INDUCED POLARIZATION AND RESISTIVITY SURVEYS
ZENITH MINES
SENECA GROUP
HARRISON LAKE AREA, B.C.

Cominco - Aug 71

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EXPLORATION

WESTERN DISTRICT

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INDUCED POLARIZATION AND RESISTIVITY SURVEYS

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SENECA GROUP

HARRISON LAKE AREA, B.C.

August 11, 1971

Brian S. Williams

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SUMMARY

Five lines of I.P. and resistivity surveys were carried out on the Seneca Group of Zenith Mines Ltd. One line provided frequency-domain data to compare with time-domain data obtained by others in 1970; the two sets of data are found to be essentially similar. The other four lines extended an anomalous trend mapped over 2000 feet by the 1970 work for an additional 800 feet northward, although this trend appears to weaken to the north. Drill testing of this trend, using several short holes along strike, is warranted.

INTRODUCTION

The data reviewed in this report were obtained by R. Bye and other staff of Cominco Exploration in June 1971, using Cominco's frequency domain I.P. gear. One line, 14S, was surveyed to compare the present data with, and to help evaluate, a time-domain survey performed by Seigel Associates Ltd. in December, 1970, and four lines were surveyed off the northern end of the 1970 grid.

The present survey was severly hampered by and eventually curtailed due to rain. Moisture impregnated the electronics in the receiver during several days of operation in wet weather, after which the receiver drifted eratically and was not able to produce reliable data.

GEOLOGY

The Seneca property covers a section of the Harrison Lake Volcanic Belt, a 9,000 foot sequence of Middle Jurassic acid and intermediate volcanics. Shallow dipping massive sulphides are exposed in a pit on line 18S. The mineralization lies at the contact between overlying andesite and underlying acid volcanics and appears to be related to a volcanic vent as expressed by the coarse rhyolite breccia footwall.

Three holes drilled on a section 160 feet southeast of the pit encountered a 20 foot thick mineralized zone which is essentially flat-lying. The sulphides consist of pyrite, sphalerite, chalcopyrite and minor galena in a barite gangue. A typical assay over 19.5 feet was 2.78 oz/ton Ag, 2.15% Cu and 6.66% Zn.

Lateral continuity of this horizon is suggested by a 1970 I.P. survey which extends 400 feet along strike to the south, and at least 1800 feet along strike to the north of the pit.

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INDUCED POLARIZATION AND RESISTIVITY SURVEY

Method

These surveys used the McPhar frequency domain I.P. unit with the P654 model receiver. Traverses were carried out using dipole-dipole array with 50 foot dipoles except on line 8N which was surveyed with 100 foot dipoles. Four separations of the dipole were taken. The measurements were made using frequencies of 0.31 and 5.0 hertz.

Data Presentation

Included with this report are four plates and five data profiles drawn as pseudo-sections. These are listed below:

Plate 1 Plan of grid showing I.P. anomalies, at a scale of 1" = 200'.

Plate 2 Model I.P. response for shallow dipping body.

Plate 3 Topographic profile of Line 14S with proposed D.D. Holes.

Plate 4 Pulse-Type I.P. profiles on Line 14S by Seigel Associates.

Dwg. I.P.-70-1	Line 14S	50' Dipole
Dwg. I.P.-70-2	Line 2N	50' Dipole
Dwg. I.P.-70-3	Line 4N	50' Dipole
Dwg. I.P.-70-4	Line 6N	50' Dipole
Dwg. I.P.-70-5	Line 8N	100' Dipole

Results

Known mineralization in this survey area occurs in roughly stratiform bands about 20 feet thick which have a dip of between 20° and 40° to the east with respect to the ground surface, which rises to the east at an angle of about 20° in the survey area. Scale model experiments suggest what may be expected with such a source-receiver geometry. An example of the model results (plate 2) is included with this report. Assuming a 50 foot dipole, this scale model shows that an 11-foot wide dipping "dyke" of 165' down dip and 300' along strike extent with a true I.P. effect in the source of 25% F.E. produces a very broad irregular frequency effect pattern with peaks to 6% F.E. and weak negative values on the footwall side. This scale model suggests that the subcrop of causative bodies at Zenith might tend to be located toward the downhill edge of the anomalous responses, assuming mineralization at Zenith is at least roughly approximated by this model.

