727

GEOPHYSICAL REPORT
ON A GROUP OF CLAIMS
FOR
COMET MINES LIMITED (N.P.L.)

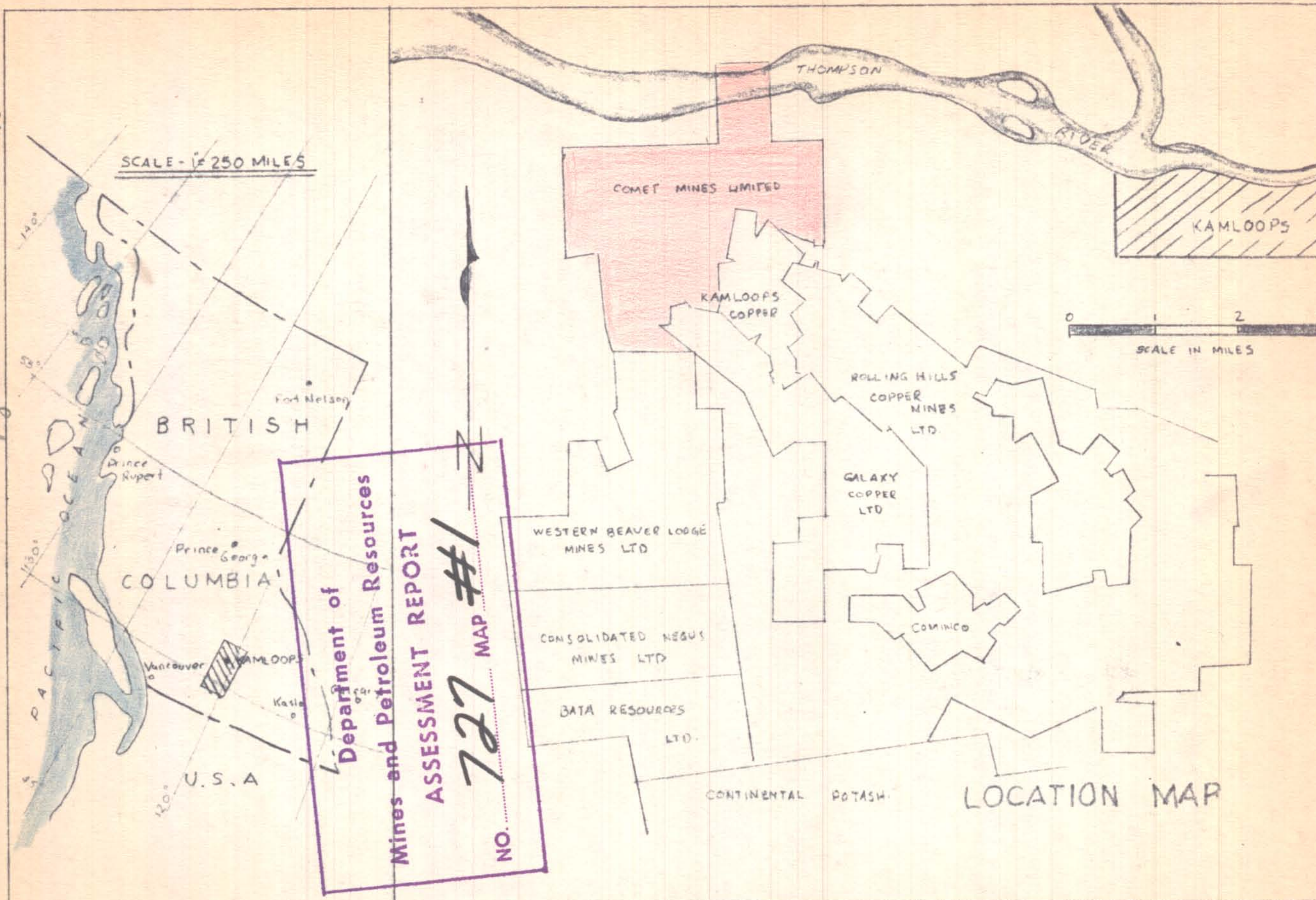
KAMLOOPS MINING DIVISION

KAMLOOPS, B.C.

VANCO EXPLORATIONS LIMITED

December 10th, 1965

C O N T E N T S


SCALE - 1" = 250 MILES
PACIFIC OCEAN
BRITISH
COLUMBIA
Fort Nelson
Prince Rupert
Prince George
Vancouver
KAMLOOPS
Kaslo
U.S.A
140°
130°
120°
THOMPSON
RIVER
KAMLOOPS
COMET MINES LIMITED
KAMLOOPS COPPER
ROLLING HILLS COPPER MINES LTD.
GALAXY COPPER LTD
WESTERN BEAVER LODGE MINES LTD
CONSOLIDATED NEGUS MINES LTD
BATA RESOURCES LTD.
COMINCO
CONTINENTAL POTASH
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SCALE IN MILES
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LOCATION MAP
Department of Mines and Petroleum Resources
ASSESSMENT REPORT
NO. 727 MAP #1

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INTRODUCTION:

In February 1965, Sulmac Exploration Services Limited, completed some 3.8 miles of magnetic surveys over a limited part of the Comet Mines property. In May of 1965, Sulmac completed approximately 5 miles of Induced Polarization surveys over essentially the same area. The Magnetometer work did not indicate any anomalous areas. The I.P., work outlined two anomalous zones which were subsequently drilled.

Vanco Explorations Limited (N.P.L.), acquired an option on the Comet Mines property along with several other mining properties in the immediate area in September, 1965.

In a continuation of the work started by Sulmac, Vanco undertook to extend the geophysical surveys over a much larger area of the property than that covered. Some 29½ miles of grid lines were put in which included a surveyed baseline at N 45 W for 8000 feet, and cross lines turned off at 400 foot intervals. The cross lines were picketed at 100 foot intervals over the length indicated on the map.

The results of the Vanco surveys are shown plotted on the maps contained in this report.

The work was started on October 6th, 1965, and continued through December 10th, 1965, and was under the overall direction of W. G. Wahl.

copy

PROPERTY, LOCATION & ACCESS:

The property of Comet Mines Limited (N.P.L.) consists of a group of sixty-six recorded mineral claims and one Mineral Lease as follows:-

Mineral Claims: R.O. 1 to 26 inclusive, and
R.O. 47 to 82 inclusive.
Lorna 1 to 4 inclusive.

Mineral Lease: Mineral Lease M.21, L.875 C.G.

The mineral claims covered in the Vanco Magnetic and Induced Polarization Surveys are as follows:-

Mineral Claims: R.O. 1 to 26 inclusive.
R.O. 48, 50, 52, 54.
Lorna 1 to 4 inclusive.
* I.C. 1 & 2
Mineral Lease 21
Crown Grant L.4667.

* The I.C. Nos. 1 & 2 mineral claims were recently staked to cover open ground, and are recorded in the name of Vanco Explorations Limited (N.P.L.).

The property is located some seven miles to the west of Kamloops, B.C., at Latitude 50° 40', and Longitude 120° 28'.

The Trans Canada Highway passes in a general east-west direction through the southern part of the claim group. Access to the claims south of the Highway is by a dirt road running southwesterly from the Highway through Mineral Lease 21. North of the Highway a dirt road connects the Thompson River Road located at R.O. 79 & 80, to the Trans Canada Highway, approximately 1½ miles east of Mineral Lease 21.

REPORT ON
INDUCED POLARIZATION SURVEY
ON
THE PROPERTY OF
COMET MINES LIMITED,
IRON MASK AREA, KAMLOOPS, B.C.,
FOR
VANCO EXPLORATION LIMITED,
BY
CANADIAN AERO MINERAL SURVEYS LIMITED,
Project No. 6018.

GEOPHYSICAL REPORT

MAGNETOMETER SURVEY
IRON MASK AREA
KAMLOOPS
BRITISH COLUMBIA

W. G. WAHL LIMITED, December 10, 1965.

Suite 1405, 302 Bay Street,
Toronto 1, Ontario

December 10, 1965.

Mr. J. F. White, Manager,
Vanco Explorations Ltd.,
935 - 470 Granville Street,
Vancouver 2, B.C.

Dear Mr. White,

Submitted herewith is a report on:

MAGNETOMETER SURVEY
COMET MINES LIMITED
IRON MASK AREA
KAMLOOPS
BRITISH COLUMBIA

The magnetometer survey effectively mapped the contact between the Iron Mask batholith and the Nicola volcanic series beneath the Tranquille beds of the Kamloops group. The magnetometer data also delineated the rock type within the batholith into two major rock types, monzonite and diorite.

There is, in general, a rough coincidence between the induced polarization anomaly and the area of high magnetic susceptibility which could lead to the assumption that the I.P. anomaly is caused by magnetite. This is not valid as the area underlain by rocks of high magnetic susceptibility is much larger than that covered by anomalous chargeability. The I.P. anomaly is elliptical in shape, approximately 3000 feet by 1500 feet, trends slightly north of east, and is centered on station 0+00 and 200+00 West.

A drill hole spotted at station 3+00 North and 202+00 West and drilled south at 45^{o} for 600 feet would determine the cause of the I.P. anomaly.

MAGNETOMETER SURVEY

The magnetometer survey was performed during the period of October to December 1965. A Sharpe MF-1 Fluxgate Magnetometer, No.506152, with a scale constant of 20 gammas per scale division was used. The field operators, Sigmund Felke and John Smith, were both trained by the writer several years ago and have proven their competence as operators on surveys in many parts of Canada. The total magnetic field values were recorded over stations at 100-foot intervals on picket lines 400 feet apart. The field data were adjusted for diurnal fluctuation in the magnetic field and were reduced to a common datum. This datum is approximately the same as that used on the contiguous properties of Galaxy Copper Limited, Kamloops Copper, and Western Beaver Lodge Mines Limited.

