

EXPLORATION OF A BASE METAL DEPOSIT  
IN THE YUKON TERRITORY BY GEOPHYSICAL SURVEY METHODS  
BY EDWARD O. CHISHOLM

INTRODUCTION

The results of the first gravimetric survey to be used for economic purposes in the northwestern Cordillera are described. It was successfully used by a mining exploration company to outline a flat-lying lead-zinc sulphide replacement deposit buried under fifty feet of glacial overburden in a mountainous region located 125 miles northeast of Whitehorse, Yukon Territory. Detailed diamond drilling verified the accuracy of the survey both as to the estimated tonnage and boundaries of the deposit. The results of auxiliary magnetometer, self-potential and geochemical surveys are also described.

LOCATION, TOPOGRAPHY, ETC.

The deposit is located at the headwaters of Vangorda Creek, a tributary of the Pelly River, on the Vangorda Mines property of Prospectors Airways Company Limited.

The surrounding country is mountainous but the deposit is located in the centre of an intermontane valley approximately  $2\frac{1}{2}$  miles wide. Differences of elevation within the area of the survey were less than 100 feet which facilitated gravity work.

The deposit lies beneath a glacial sand and boulder ridge varying in thickness from 25 to 80 feet. The ridge is traversed by Vangorda Creek, a small glacial stream and a smaller tributary. Outcrop is exposed in the area of the survey at one location only on the bank of the stream, and consists of massive sulphides 100 feet in length, 10 feet in height. Permafrost, though usual in this latitude, was not encountered.

Overlying the glacial deposit is a persistent layer of volcanic ash approximately 4 inches thick. Climatic conditions are sub-arctic and the soil profile is immature with zones of leaching and oxides extending less than one foot below surface. This effects a smaller residual base metal content of the soil and water than is normal to central latitudes.

GEOLOGY, MINERALIZATION, ALTERATION

The deposit is comprised of an overlapping series of horizontal lenses of sulphides that appear to replace a favorable sedimentary bed. A longitudinal section of the body is shown in Figure (4). Seventy-three diamond drill holes indicate a length of 3,200 feet with an average width of 490 feet and a tonnage of 9,400,000 tons of sulphide containing 3.16% Pb; 4.96% Zn; 0.27% Cu; 1.76 oz. Ag; 0.02 ozs. Au., and an additional tonnage of 12,600,000 tons of low-grade to barren sulphides. The total mass

of sulphides is estimated from diamond drilling to be in the order of 22 million tons. The mineralized body extends from bedrock surface to a depth of 300 feet. No underlying body has been encountered to a depth of 1,000 feet.

The host rocks are comprised of a flat-lying sedimentary assemblage which can be divided into two main horizons, one predominantly chloritic sericite schist and the other predominantly graphitic schist. They are intimately associated and considerable intercalation takes place at the edges of the graphitic horizon. The graphitic schist is minutely crumpled, breaks easily along cleavage planes, and contains narrow (up to 1 mm) quartz stringers which are often mineralized by pyrrhotite, with minor chalcopyrite and pyrite. In thin section, it consists of minutely folded bands of white mica (sericite) and black carbonaceous matter intercalated with bands of anhedral, interlocking quartz grains, and isolated siliceous lenses. Sparse mineralization is confined to the siliceous bands, pyrrhotite apparently replacing quartz.

The rock seems to have been produced by strong metamorphism of impure carbonaceous slate interbedded with thin sandy layers. Calcite is present in small amounts and may have been introduced with the sulphides.

The sericitic horizon consists of light greenish-gray, chlorite schist. It appears less deformed than the black schist. It is sparsely mineralized in siliceous bands (mainly pyrrhotite with some galena and chalcopyrite). In thin section, it appears to be a succession of thin bands of sericite; alternating with somewhat wider layers of quartz and chlorite containing minor amounts of orthoclase and sericite.

The rock appears to have originated by strong regional metamorphism of a succession of thin sedimentary beds, probably of impure sandstone interbedded with shale. Occasional siliceous lenses now containing sulphides may have been originally small pebbles in the sediment. No intrusive rocks were encountered within the confines of the above area, although granite, gabbro, diorite and porphyry are present elsewhere on the claims.

The mineralization consists of a fine-grained aggregate of sulphides in a siliceous matrix. Sulphide content is variable but might average 60% overall. Minerals present in their order of abundance follow:

Pyrite	35%
Sphalerite	25%
Galena	15%
Pyrrhotite	10%
Chalcopyrite	6%
Arsenopyrite	5%
Magnetite	3%
Marcasite	1%
Tennantite	Small amount.

The assemblage indicates a hypothermal replacement deposit.

Alteration is predominantly sericitic and chloritic and is intensified in an envelope surrounding the mineralized deposit.

The control of deposition appears to be lithological rather than structural but there is insufficient evidence to decide at this stage. There is a suggestion that the northwest extremity of the deposit is terminated by a thrust fault along Vangorda Creek. There is also a suggestion that the long axis of the deposit is controlled by faulting and/or folding. These structural elements are reflected in the magnetometer and gravity surveys.

