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THE EXPLORATION OF A LEAD-ZINC DEPOSIT

IN THE YUKON TERRITORY

BY GEOCHEMICAL SURVEY METHODS

- by -

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Introduction:

This report describes the geochemical methods used by Prospectors Airways Company, Limited, in the exploration of a large lead-zinc deposit lying beneath shallow, glacial overburden at Vangorda Creek, Yukon Territory.

The main object of the survey was to locate extensions of a known deposit and to indicate the location of any unknown deposits in the vicinity. It was successful under the conditions prevailing.

Location:

The deposit is located at the headwaters of Vangorda Creek (Fig. #1), a tributary of the Rally River, about 150 miles north-east of Whitehorse, Yukon Territory. It is situated at an elevation of 3,500 feet in rolling, forested country, in the centre of an intermontane valley (Fig. #2).

It lies beneath a glacial ridge, from 25 to 80 feet thick, which is transected by Vangorda Creek, a small, fast-flowing glacial stream. The deposit outcrops at one location only, on the bank of the creek, where massive sulphides are exposed over an area 100 feet by 10 feet. Rock outcrop is very sparse, although large boulders from sub-surfaces are often exposed by frost heaving action. The depth of overburden within a radius of five miles of the deposit averages less than 25 feet.

A typical vertical section of the overburden follows:

- a) Sub-soil several inches thick comprised of organic material, detritus from trees, grass, Labrador Tea, moss, etc. Its hydrogen-ion concentration varies from 6 to 7.
- b) Unconsolidated volcanic ash, up to 6 inches thick.
- c) Glacial gravel, sand and clay to bedrock, varying in thickness from a few feet to tens of feet.

Although usual in this latitude, permafrost was absent within the confines of the survey.

Climatic conditions are sub-Arctic and the soil profile is immature with zones of leaching and oxidation usually extending less than 2 feet beneath surface. This tends to reduce the residual base metal content of the soil and water, and under these conditions, a heavy metal content of over 200 ppm is considered significant for soil and over 0.01 ppm for water. In central latitudes the heavy metal content of soil and waters may be several times this figure.

Figures 13 and 14 show the results of a soil profile over the main deposit and illustrate the variations in zinc-iron concentration within individual soil layers. The "C" soil zone, namely the zone undisturbed by oxidation or enrichment, is the most reliable zone to sample.

Geology, Mineralization, Alteration:

The deposit is comprised of an overlapping series of horizontal lenses of sulphides that appear to replace a favourable sedimentary bed. A longitudinal section is shown in Fig. 15. It has a length of 3,200 feet; an average width of 490 feet; and an indicated 9,400,000 tons of sulphides containing 3.1% lead; 4.96% zinc; 0.27% copper; 1.76 ounces of silver; and 0.02 ounces of gold. There is an additional indicated 12,600,000 tons of low grade to barren sulphides. The total mass is estimated at 22 million tons. It extends from bedrock to a depth of 300 feet and 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 graphite schist. They are intimately associated and considerable intercalation takes place at the edges.

The graphite schist is minutely crumpled and breaks easily along cleavage planes. It contains narrow (up to 1") quartz stringers, mineralized by pyrrhotite, with minor chalcopyrite and pyrite. In thin section it consists of minutely folded bands of white mica and black carbonaceous matter intercalated with bands of anhedral, interlocking quartz grains, and isolated siliceous lenses. Mineralization is confined to the siliceous bands and pyrrhotite apparently replaces quartz.

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

The sericite schist horizon consists of light, greenish-gray, chlorite sericite schist. It appears less deformed than the black schist. It is sparsely mineralized with pyrrhotite, containing some galena and chalcopyrite. In thin section it appears as 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 in the claims (Fig. 16).

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

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

The assemblage indicates a hydrothermal replacement deposit.

Alteration is predominantly sericitic and chloritic and is intensified in an envelope, averaging perhaps 200 feet wide, 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 north-west extremity of the deposit is terminated by a thrust fault along Vanguarda 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 magnetometer and gravity surveys.

