0590 0011

270 Item 14

HEINRICHS

GEOEX

270 Item

GEOPHYSICAL ENGINEERS
TUCSON, ARIZONA

0590 0011

INDUCED POLARIZATION SURVEY

BUG PROPERTY

PERSHING COUNTY, NEVADA

For

Cerro Mineral Exploration Company

October 1968

By

Heinrichs Geoexploration Company
P. O. Box 5671 Tucson, Arizona 85703
Phone: 623-0578 Area Code: 602

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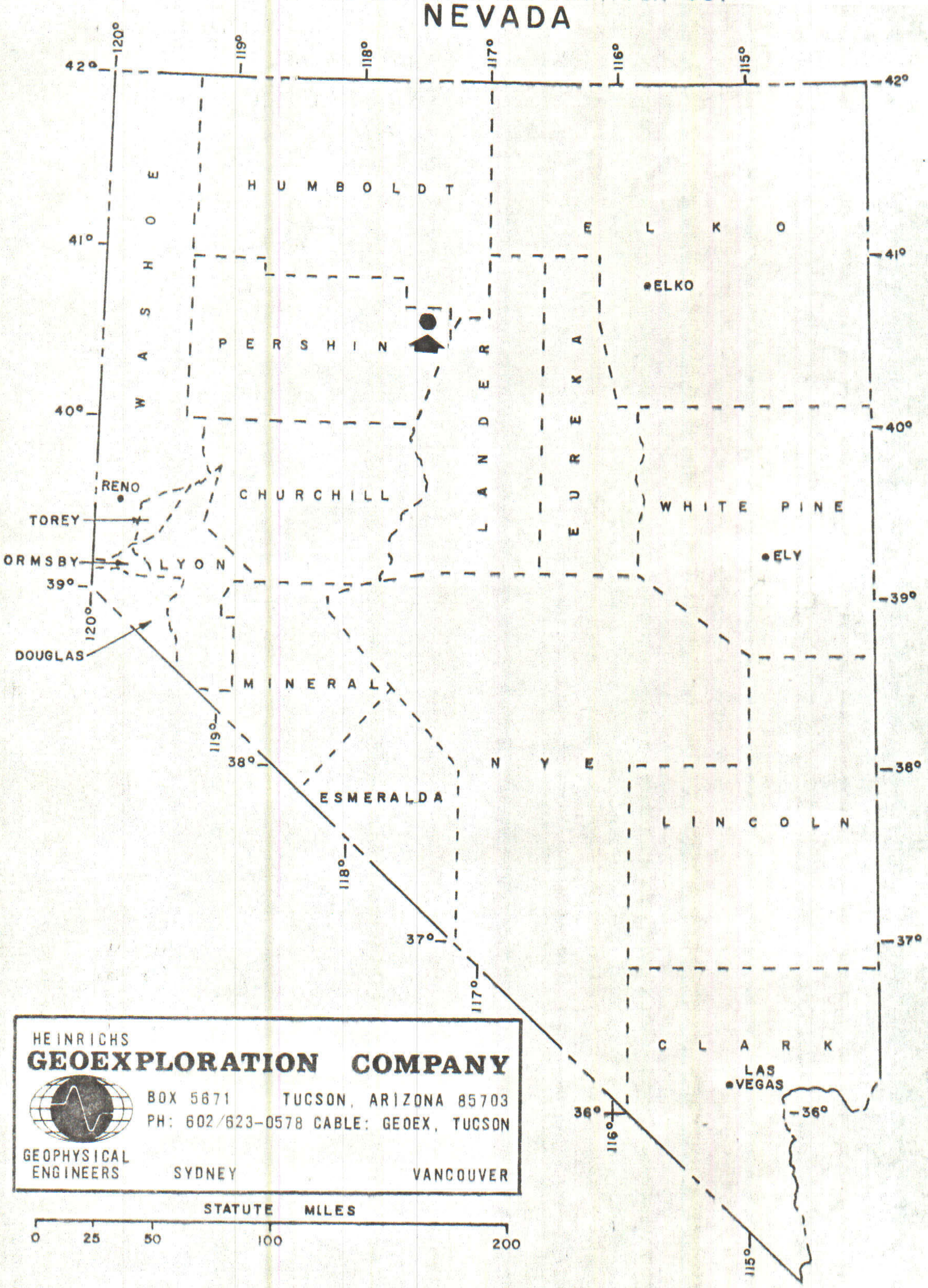
GENERAL LOCATION OF
BUG GROUP CLAIM AREA
for
CERRO MINERAL EXPLORATION CO.
NEVADA



INTRODUCTION

At the request of Cerro Mineral Exploration Company, Heinrichs Geoexploration Company, conducted a preliminary reconnaissance induced polarization survey on the Bug Property, Pershing County, Nevada, during October 29-30, 1968.

Two induced polarization lines were surveyed, consisting of two spreads, giving a total surface coverage of 6,000 feet, of which 3,500 feet is subsurface plotted data. Lines 1 and 2 are oriented N 55° E and spaced 1,500 feet apart with a 250 foot dipole spacing.

The selection of a 250 foot dipole spacing was to give detailed information down to 300 feet in the vicinity of reported slight surface geochemical anomalies.

The induced polarization measurements were made with the dual frequence technique, on a dipole-dipole electrode configuration. Frequencies used were 0.1 and 3.0 hertz.

Equipment used for this work was a Geoex Mark 7 sender and a Mark 3 receiver.

The data are presented on sectional data sheets, one for each line, showing resistivity, percent frequence effect (PFE), and metallic conduction factor (MCF), contoured in section with self potential (SP) in profile form. An induced polarization location and interpretation plan is also included.

Heinrichs personnel involved in the field work were Bill Rasmussen, crew chief, Tony Silva, technical assistant. Interpretation, compilation and report by Bill Rasmussen, Paul Head, and the Geoex, Tucson staff.

The cooperation and assistance provided by Cerro and Big Mike personnel, particularly Mr. Ward Crithers, Jay Santos, and Bill Wegman is most appreciated.

CONCLUSIONS AND RECOMMENDATIONS

1. A zone of moderate to weak anomalism was located on Line 1 which might have as its cause a mineralized fault along with some polarizing body at 2.5 SW.

2. A weak anomalism was located on Line 2 at 1.0 NE quite close to the surface (50-150 feet).

3. Both lines have resistivity interfaces close to their centers with lower resistive material to the SW. The SW material on Line 1 however, shows more electrical polarizability than the SW material on Line 2.

4. Self potentials show only background variations, indicating no significant concentrations of near surface oxidizing sulfides along both I. P. lines.

5. No further geophysics is suggested pending some other positive geological encouragement or needed answers.

INTERPRETATION

Line 1

This line shows a moderate anomaly beginning at 5.0 SW and continuing to 1.25 SW where it changes its character to weak up to 2.5 NE. There is a fairly marked resistivity interface at 0.0 SW/NE. This interface may be due in part to polarizable conductive alluvium to the SW of center. The moderate anomaly lies in the lower resistivity media to the SW. The anomalism may be due in part to possible mineralization along the interface with another cause being some polarizing body about 200 +/- 100 feet below 2.5 SW.

Only background variations are seen in the self potentials which imply no, or little, oxidizing sulfides near surface.

Line 2

This line shows a weak anomalism beginning at 2.5 SW and extending NE an indefinite amount to perhaps 5.0 NE. There is a resistivity interface at 2.5 SW. On this line the lower resistive (SW) portion of the line does not show generally higher PFE's than the higher resistive (NE) part as is seen on Line 1, possibly implying deepening alluvium to the SW. The metallic conduction factors however do show a somewhat higher trend to the SW but this is probably due to the lower resistivity in this area. One cause of the anomalism seems quite shallow (approximately 50-150 feet) below 1.0 NE.

