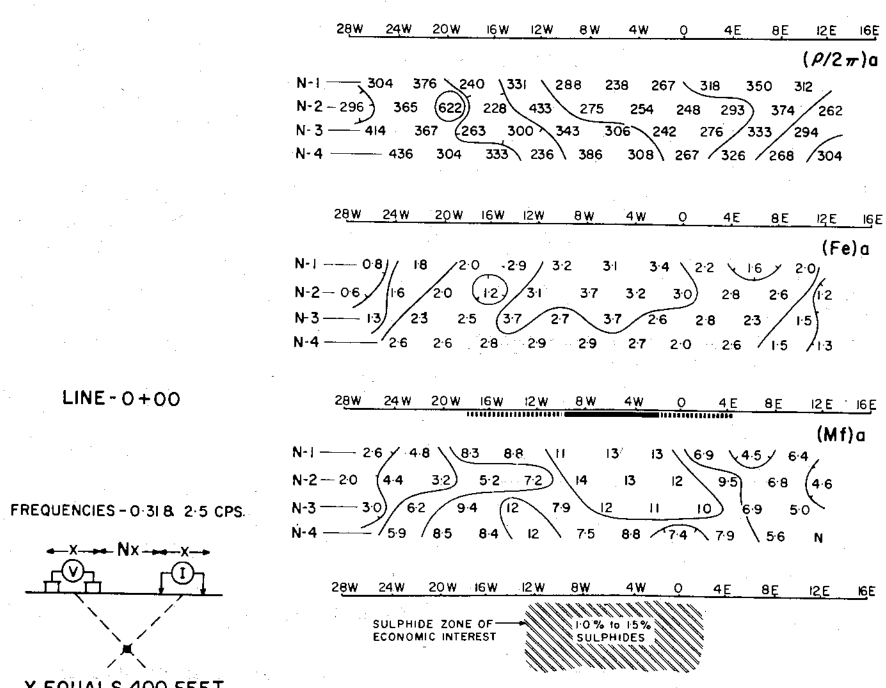

Figure 2.—Induced Polarization and Drilling Results.

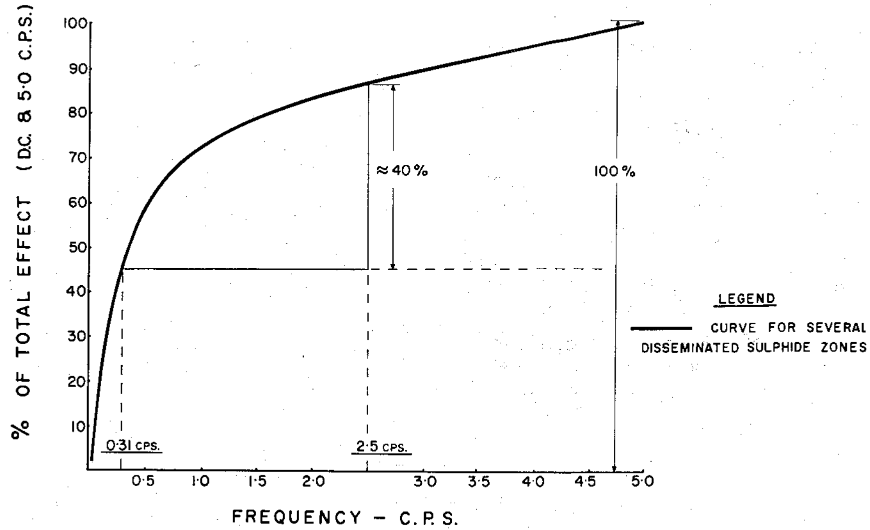

Figure 4.—Frequency Spectra for I.P. Field Results.

lines, depending upon their distinctiveness. The limits of effective coverage along the traverse lines are indicated by bracket-arrows. Where these do not occur, it indicates that the line extends beyond the limits of the diagram area. All the lines indicated in *Figure 1* were surveyed with 400-foot electrode dipoles except for line 4N and line 12N, which were surveyed with 200-foot electrode dipoles to better evaluate the narrow zone to the northwest.

The over-all anomalous I.P. zone is also outlined in *Figure 1*. Superimposed on the I.P. zone is the approximate outline of the concentration of mineralization as indicated by the drilling to date. It is important to note that this outline is based upon an economic cut-off which is partly determined by mining methods. In many cases, it does not indicate a sharp discontinuity in the presence of metallic sulphides, the source of the I.P. response.

It can be seen that the anomalous I.P. zone fits very closely to the outline of the concentrated mineralization. The narrow northwest extension has been joined to the main zone, although the I.P. results there suggest a different character of source from that encountered in the main zone. Insufficient drilling has been carried out to accurately confirm it, but the source of this anomaly may be a mineralized shear zone, although it would not be of economic interest.

The results of the I.P. survey indicate a rather sharp cut-off of the mineralization to the west; to the east, the cut-off is more gradual. This is in general agreement with the geology. Mineralization does correlate with the northeast and southeast extensions of the I.P. zone, but insufficient drilling has been carried out to determine its economic significance.

Figure 2 presents the I.P. results for line 0+00 across the zone of mineralization. The measured results are plotted in the "pseudo-section" form commonly employed in the variable-frequency method. This method of plotting is indicated in the lower left-hand corner of the diagram. It should be mentioned here that the sectional plot does not represent an electrical cross section of the ground. The patterns developed from the observed readings can be interpreted by comparison with expected patterns obtained from computer programs, model studies and previous experience. On the right and across the top of *Figure 2* are the results of the measurement of the Apparent Resistivity in units of $\rho/2\pi$ ohm-feet. Beneath these are the results of the measurement of the Apparent Per Cent Frequency Effect — the measurement of the induced polarization. The third and lower section presents the values of the Apparent Metal Factor. The metal factor is obtained by normalizing the per cent frequency effect for varying resistivities, and is a useful interpretative aid. On this section, the I.P. anomaly has been indicated by a solid and dashed line, as on *Figure 1*. At the extreme bottom of the diagram is a schematic section of the sulphide zone of economic interest.

The I.P. 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 per cent frequency effects are low; anomalous values being only 1 to 1.5 units over background.