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A discussion of field results follows:

(i) Line 14S

This line was surveyed as an orientation and comparison line across anomalies detected by the Seigel Geophysics survey of 1970.

At the western end of the line a zone of high resistivities, and consequently higher than average frequency effects were measured from 10W to the end of the line. This zone probably represents either an extremely resistive lithology or surficial deposit that has been leached of conducting ions by the heavy rain. The very high resistivities, in the order of 20,000 ohm feet/2*, radiating west from 10 + 50W associated with a conjugate set of low resistivities are probably due to a shortened dipole from the 1970 line chaining.

Two anomalies were detected on this line. The major anomaly is large, for the dipole length, and occurs between 0 + 50W and 3 + 50W. The large width and irregular pattern of the frequency effect anomaly are characteristic of a shallow dipping source according to model work, although the anomaly is large the causitive body could be fairly narrow if dipping at the same shallow attitude as the local geology. There are two erratic frequency effects at 2 + 50W and these are believed to be due to poor contact in an old mine dump.

The smaller anomaly on this line occurs between 6 + 00W and 7 + 50W and again has a poor frequency effect pattern which is slightly asymmetrical. The reduced width of the anomaly indicates that it is due to a narrower source or a steeper dipping source than the other anomaly.

The sources of the anomalies, if dipping at a shallow angle into the hillside, would be expected to have their sub-crop fairly close to the western end of the horizontal projection of the anomaly, as indicated by the model work. Drilling on Line 14S is warranted as detailed in the recommendations and in Plate 3.

The Seigel 1970 I.P. data also indicates two anomalies on this line. The longer anomaly is between 3 + 50W and 2 + 50W, possibly extending as far as 1 + 50W, and is present on the 50', 100' and 200' arrays. The other anomaly lies between 6 + 50W and 7 + 50W and is present only on the 50' and 100' array data, suggesting that is is due to a thiner causative body than that which causes the larger anomaly. Thus it would appear that the pulse and frequency data are essentially similar, although the pulse data has twice the quantitative response of the frequency data, which is quite usual.

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(ii) Four lines, numbered 2, 4, 6 and 8N, were surveyed to the north of the 1970 grid. They show two possible anomalous zones.

The most persistent anomaly occurs on all four lines and is centred around 1 + 00E on each line. This anomaly shows poor frequency effect patterns on all the lines, the best pattern being on line 8N which was surveyed with 100 foot dipoles. The response on this line shows some asymmetry, the higher frequency effects on the expected up-dip, i.e. eastern side of the anomaly, this anomaly is also coincident with a resistivity low.

On line 2N the second anomaly shows a very broad anomaly for the dipole length that has its greatest frequency effects on the east side, agreeing with the geological model of a shallow dip of the source to the west. The anomaly is still strong on line 4N, though less broad. On line 6N, strongly negative readings that may be due to instrumental troubles are located along strike from the position of the second anomaly on the southerly two lines. On line 8N this trend may be present again, although the profile is not completed, and was obtained with the larger 100 foot dipole.

CONCLUSIONS

(i) Survey results with frequency domain gear are essentially similar to those obtained with the time-domain I.P. unit on line 14S.

(ii) An anomalous trend mapped over 2200 feet by Seigel in 1970 has been extended for a further 800 feet to the north on the basis of the present data.

(iii) Numerous showers and rainstorms affected the performance of the I.P. receiver, and eventually caused the survey to be curtailed.

RECOMMENDATIONS

(i) On line 14S two drill locations have been indicated, at the Baseline and, at 5 + 00W, as shown on the accompanying sketch (Plate 3), to test the two responses on this line. The eastern anomaly is the most favourable geophysically. The dip of the proposed causative bodies have been assumed to be approximately 10° on the basis of geology.

(ii) If drilling on this anomalous trend is encouraging enough to warrant holes north of Line 0, the following collar locations are suggested, in order of decreasing priority:

...continued...