Only background variations are seen in the self potentials.

Respectfully submitted,

HEINRICHS GEOEXPLORATION COMPANY

William O. Rasmussen

William O. Rasmussen
Geophysicist

APPROVED: W. E. Heinrichs Jr.
Walter E. Heinrichs, Jr.
President & General Manager

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BASIS OF THE INDUCED POLARIZATION METHOD

The induced polarization method is based on the electrical properties exhibited by electronic or metallic conductors embedded in an ionic or electrolytic conducting matrix. These properties are noticed in that the potential across a block of this dual conduction mode material will increase with time, approaching a constant value, when a constant current is made to flow through the block. This phenomenon occurs because at the boundaries between the two conductor types, electrolytic ions have to give up or take on electrons thereby requiring an additional force (overvoltage) over that which would be needed with only one mode of conduction; showing up as a building of potential across the block with time as more ions are backed up. This potential approaches a constant value when an equilibrium is established between the ions backed up at the boundaries and those flowing across the boundaries. Therefore, from the preceeding discussion, it is seen that the gross effect is quite similar to the charging of a leaky capacitor and for most applications, it is proper to use this model as a guide. These capacitive-like properties are normally measured by one of three different field techniques.

In the time domain (pulse) method, a steady direct current is imposed in the ground for a few seconds and abruptly terminated so that the resulting capacitive-like voltage decay (discharge) curve can be measured or recorded. Usually, the voltage decay curve is integrated with respect to time to give the area under the decay curve in units of volt-seconds. This value is then normalized by the primary voltage measured while the steady current is on. The more area determined, the more capacitance or polarization the ground exhibits.

In the frequency domain (dual frequency) method, the percentage difference between the impedance (AC resistance) offered to a lower and higher frequency is measured. A capacitor offers a lower impedance to a higher frequency than it does to a lower frequency, therefore, the percentage difference between the impedances will increase with increased polarization.

A third technique is to measure the phase angle or delay between an introduced current wave-form and the received voltage wave. This phase delay also increases as polarization increases.

Almost all metallic lustered minerals, including most sulfides, for example: pyrite, chalcopyrite, chalcocite, bornite, and molybdenite are electrical conductors. The rocks and groundwater, with which they permeate or are permeated, are also ionic conductors; therefore, if an electrical current is made to flow through a sulfide deposit, it will polarize and often can be detected by the three methods described above.

The induced polarization property is not entirely unique with sulfides since magnetite, graphite (which are both metallic lustered) and some clays will exhibit it; however, with sufficient geological and geophysical data, effects due to sulfides can generally be interpreted apart from non-sulfide anomalism. The type of sulfide however, say pyrite, as distinct from chalcopyrite, cannot yet be distinguished with present induced polarization techniques since all types give quite similar response.

The I.P. technique was developed primarily for porphyry type deposits and is perhaps the only reliable means of detecting hidden disseminated sulfides. However, the I.P. method works just as well or perhaps better on semi-massive to massive sulfides, contrary to some of the earlier thinking, for it generally gives increased response with increased volume percentage of sulfide.

FIELD TECHNIQUES AND INTERPRETATION

For routine exploration, we prefer and use the dual frequency system because of its greater simplicity of instrumentation, operation, and greater accuracy as well as simplicity of interpretation. However, all three methods give basically the same results and the choice is either a matter of opinion or highly technical reasons and therefore should be left to the particular application and the geophysicist's discretion.

The two frequencies we most commonly use are 0.05 and 3.0 cycles per second, or so called "D.C." and "A.C." modes respectively. Other frequencies are available with our equipment and are occasionally used when desired. The usual frequency range used is from about 0.01 cps to 10 cps. The lower frequency limit is due to naturally existing, time-varying, telluric (natural earth) currents, and electrode polarization. The upper limit is determined by electromagnetic coupling effects which increase rapidly with increasing frequency.

In our standard reconnaissance field practice, five equally spaced collinear current electrodes are placed in the ground by burying aluminum foil in pits wetted with brine to insure good electrical contact. Observations are made using a symmetrical dipole-dipole electrode configuration where the distance (a) between adjacent receiver (potential) electrode pairs (or dipoles) is kept equal to the distance between adjacent sender (or current) electrode pairs. Generally the receiving dipole is separated by one to six dipole units ("n" separation) from the sending dipole. Figures 1 and 2 indicate this configuration and resulting data plotting positions. A precisely controlled square wave current is sent through a sending dipole at 0.05 and 3.0 cycles per second from which, at the receiving dipole, a "D.C." and an "A.C." voltage is measured respectively. By knowing the geometry involved (the dipole length or spacing and the separation distance between the two receiving-sending dipole pairs), along with the two voltages, an apparent "D.C." and an "A.C." resistivity can be calculated. From these apparent resistivities, their percentage difference is determined, thus giving the Percent Frequency Effect (PFE). A third quantity porportional to PFE and inversely porportional to "D.C." resistivity, called Metallic Conduction Factor (MCF) is computed in order to somewhat normalize PFE for variations in ground conductivity purely as a technical interpretational aid. Formulas for these various quantities are given on page 5.

Selection of electrode spacings [(a) in Fig. 1] is determined by the objectives to be reached in a given survey. This spacing will range from very small (50 ft. or less) for very detailed and shallow surveys, up to 1,000 ft., or occasionally more, for broad, deep reconnaissance work. Other factors involved in the selection of spacing are concerned with the anticipated physical geometry of any possibly existing mineral occurrence. This includes consideration of expected depth of burial to the top of the deposit, the dimensions of the deposit itself, its orientation, strike and dip, etc., as well as its expected electrical properties.

In general, the greater the dipole spacing and "n" separation, the greater the depth penetration and the less the resolution. An average rule of thumb, with a good contrast of electrical properties, using the symmetrical co-linear dipole-dipole system, and having data from 1 through 4 in "n" separations, is that two times the dipole length is the maximum depth of detectable penetration for a body having two or three of its dimensions large in relation to the dipole spacing. However, a body having two or three of its dimensions less than the dipole spacing, and buried more than one spacing probably will not be detectable. A zone, regardless of orientation, having a dimension less than 0.1 the dipole spacing likely will not be detected. Also, zones differing by less than about 30% in electrical conductivity will not be very easily resolved by resistivity measurements, but may still be detected if a polarization contrast exists.

To illustrate the above in more concrete terms, consider a dipole spacing of 1,000 ft. for the following: An overburden of more than 2,000 ft. would likely not allow enough current penetration into bedrock to detect even a large and highly mineralized zone in the bedrock. Also, a sulfide zone lying completely within 200 ft. of the surface generally would not be detected. A spherical or elongated cylindrical body whose diameter is much less than 1,000 ft. would be just out of the range of detectability. A dike-like or sill-like zone whose width is less than

100 ft. probably would not be detected regardless of how it lies relative to the spread.

So far, only the maximum and minimum limits of detection and resolution relative to the various geological and geometrical configurations have been discussed, thus omitting optimum conditions. Generally, we attempt to make the dipole spacing one or two times the expected depth to the target in order to obtain a good electrical response. Of course, where it is suspected that the zone has a good depth extent, say two or three dipole spacings, as is typical of most porphyry type copper deposits, a spacing considerably more than two times the expected depth to sub-outcrop can be used to obtain broader and more rapid coverage, as long as we do not exceed the width. Because of these factors, we usually use 500 to 1,000 ft. dipole spacings in prospecting for porphyry-type deposits.

The field data are interpreted after plotting the PFE, MCF and resistivity as in Figures 1 and 2. These values are then contoured in sections, the resistivity and metallic conduction factor logarithmically (because of the usual large variations in magnitude) and the percent frequency effect on a constant interval. This two dimensional method of plotting gives an additional advantage over the standard profile methods in that easily recognizable patterns are associated with various subsurface geometrical configurations and that lateral variations can be separated from vertical effects. See the four appended examples of plotted field and theoretical sectional data sheets.