The attached map at a scale of 400 feet to one inch shows the corrected station values and a contoured interpretation of these results. The contour interval is 1000 gammas.

Field examination and testing indicate that the Nicola volcanic rocks have a very low magnetic susceptibility and,in general, are characterized by magnetic intensities of less than 500 gammas when related to the local magnetic datum. The fine-grained acid intrusive has a medium magnetic susceptibility with a magnetic intensity range from approximately 500 to 2,000 gammas. The mafic phase of the batholith, a diorite, has a relatively high magnetic susceptibility, as shown by an intensity range from 2,000 to more than 10,000 gammas.

Small, local magnetic highs are found along the intrusive contact and are caused by small zones of alteration rich in magnetite.

The volcanic rocks cause broad linear anomalies with low magnetic gradients. The acid intrusive shows a gentle undulating pattern with many small changes in magnetic gradient. The more mafic phases of the intrusive cause lenticular anomalies with very large magnetic gradients.

No magnetic anomalous areas indicative of ore occurrences were mapped but the coincidence of the I.P. anomaly over an area of strong magnetic relief could be caused by magnetite-sulphide mineralization.

GEOLOGY

The geology as reported in the literature was confirmed by field mapping, and was extended from the outcrop areas into areas of heavy overburden by the magnetometer data.

The approximate trace of the rock units is shown on the attached magnetometer map.

The Kamloops group of rocks is flat-lying and thin and has almost no magnetic susceptibility. These rocks show no more magnetic effect than normal overburden. It is the magnetic pattern of the underlying rocks which was mapped.

The northernmost contact of the Iron Mask batholith was mapped and the area underlain by diorite near Iron Mask Lake was extended to the west.

No new zones of mineralization were found but one can be inferred from the I.P. and magnetic data in the vicinity of station 0+00 on line 200+00 West. Of the two types of mineralization present in the Iron Mask batholith the pink-feldspar, magnetite, and sulphide alteration could give rise to these geophysical anomalies.

A hole drilled on an azimuth of 180° true, at an angle of 45°, from station 3+00 North and 202+00 West, for 600 feet would intersect the cause of the anomaly.

All of which is respectfully submitted.

Sincerely yours,

W. G. Wahl, Ph.D., P.Eng.
W. G. WAHL LIMITED

Certificate

With reference to this report, I wish to state that:

1. I received my M.Sc. in 1941 and my Ph.D. in 1947 from McGill University.

2. I have practiced my profession as a geophysicist for the past eighteen years.

3. I am a registered Professional Engineer of Ontario.

4. I am a member of:
   American Geophysical Union
   Canadian Exploration Geophysicists (Past President)
   Canadian Institute of Mining and Metallurgy
   American Institute of Mining and Metallurgy
   Geological Association of Canada
   Geological Society of America
   Society of Economic Geologists

5. I have made several contributions to the literature relating to my profession.

6. This report is based on a personal field examination of the Comet claims made between November 5th and 9th, 1965.

W. G. Wahl, Ph.D., P.Eng.

<u>A P P E N D I X</u>

The following personnel were engaged on the geophysical surveys carried out on the Comet Mines Property, during October to December, 1965.

Dr. W. G. Wahl	- Consulting Geophysicist	Nov. 5-9 incl. Dec. 7-8 incl.
P. Norgaard	- Geophysicist	Nov. 13-14 incl.
J. G. Denholm	- Geophysicist - Field	Oct. 19-29 incl.
A. R. Rattew	- Geophysicist	Nov. 13-15 incl. Dec. ?
P. Tallyhoc	- Draftsman	Nov. 13-17 incl.
R. Brown	- Linecutter	Oct. 8-20 incl.
A. Gillmor	- Linecutter	Oct. 8-20 incl.
J. Smith	- Linecutter	Nov. 1-2 incl.
S. Selke	- Linecutter	Nov. 1-2 incl.
J. Smith	- Surveyor	Oct. 27-28 incl.
S. Selke	- Surveyor	Oct. 27-28 incl.
J. Smith	- Geophysical Operator	Oct. 14-16 incl. Nov. 4, 10-12 incl., 16-18 incl. 24-26 incl.
S. Selke	- Geophysical Operator	Oct. 14-16 incl.
R. Burgess	- Geophysical Assistant	Oct. 19-22 incl.
B. Nichol	- Geophysical Assistant	Oct. 19-22 incl, Nov. 6, 8-10 (11-12) incl.
J. Curzon	- Geophysical Assistant	Oct. 19-22 incl. Nov. 6, 8-10 (11-12) incl.
R. Hadley	- Geophysical Assistant	Oct. 19-22 incl. Nov. 6, 8-10 (11-12) incl.
P. Samborsky	- Geophysical Assistant	~~Oct. 19-22 incl.~~ Nov. 6, 8-10 (11-12) incl.
J. DeLatre	- Geologist & General Supervision	Nov. 4-6 incl.
D. Nicholson	- Engineer & Draftsman	Dec. 2-3 incl.
T. Lisle	- Draftsman	Dec. 6-7 incl.

REPORT ON

INDUCED POLARIZATION SURVEY

ON THE PROPERTY OF

COMET MINES LIMITED,

IRON MASK AREA, KAMLOOPS, B.C.,

FOR

VANCO EXPLORATION LIMITED,

BY

CANADIAN AERO MINERAL SURVEYS LIMITED,

Project No. 6018.

OTTAWA, Ontario.
December 9, 1965.

J.G. Denholm,
Geophysicist.

A.R. Rattew, P.Eng.,
Geophysicist.

T A B L E O F C O N T E N T S

ACCOMPANYING THIS REPORT:-

- One Profile Presentation at the scale of 1" = 400 feet.
- One Chargeability Contour Plan at the scale of 1" = 200 feet.

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S U M M A R Y

From October 13 to November 12, 1965, Canadian Aero Mineral Surveys Limited conducted induced polarization surveys in the Iron Mask Area near Kamloops in British Columbia on behalf of Vanco Exploration Limited. One area covered was the property of Comet Mines Limited.

The purpose of the survey was to use IP as a reconnaissance tool in looking for further mineralization on claims adjoining those previously survey by Sulmac Exploration Limited.

A large anomalous zone characterized by moderately high chargeabilities and closely related high magnetics was located in the southern portion of the survey area. It appears that magnetite is largely responsible for the response here.

A major masking problem due to conductive overburden in much of the northern portion of the Comet Mines grid rendered IP of limited use.

Geochemical reconnaissance surveying and further drilling is recommended.

OTTAWA, Ontario,
December 9, 1965.

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REPORT ON INDUCED POLARIZATION SURVEY ON THE PROPERTY OF COMET MINES LIMITED, IRON MASK AREA, KAMLOOPS, B.C., FOR VANCO EXPLORATION LIMITED

I. INTRODUCTION

In the period from October 13 to November 12, 1965 Canadian Aero Mineral Surveys Limited conducted induced polarization surveys in the Iron Mask Area near Kamloops, British Columbia on behalf of Vanco Exploration Limited. One of the areas covered in this period was the property of Comet Mines Limited.

The purpose of the induced polarization survey was to map the sub-surface distribution of metallic sulphide mineralization in order to localize the presence of any copper deposits on claims adjoining those previously surveyed by Sulmac Exploration Limited.

A reprint of the paper entitled "A Decade of Development in Overvoltage Surveying" by Robert W. Baldwin, which is attached to this report describes the phenomena involved and the methods of measurement and interpretation of this type of survey. For the present survey, high sensitivity, pulse-type equipment was employed with a current on-time of 1.5 seconds and a measuring time of 0.5 seconds.

At each observation point both the primary and secondary voltages are measured. The primary voltages (steady state voltages) are converted by formula to apparent resistivities in units of ohm meters. The secondary voltages (polarization voltages) are measured by integration and then divided by the corresponding primary voltages to obtain the apparent "chargeability", the resulting polarization property characteristics of the region. It is expressed in units of milliseconds or millivolt seconds per volt.

The chief application of induced polarization is in the direct detection of disseminated metallic sulphides. However, any transition in conduction from ionic to electronic and vice versa, will give rise to IP effects. For this reason, all metallic conducting sulphides, including pyrite, pyrrhotite, chalcopyrite and chalcocite etc., and arsenides will be detectable as well as graphite. The latter may be expected to occur primarily in carbonaceous shales and limestones. Occasionally, abnormal IP effects may be experienced from magnetite concentrations and from serpentines. There is no way at present in which IP effects from any one of these sources can be differentiated from those arising from any of the others using the IP data alone.

Throughout this survey a standard, equispaced three electrode array was used employing an electrode spacing of 400 feet. Readings were normally taken at 200 foot intervals along parallel lines spaced at 800 foot intervals. In areas of low background response or where problems with masking effects prevailed, the reading interval was 400 feet along the survey lines.

Approximately 12 line miles of survey coverage was completed on the Comet Mines Property.

About two line miles of surveying was done in the Galaxy and Western Beaver Lodge properties for the purpose of detailing anomalies locating during the Sulmac IP survey and for comparing the results obtained with the Sulmac and Canadian Aero Mineral Surveys' instruments.

II. DISCUSSION OF RESULTS

The apparent chargeabilities and apparent resistivities are presented in profile form at the following scales : 1 inch = 400 feet, 1 inch = 5.0 milliseconds for chargeability and the resistivity results on a logarithmic scale as shown.

The apparent chargeabilities are also presented in contour form on a plan of 1" = 400 feet.

The check work on the Galaxy and Western Beaver Lodge properties shows good correlation in the apparent chargeabilities both in profile shape and in absolute magnitude. This should be the case since both instruments are of the same design and employ approximately the same charging time and measuring time. The apparent resistivities were in some cases slightly lower than those obtained by Sulmac. However, this is accounted for by the very wet ground surface on the day of the repeat survey.