(ii) Con't.

LINE NO.	CHAINAGE
8 + OON	3 + 50E
2 + OON	1 + 50E
2 + OON	2 + OOW
4 + OON	3 + 50E
6 + OON	3 + 50E

Assuming gentle easterly dips which are thought to exist in this area are in fact present, these holes should be drilled westerly along line at an angle of -70°.

(iii) If drill testing of I.P. anomalies on this property provides further encouragement, I.P. work should be extended north, at least to cover presently cut but not surveyed lines at 10, 12 and 18N.

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APPENDIX I

NOTES ON THE INDUCED POLARIZATION METHOD

March 10, 1969.   John M. Hamilton

THEORY:

Polarization is the separation of charge, or blocking action, of metallic or electronic conductors within a medium of ionic solution conduction. Induced polarization refers to this blocking action when caused by an applied electric current.

In its geological context, polarization, or I.P., refers to the electrochemical blocking phenomenon exhibited by metallic minerals such as most sulphides, magnetite and graphite, under the influence of an applied current. When a current is passed through the subsurface, conduction is ionic and is dependent upon ions in the water content of the subsurface because most minerals have a much higher specific resistivity than ground water. The "metallic" minerals have specific resistivities which are much lower than ground water. The I.P., effect occurs at the interfaces between ionic conductive conditions in ground water and electronic conductive conditions in metallic minerals. Electronic charges are built up on these interfaces which oppose the flow of current that produces them.

The blocking action, or I.P. effect, increases with the time during which the current is flowing in a given direction. Hence, if the current is periodically reversed, a high frequency current will be subject to less blocking, or I.P. effect, than will a low frequency, since less time is available for the blocking to occur at a high frequency. It is therefore possible to measure the I.P. effect by measuring resistivity at two frequencies. This is the basis of the frequency domain I.P. system. Field readings consist of current readings between the transmitter electrodes, and voltage readings between the receiver electrodes, at both the high and the low frequency. From these readings a resistivity can be calculated for each frequency, using the relationship V= IR (Ohm's Law) and geometrical constants applicable to the electrode array.

The resistivity values so obtained are actually apparent resistivity values, being an average of all the material sampled for each reading. The resistivity plotted is the high frequency value, since it is least dependent on blocking action or I.P. effect, and hence is a truer value if polarizable material is present. The units used are ohm-feet/2π. To convert these units into ohm-meters used in some other I.P. systems, the ohm-feet/2π values should be multiplied by 1.9.

The percent frequency effect, actually an apparent frequency effect, is defined as $(R_L - R_H)/R_H \times 100\%$, where R_L and R_H are the resistivities at the low and high frequencies, respectively. The percent frequency effect is the parameter measured to show the I.P. effect, and is the frequency domain equivalent of the chargeability "m" used in time domain I.P. work,

The metal factor values are obtained by dividing the percent frequency effect by the resistivity and multiplying by 1000. The metal factor is proportional to the change in conductivity as the frequency of the applied current is varied, and can be shown to be equal to $(\sigma_H - \sigma_L) \times 2\pi \times 10^5$, where σ_H and σ_L are the conductivities at the high and low frequencies, respectively. The metal factor is generally more indicative of the conductive metallic content than is the frequency effect, although there are exoeptions to this.

FIELD PROCEDURE:

Current is applied to the ground at two current electrodes (C_1 and C_2) spaced a distance x apart as shown in the accompanying diagram. The potential is measured at two potential electrodes (P_1 and P_2) also spaced a distance x apart and in line with the current electrodes. For any given locations of C_1 and C_2, readings are taken when the distance between the nearest current and potential electrodes is equal to nx, and n has values of 1, 2, 3, etc. The electrode spacing x is determined by the requirements of the survey. Larger values of x would be used when the object is greater depth penetration and faster progress, whereas smaller values of x are employed in more detailed surveys, to provide more accurate anomaly location, but for the smaller values of x, the penetration is less and the survey slower. The value chosen for x should not greatly exceed the width of the target sought. The penetration is greater for the larger values of n.