It should be realized that there is no definite relation between the vertical scale on these plots and actual subsurface depth. The data point values are a complexly weighted average of the electrical contrast distribution in the vicinity of the sending-receiving dipole pair and contain depth as well as lateral information. About all that can be said is that by increasing the dipole length and the dipole separation ("n" separation) more volume of ground is being affected and therefore more depth penetration.

There are cases where the depth to a subsurface feature can be determined fairly precisely as in the two horizontal layer situation. The field data is compared with theoretical type curves for various resistivity contrasts between the top and bottom layer and various thickness of the top layer until a close match is found. This enables the depth to the bottom layer in the field to be determined as well as the true resistivity of both layers. A major limitation of this interpretational technique is that only a few simple geometric cases related to a relatively few numbers of layers have been theorectically developed. However, extremely valuable information can still be derived in alluvial and lake bed applications for depth to bedrock and groundwater purposes, etc.

In interpreting PFE's, values of 0 to 4% are usually considered background, 4 to 8% marginally anomalous, and 8 to 40% plus definitely anomalous, but they must be considered in light of the associated resistivity. Very low resistivities give an increased background frequency effect due to an electromagnetic inductive coupling interference phenomenon that must be corrected for. The MCF tends to correct any high resistivity increased background effects, but tends to amplify the electromagnetic frequency effects making a correction imperative.

<u>FORMULAS</u>: $PFE = [\rho_{dc}/\rho_{ac}-1]\ 100$

Where PFE is Percent Frequency Effect, ρ_{dc} is the apparent resistivity at the lower frequency and ρ_{ac} is the higher frequency apparent resistivity.

$$\rho = 2\pi V K_n / I$$

Where ρ is either ρ_{dc} or ρ_{ac} depending on frequency of the current I which is measured in amperes. The potential V, arising from I, is measured in volts. K_n is the geometric factor given by:

$$K_n = \tfrac{1}{2}an(n+1)(n+2) \quad \text{(Only for dipole-dipole arrays.)}$$

Where "a" is the dipole spacing in feet and "n" is the number of dipoles separating the sending and receiving dipoles; this gives, for apparent resistivity:

$$\rho = [2\pi V/I][\tfrac{1}{2}an(n+1)(n+2)]$$

from which we see that ρ is in units of ohm-feet. However, the apparent resistivity usually is plotted: $\rho/2\pi$

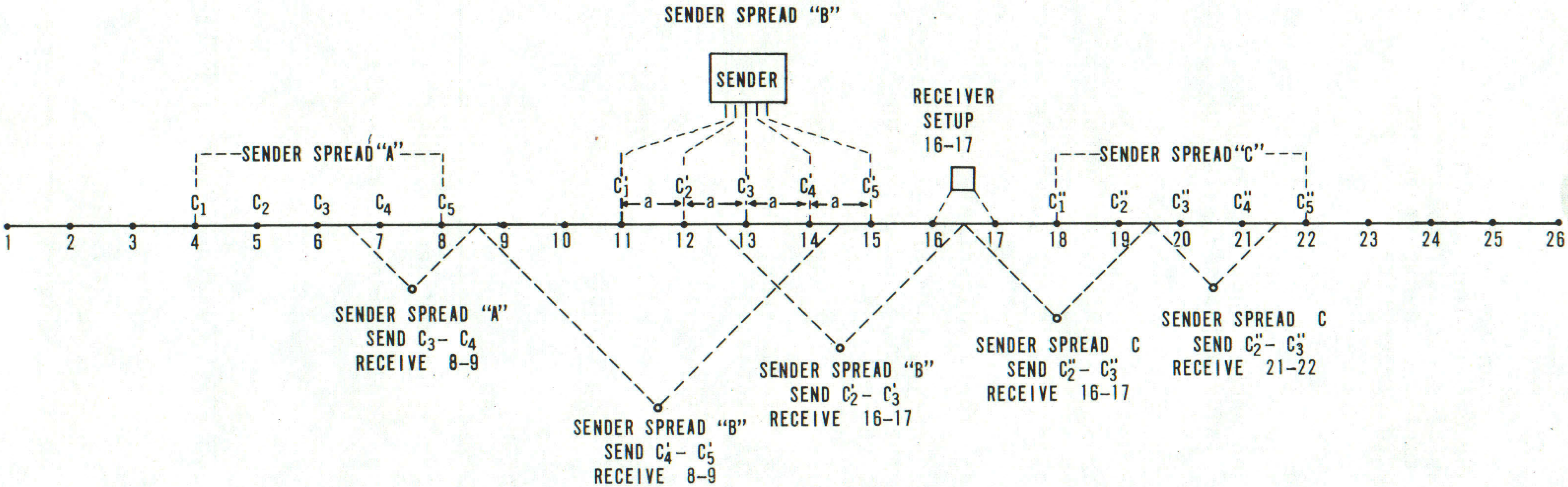
$$\rho/2\pi = VK_n/I = [V/I][\tfrac{1}{2}an\ (n+1)(n+2)]$$

$$MCF = 1000 \times PFE/[\rho_{dc}/2\pi]$$

Where MCF is the Metallic Conduction Factor and $\rho_{dc}/2\pi$ is apparent "D.C." resistivity.

References:
1. Wait, James R., "Overvoltage Research and Geophysical Applications", Pergamon Press, 1959.
2. "Mining Geophysics", Society of Exploration Geophysicists, Vol. I, Case Histories, October 1966.

Published by W. E. Heinrichs, Jr., et al., Engineering and Mining Journal, September 1967.



SCHEMATIC DIAGRAM ILLUSTRATING THE METHOD OF OBTAINING AND PLOTTING DIPOLE-DIPOLE I.P. DATA

Diagram shows three separate current electrode spreads along a traverse line. In normal procedure, there are three dipole separations between current electrode spreads. The receiver setups are moved outwards from the ends of each current electrode spread usually until three dipole spacings separate the potential electrode setup from the near end of the spread. Current is "sent" to each possible pair of electrodes for each receiver setup. For instance, in Sender Spread "B" when the receiver setup is between 14 and 15 only $C'_3 - C'_2$ and $C'_2 - C'_1$ can be "sent" so that data at 1 and 2 dipole separations is obtained respectively When the receiver is setup between 16 and 17; $C'_5 - C'_4$, $C'_4 - C'_3$, $C'_3 - C'_2$ and $C'_1 - C'_2$ are sent and data is obtained for 3, 4, 5 and 6 dipole separations respectively. Each sender spread provides 33 data points.

Fig. 1

(DATA POINTS OBTAINED FROM THE THREE SPREADS OF FIGURE 1)