Method of survey:

The method of geochemical survey is a variation of a rapid and simple field technique devised by H.A. Bloom<sup>1</sup>, that involves extraction of heavy metal ions from a small soil sample, with a cold solution of ammonium-citrate in the presence of dithizone solution in xylene.

The test is normally sensitive to ions of zinc, copper, lead, cobalt, and nickel, but for all practical purposes the zinc ion concentration is the only factor measured in the survey, since the other ions were found to be negligible in amount.

A resume of the procedure devised for this survey follows:

Preparation of Buffer Solution:

Mix 100 grams (182 millilitres dry equivalent) ammonium citrate and 10 grams (18 millilitres dry equivalent) hydroxylamine hydrochloride in a 32 ounce polyethylene bottle and fill about half full with water passed through the demineraliser; add ammonium hydroxide until the pH is 7.5 as shown by hydriom papers; add a 15 millilitre amount of dithizone cleaning solution (prepared by dissolving .1 millilitre capsule of dithizone in 8 ounces of chloroform) to the bottle and shake vigorously for 30 seconds or more and let the chloroform settle; decant supernatant liquid and discard purple coloured cleaning solution in the bottom of the bottle. Repeat this procedure until the cleaning solution remains blue coloured.

<sup>1</sup>Bloom, H.A., "A Field Method for the Determination of Ammonium-Citrate Soluble Heavy Metals in Soils and Alluvium". Economic Geology, Vol. 50, p.p. 533-541.

This procedure extracts all of the interfering heavy metal contamination. The dithizone which is dissolved in the buffer solution is removed by two or three extractions (similar to the previous extraction) with some pure chloroform until the extracted chloroform is only lightly coloured.

The alkalinity of the solution is then adjusted to the higher value of 8.5 by slowly adding ammonium hydroxide and checking with the hydric paper. The bottle is then filled to the neck with purified water and the solution is ready for use.

NOTE: Water used for the manufacture of solutions should be run through a portable demineraliser to remove heavy metals and other interfering substances.

Preparation of Stock Dithizone Solution:

Prepare .01% stock solution by dissolving a .01 gram dithizone capsule in 100 millilitres of xylene approximately 12 hours before using.

Preparation of Working Strength Xylene Solution:

Prepare .003% field solution by diluting 30 millilitres of stock solution with 70 millilitres of xylene.

NOTE: This is the field strength solution for all test work.

Analytical Procedure - Soils:

Fill soil scoop to .1 grams with soil taken from sampling tool, dump into 10 millilitre graduate and add 5 millilitres of buffer solution, shake for at least 30 seconds. Add 1 millilitre shots of field strength dithizone solution in xylene until a neutral grey tint is obtained; note amount of dithizone solution added; multiply number of one millilitre shots used by 25 to obtain total ppm of heavy metals in soil.

EXAMPLE: If four millilitre shots were used to obtain neutral grey tint, the heavy metal content of the soil would be 4 times 25 equals 100 ppm.

Water Test Procedure:

Take 12.5 millilitre sample of water to be tested; add 1 millilitre buffer solution; add 1 millilitre shots of field strength dithizone solution until neutral grey tint is obtained. Heavy metal content of water is number of shots obtained times .04 ppm.

EXAMPLE: If four 1 millilitre shots were used to obtain neutral grey tint, heavy metal concentration of water would then be 4 times .04 equals .16 ppm.

NOTE: Prepare fresh field strength solution daily from stock solution.  
Prepare fresh stock solution every two weeks.

Sampling:

The analytical error involved in the method is in the order of plus or minus 25% of the actual metal present in the soil. Because of this large inherent error in any one soil sample, the main usefulness of this geochemical method appears to be in the quick determination of larger targets, rather than the time-consuming investigation within narrow limits. Most geochemical anomalies show a contrast of anomalous values against a background equal to many times the errors in the analytical test. Accuracy and precision of analytical data are not so important as the reliability with which the figures reflect the geochemical pattern.