When the magnitude of the I.P. response is low, as is the case in a situation like that at Brenda, spurious I.P. effects due to electrical noise, either man-made or natural, can create problems. In most cases, where the target sulphide mineralization is more concentrated, this noise can easily be kept to a level much below the significant anomalous response expected. One method employed at Brenda to test the validity of questionable anomalies was to resurvey the area con-

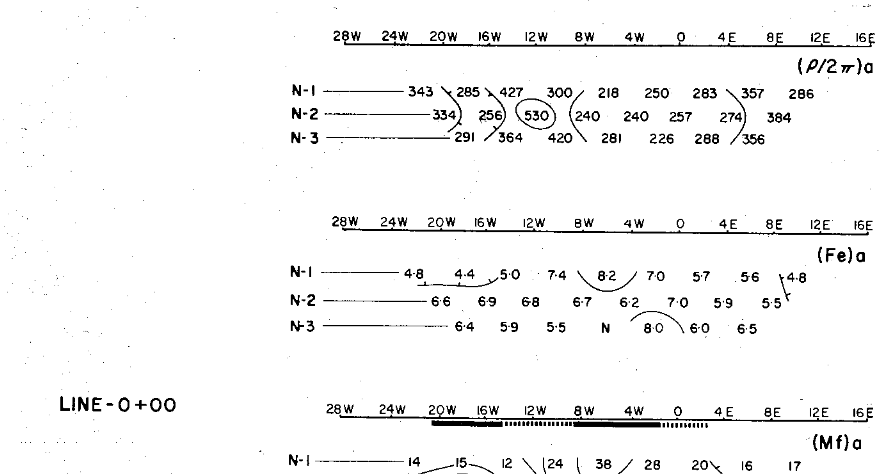

Figure 3.—Induced Polarization and Drilling Results.

cerned using a different frequency interval. If the anomaly is caused by metallic mineralization, then there will be a diagnostic relationship for the difference in I.P. response for the two frequency intervals employed. *Figure 3* shows the results of resurveying the anomalous area of line 0+00 utilizing D.C. frequencies and 5.0 cps. The results presented in *Figure 2* for line 0 were obtained utilizing frequencies of 0.31 and 2.5 cps. From *Figures 2* and *3*, it can be seen that the anomalous I.P. response for frequencies of 0.31 and 2.5 cps is approximately 40 per cent of the response obtained utilizing D.C. and 5.0 cps.

Figure 4 presents a plot of the variation of I.P. response with various frequency intervals, assuming the response for the D.C. frequency interval and 5.0 cps to be 100 per cent. This curve is drawn from measurements made over several disseminated sulphide deposits. It can be seen that the change in response of approximately 40 per cent obtained from the results on line 0 agrees with the expected change obtained from the curve.

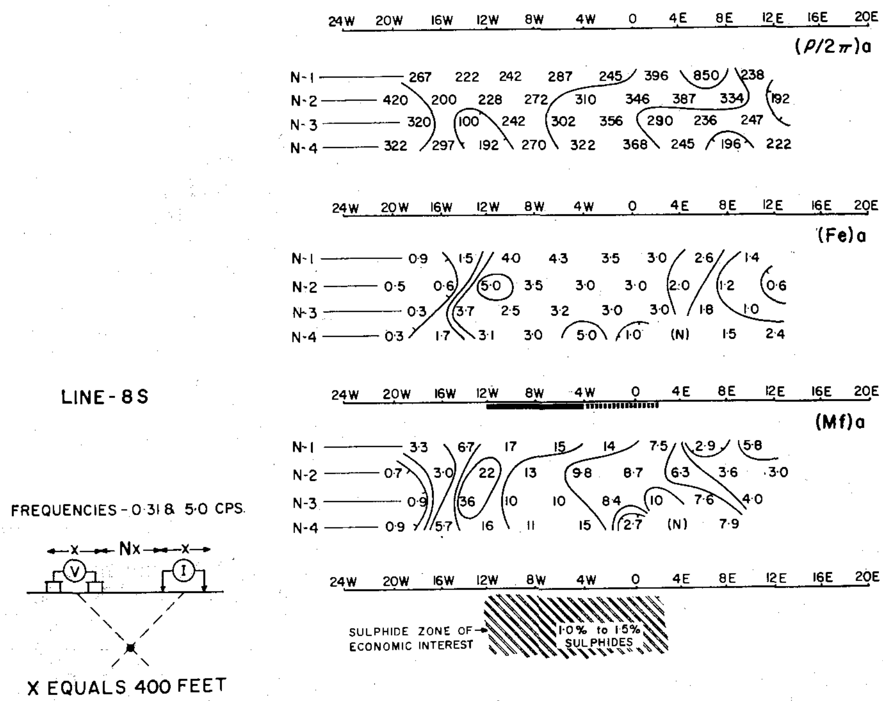

Figure 5.—Induced Polarization and Drilling Results.

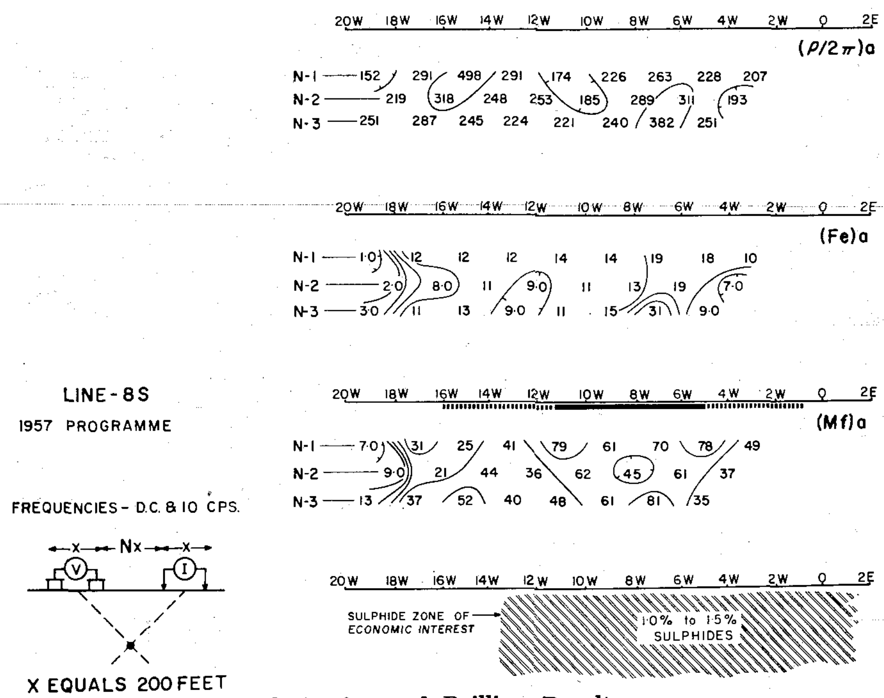

Figure 6.—Induced Polarization and Drilling Results.

The results of the I.P. survey on line 8S across the mineralized zone are presented in *Figure 5*. Again, the I.P. anomaly correlates very well with the outline of 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 the sulphide mineralization in this direction. A portion of the section of line 8S presented in *Figure 5* was also covered by the I.P. survey carried out in 1957. The results from the older survey are seen in *Figure 6*. This work was carried out using 200-foot dipoles, so the scale in *Figure 6* is twice that in *Figure 5*. The limit of coverage did not extend far enough to delimit the eastern edge of the anomaly, but there is fairly good correlation between the anomalies obtained on the two surveys. The over-all magnitude of the results of the 1957 work are greater than those obtained in the recent work. This is due to the use of a large frequency interval as well as some basic differences in instrumentation.