#### SELF-POTENTIAL SURVEY

The outline of the self-potential survey and its relation to the mineralized zone are shown in Figure (1).

Readings were taken at 50-foot intervals along lines 200 feet apart, and tied in to a base reading of zero on the baseline at station 2000 east. This base station was chosen arbitrarily and ensures that anomalous readings are high positives in relation to normal base-level values. The correction of readings in to the base reading was determined on the potential of the roving contact of the instrument. A negative reading on the instrument, indicating that the roving pot was at a higher potential, was added to the base reading, or value at the station on which the instrument was set up; a positive reading or lower potential was subtracted.

#### Observations

(a) The contoured results show several large and continuous high anomalies.

(b) Overburden in excess of 25 feet blanketed out any currents associated with the mineralized deposit.

#### Conclusions

(1) The anomalies represent an expression of the ground currents associated with the graphitic schist horizon underlying the deposit.

(2) The self-potential method though cheap and fast would be of use under the present geological association only in tracing the black schist horizon under shallow overburden less than 25 feet in depth. Where depths of overburden are unknown the interpretation of results would be difficult and the electromagnetic method would offer more effective technique due to its greater penetration.

#### AEROMAGNETIC SURVEY

A series of lines approximately 5,000 feet apart were flown over the central part of the claims at a height of 500 feet to test the effectiveness of this type instrument for reconnaissance.

#### Observations

No higher than normal readings were obtained over the mineralized zone but a general higher level of readings was noted over the basic intrusives one mile to the southwest of the deposit.

### Conclusions

Although insufficient lines were run over the zone to be conclusive, the airborne instrument does not appear sensitive enough to outline this type of mineralization.

### MAGNETOMETER SURVEY

The outline of the magnetometer and its relation to the mineralized zone is shown in Figure (2).

Readings were taken by Askania instrument at 50-foot intervals on lines 200 feet apart. Sensitivity was 25.6 gammas per scale division. No magnetic storms or side hill effects from surrounding masses were noted.

### Observations

- (1) Six anomalies were obtained within the area of mineralization with residual magnetic values ranging from 800 to 2,000 gammas.
- (2) Contours are lenticular along the length of the deposit.
- (3) The most intense anomalies were obtained where overburden is shallow.
- (4) Anomalies of similar magnitude and shape were obtained outside the mineralized zone.
- (5) Certain sections of massive mineralization gave no magnetic anomalies.
- (6) Sufficient spot drilling has been done to signify the cause for most anomalies.

### Conclusions

The magnetometer alone would not produce definitive anomalies signifying underlying sulphide mineralization, due to the variable magnetite content of the sulphide deposit itself, and the presence within the confines of the survey of other factors contributing to a magnetic condition of similar magnitude to that encountered over the mineral deposit. These factors are as follows:

- (1) Concentration of magnetite in residual gossan material underneath an eroded section of sulphides.
- (2) Small gabbro intrusive plugs located outside the confines of the mineralized zone.
- (3) Widely disseminated magnetite in certain sections of the graphitic schist horizon which, when located near surface, produced a mass effect equal in magnitude to the magnetic section of the main mineralized zone.

The magnetometer proved useful in indicating favorable terrain; in determining the strike of mineralized zones; in pinpointing thick sections of sulphide containing magnetite. It also indicates a possible normal fault that terminates the deposit abruptly along Vangorda Creek between anomaly (1) and (2). Confirmation of this fault zone was encountered in drilling.

The magnetometer is best used in conjunction with other exploration survey methods under the above geological conditions.

### GRAVIMETER SURVEY

The outline of the residual gravimeter anomaly and its relation to the mineralized zone is shown in Figure (1).

Readings were taken with a Worden gravimeter with sensitivity of 0.10024 mgs. per scale division at 100-foot intervals with varying line separation. Gravity and elevation runs were made in closed loops with all errors being adjusted. Elevation misclosures were kept under 0.5 feet and gravity misclosures under 0.5 milligals. Drift, elevation, latitude and terrain corrections were applied to the gravity readings.

Density measurement carried out on both surface and core specimens gave the following values:

<u>Specimen</u>	<u>Depth</u>	<u>Type of Material</u>	<u>Density</u>
1	Surface	Granite	2.64 gms/cc
2	139'	Sericite Schist	2.69 "
3	188'	Sericite Schist	2.75 "
4	393'	Sericite Schist	2.76 "
5	188'	Graphite Schist	2.78 "
6	45'	Gabbro	2.85 "
7	50'	Gabbro	2.84 "
8	-	Massive Sulphides	4.34 "
9	-	Massive Sulphides	4.23 "
10	"	Massive Sulphides	4.62 "

The schists are of relatively uniform density, with the granite slightly lighter and the gabbro slightly heavier.

### Observations

The mineralized zone is clearly detected and its edges well defined. It shows a remarkable coincidence with the zone as outlined by drilling.