The dithionite reagents are highly sensitive and specific and great precautions must be taken to avoid unintentional casting of results. Field strength dithionite solutions deteriorate quickly and fresh solutions should be made daily from a concentrated stock solution, to ensure uniformity.

Soil Survey:

Earth in the vicinity of a base metal ore body has, in general, a higher concentration of ions than other soils further from the ore. The ions dissolved in the surface of the ore body are pushed by force of upset equilibrium in the ion concentration. Ions from places of higher concentration migrate to solutions with lower concentration. In this process, equilibrium is never reached, because of: the very low concentration of ions; the distance to which ions can travel; and the continuous movement of the earth's crust. The differences in concentration is easily detected by soil survey and from this the ore may be located. Concentrations as low as 10 ppm of ions in the soil are measured, but the differences in concentration vary as much as one thousand percent.

The survey is carried out in the manner of many geophysical methods. A certain property of the matter is measured at regularly spaced intervals, and from the variation the location of the ore is suggested. The precision of the survey depends on the interval chosen. To ensure sufficient accuracy in the detailed survey over the ore zone, samples were tested on a 200 foot grid. For reconnaissance purposes in unknown terrain, samples were taken on a 500 foot grid and areas of higher than normal tests were investigated in more detail. A suitable topographical survey was run in conjunction with the soil survey.

Samples were taken at a uniform depth of 2 feet, where possible, by means of a 1/2" pointed steel rod, with an upward slanting 1/4" hole near the bottom end. On being driven downward the diagonal hole remained open, but when twisted and eased upward it fills with soil from the desired depth. The individual samples were placed in plastic sample envelopes marked with the location, depth and a description of the topography and geology. Samples were air dried and pulverized to 80 mesh. They were tested at the field base camp and results plotted on a suitable scale map.

One man can easily make 30 determinations per working day, and the rate may be up to 100 per man day. The bulk of the survey cost is labour, since material cost is negligible.

### Water Survey:

The objective of the water survey was to find higher than normal base metal concentrations in streams and to trace them to their sources. Surveys were carried out in July, after seasonal run-off had taken place and the water table had reached a state of equilibrium. The ~~max~~ test kit was used in the field to test the water upstream at regular 200 foot intervals. Smaller creeks are usually better targets than large, fast running streams, due to the dilution factor.

Water survey is a quick and efficient method. Even an unskilled operator can be quickly trained. Costs are low compared with other surveys. It is recommended for rough, preliminary location surveys and should be an excellent prospectors tool.

### Discussion of Results:

Before discussing results of the Vangorda survey, some remarks are in order on the meaning of geochemical patterns in general. Many factors may influence the migration of elements and these should be properly assessed when a heavy metal anomaly is indicated. An American authority, H.E. Haskin<sup>2</sup>, emphasizes certain considerations in his book on geochemical principles, extracts from which follow:

#### \*Background Values:

Geochemical anomalies, indicative of commercially important concentrations of elements can be recognized only by their contrast with unmineralized areas. The normal abundance of an element in any material, where the equilibrium has not been upset by the presence of a mineral deposit, is commonly referred to as "background". Background values can vary widely, owing to natural chemical and physical processes, whereby certain elements are enriched and others correspondingly impoverished. Data has been published as a general guide to the range of background values that may be expected. Anomalies may be formed either at depth, by igneous and metamorphic processes, or at the earth's surface by agents of weathering, erosion, and surficial transportation. The ones we are interested in are the anomalies of surficial origin - secondary anomalies. These take the form, either of residual materials from the weathering of rocks and ores in place, or of material dispersed from the ore deposit by gravity, moving water, or glacial ice. The mobility of an element, or tendency for it to migrate in the surficial environment, determines the characteristics of the geochemical anomalies it can form. Water is the principal transporting agency for the products of weathering. Mobility is, therefore, more closely related to the tendency of an element to be stable in water form. The chemical factors affecting the mobility of the elements include: hydrogen-ion concentration, solubility of salts, precipitation, absorption, oxidation potential, and the formation of complexes and colloidal solutions. The mobility of the elements may be further modified by biological factors.