There are several aspects of the form of occurrence of the mineralization that have contributed to the successful application of the I.P. method at the Brenda property. In normal field applications, the I.P. method does not differentiate between pyrite and the economically important sulphides such as chalcopyrite. Where directly associated with the economic mineralization, pyrite will assist in the detection of the target by both increasing the magnitude of the anomaly (increase total sulphide content) and, in some cases, increasing the actual size of the target sought. At Brenda, the presence of little or no pyrite mineralization, although decreasing the magnitude of the anomaly, does mean that the strongest I.P. anomalies will represent the greatest concentration of economic mineralization. This allows for greater application of I.P. results in planning the drill program.

The granodiorite host rock is fresh, resulting in a uniform and low background I.P. response, and thus the weak but significant anomalous responses can be detected. However, experience has shown that the over-all background I.P. response in the area of the volcanics is so high that it would not be possible to detect the weak Brenda anomaly. This is especially true

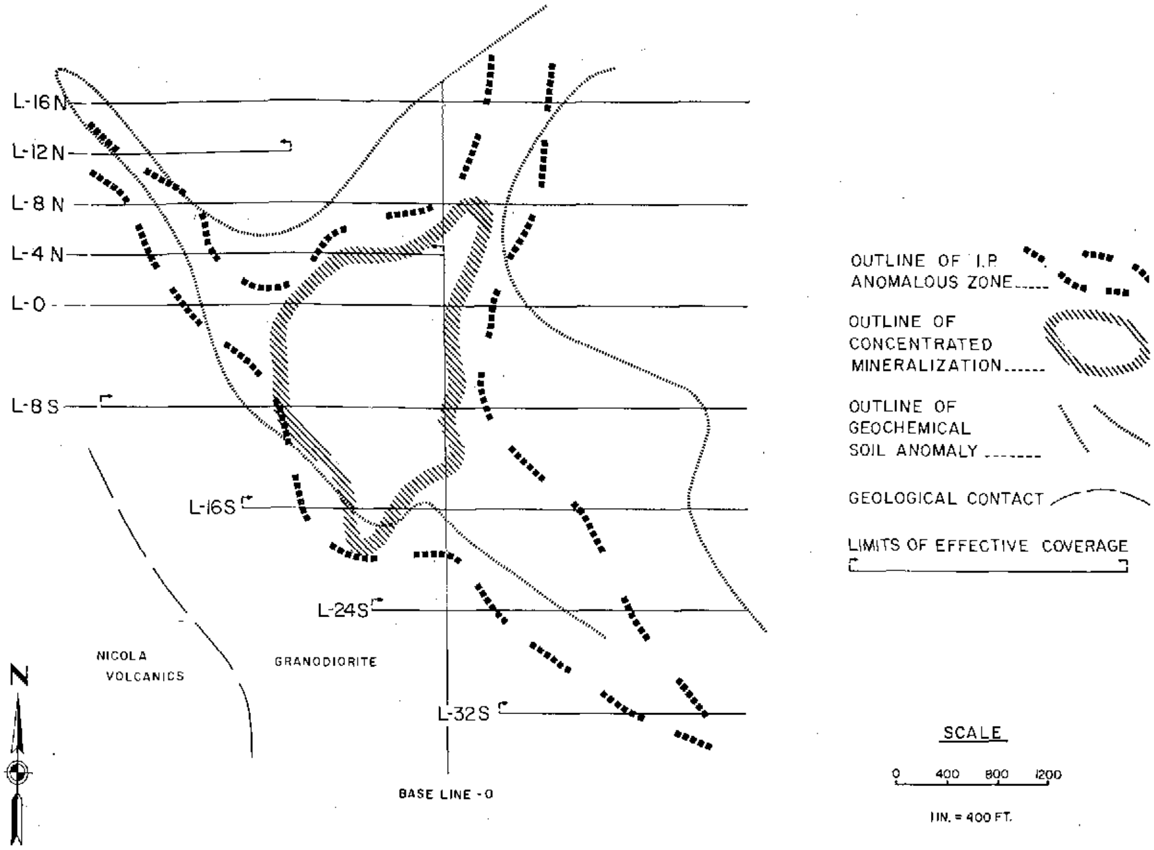

Figure 7.—I.P. - Geochemical Comparison at Brenda Mines.

in the region of the contact between the volcanics and the granodiorite, where I.P. anomalies with magnitudes greater than ten times that of the Brenda mineralization were detected. The source of these anomalies is primarily pyrite, with some magnetite and possibly graphite. These results indicate that the geophysical survey must be planned giving due consideration to the geological environment.

Other Surveys

The Induced Polarization Method was only one of the exploration tools used to evaluate the Brenda prospect. In the earlier programs, limited magnetometer and spontaneous potential surveys were carried out, but proved to be of little assistance. Geochemical programs, both silt and soil sampling, have also been carried out on the property. *Figure 7* shows the outlines of the concentrated mineralization, the I.P. anomaly and the soil geochemical anomaly. There is good correlation between the I.P. and geochemical results. In addition, a fracture intensity study of the available outcrop has indicated good correlation with geochemical and I.P. results.

Summary

The results of the work on the Brenda property indicate that the Induced Polarization Method can be successfully applied to explore for and evaluate even very low grade metallic sulphide mineral deposits. The anomalous I.P. response, however, will be small; and the survey must be carried out with a full understanding of the geological situation and the nature of the target sought. This will require a close correlation of geochemical, geological and geophysical information.

The results also indicate that the successful exploration program must consist of close co-operation between the geophysicist and/or geochemist who understands the limitations and capabilities of the method, and the geologist who has a good knowledge of the geological situation.

Acknowledgments

The author wishes to thank both Noranda Exploration Company, Limited and Brenda Mines Limited for permission to present this paper. He would also like to express his appreciation to Chapman, Wood and Griswold Limited and McPhar Geophysics Limited for their co-operation and assistance in preparing the paper, and to Kennco Explorations, (Canada) Limited for permission to use the data from the 1957 survey.