INTERPRETATION:

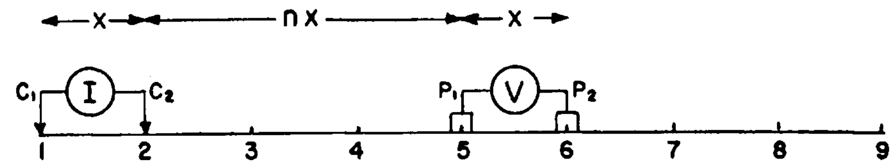
The values of the resistivity, metal factor and percent frequency effect are plotted on "pseudo-sections", where the plotting point is determined by the intersection of lines drawn at 45° from the horizontal, and originating at the mid-points of the current electrode spread and the potential electrode spread, as shown in the accompanying diagram. The choice of 45° from the horizontal is made because it simplifies plotting on gridded paper. There is no other basis for it, and lines at any other angle would produce just as "correct" a distribution of plotted values. The percent frequency effect is shown either as a superscript to each metal factor value, or as a separate, contoured plot similar to the first two. Depths to causative bodies cannot be scaled from the "pseudo-section," because the relationship between "pseudo-section" depths and true depths depends on anomalous body configuration and size, and other other inhomegeneities in the true resistivity distribution in the earth, as well as on the method used to plot the section.

The most favourable type of anomaly would show a frequency effect high with a resistivity low, to provide a marked metal factor high. A frequency effect high, with little or no change in resistivity, to provide a metal factor high, mirroring the frequency effect high, is also favourable. Of lesser interest, but of possible importance, are those anomalies showing no frequency effect change, but a distinct resistivity low, to produce a metal factor anomaly. The type of anomaly, its strength, size and shape should be considered in relation to the geological setting and the target sought.

The surface projection of anomalous zones are shown under the base line of the "pseudo-sections", or data plots. The location of anomalous zones is made after studying the responses at all separations, and is aided by data from computer and tank model-studies, as well as case histories and local geology when known. The source of an anomaly can at best be located only to within one electrode interval or x distance.

Anomalies are classified into three groups: definite, probable and possible. Grouping is based on the strength of the metal factor, the frequency effect, and the pattern of the anomaly. In general, the <u>true</u> metal factor is dependent on the concentration and distribution of chargeable material in the source, but the survey measures the <u>apparent</u> metal factor, which is an average. A large volume with a small percentage of sulphides could show the same metal factor as a smaller body with more concentrated sulphides. The apparent metal factor will approach the true metal factor when the anomalous body is large, and its depth to top small, relative to the electrode interval.

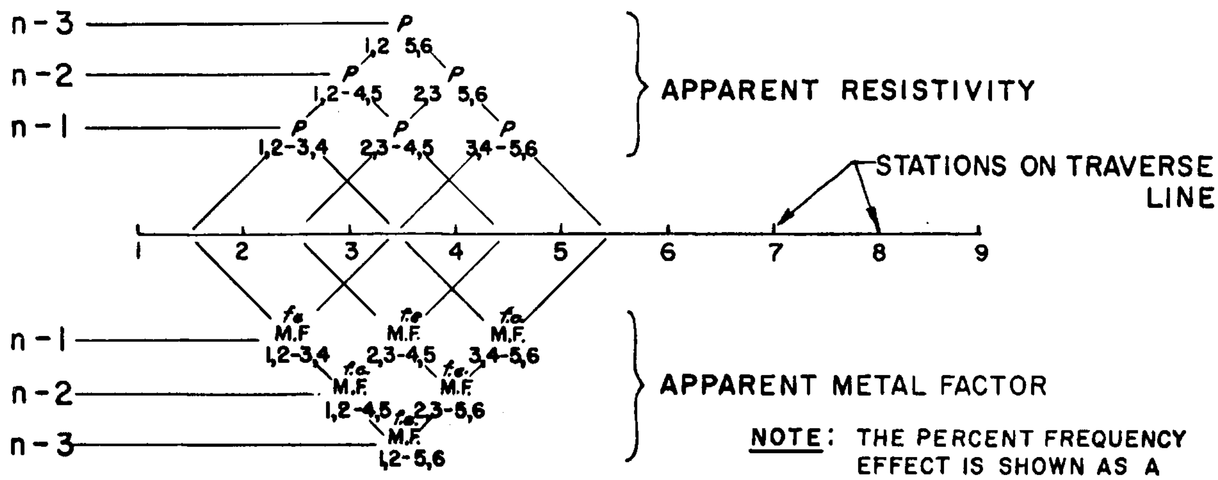
In some cases, a contoured data-plan is prepared, to show frequency effect, metal factor or resistivity values. Only data obtained at one separation is used on such a plan, and commonly the second separation data is plotted, to show results from an intermediate level of investigation. The surface projection of anomalous zones, as determined from the profiles, are also shown, and in many cases these will not coincide with contoured peaks, because data at other separations, if anomalous, will have been considered when locating anomalies. The most profitable use of contoured plans is as a trend indicator.