<sup>2</sup>Haskin, H.E., "Principles of Geochemical Prospecting", U.S. G.S., Survey Bulletin 1000-F.

Secondary anomalies may occur in residual materials or in materials transported by ice, frost, underground water, animals, soil forming processes, plant activity and surface water. Each of these transporting agencies give characteristic distribution pattern to the weathering products of ore deposits.

Secondary patterns have been further classified as halos, fans, and trains, according to the characteristic shape of the pattern and its geochemical or geometrical relationship to the ore deposit or other locus of enrichment. A halo is a nearly equidimensional dispersion pattern, enclosing or overlying the source of material. A fan is a pattern spreading outwards in one direction from a well-defined source. A train is a linear dispersion pattern formed by movement along drainage channels.

One of the principal problems in interpreting the data of geochemical surveys is distinguishing the geochemical anomalies caused by an ore deposit from geochemical dispersion patterns of no economic significance.

Certain empirical criteria can be worked out, that are helpful in identifying and interpreting geochemical anomalies. These involve a consideration of:

- 1) The range of non-significant variations in background.
- 2) The threshold between non-significant and anomalous values.
- 3) The contrast between anomalous and background values, and
- 4) The homogeneity of the anomalous pattern.

Background Range:

Normally, the geochemical data obtained in areas where the equilibrium has not been upset by the presence of the mineral deposit lies statistically within a well defined range. Geometrical patterns of non-significant variations can readily be misinterpreted as geochemical anomalies, if their true significance is not recognized. Background is similar to static in a radio signal.

Threshold:

In interpreting the geochemical pattern of an area containing anomalies, it is usually possible to select a certain limiting cut-off, or "threshold" value below which the variations represent only normal background effects and above which they have a significance in terms of possible ore. No hard and fast rule can be established as to what the threshold value is likely to be in any given area, because it will depend on local geochemical factors which are different for different areas. However, it is usually possible to select a threshold contour suitable for the area in question, by careful appraisal of all the geochemical data from the area.

Content:

This criterion for the significance of an survey is the geochemical relief or contrast between analytical values and background values. This contrast may be expressed as the ratio, either of analytical to threshold, or analytical to background, or threshold to background, depending on which figure appears to be the most significant. Each element will normally show a different and characteristic degree of contrast with its background. It will be a regular effect of the contrast factor in the area and the factors affecting the reliability of the element in surficial environment.

Homogeneity:

The homogeneity of a geochemical survey is a measure of the smoothness or absence of strong, local variations in the distribution of the indicator element. Anomalous areas, where smooth geochemical profile curves or contours can be drawn, are relatively homogeneous. Anomalies within which values vary erratically through a wide range within short distances, may be considered relatively heterogeneous. The homogeneity of a geochemical survey is a prime consideration in establishing the optimum spacing of samples for a geochemical survey.

Results of Vungonda Creek Soil and Water Survey:

Fig. 66 shows the original reconnaissance geochemical survey on the Vungonda Mines Property. Samples, at 500-foot intervals, outlined four geochemical targets. Drilling subsequently proved that Lead-zinc mineralization existed under three of these areas and a carbonate area containing very low values in zinc was encountered under the fourth.