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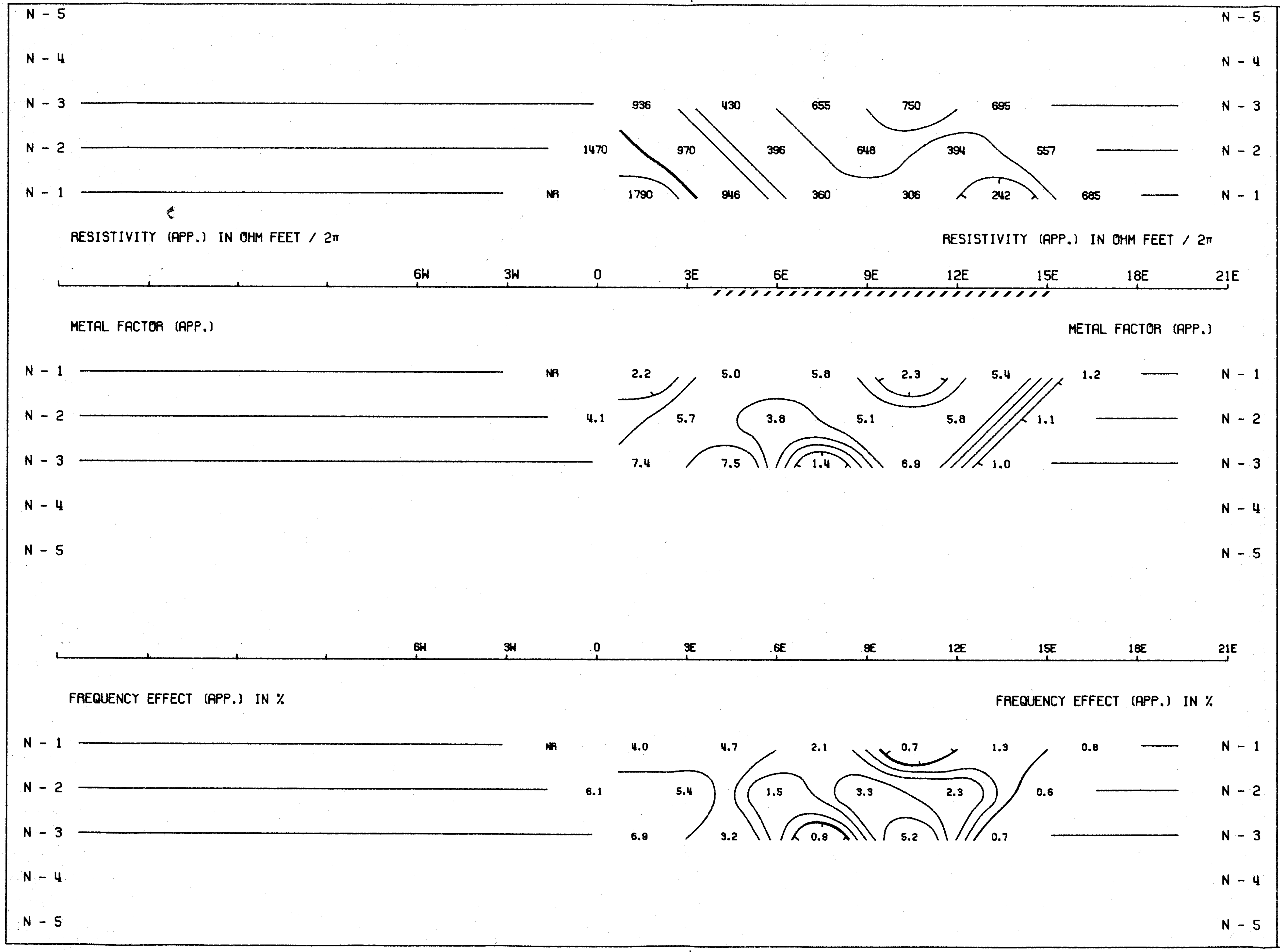

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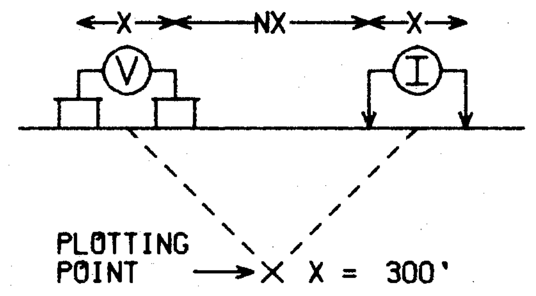

SURFACE PROJECTION OF ANOMALOUS ZONES

DEFINITE ▬▬▬

PROBABLE ||||||||||

POSSIBLE / / / / /

FREQUENCIES: 0.31-5.0 HZ

DATE SURVEYED: JUL 1971

APPROVED: [signature]

DATE: 8/20/71

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Expiry Date: February 25, 1972

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

McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY

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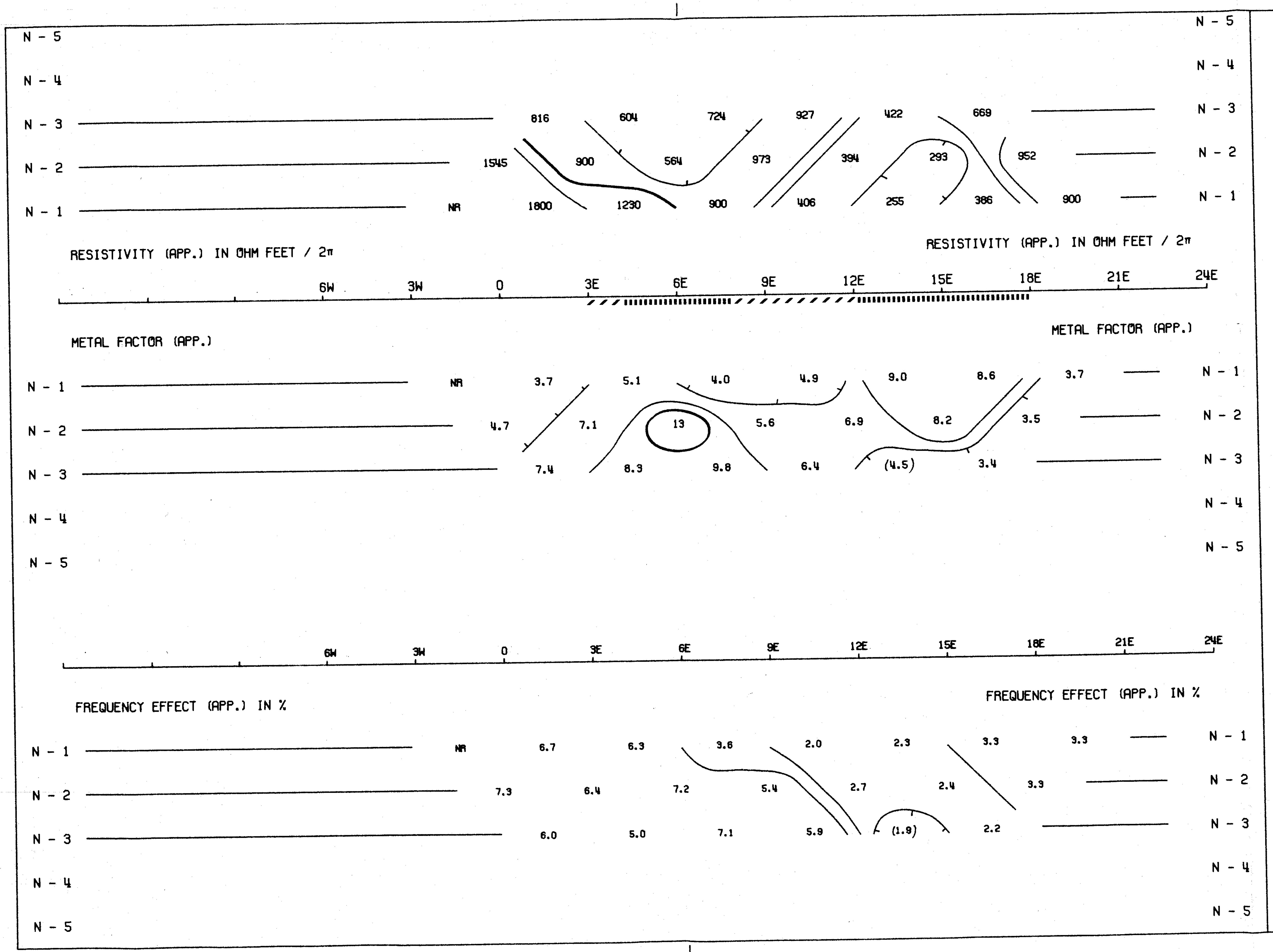