On the Comet Mines property, one large anomalous zone was located in the southern part of the grid between 20N and 12S on lines 176W to 216W. The strike of the zone is east-west with peak chargeabilities of 17 milliseconds on line 200W. The position and strike of the anomaly coincides closely with the topography where there are many diggings and addits and very little overburden.

Although the peak chargeabilities indicate from 2% to 6% total mineralization, the closely related high magnetics suggest that a large portion of this mineralization is magnetite.

Because of two high tension power lines and the Trans-Canada Highway with association power lines all crossing the property in different directions, the electrical noise level was too high to permit the taking of good IP readings over much of the Comet grid. However, enough good readings were taken on lines 192W, 200W, 240W, 248W and 256W to determine the fact that no IP anomalous zone exists in the northern and western portions of the grid. Instead, a conductive overburden is widespread causing low chargeabilities and resistivities indicating masking.

III. CONCLUSIONS

One large anomalous zone characterized by moderately high chargeabilities and closely related high magnetics was located in the southern part of the grid area.

It appears that magnetite contributes considerably to the anomalous response which indicates from 2% to 6% average mineralization by volume.

A major masking problem due to conductive overburden in much of the northern portion of the grid rendered IP of limited use in about 40% of the area surveyed.

IV. RECOMMENDATIONS FOR FUTURE EXPLORATION

Widespread reconnaissance geochemical surveying is suggested particularly in areas where "masking" due to conductive overburden has limited the effectiveness of IP as a mapping tool.

Since it is known that copper is associated with magnetite in the Iron Mask Area, vertical drill holes are suggested on the anomalous zone. The positionsof these holes are to be determined on the basis of further geological and geochemical surveying.

Respectfully submitted,

J. G. Denholm,
Geophysicist.

A. R. Rattew, P. Eng.,
Geophysicist.

OTTAWA, Ontario,
December 9, 1965.

P E R S O N N E L

The following is a list of the Canadian Aero Mineral Surveys Limited personnel engaged in the work necessary to the IP survey of the Comet Mines Limited property located in the Iron Mask Area of British Columbia:

J. G. Denholm, Geophysicist,
Elora, Ontario.

P. Norgaard, Geophysicist,
Ottawa, Ontario.

A. R. Rattew, P.Eng., Geophysicist,
Ottawa, Ontario.

P. Tallyhoe, Draftsman,
Ottawa, Ontario.

A. R. Rattew, P.Eng.,
Geophysicist.

APPENDIX

The following personnel were engaged on the geophysical surveys carried out on the Comet Mines Property, during October to December, 1965.

Dr. W. G. Wahl	- Consulting Geophysicist	Nov. 5-9 incl. Dec. 7-8 incl.
P. Norgaard	- Geophysicist	Nov. 13-14 incl.
J. G. Denholm	- Geophysicist - Field	Oct. 19-29 incl.
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J. DeLatre	- Geologist & General Supervision	Nov. 4-6 incl.
D. Nicholson	- Engineer & Draftsman	Dec. 2-3 incl.
T. Lisle	- Draftsman	Dec. 6-7 incl.

A DECADE OF DEVELOPMENT IN OVERVOLTAGE SURVEYING

CANADIAN AERO *Mineral Surveys* LTD.

by ROBERT W. BALDWIN

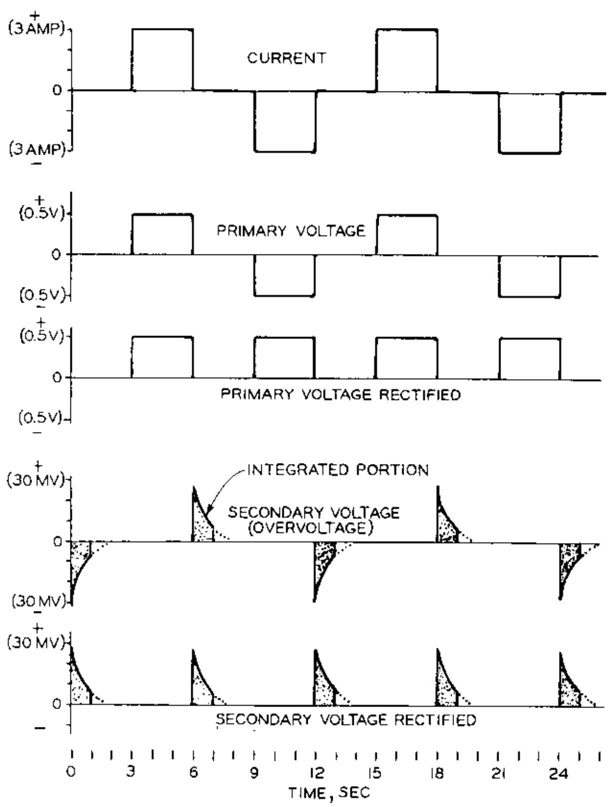
As used in geophysical exploration, the term *overvoltage* applies to secondary voltages set up by a current into the earth which decay when the current is interrupted. These secondary effects may be measured by pick-up electrodes. The term *induced polarization* has often been employed to describe this same phenomenon. In its own operations Newmont Exploration Ltd. commonly uses the word *pulse*.

The basis of this method in prospecting is that metallic particles, sulfides in particular, give a high response, whereas barren rock, with certain exceptions, gives a low response. Overvoltage has been tried in searching for many types of mineral occurrence but has been most successful in outlining the widespread disseminated mineralization associated with porphyry coppers.

History:[1] Newmont Mining Corp. has been interested in overvoltage since 1946, when Radio Frequency Laboratories of Boonton, N. J., drew the company's attention to phenomena observed in the laboratory. At the instigation of A. A. Brant further model studies were undertaken, and the first tests were performed in 1947. Tests at San Manuel, Ariz., in 1948 were very encouraging, clearly demonstrating that the method could be used to distinguish scattered sulfides at depth. H. O. Seigel followed up the San Manuel work with a study to determine the phenomena involved.[2]

R. W. BALDWIN, Member AIME, is with the Geophysical Department, Newmont Exploration Ltd., Danbury, Conn. TP 4793L. Manuscript, June 25, 1958. New York Meeting, February 1958. AIME Trans., Vol. 214, 1959.

Fig. 1—Current and voltage sequences, typical measurement. Overvoltage response to be plotted equals integrated secondary voltage divided by primary voltage.



Further field experiments took place at Jerome, Ariz., in 1949-1950. Since 1950 this method has been a standard prospecting tool of Newmont Exploration Ltd. Overvoltage surveys have been carried out in the U. S., Canada, Latin America, and Africa. Field equipment has been constantly improved.

Concurrent with field exploration, theoretical and experimental investigations were pursued at Jerome. H. O. Seigel, J. R. Wait, V. Mayper, E. H. Bratnober, and L. S. Collett were notable contributors. Work at the Jerome laboratories included:

1) Study of the phenomena involved, with extensive investigation into the causes of background nonsulfide effects.

2) Study of the possibilities of taking induced polarization measurements with low-frequency alternating current instead of pulsed direct current.

3) Mathematical development of type curves showing the anomalies to be expected from mineralized bodies of various shapes and sizes under varying depths and conditions of cover.

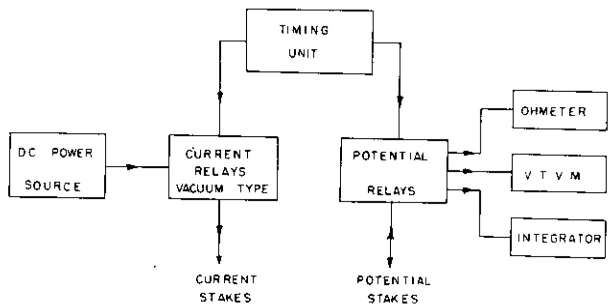


Fig. 2—Block diagram of typical field equipment.

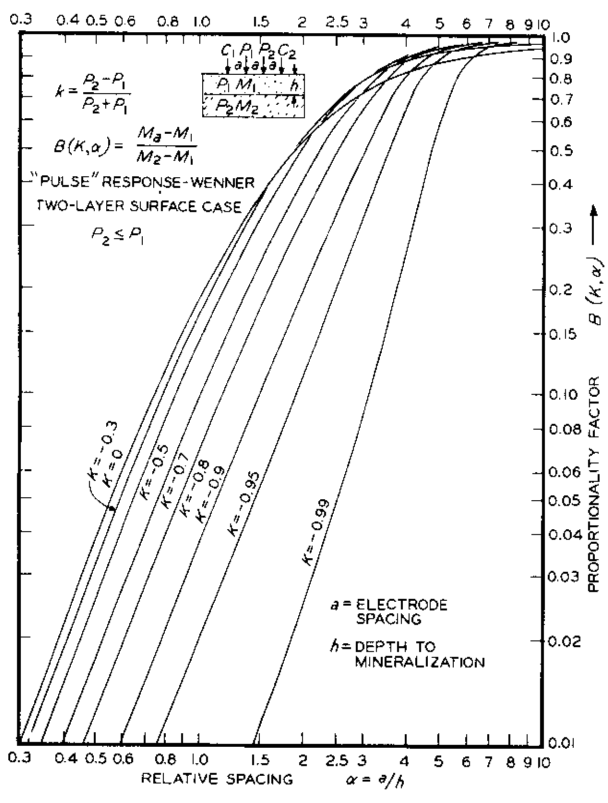


Fig. 3—Typical theoretical overvoltage response curves.

4) Laboratory testing of rock samples, study of the form of overvoltage decay and the a-c response for various types and sizes of mineral particles, and model orebody studies.

Operational Methods: The overvoltage method requires direct connection to the ground, by means of two current electrodes and two potential electrodes. Field methods are thus similar to those of resistivity surveys. Various electrode arrays have been used; electrode spacings are chosen according to the type of target and expected depth. Spacings as wide as 1500 ft have been regularly employed. In laboratory work also, four direct connections must be made to the specimen or model.