Due to the wide spacing of samples, the results were not homogeneous enough to contour the dispersions, and targets could only be indicated in a general way. The only area investigated by detailed geochemistry was the Vungonda Creek deposit. Fig. 67 shows the outline of the deposit and the results of a self-potential survey. The self-potential survey was flat over the sulphide body, due to a thick layer of gneiss material in this locality. Its position along the creek to the south is thought to indicate the migration of the Lead-zinc ions downwards. Fig. 68 shows the results of the detailed water and soil geochemical survey conducted over the west end of the deposit. The concentration of the ions did not depend entirely on the presence of the deposit, but on many other factors. If the indication of the survey is considered, however, it is a very useful tool in mineral exploration. The concentration varied with the depth of the deposit and the thickness of the overburden. It was also affected by topographical relief and it seemed to be generally higher on the base of hill sides, due to drainage and slump of the earth. Finally, other considerations being equal, it varied with the nature of the soil being tested. For example: Carbonates in rock fragments gave higher values than sulphides; and lighter soils generally gave higher concentrations than heavier ones; although sand itself gave low values. Siltes also usually gave a low ion concentration. For these reasons, sampled materials should also be indicated on the geochemical map.

Water samples are generally more uniform and fewer factors influence the ion concentration. They are influenced, however, by geological and chemical properties of the surroundings. The size of the creek also affects the concentration.

The results of soil survey are usually represented by contour and concentration plans and on profiles along lines of samples. The water survey map is usually drawn separately, showing the location of tests and their concentrations. Both soil and water surveys indicated a high concentration of silts along directly above the deposit on the north-west side of Vangorda Creek; along a small creek to the west of this; and in the vicinity of a small creek in the southern part of the area. Highest readings were observed in the soil and water plots to the above, and on the small creek in the west. The anomalies along the small creek were, apparently, caused by silt from sources close to the courses of these creeks. The creek in the south flows from the main deposit and the anomaly coincided with the valley of this creek.

The mineralization on the north-west side of Vangorda Creek is well delineated by the soil survey results. However, the south-east side of the creek does not show anomalous concentration directly above the deposit. The reason for this is that a thick layer of clay and glacial drift covers it here. Silt migrating from it are dissolved in the water flowing in the glacial drift and concentrated at the intersections of the water table with the stream valley. This theory is supported by less silt concentration in an artesian well flowing through a discarded drill hole in the central part of the deposit. It is suggested that the artesian water comes from the elevated area north-east of the deposit and carries the silt to the lower area of the creek in the south. On the side of the creek from-south conglomerate is also found. Figs. 79 and 810 show geochemical soil profiles over the sections of the mineralized body. Fig. 79 shows a sharp rise in the heavy metal content of the soil on line 0-00 and 12 south, where massive sulphides are located near rock surfaces and overburden is light.

Fig. 810 shows a sharp rise in the heavy metal content of the soil on line 4-00 east and 12 south, down slope from the deposit. The thick glacial overburden reduces surface concentration of heavy metal ions. Fig. 811 again shows the results of the water survey in the vicinity of the Vangorda deposit and illustrates a marked increase in the silt concentration of the water, as mineralized body is approached. This is indicated by the deeper shade of darkening on the diagram. Fig. 812 shows the result of another geochemical survey conducted over a heavy green zone covered with silt distant from the Vangorda deposit. This survey indicates high content, and accordingly affect the interpretation of geochemical surveys. Ordinarily, four anomalies areas were delineated on the survey. A detailed consideration of results, however, showed these did not indicate an underlying mineral deposit, when compared with results over the Vangorda deposit. The content showed a ratio of little more than 3 times background to normal, while over the Vangorda deposit the ratio is 10 times background to normal. When considering heterogeneity; the results could not be contoured and erratic highs represent stable in the background, rather than concentration of ions due to underlying mineralization. Subsequent drilling in this area substantiated these conclusions. Fig. 813 shows the results of a similar survey from which similar conclusions were drawn. The anomalies areas were rejected on the basis of heterogeneity and lack of content. Here, as in the previous survey, the content in only one instance, was 5 times background, and the average was only 2 to 3 times background. Later drilling showed that the higher than normal readings were caused by accumulations of heavy metal ions in low, sandy ground.

Conclusions:

It may be concluded that:

- 1) The geochemical water test is a cheap and useful prospecting tool for testing streams and tracing heavy metals to their points of maximum concentration.
- 2) Soil testing is a useful auxiliary exploration tool where overburden is light, if a careful analysis of results is made in relation to the geological and physical environment.

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