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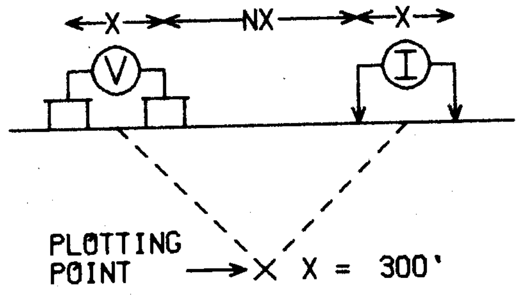
LINE NO.- 16N

ELECTRODE CONFIGURATION



SURFACE PROJECTION OF ANOMALOUS ZONES

DEFINITE
PROBABLE
POSSIBLE

FREQUENCIES: 0.31-5.0 HZ

DATE SURVEYED: JUL 1971

APPROVED:

DATE: 8/26/71

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

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McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY

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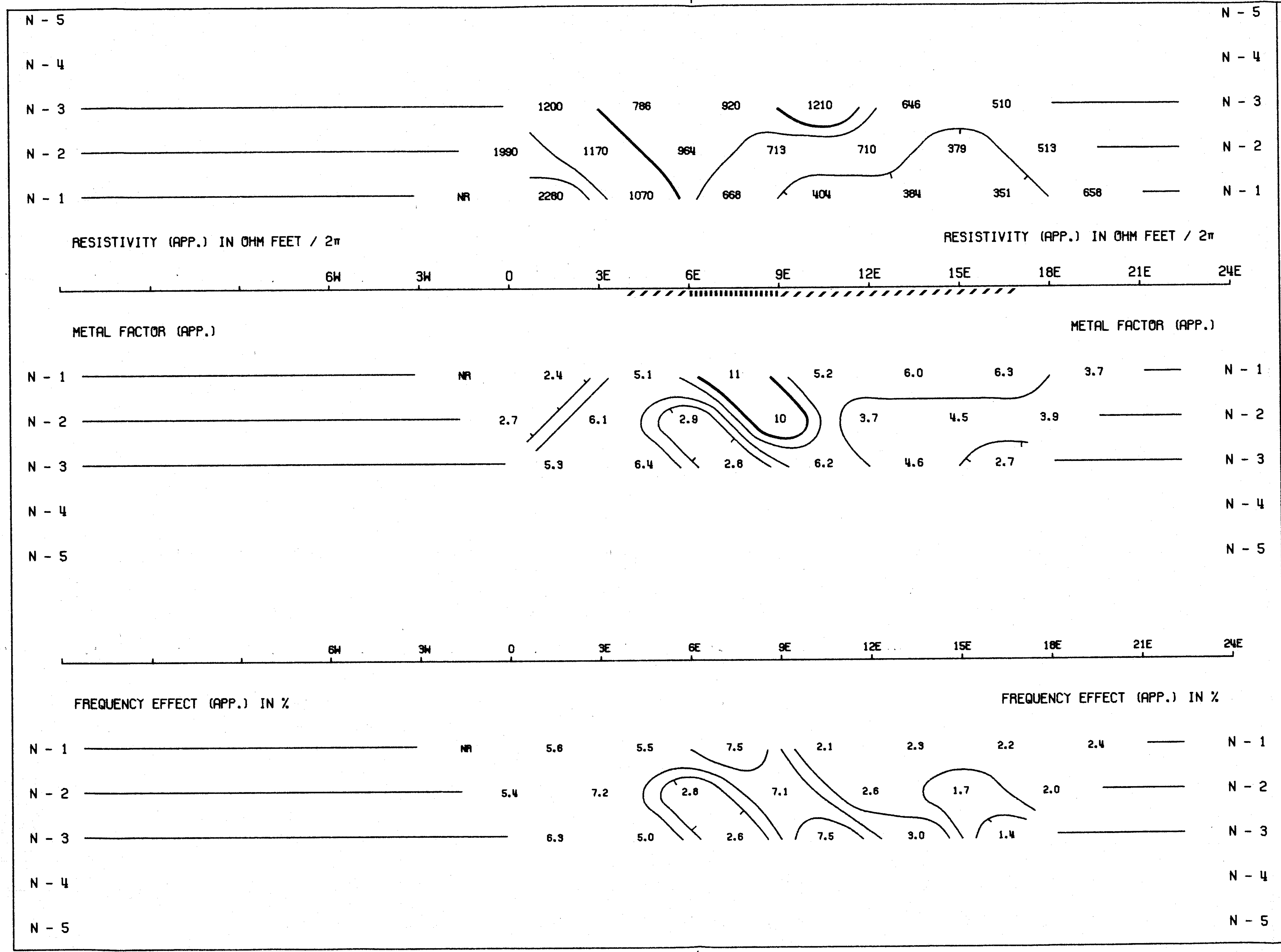

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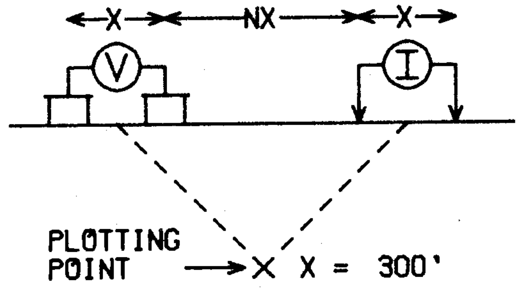
OMINECA M.D., B.C.