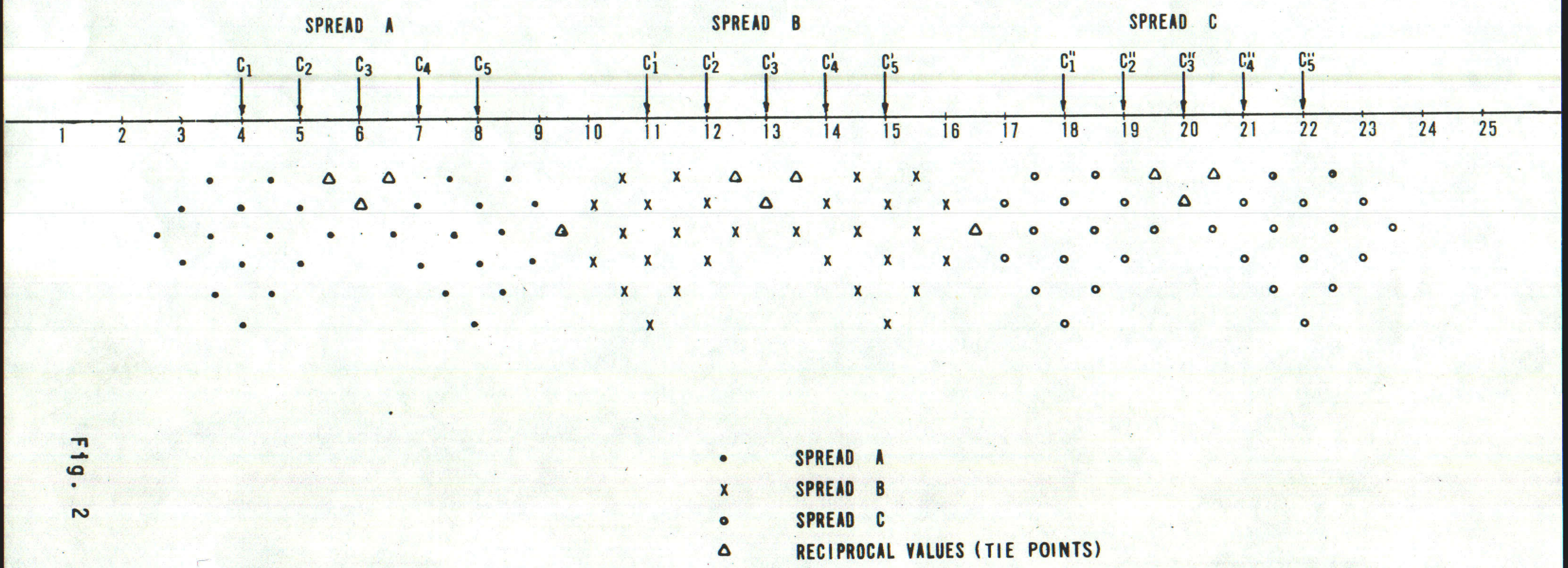
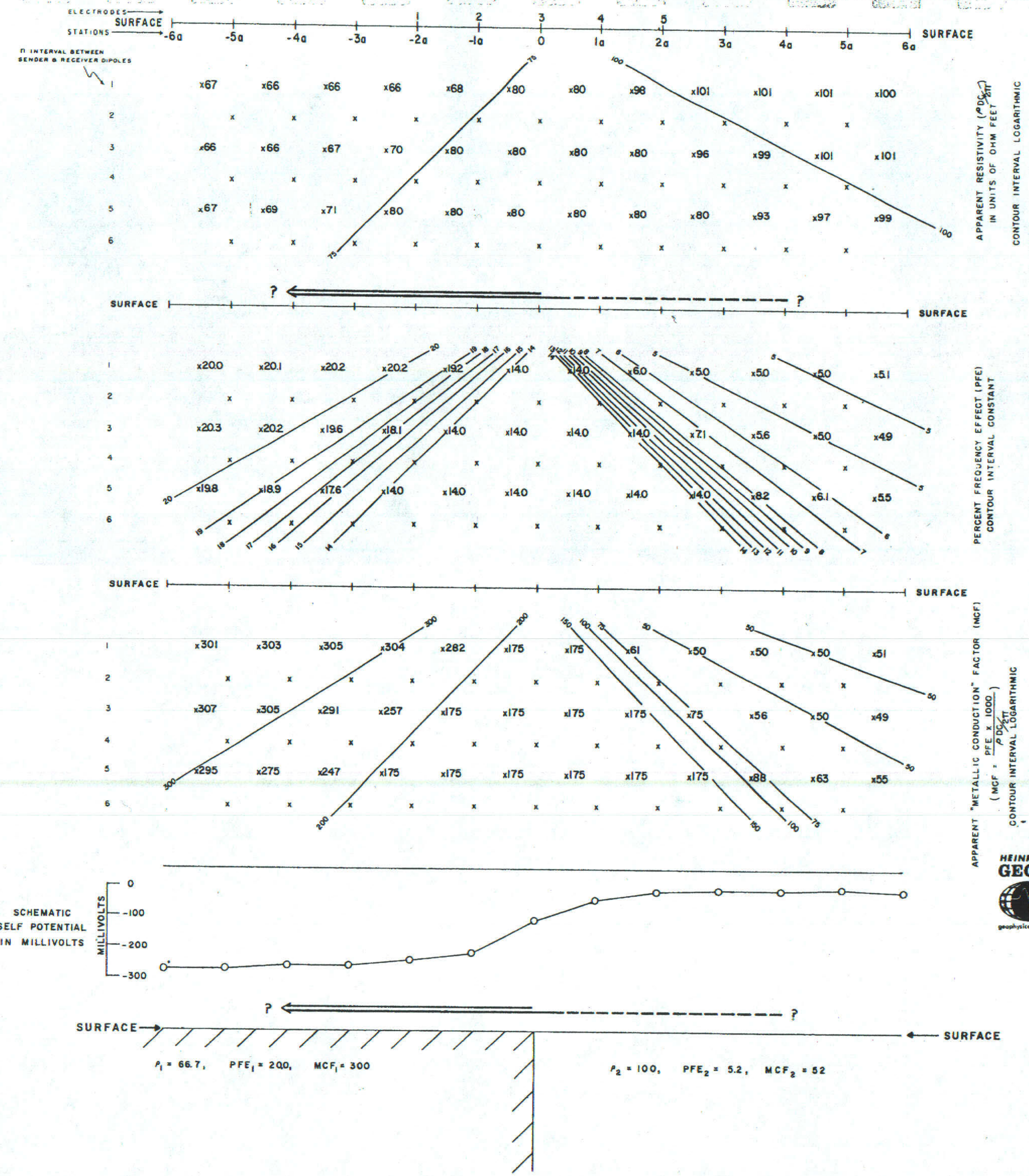
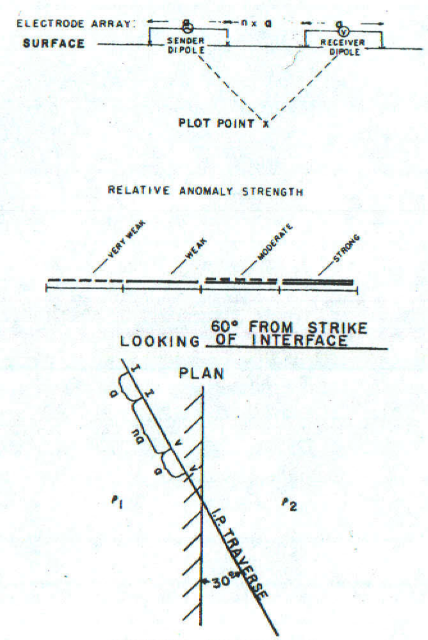