Fig. 1 illustrates, in idealized form, the sequences encountered in a typical d-c overvoltage measurement.* While the current is on there is a primary voltage across the potential electrodes which may be measured with a vacuum tube voltmeter—a simple resistivity measurement. On cessation of current (allowing 10 to 15 milliseconds for inductive and capacitive coupling effects to disappear) the decaying secondary voltage or overvoltage appears at the potential electrodes. This decay curve may be presented on an oscilloscope and photographed—the procedure in many laboratory experiments. Field practice is to integrate the decay voltage over an interval following current cessation. Common operating times are 3 sec of current pulse and 1 sec of integrating time. To obtain a reading the integrated secondary voltage is divided by the primary voltage. The units are then millivolt-seconds per volt.

* The voltage and current values quoted are samples to indicate an order of magnitude.

In practice, of course, not just one pulse of current is applied but a succession of pulses as shown, every second pulse being of reversed polarity. Rectifying relays are provided so that the primary and secondary voltages always read positively.

Field Equipment:[3] Fig. 2 is a block diagram of typical field equipment. The heart of the equipment is the timing unit, which controls both current switching and the connections of potential electrodes to the vacuum tube voltmeter for primary voltage and to the integrator for secondary voltage measurement. Two types of timing units have been employed: the first electronic, using multivibrators, and the second mechanical, using a constant-speed motor and cam-operated switches. The integrating device is a General Electric fluxmeter, model 32C248. The d-c power supply has usually consisted of a gasoline-motor a-c generator followed by a high-voltage d-c rectifier unit. The smaller units (order of 1000 to 1500 w) are relatively mobile and have been transported by burros; the larger units (up to 25,000 w) are mounted in heavy-duty trucks.

Most field equipment was designed and constructed in the Jerome laboratories by A.W. Love, K. E. Ruddock, and W. E. Bell.

Type Curves:[4] H. O. Seigel has developed mathematical expressions for the overvoltage response to be expected from mineralized bodies of various geometric forms. The analysis is equally applicable if the source of overvoltage effects is not mineralization. Seigel uses an electrodynamic model of overvoltage which considers the effect of resistivity contrasts within the region of measurement on both primary and secondary fields. His basic postulate is that the action of the primary field sets up a volume distribution of current dipoles—all antiparallel to the primary field—whose moment equals the product of the primary current density and a mineralization*

* The term *mineralization* is understood to include other sources of overvoltage effects.

factor which is a property of the medium. He then develops a procedure for calculating overvoltage responses from associated resistivity curves by weighting the overvoltage contribution of any medium according to the logarithmic derivative of apparent resistivity with respect to the resistivity of that medium.

Mathematically,

$$M_a = \sum_i M_i \frac{\partial \log \rho_a}{\partial \log \rho_i}$$

where M_i and ρ_i are the *mineralization* factor and apparent resistivity of the ith medium, M_a and ρ_a are the overvoltage response and apparent resistivity at the point of measurement and $\sum_i$ represents a summing of the terms for all media.

Where there are only two media concerned the above formula reduces to

$$\frac{M_a - M_1}{M_2 - M_1} = \frac{\delta \log \rho_a}{\delta \log \rho_a}$$

where the subscripts 1 and 2 refer to media 1 and 2.

An important approximation of overvoltage surveys is the two-layer case. This assumes a horizontal layer of barren material overlying an infinite layer of mineralized material. The overvoltage responses have been derived directly from the well known resistivity two-layer formula. Fig. 3 gives the type curves when the lower layer has the lower resistivity. The abcissa is relative electrode spacing (i.e., in terms of thickness of top layer) and the ordinate, in effect, indicates what proportion of the lower layer mineralization factor should appear in the observed reading. The different curves are for different resistivity contrast conditions. Note that the plotting is logarithmic. Examples of the use of these curves are given in the field results to follow.

Phenomenological Theory:[5] To account for overvoltage effects, J. R. Wait has proposed the following theoretical model:

Each conducting particle is considered to be coated with a thin dielectric film that poses a block action to current flow into the particle. Thus the action at the interface of each particle is somewhat comparable to that of a lossy condensor, and any ground exhibiting an overvoltage response may be considered to contain in effect a large number of tiny condensers. It should be noted, however, that the dielectric constant of these condensers may vary with frequency.

Wait applied his model theory to predict the form of the decay curve and its variation with particle size. His predictions have been borne out by laboratory experiments. Some typical results are shown in Fig. 4. The tests were performed on a compact mixture of 98 pct andesite and 2 pct pyrite particles, plus a weak electrolyte. Different samples contained different sizes of pyrite particles, ranging from 0.25 to 12-mm diam. Duration of current pulse was 1 sec. Primary voltage was the same in all cases. Note that the time scale is logarithmic. It will be observed that decay is more rapid with the smaller sulfide particles. It can also be noted that at any time following the cessation of current there is an optimum particle size for which the decay voltage is maximum.

A-C Overvoltage Methods:[6] As is perhaps suggested by the condenser analogy mentioned above,

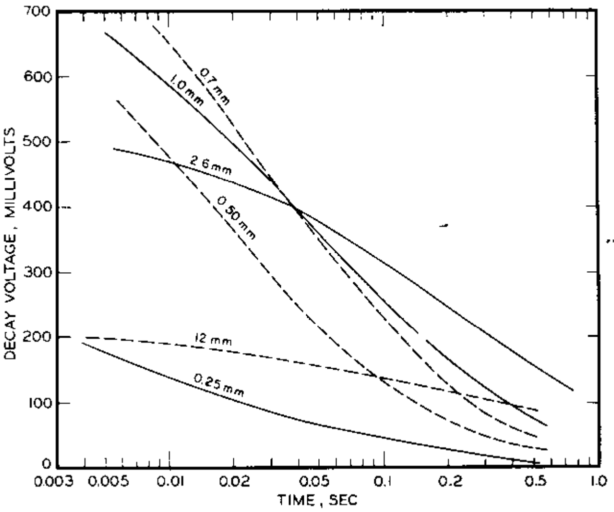


Fig. 4—Observed decay voltage e(t) as a function of time. For V = 15 volts, v = 0.02 and σ = 5x10⁻³ mhos/m. This graph and Fig. 5 are examples of extensive overvoltage experiments at Newmont's laboratories in Jerome, Ariz. Fig. 4 illustrates work in transient domain, Fig. 5 work in frequency domian.

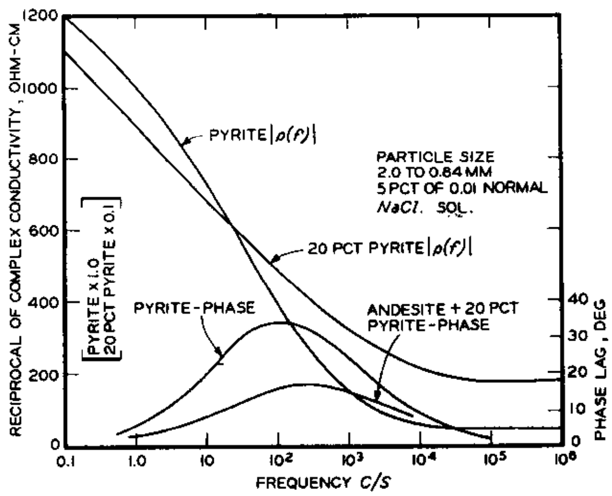


Fig. 5—Variation of complex conductivity with frequency. From experiments at Newmont laboratories.

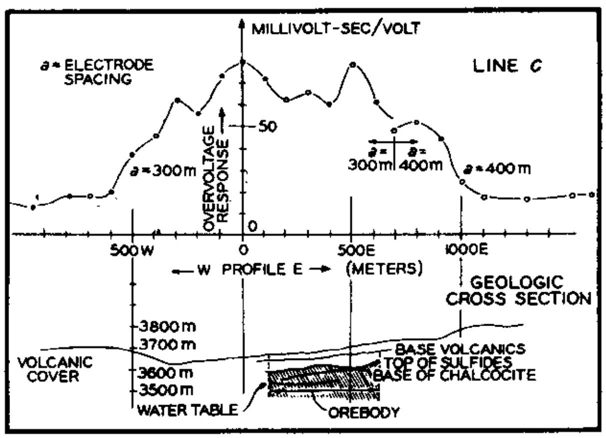


Fig. 6—Overvoltage profile, north end, Quellavaco.

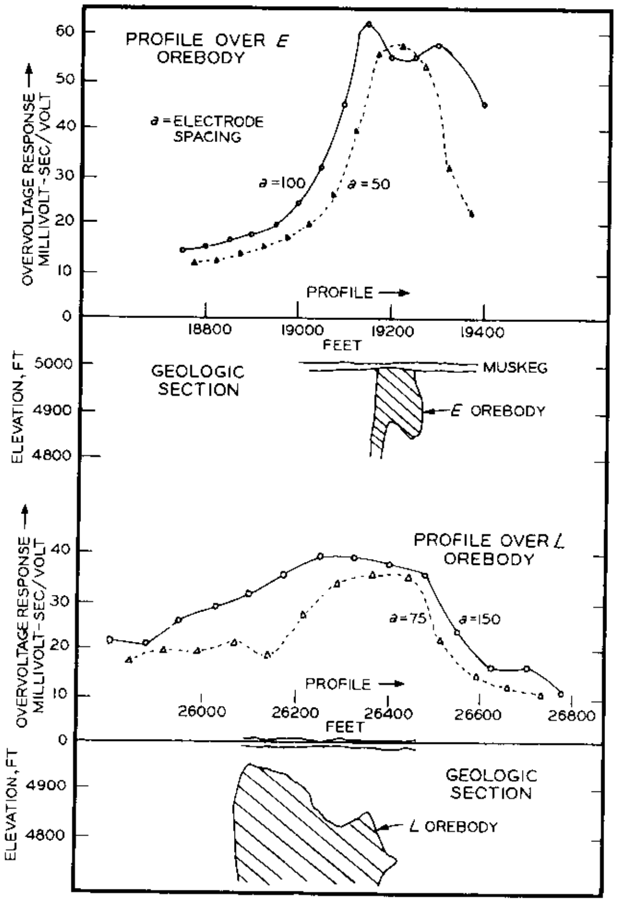


Fig. 7—Overvoltage profiles at Lynn Lake, Manitoba.