LINE NO.- 11.5N

ELECTRODE CONFIGURATION



PLOTTING POINT → X X = 300'

SURFACE PROJECTION OF ANOMALOUS ZONES

DEFINITE
PROBABLE
POSSIBLE

FREQUENCIES: 0.31-5.0 HZ

DATE SURVEYED: JUL 1971

APPROVED:

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

DATE: 8/3/71

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McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY

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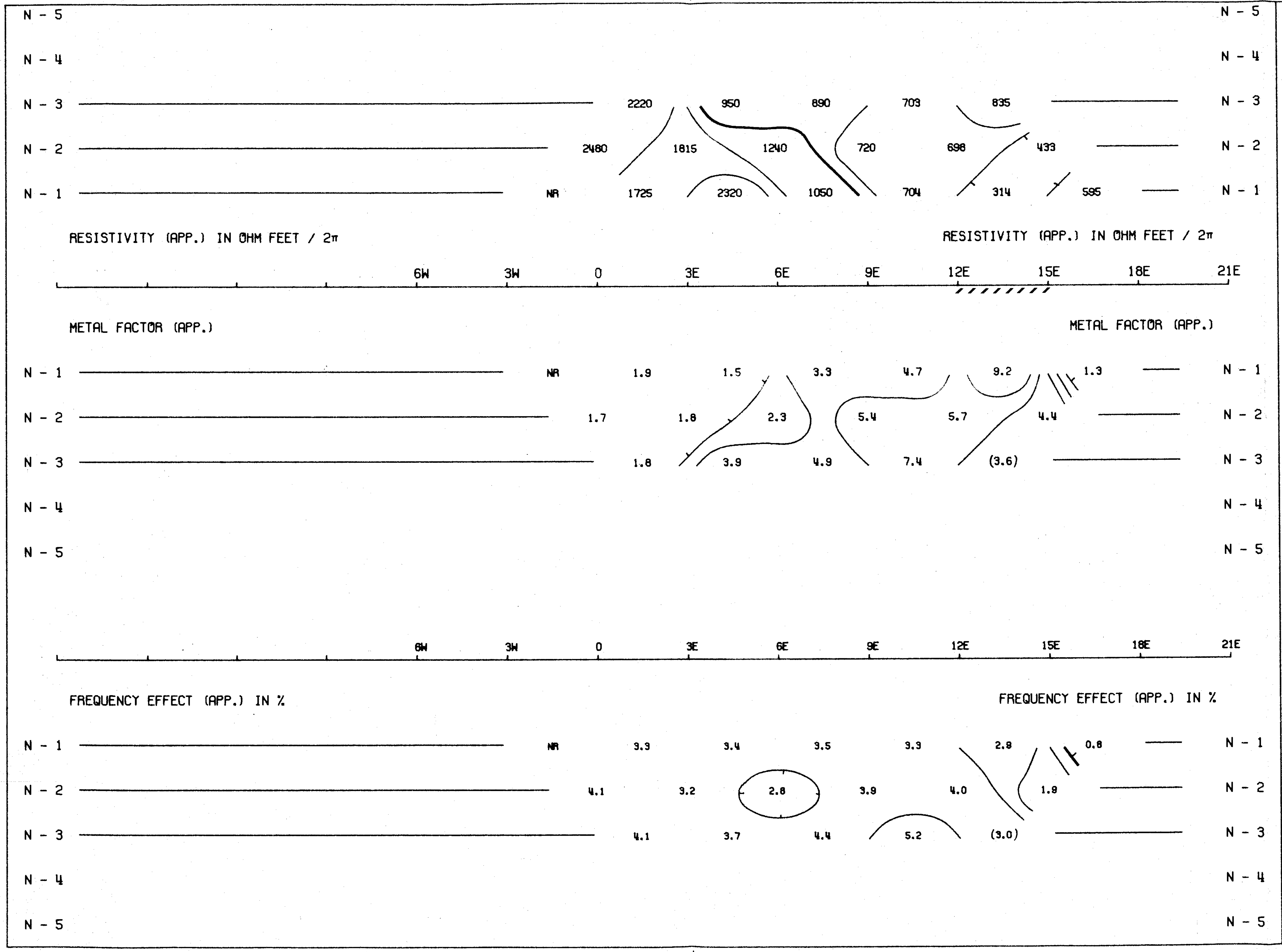

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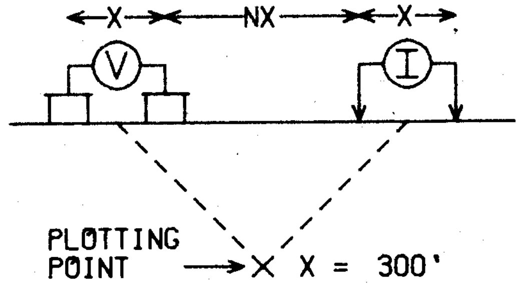
LINE NO.- 7N