Fig. 2



EXPLANATION



VERTICAL INTERFACE

SECTIONAL DATA SHEET

LINE NO. ——

INDUCED POLARIZATION TRAVERSE

SCALE: 1" = a DATE: ——

FOR ——

HEINRICHS
GEOEXPLORATION COMPANY
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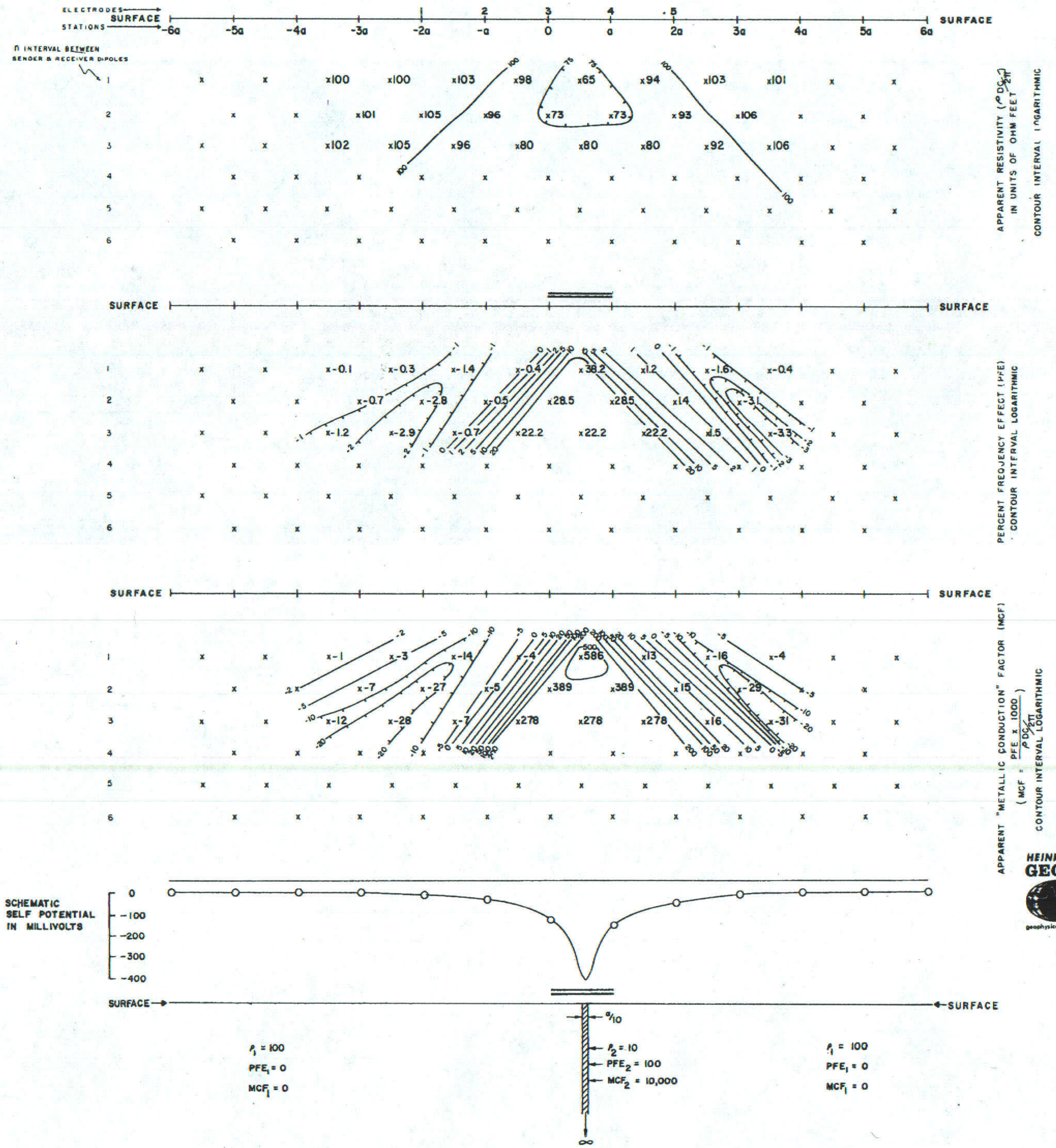
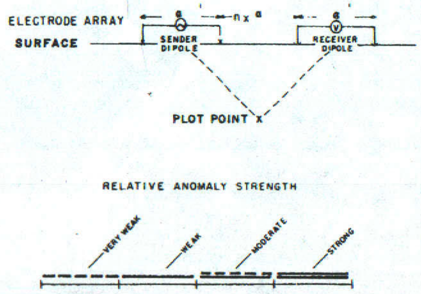
geophysical engineers
vancouver
sydney

THEORETICAL INDUCED POLARIZATION TRAVERSE ACROSS A VERTICAL INTERFACE AT 30° – DIPOLE-DIPOLE ELECTRODE ARRAY.



EXPLANATION



LOOKING NORMAL TO STRIKE

VERTICAL
TABULAR BODY

SECTIONAL DATA SHEET

LINE NO. ——

INDUCED POLARIZATION TRAVERSE

SCALE: 1" = a DATE: ——

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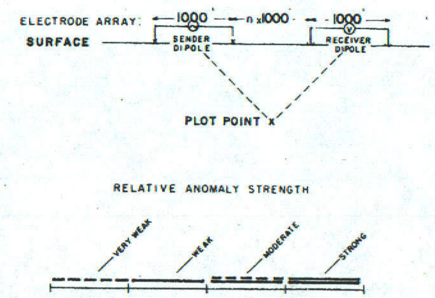
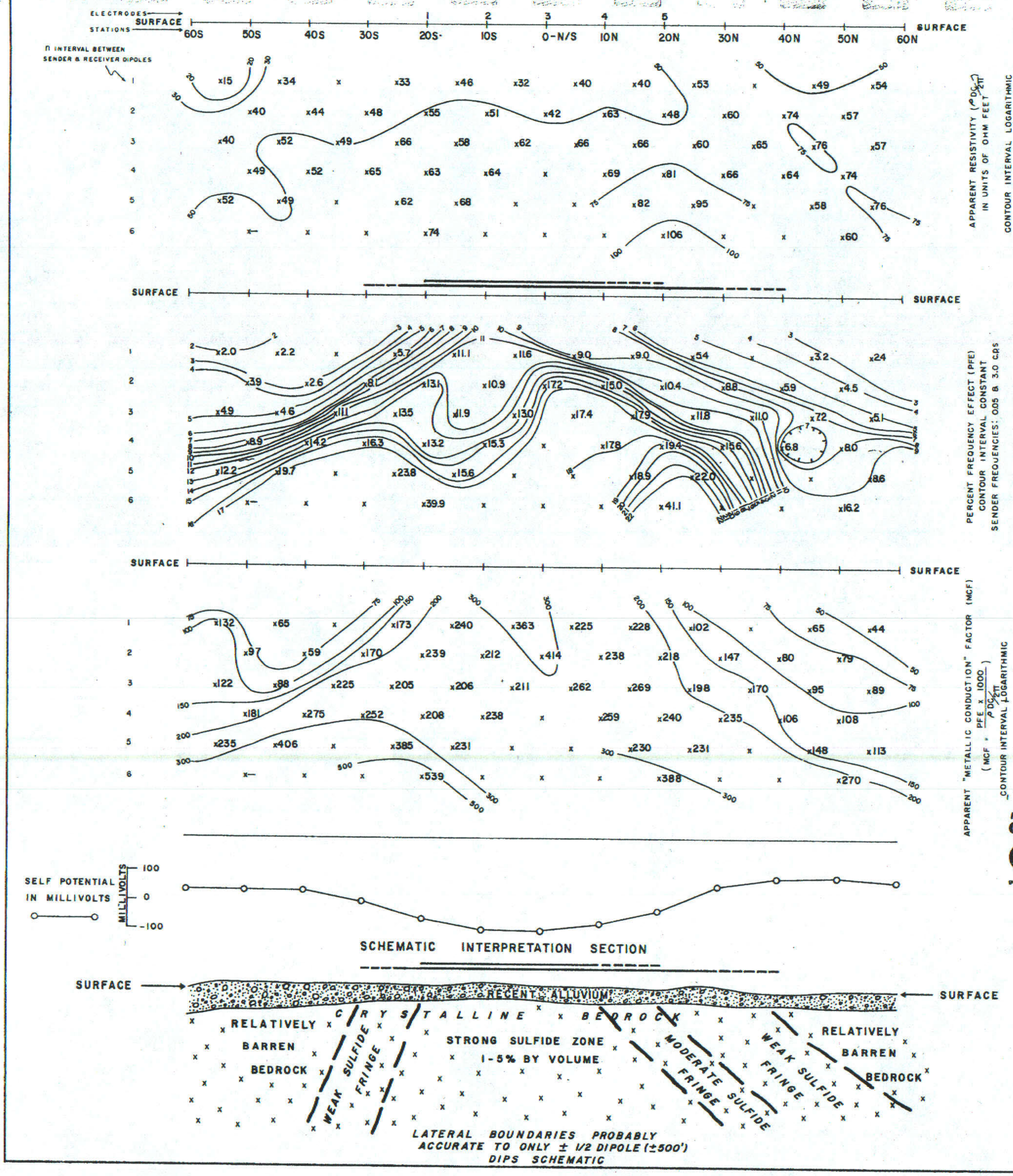
THEORETICAL DIPOLE-DIPOLE INDUCED POLARIZATION RESPONSE OVER A CONDUCTIVE VERTICAL TABULAR SULFIDE BODY CROSSED NORMAL TO THE STRIKE [HAVING A THICKNESS OF 1/10 THE ELECTRODE SPACING (a), A RESISTIVITY CONTRAST OF 10:1, A BACKGROUND RESISTIVITY (ρ_1) OF 100, A BACKGROUND PFE$_1$ OF 0, AND A PFE$_2$ OF 100 IN THE SULFIDE ZONE]