Tonnage calculations made from the residual anomaly (total anomaly minus regional anomaly) gave an excess tonnage of 6 million long tons. Transferred into actual tonnage, on the assumption that the schists average density is 2.8 gms/cc and the mineralization averages 4.0 gms/cc, a total tonnage of 20 million tons is indicated. This is remarkably close to the total sulphide tonnage of 22 million tons indicated by drilling.

The regional gravity not shown on the accompanying map consisted of a gradual slope to the southwest and is caused by a series of gabbro intrusions in this direction.

The shape of the anomaly indicates that the mineralization is banded in parallel zones along its length. The portions of greatest thickness near Vangorda Creek as shown on the longitudinal section Figure (4), are reflected in high gravity values up to a peak of 2.02 milligals. The lensing out of the deposit to the edges is also reflected in lower gravity values.

Some of the edges of the deposit as indicated by the gravity anomaly are noticeably sharp, others gradual. This may be a reflection of faulting especially in the northwestern end of the deposit.

Approximately 500 feet southwest of the mineralized deposit and parallel to it, is a small broad low. This appears to be a reflection of a graphitic schist horizon which outcrops in this area. Its overall density is lower than surrounding schists.

No anomalous regional effects that might be expected in the disturbed zone of intermontane terrain, were noticeable in the gravity survey.

### Conclusions

Near surface deposits of massive sulphides enclosed in light schists that provide a marked density contrast produced sharp high gravity anomalies. Values above 0.5 milligals were considered anomalous.

The gravimetric method is a definitive tool for outlining sulphide masses located in the geological conditions herein described.

### GEOCHEMICAL SURVEYS

The outline of geochemical heavy metal surveys conducted in the soil surrounding part of the deposit and in the drainage system cutting through it are shown on Figure (8) and Figure (7) respectively. Geochemical profiles showing the relationship between heavy metal content in the soil, topography, location of sulphides, gravity and magnetic determinations, are shown in cross-sections 5 and 6.

Soil samples were taken at 100-foot intervals on lines spaced 200 feet apart at uniform depth of two feet. This represents the "C" or parent soil zone. It was tested for heavy metal content by the cold extraction method devised by Bloom<sup>1</sup>. Surveys were carried out in July after the seasonal run-off had taken place and the water table had reached a state of equilibrium.

The method is a rapid and simple field technique that involves extraction of (Zn, Cu, Pb, Co, Ni) ions from a soil sample with a cold solution of ammonium citrate in the presence of dithizone-xylene solution. The method may also be used for water samples taken at regular intervals along streams.

1. Bloom, H.A. "A Field Method for the Determination of Ammonium-Citrate Soluble Heavy Metals in Soils and Alluvium". Econ. Geol. Vol. 50 pp 533-541.

### Observations

Figure (7) shows distinct heavy-metal anomalies in the soil near the mineralized zone on the down slope side.

Deep overburden blanketed out anomalies.

Similar results are noted also in Figure (5) and (6) where sharp increases were obtained in the heavy metal content of the soil on Sections 0 plus 00 and 4 plus 00 east at 12 plus 00 south, down slope from the mineralized zone.

Figure (5) shows a sharp rise in the heavy-metal content of the soil at 0 plus 00 south where the massive sulphides are located near surface and where overburden is light.

In these conditions a heavy-metal content of over 200 parts per million was considered significant for the soil and over 0.01 parts per million for water.

Figure (7) shows a gradual build up in the heavy-metal content of the water in Vangorda Creek up to the point where it cuts through the mineralized zone. Similar increases in heavy metals were noted in the tributaries of the main creek as they approached the mineralized zone.

### Conclusions

The geochemical water test is a cheap and useful prospecting method for testing streams and tracing heavy metals to their point of maximum concentration.

The soil testing is useful as an auxiliary exploration tool where overburden is light.

The main usefulness of geochemical methods lies in the quick determination of large targets for subsequent exploration by other methods rather than time-consuming investigation within narrow limits. This is because of the large inherent sampling error in any soil sample.

### GENERAL CONCLUSIONS

The results of geophysical and geochemical work carried out over the sulphide deposit at Vangorda Creek indicate that the optimum combination of preliminary exploration techniques elsewhere on the property would consist of a geochemical soil and water reconnaissance followed by electro-magnetic and gravity survey.

The assistance of the following is gratefully acknowledged. Radar Exploration Co. (Gravity Survey); R. W. Baker (Engineering and Diamond Drilling Data); D.R.S.Doal (Magnetometer Survey); V. Papezik (Geological Survey);

G. Novak (Geochemical Survey); F. A. Campbell (Self-Potential Survey);  
Staff of Prospectors Airways Company Limited.

Edward O. Chisholm, P.Eng.,  
Chief Geologist,  
Prospectors Airways Company Limited,  
Toronto, Ontario.

May 18th, 1956.

Exploration of a Base metal  
Deposit

In the Yukon

By geophysical methods