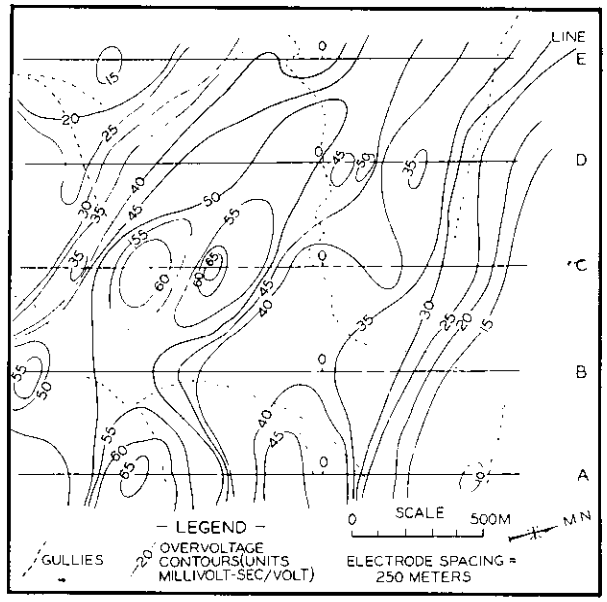


Fig. 8—Copper prospect, Peru. Overvoltage contours here directly outline distribution of sulfides.

the overvoltage phenomena may be measured in the frequency domain instead of in the transient domain, that is, by applying alternating current instead of pulsed direct current. The earth in general has a complex impedance in which the d-c resistivity is a pure resistive component and the overvoltage contributes a somewhat complicated combination of capacitance and resistance. The complex impedance and the phase angle vary with frequency. This variation is especially pronounced in the case of sulfides.

Results of some complex impedance measurements in the laboratory are shown in Fig. 5. Complex impedance and phase angle for pyrite and for pyrite in andesite particles are plotted against log frequency. The maximum slope of the impedance curve occurs at that frequency at which phase angle is a maximum. In comparison, impedance vs frequency curves for barren rock material (over the frequency range up to the order of several hundred cycles) are almost flat and the phase angle remains low.

It should be noted that a-c overvoltage measurements should be made in the low frequency range where electromagnetic propagation effects are negligible. Caution should also be taken to avoid excessive line coupling between the current and potential circuits. Probably several tens of cycles is about the upper frequency limit for operations in the field.

Wait has demonstrated the relation between the response in the frequency domain and that in the transient domain. From experimentally observed frequency response data he derived the overvoltage decay curve to be expected following a pulse of direct current. The agreement with the experimentally observed decay curve was excellent.

Field Results:[7] To date pulsed d-c methods have been used in field exploration. The technique of measurement is described above under Operational Methods and Field Equipment.

To repeat, the basis of the overvoltage method as a prospecting device is that metallic particles, especially sulfides, give a high response, whereas barren rock, with certain exceptions, gives a low response.

In the earlier days it was not realized that barren rock could display a considerable range of response, and minor anomalies of less than 50 pct of background were deemed evidence of sulfides. At Jerome, Ariz., anomalies of this order were found to be caused by certain portions of the Pre-Cambrian basement beneath the Palaeozoic cover. At the present time overvoltage readings of two to three times background are usually necessary to excite interest. Even then it must be recognized that some anomalies may have causes other than sulfides.

In overvoltage surveys results fall into four classes:

1) No significant anomalies.
2) Anomalies due to economic sulfides.
3) Anomalies due to noneconomic sulfides.
4) Anomalies due to nonsulfides.

Groups 2 and 3 above may both be considered geophysical successes if not exploration successes. The ratio of noneconomic to economic mineralization disclosed is certainly no worse than for other geophysical methods. The chief villain has been disseminated pyrite. Many porphyry copper deposits have a surrounding halo of disseminated pyrite, and the zone of maximum sulfides is not necessarily the zone of maximum copper.

While there have been a few striking examples of nonsulfide anomalies, most major anomalies have been explained by sulfides. For example, in almost four years of work in Peru, only one recommended

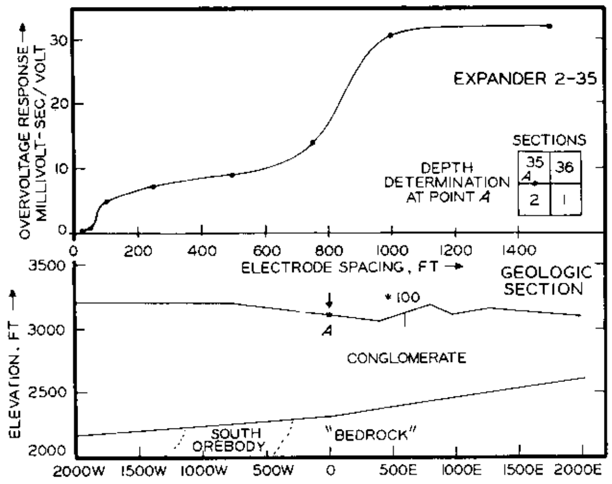


Fig. 9—Detection of deep mineralization is possible at San Manuel by use of large electrode spacings.

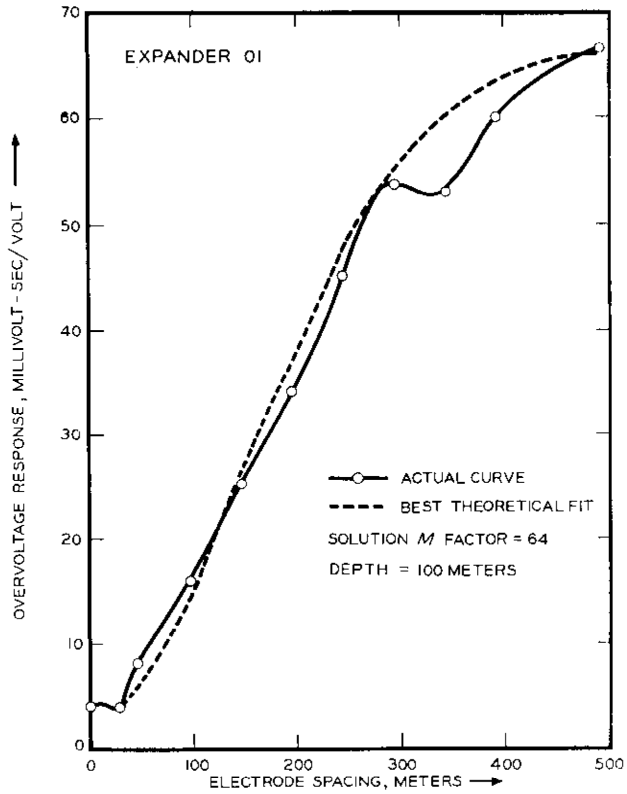


Fig. 10—Mineralization and depth, Cuajone.

drillhole completely failed to find a reasonable quantity of sulfides.

Over a disseminated sulfide deposit the anomalous overvoltage response (i.e., in addition to the rock background) will depend on:

1) The percentage by volume of sulfides.

2) The geometry of the deposit with respect to surface and the electrode array in use. Geometry thus includes size and depth below surface.

3) The resistivity contrast conditions between the sulfide zone and the cover and surroundings.

In any one area the overvoltage response of a mineralized zone has been found to vary more or less directly with the percent of volume of sulfides for moderate percentages of sulfides. It is not safe, however, to project from one area and type of mineral occurrence to another.

A fair number of the examples to follow were obtained over known or later proven orebodies. In attacking any new area, it has been the general policy to test over known mineralization first, where possible, and work out from there, so that the type of anomaly to be sought is known.

Fig. 6 shows an overvoltage profile over the north end of the orebody at Quellaveco, Peru. The ore zone is covered by about 40 meters of postmineral volcanics, and depth to sulfides is from 60 to 100 meters. The orebody is well detected; however, it is to be noted that the anomaly is some 800 meters wider than the orebody, presumably because of a surrounding zone of disseminated pyrite.

Fig. 7 shows the response over an entirely different type of orebody, the *E* and *EL* orebodies at Lynn Lake, Manitoba. The scale of operations is reduced here: to discriminate those relatively narrow bodies, an electrode spacing of about 100 ft was used as opposed to 300 meters at Quellaveco, and readings were taken every 50 ft instead of every 100 meters. The smaller *E* body gives a better response than the *EL*. Some reasons for this are: 1) the *EL* body has massive sulfides, whereas the *E* is more disseminated,* and 2) the overburden is deeper over the *EL*. While both these bodies are adequately detected from their immediate surroundings, varying rock backgrounds reduce the certainty of the method in this area. For instance, not far to the west of the *EL* a quartzite formation gave response in the 50's, higher than that obtained over the *EL* itself. Disseminated pyrite possibly contributed to the high quartzite response.

* The overvoltage method works best with disseminated sulfides.

A contour map of anomalous overvoltage response provides a good picture of the distribution of sulfide mineralization; in regions where the depth to top of sulfides is less than about a third the electrode spacing and resistivity contrasts are not extreme. An example is given in Fig. 8, which is from a prospect in Peru; the contours here include a background response of about 5. Drilling in the highs provided approximate confirmation of the distribution in a limited portion.