EXPLANATION



LOOKING WEST



PIMA MINING DISTRICT
PIMA COUNTY, ARIZONA

SECTIONAL DATA SHEET

LINE NO. —

INDUCED POLARIZATION TRAVERSE

SCALE: 1" = 1000' DATE: —

FOR ____________

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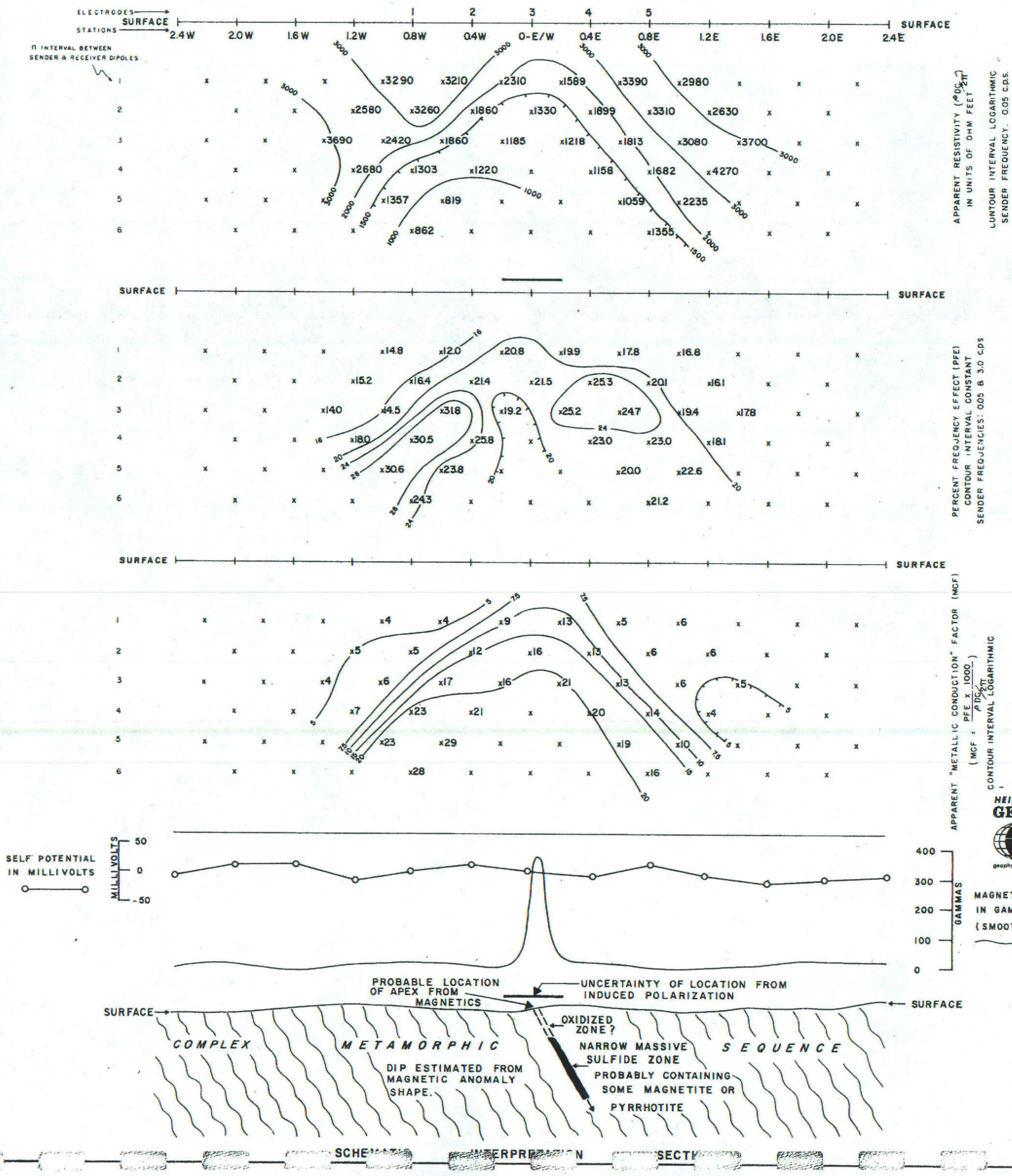
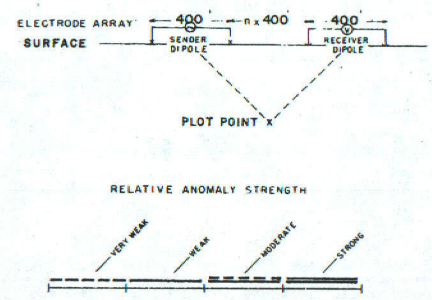
ACTUAL FIELD EXAMPLE OF INDUCED POLARIZATION TRAVERSE OVER DISSEMINATED PORPHYRY TYPE SULFIDE MINERALIZATION



EXPLANATION



LOOKING NORTH

MASSIVE SULFIDE VEIN
APPALACHIAN SULFIDE DISTRICT

SECTIONAL DATA SHEET
LINE NO. —
INDUCED POLARIZATION TRAVERSE

SCALE: 1" = 400'   DATE: —

FOR ______

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ACTUAL FIELD EXAMPLE OF COMBINED INDUCED POLARIZATION, RESISTIVITY, MAGNETIC AND SELF POTENTIAL SURVEY ACROSS A NARROW-STEEPLY DIPPING MASSIVE SULFIDE VEIN.

NOTE: INDUCED POLARIZATION ANOMALY ONLY INDICATES A STEEP BUT UNKNOWN DIP. DEPTH TO SULFIDES PROBABLY BETWEEN 200 AND 400 FEET BASED ON ROUNDED APPEARANCE OF INDUCED POLARIZATION ANOMALY AND LACK OF SELF POTENTIAL RESPONSE.

(270)

Item 14A

HEINRICHS GEOEXPLORATION COMPANY

806 WEST GRANT ROAD, TUCSON, ARIZONA, 85703. P.O. BOX 5671. PHONE: (AREA CODE 602) 623-0578

December 24, 1968

Mr. H. R. Craig, Jr.
Chief Exploration Geologist
Cerro Mineral Exploration Co.
300 Park Avenue
New York, New York 10022

Dear Mr. Craig:

Upon reviewing the interpretation of the Bug Property, Pershing County, Nevada, it has come to our attention that the Induced Polarization Line #1 is almost identical in character and only slightly weaker in response than the almost parallel Line L run over the main orebody on the Big Mike Prospect.

Due to this similarity in response we recommend that consideration be given to testing this target. The target seems to be 200 ± 100 feet in depth below the vicinity of 1.25 to 2.5 SW on Line 1. Because of this uncertainity in position and expected narrowness of the target an angle hole is recommended.