X = ELECTRODE SPREAD LENGTH OR ELECTRODE SPACING OR DIPOLE LENGTH

n = ELECTRODE SEPARATION = 1, 2, 3 . . . .

DIPOLE – DIPOLE ELECTRODE ARRAY



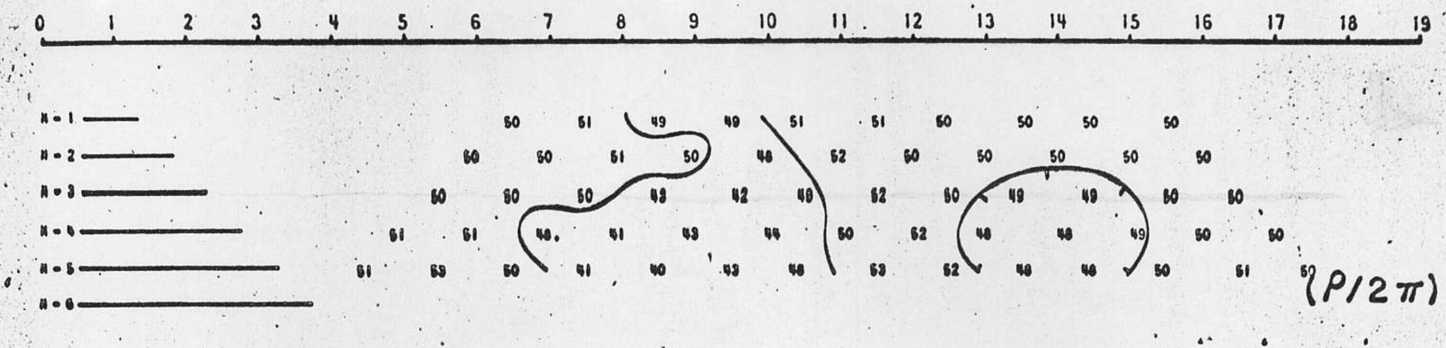
NOTE: THE PERCENT FREQUENCY EFFECT IS SHOWN AS A SUPERSCRIPT TO EACH METAL FACTOR VALUE, OR AS SEPARATE CONTOURED PLOT.