ELECTRODE CONFIGURATION



SURFACE PROJECTION OF ANOMALOUS ZONES

DEFINITE ▬▬▬

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

POSSIBLE / / / / /

FREQUENCIES: 0.31-5.0 HZ

DATE SURVEYED: JUL 1971

APPROVED: P. G. Hallof

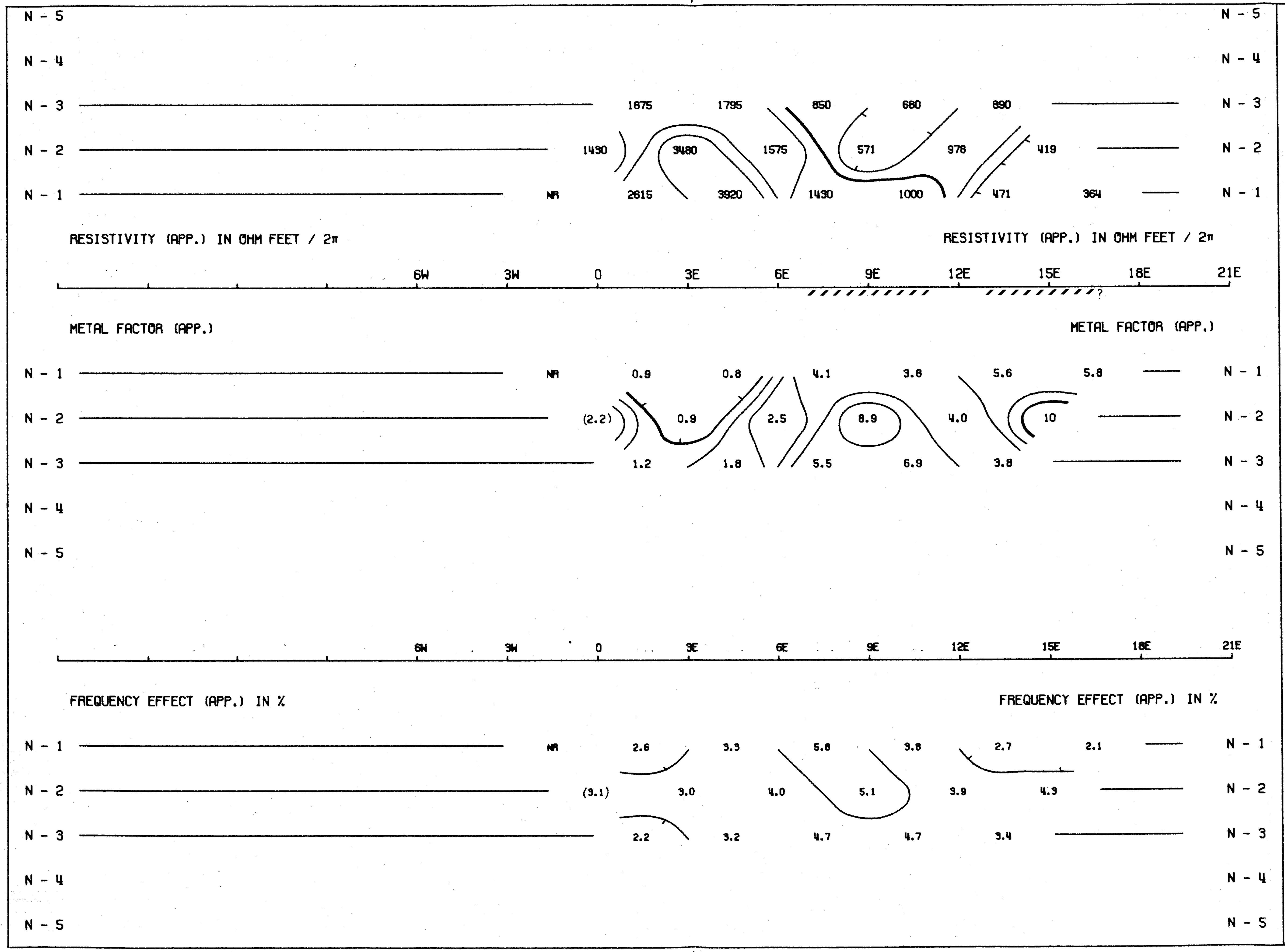
DATE: 8/20/71

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

McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY

NOTE: THIS PLOT WAS PRODUCED WITH AN IBM 360/65 COMPUTER AND A CALCOMP PLOTTER



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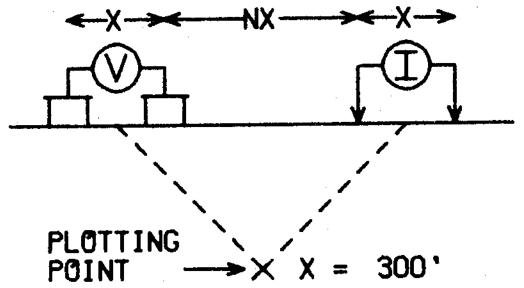
LINE NO.- 3.5N

ELECTRODE CONFIGURATION



SURFACE PROJECTION OF ANOMALOUS ZONES

DEFINITE
PROBABLE
POSSIBLE

FREQUENCIES: 0.31-5.0 HZ

DATE SURVEYED: JUL 1971

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DATE: 8/26/71

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

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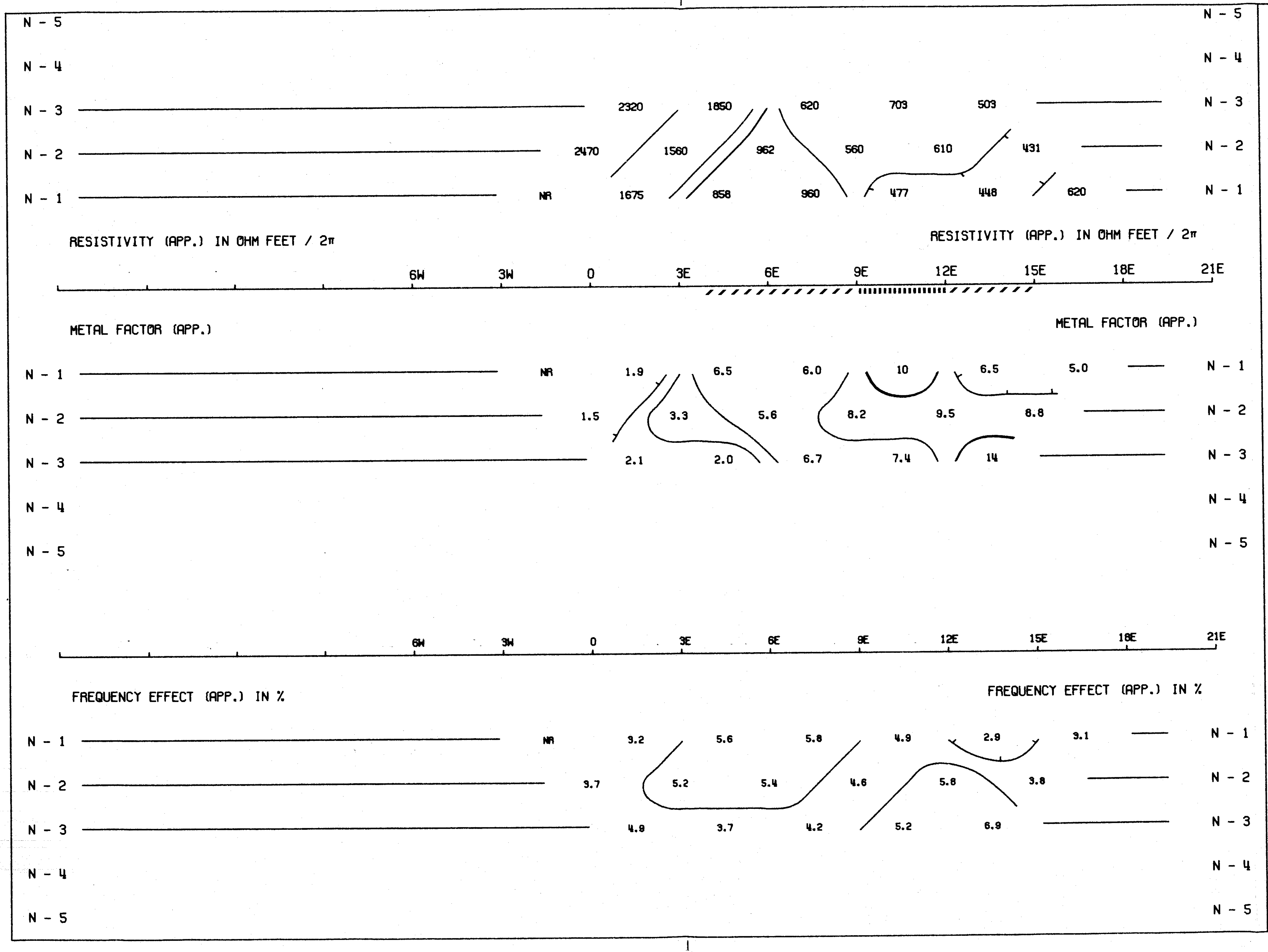
INDUCED POLARIZATION AND RESISTIVITY SURVEY