A reading on one electrode spacing only gives no indication of depth of cover. This information can be obtained from expanders. An expander is a series of readings at different electrode spacings taken at one station. The results are then compared with type curves. In a great many cases the simple two-layer approximation is adequate. The derivation of two-layer type curves has been discussed under Type Curves. The investigator solves for depth and for anomalous response or mineralization factor of the underlying zone. The examples below are plotted linearly for greater clarity, but the method of solution requires the field results to be plotted on two-cycle logarithmic paper of the same size as the type curve paper. An expander is entirely analogous to the vertical profile of resistivity surveys.

Fig. 9 shows an expander taken at San Manuel, Ariz., plus a geological section in the region. The surrounding pyrite mineralization presumably renders the two-layer case applicable. This example is particularly interesting in illustrating how such deep mineralization as San Manuel's is detectable.

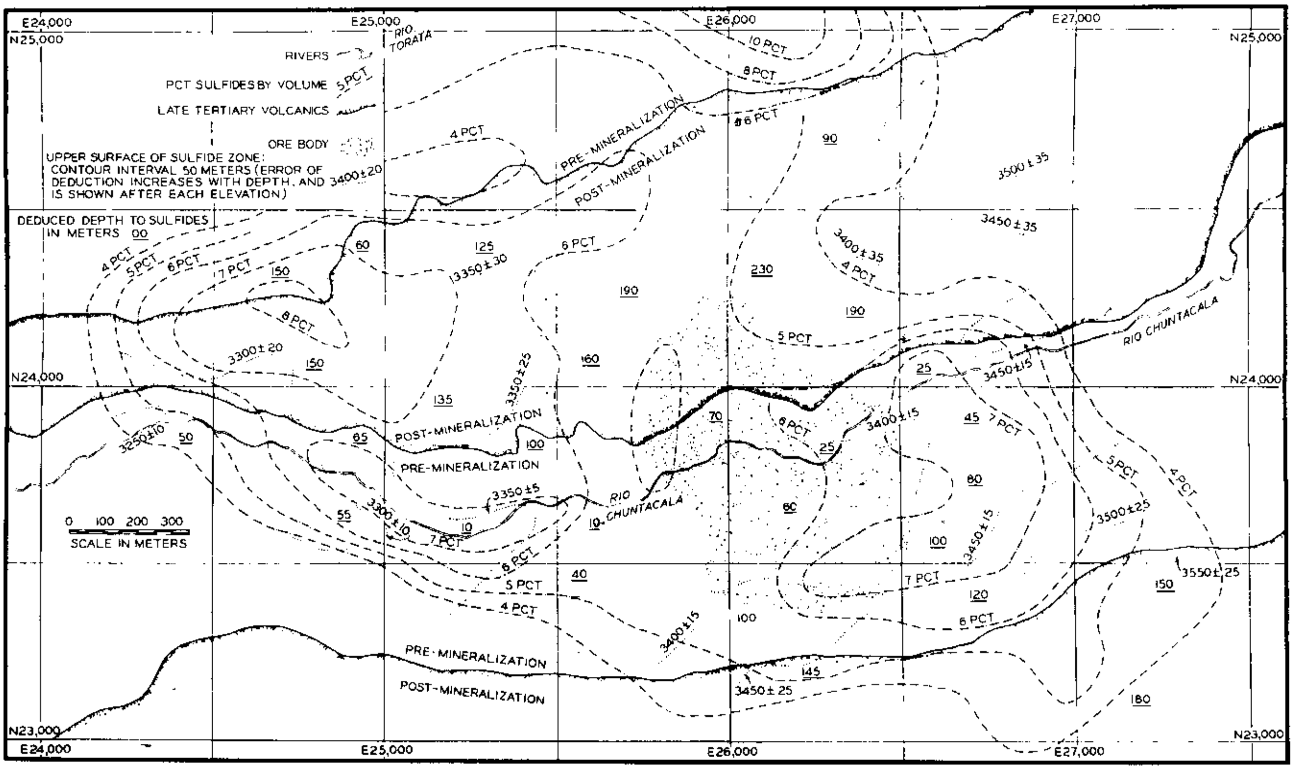


Fig. 11—The sulfide distribution at Cuajone, Peru, as deduced from the overvoltage data. Note the great variation in depth to the top of the sulfides. The mineralization that is outside the orebody consists mostly of pyrite.

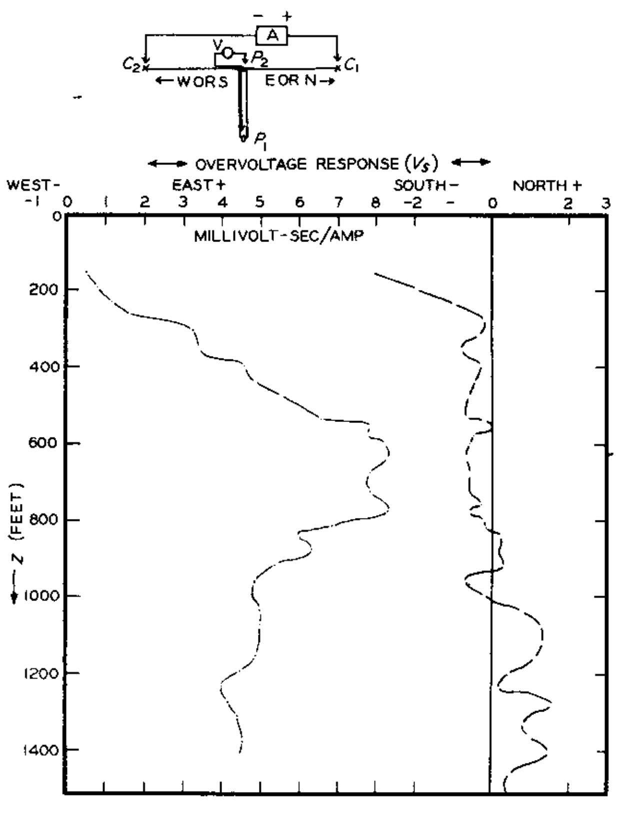


Fig. 12—Nababeep West, South Africa, borehole WP 12. The direction of mineralization from a drillhole is indicated here by the overvoltage azimuth survey.

An expander across the south end of the orebody at Cuajone, Peru (Fig. 10) gives depth to sulfides as 100 meters. Depth actually is about 90 meters.

With the aid of readings on more than one electrode spacing over a large area, it is possible to obtain mineralization factors and depths at a great number of points and then to contour this deduced data. At Cuajone two electrode spacings, one twice the other, were used on every line throughout the anomalous area, and additional control was provided by short spacing readings on several lines and by a few formal expanders. Fig. 11 shows a portion of the deduced mineralization and top of sulfide contour map; Fig. 11a, an aerial photograph of the region, illustrates to some extent the type of topography. For mineralization, it was assumed that a mineralization factor of 10 represented 1 pct sulfides by volume.* Depth to sulfides varies from less than 10 meters in the Chuntacala Valley to more than 160 meters where the late Tertiary volcanics cap the pampa or mesa to the north. The Cuajone orebody has now been extensively drilled and a rough outline is shown on the map. The deduced mineralization extends more than a kilometer to the west and more than half a kilometer to the east of the orebody, also (not shown here) far to the northwest. The deduced mineralization is at some points actually higher on the rim than directly over the orebody. The mineralization rim is disseminated pyrite. The drilling has in general verified the deduced mineralization pattern, but only relatively. A recent study of the assays from 35 drillholes has revealed that predicted sulfide content was on the average 1.95 times actual

* This factor was based on tests made in Arizona.