Assuming that the possible target on Line 1 of the Bug Property is dipping at about the same angle to the NE as the main orebody is dipping on Line L, a 500' long hole collared at 1.25 NE angled 45° or so to the SW should intersect the zone of interest at the proper depth. Point 103 on Line L appears to correspond to point 1.25 on Line 1 of the Bug Property for correlation purposes. ?

Your own information on the position of the orebody relative to Line L should give you a better idea of the position and angle of the hole to be drilled than could be given by us. Also, geologically you may have dip and strike information in the Bug Area that could further help spot a drill site.

No 103 - Means 108?

Seems to me a hole collared here would go over the top of any target. Suggest a western hole at about "2" NE

WC.

MINERAL ENGINEERING CONSULTANTS AND CONTRACTORS. GEOPHYSICAL, GEOLOGICAL AND ECONOMIC APPRAISALS.

All questions are welcome. Please keep us posted on progress on these prospects. Our best wishes for a Merry Christmas and a Prosperous New Year.

Very truly yours,

HEINRICHS GEOEXPLORATION COMPANY

William O. Rasmussen

Chris S. Ludwig

cc: Mr. Ward Carithers

WOR-CSL/plg


13
9
1
5
14
10
2
6
11
7
3
②
①
N
RELATIVE ANOMALY STRENGTH
VERY WEAK
WEAK
MODERATE
STRONG
I.P. LINE NO.
STATIONS
ELECTRODES
INTERFACE
HEINRICHS
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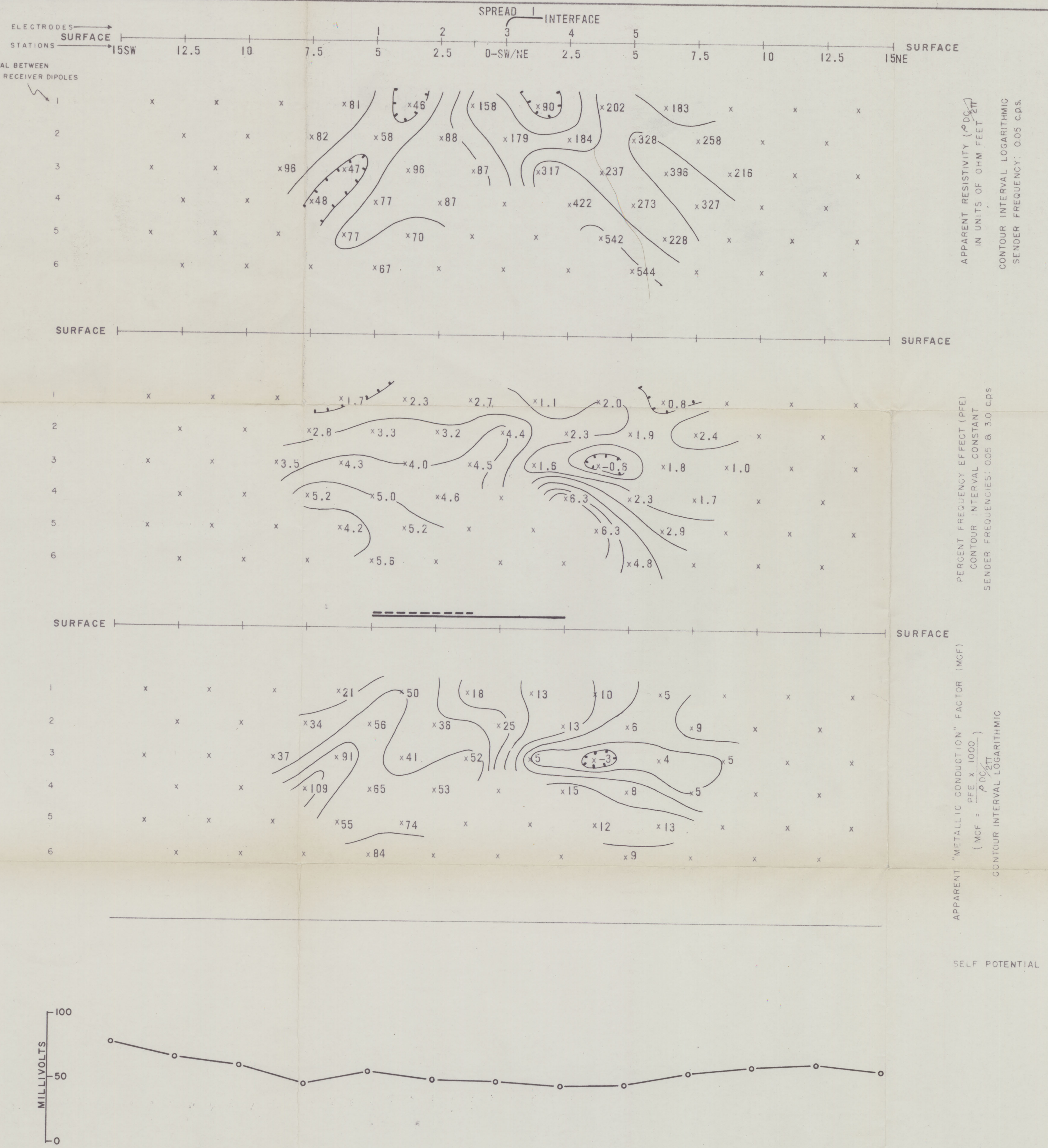
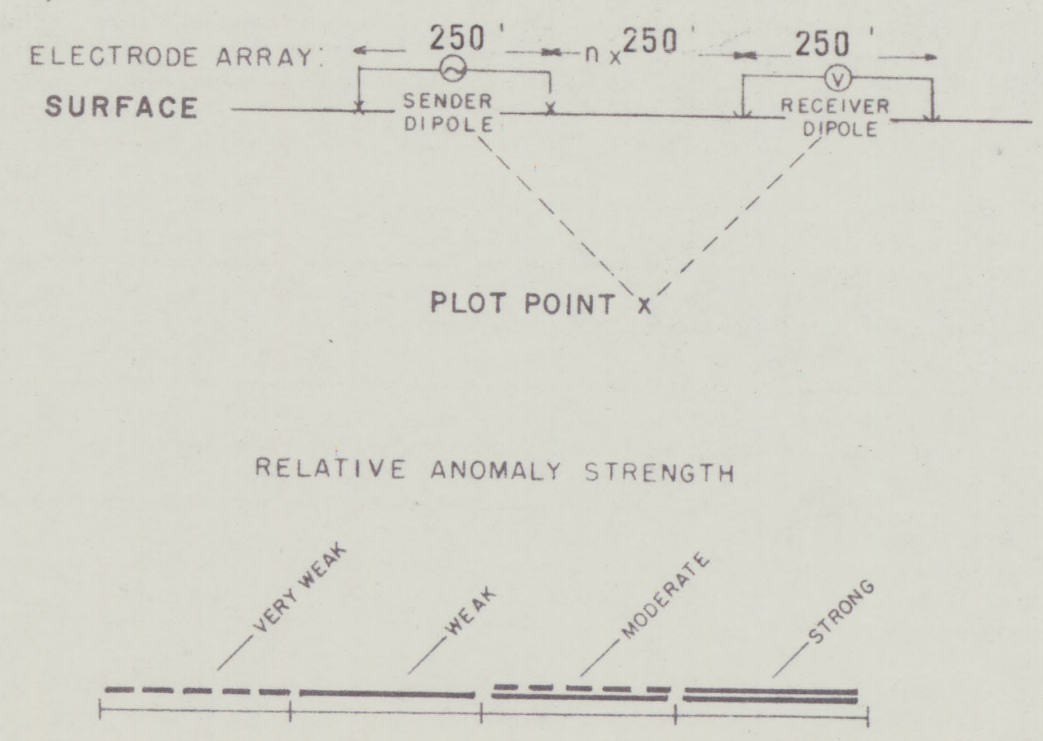
sydney
geophysical engineers
INDUCED POLARIZATION LOCATION AND INTERPRETATION PLAN
BUG GROUP AREA
PERSHING CO., NEVADA
FOR
CERRO MINERAL EXPLORATION CO.
SCALE: 1" = 200'
DRAWN BY: JAY DOWNS
DATE: NOV. 1968
REVISIONS
SURVEY BY
GEOLOGY BY
DRAWN
TRACED
DATE
CERRO CORPORATION
NEW YORK
BLOCK
DRAWING No.
SCALE —
COORD —
DATUM —

0590 0011





LOOKING N 35° W

BUG PROPERTY

SECTIONAL DATA SHEET

LINE NO. 1 (SPREAD 1)

INDUCED POLARIZATION TRAVERSE

HEINRICHS GEOEXPLORATION COMPANY

SCALE: 1" = 250'   DATE: OCT 1968

FOR

CERRO MINERAL EXPLORATION CO.