NOTE: THIS PLOT WAS PRODUCED WITH AN IBM 360/65 COMPUTER AND A CALCOMP PLOTTER



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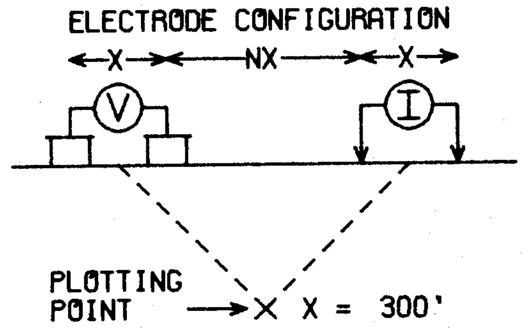
LINE NO.- 0



SURFACE PROJECTION OF ANOMALOUS ZONES

DEFINITE
PROBABLE
POSSIBLE

FREQUENCIES: 0.31-5.0 HZ

DATE SURVEYED: JUL 1971

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DATE: 8/Feb/71

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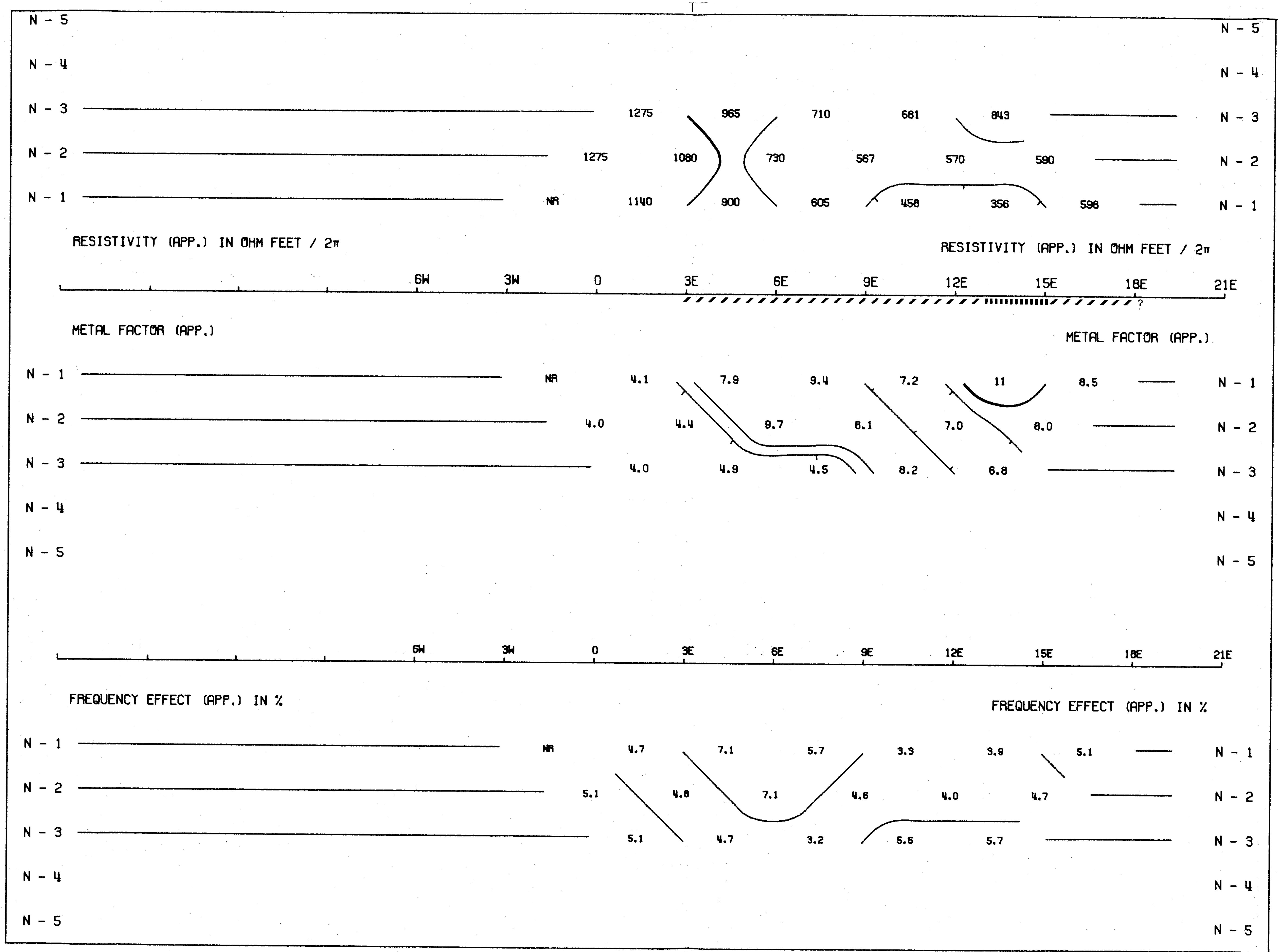
McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY

NOTE: THIS PLOT WAS PRODUCED WITH AN IBM 360/65 COMPUTER AND A CALCOMP PLOTTER



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LINE NO.- 4.5S

ELECTRODE CONFIGURATION

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V I

PLOTTING POINT → X X = 300'

SURFACE PROJECTION OF ANOMALOUS ZONES

DEFINITE
PROBABLE
POSSIBLE

FREQUENCIES: 0.31-5.0 HZ

DATE SURVEYED: JUL 1971

APPROVED:

DATE: 8/20/71

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Expiry Date: February 25, 1972

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

McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY

NOTE: THIS PLOT WAS PRODUCED WITH AN IBM 360/65 COMPUTER AND A CALCOMP PLOTTER

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Department of Mines and Petroleum Resources
ASSESSMENT REPORT
NO 3265 MAP #1

McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY

PLAN MAP

SURFACE PROJECTION OF ANOMALOUS ZONES

DEFINITE

PROBABLE

POSSIBLE

Numbers at the end of the anomalies indicate electrode interval

CORDILLERAN ENGINEERING LTD.

J.K. CLAIM GROUP, TOODOGGONE RIVER AREA

OMINECA M.D., B.C.

SCALE

ONE INCH EQUALS FOUR HUNDRED FEET

I.P. ANOMALOUS ZONE

DRAWN: P.A.T.

DATE: AUG. 1971

APPROVED:

DATE: 8/20/71

PROFESSIONAL ENGINEER, PROVINCE OF BRITISH COLUMBIA, P. G. HALLOF
Expiry date: February 25, 1972

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