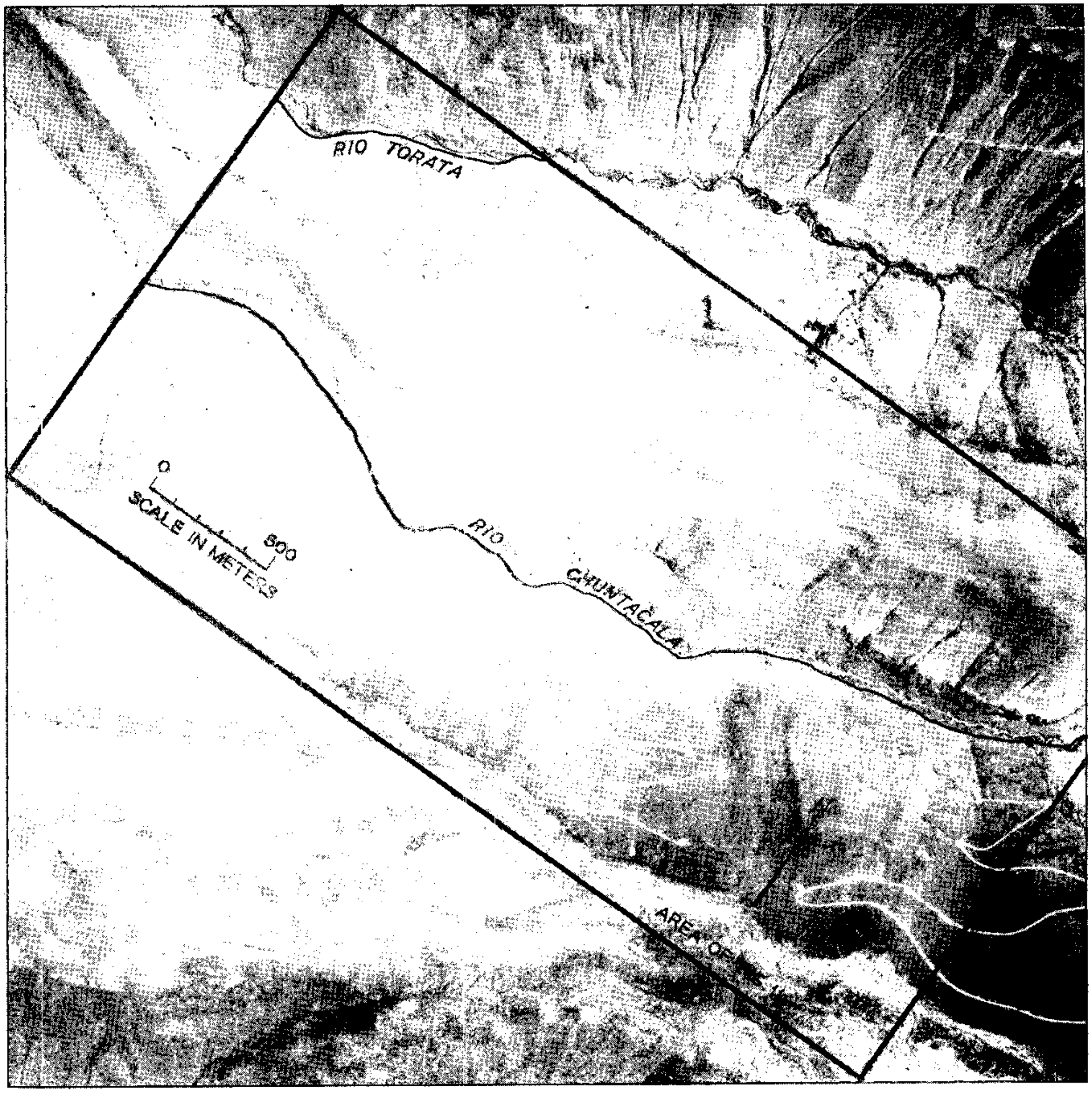


Fig. 11a—Air photo of Cuajone site shows steep hillsides, especially bordering the Rio Torata.

sulfide content. If this correction had been known in advance, the probable error of mineralization prediction at any point would have been about 30 pct of the predicted sulfide content, or less than 1 pct sulfides by volume. The probable error of depth prediction at Cuajone was 10 meters.

The overvoltage method has been tried in drillholes. This application, though it has given useful indications, has not had the widespread success that was first expected. One major problem has been correcting for the masking effect of low resistivity fluid in the drillhole, especially when working in very high resistivity Pre-Cambrian formations.

One important sideline to drillhole work is azimuth determinations. Once a significant anomaly is obtained in a drillhole using normal electrode arrays, direction is determined by placing the two current electrodes on surface an equal distance on each side of the collar, lowering one potential electrode down the hole, and measuring the overvoltage response with respect to a reference electrode. A positive response indicates that the source of the anomaly lies in the direction of the negative current electrode and vice versa. Two azimuth runs (north-south and east-west) are necessary to fully establish direction. Results in Nababeep West, South Africa, drillhole No. 12 (Fig. 12), suggest that in the upper part of the hole mineralization lies chiefly west, whereas in the lower part it lies chiefly to the south. These deductions were confirmed in the course of drilling the orebody.

There remain to be mentioned those unfortunate cases where overvoltage anomalies are not caused by sulfides.

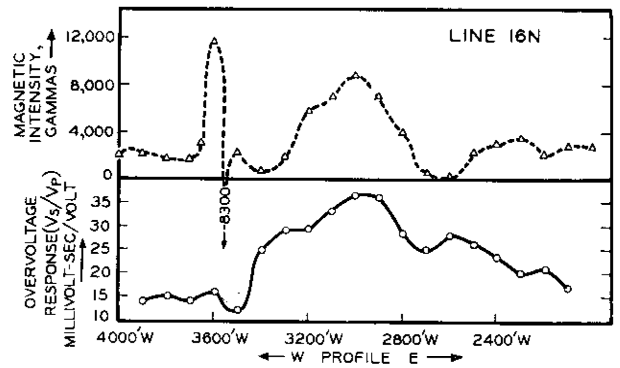


Fig. 13—Magnetic and overvoltage profiles at Engels, Calif. Overvoltage anomaly is attributed to magnetite.

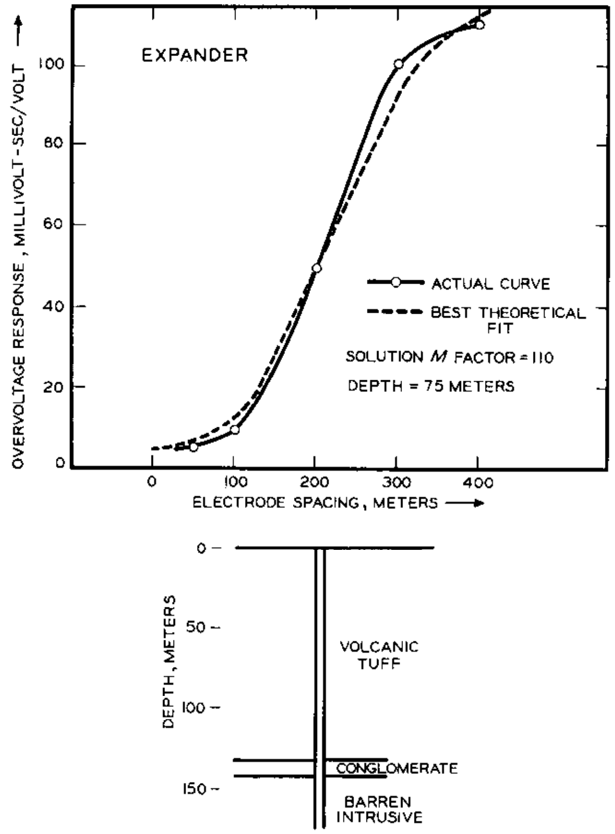


Fig. 14—Unexplained anomaly, Wildcat prospect, Peru.

Magnetite, being a metallic substance, gives an overvoltage response. An example of an anomaly presumably caused by disseminated magnetite comes from Engels, Calif. (Fig. 13). There is good correlation between the overvoltage and magnetic profiles. Of course the presence of an associated magnetic anomaly is not necessarily unfavorable. The two Lynn Lake examples both had excellent magnetic anomalies also.

Response from graphite has been observed in the laboratory, and in Southern Rhodesia a field anomaly was attributed to this mineral. However, graphite has not proved generally troublesome, for the simple reason that most surveys have not been in graphitic areas.

A wildcat anomaly obtained in Peru is still not satisfactorily explained. This occurred in a trough of post-mineral volcanic tuff. The expander taken at the center of the anomaly is shown in Fig. 14. Mineralization was predicted at less than 100 meters, the best solution being about 75 meters. In fact, drilling disclosed no lithological change for nearly twice this depth and the basement was only negligibly mineralized.

Victor Mayper[8] has shown that clay minerals with high ion exchange capacity can give a considerable overvoltage response. Notable extraneous anomalies were obtained in low resistivity phyllites in South West Africa and in certain schists in British Columbia.

The process of taking an overvoltage reading provides a resistivity reading automatically. The resistivity data are of direct use to the overvoltage survey in providing information necessary in depth calculations. A resistivity survey also has many well known applications—such as determining depth of overburden—and in itself is often a guide to mineralization. Porphyry coppers, for example, offer a fairly limited range of resistivity values. Most of the examples given in this article have accompanying resistivity anomalies. It is standard practice always to consider overvoltage results in conjunction with resistivity data.

Despite some unforeseen complications, e.g., the high response from certain nonsulfide material, the overvoltage method has proved its usefulness in detecting and outlining disseminated sulfide mineralization, even at depths as great as 200 meters.

The following firms have kindly granted permission to publish various items of information: Newmont Mining Corp., American Smelting & Refining Co., Cerro de Pasco Corp., San Manuel Copper Corp., Sherritt Gordon Mines Ltd., and O'okiep Copper Co. Ltd.

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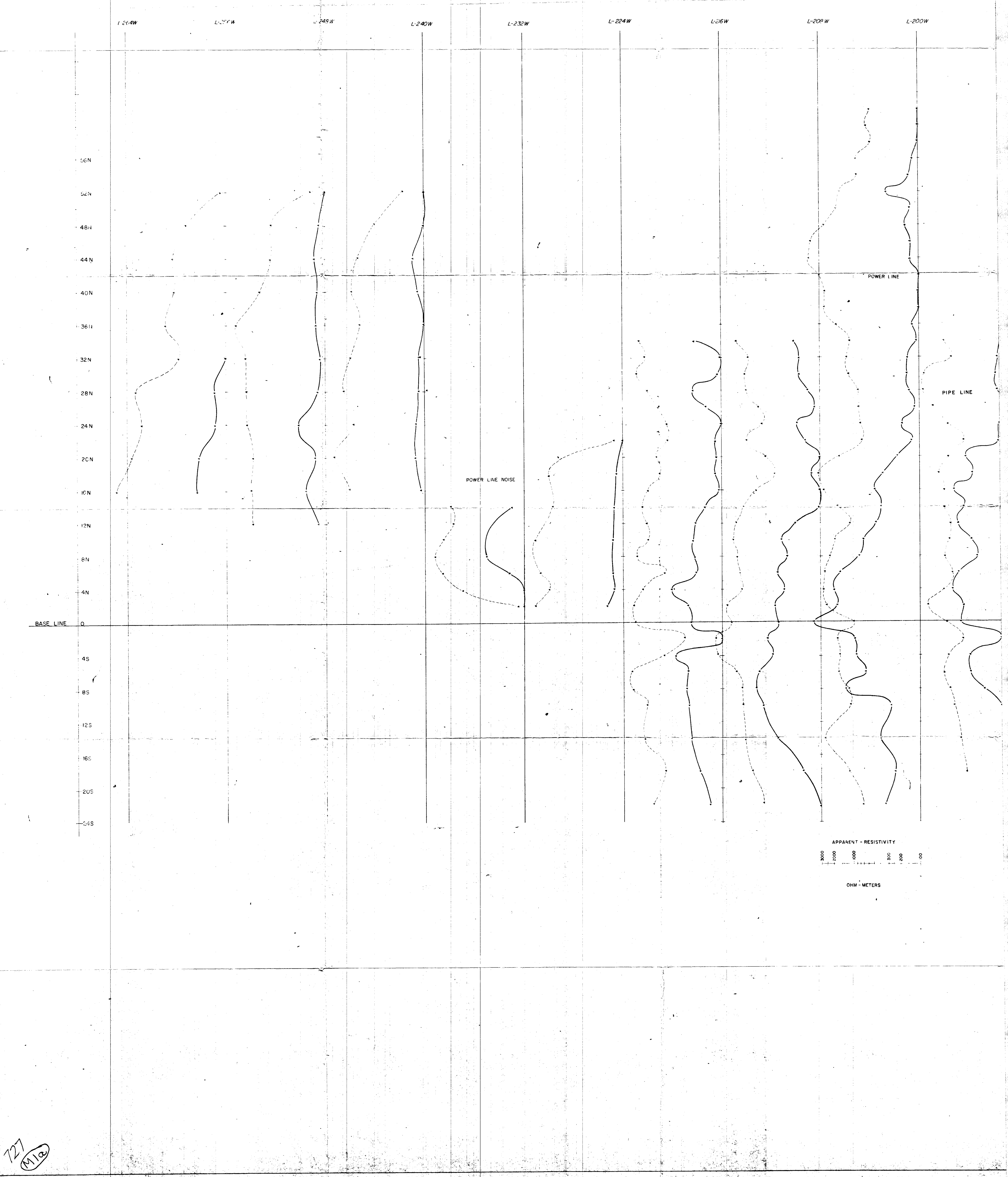
* These items are private company papers, but it is hoped that they will soon be presented in a monograph to be published by the Pergamon Press.