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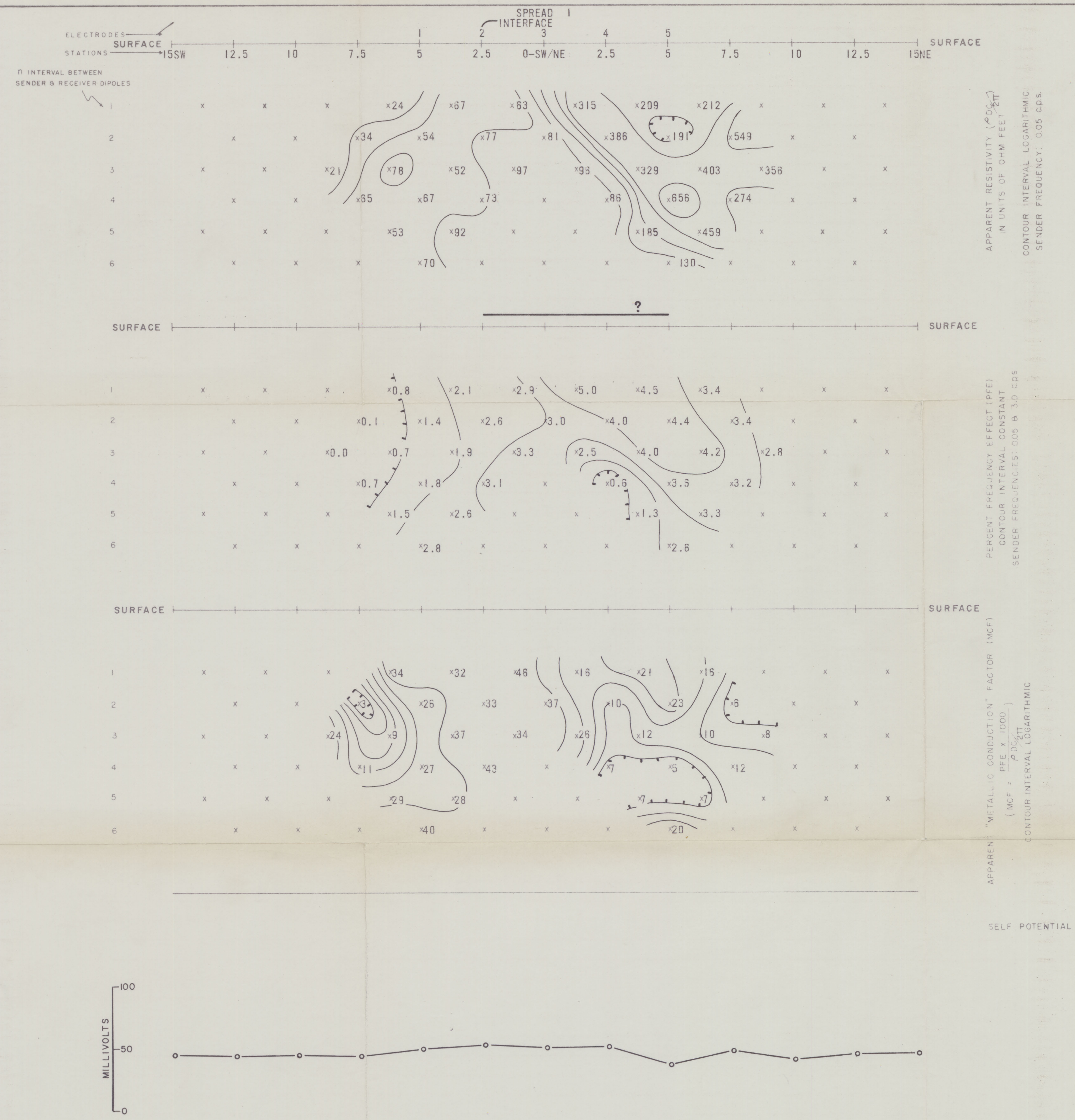
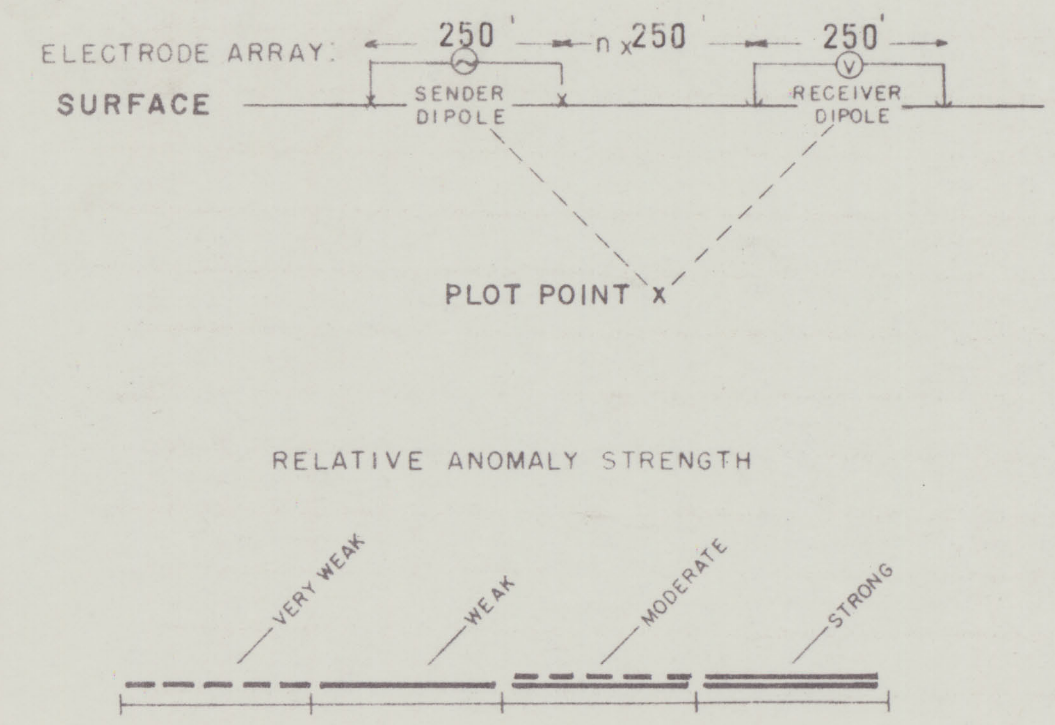


EXPLANATION



LOOKING N 35° W

BUG PROPERTY

SECTIONAL DATA SHEET

LINE NO. 2 (SPREAD I)

INDUCED POLARIZATION TRAVERSE

HEINRICHS GEOEXPLORATION COMPANY

SCALE: 1" = 250' DATE: OCT 1968

FOR

CERRO MINERAL EXPLORATION CO.

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