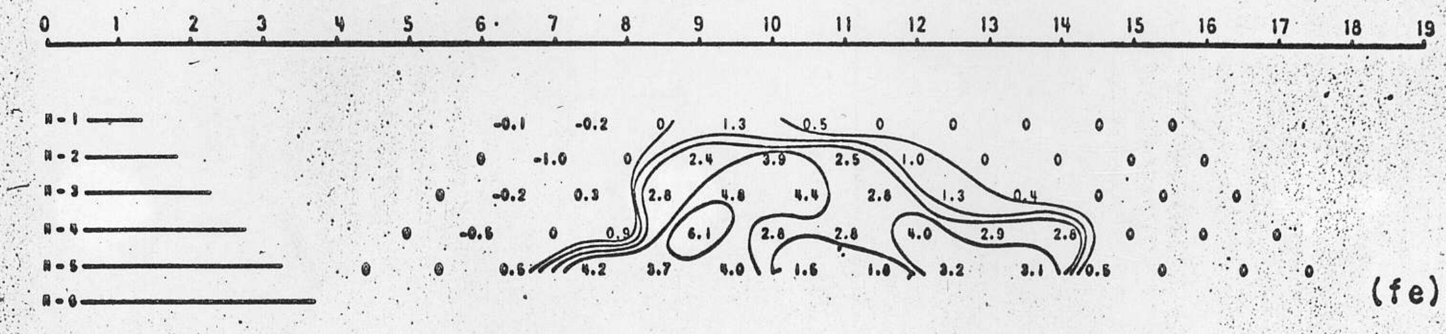
DIAGRAM SHOWING PLOTTING METHOD

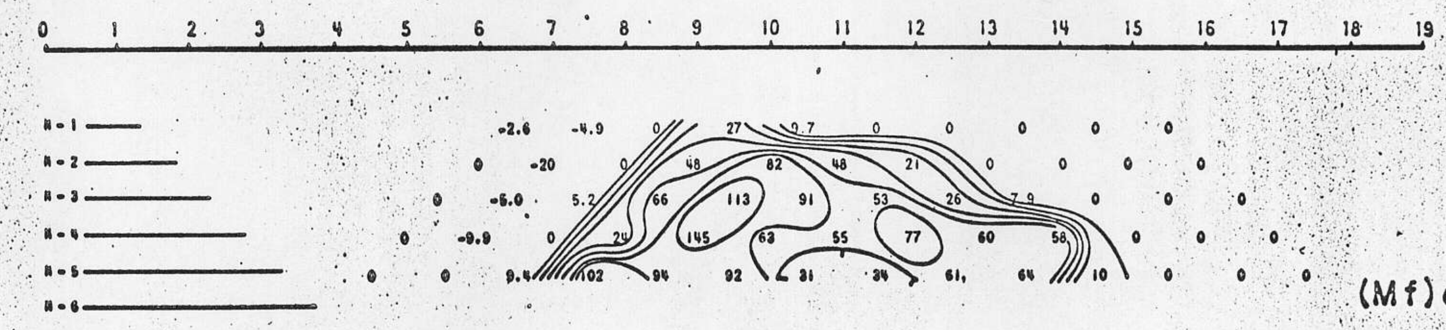
McPHAR GEOPHYSICS LIMITED

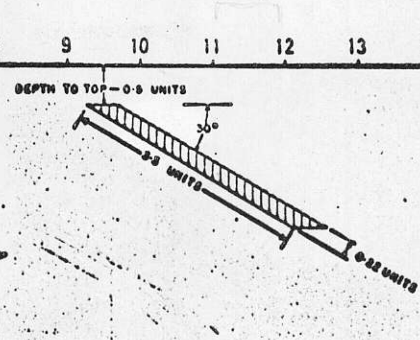
Theoretical Induced Polarization and Resistivity Studies

Scale Model Cases





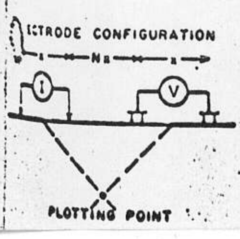




$(\rho/2\pi)_1 = 50$ $(\rho/2\pi)_2 = 2{\cdot}0$

$(Mf)_1 = 0$ $(Mf)_2 = 12{,}500$

$(fe)_2 = 25\%$



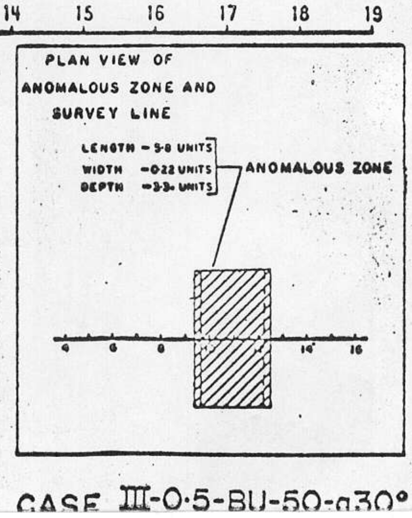


PLATE 2

CASE III-0·5-BU-50-a30°