Discussion of this article sent (2 copies) to AIME before April 30, 1959, will be published in MINING ENGINEERING.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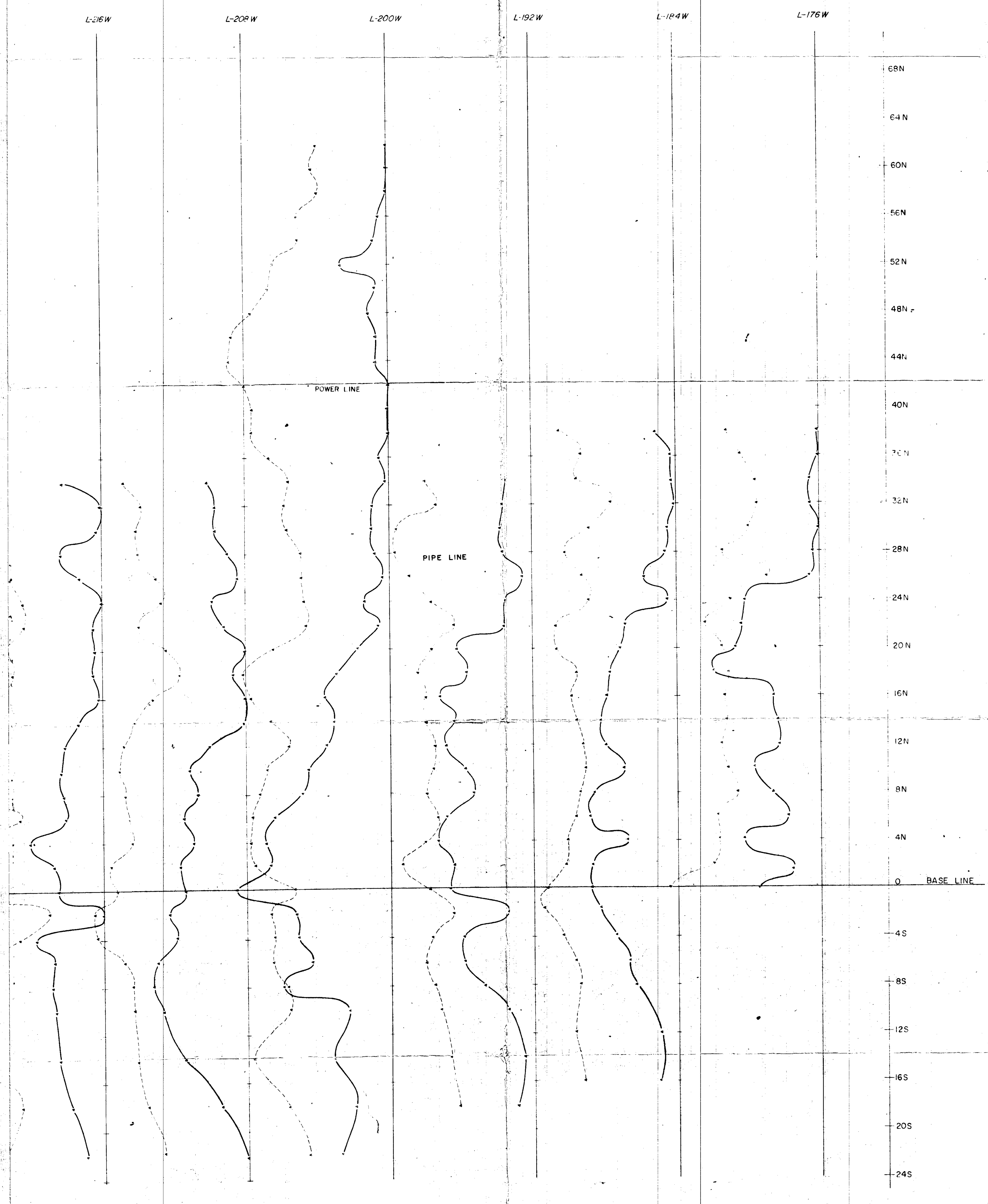
APPARENT - RESISTIVITY
OHM - METERS



727

INDUCED POLARIZATION SURVEY

PROFILE PRESENTATION

COMET MINES AREA

FOR

VANCO EXPLORATION LIMITED

BY

CANADIAN AERO Mineral Surveys LTD.
OTTAWA & TORONTO ONT, CANADA

LEGEND

ELECTRODE CONFIGURATION .... 3 ARRAY
ELECTRODE SPACING .... 400 FEET
APPARENT CHARGEABILITY ...... 1" = 5.0 MILLISECONDS
APPARENT RESISTIVITY ... 2" = 1 log. cycle 0 - 100 - 1000 ohm - meters

SCALE

1 INCH = 400 FEET
NOTE: LINES NOT SPACED TO SCALE

(APPROX.)

C.A.M.S. - 6018


264 W
256 W
248 W
240 W
232 W
224 W
216 W
BASE LINE
40 N
30 N
20 N
10 N
00 N
10 S
POWER LINE
POWER LINE NOISE
POWER LINE NOISE
POWER LINE NOISE
POWER LINE NOISE
POWER LINE NOISE
POWER LINE NOISE
POWER LINE
MASKING
727
M2a

232W
224W
215W
208W
200W
192W
184W
176W
50 N
40 N
30 N
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POWER LINE
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NOISE
LEGEND
ELECTRODE CONFIGURATION 3 ARRAY
ELECTRODE SPACING 400 FEET
CONTOUR INTERVAL 2.0 MILLISECONDS
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INTERMEDIATE CONTOUR
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727
M2b


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INDEX CONTOUR ....
INTERMEDIATE CONTOUR ....
SCALE-
1 INCH = 200 FEET
(APPROX)
Department of Mines and Petroleum Resources
ASSESSMENT REPORT
NO. 727 MAP #3
INDUCED POLARIZATION SURVEY
CHARGEABILITY CONTOUR PLAN
COMET MINES AREA
FOR
VANCO EXPLORATION LIMITED
BY
CANADIAN AERO Mineral Surveys LTD.
OTTAWA & TORONTO
ONT, CANADA
727 M2c


NICOLA VOLCANICS
MONZONITE
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VOLCANICS
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DIORITE
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42N
22N
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To accompany geophysical report by
W.G. Wahl, Ph.D. P.Eng on the Comet Mines Limited
Iron Mask Area
Kamloops, British Columbia
Dated Dec. 10. 1965
VANCO EXPLORATIONS LTD.
COMET OPTION — KAMLOOPS B.C.
MAGNETOMETER SURVEY
Scale: 1 inch = 400 feet
Date: December 10, 1965
Contour Interval: 1000 gammas.
Drawn by T. LISLE.
Department of
Mines and Petroleum Resources
ASSESSMENT REPORT
NO. 727 MAP #4
727
GRID SAME AS USED ON VANCO CLAIM MAP.


R.O. 77 to R.O. 82 CLAIMS EXTEND NORTH FROM HERE
R.O. 47
R.O. 49
R.O. 51
R.O. 53
R.O. 55
R.O. 57
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R.O. 9
R.O. 11
R.O. 13
R.O. 76
R.O. 75
R.O. 6
L4667 C.G.
R.O. 10
R.O. 12
R.O. 14
R.O. 4
LORNA 2
LORNA 1
I.C. 1
IRON MASK LAKE
M.L. 21
L875 C.G.
R.O. 3
LORNA 3
LORNA 4
I.C. 2
R.O. 1
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Department of
Mines and Petroleum Resources
ASSESSMENT REPORT
NO. 727 MAP #5
VANCO EXPLORATIONS LTD.
COMET OPTION — KAMLOOPS B.C.
CLAIM MAP
1 inch = 400 Feet.
December 10, 1965.
Drawn by T. Lisle.
To accompany geophysical report by W. G. Wahl
NOTE: Mineral Claims R.O. 77 to R.O. 82 inclusive are not shown. These claims extend north to the Thompson River and adjoin the R.O. 59 and R.O. 61 mineral claims as indicated. No geophysical work was completed on these claims. TL.
R.O. Claim Group.
RIVER Claim Group.
Lorna Group.
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