REPORT ON A
COMBINED HELICOPTER BORNE
MAGNETIC, ELECTROMAGNETIC AND VLF
SURVEY
TREATY CREEK PROPERTY
ISKUT RIVER AREA
BRITISH COLUMBIA

FOR
MILLAR WESTERN ENGINEERING LIMITED
BY
AERODAT LIMITED
June 26, 1991

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J9126

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1. INTRODUCTION

This report describes an airborne geophysical survey carried out on behalf of Millar Western Engineering Limited by Aerodat Limited. Equipment operated included a four frequency electromagnetic system, a high sensitivity cesium vapour magnetometer, a two frequency VLF-EM system, a video tracking camera, and a radar altimeter. Electromagnetic, magnetic and altimeter data were recorded both in digital and analog form. Positioning data were recorded on VHS video tapes as well as being marked on the flight path mosaic by the operator while in flight.

The survey area, comprised of a block of ground in the Treaty Creek area, is located approximately 80 kilometres north of Stewart, British Columbia. Two (2) flights, which were flown on May 19, 1991, were required to complete the survey with flight lines oriented at an Azimuth of 090-270 degrees and flown at a nominal line spacing of 100 metres. The degree of difficulty in flying the survey area, was related to the ruggedness of the mountainous terrain and the extremely unpredictable weather conditions in the region. Coverage and data quality, however, were considered to be well within the specifications described in the contract.

The survey objective is the detection and location of mineralized zones which can be directly or indirectly related to massive or disseminated sulphide targets. Of importance, in this area, are conductors which display either good or weak conductivity, and may be related to contact metamorphism within surrounding sedimentary rocks in contact with felsic intrusives. There may also be gold-bearing horizons within a distal skarn or hornfels genetically related to the felsic stocks. Structures would be extremely important as the faults may have acted as either impermeable barriers or conduits for laterally and vertically migrating mineralizing fluids. Therefore, the interpretation of the magnetic data and, to a lesser degree the apparent resistivity and VLF-EM, for structural effects, will also be extremely important in the overall data interpretation process for this area.

A total of 80 line kilometres of the recorded data were compiled in map form and are presented as part of this report according to specifications outlined by Millar Western Engineering Limited.

2. SURVEY AREA LOCATION

The survey area is depicted on the index map as shown. It is centred at Latitude 56 degrees 36 minutes north, Longitude 130 degrees 04 minutes west, approximately 80 kilometres north of Stewart, British Columbia. It is located in the proximity of Treaty Creek, which is about 8 kilometres south of the Unuk River.

The majority of the survey block will be rather difficult to access because of the mountainous terrain conditions of the Boundary Ranges. The peaks of the mountains are rugged, the slopes are steep and there are also widespread glaciers in the region. Access then, will have to be made by helicopter from the Town of Stewart.

As mentioned earlier, the survey area is extremely rugged, and this, of course, is all part of the tectonic changes of the Coast Mountains. Within the survey area, the average terrain elevation is approximately 4000 feet above sea level. The lowest elevations are along the northern portions of the survey block, near Treaty Creek, where the river is 3000 feet A.S.L., whereas the highest elevations are towards the south-southeastern portions of the block where it is approximately 6434 feet A.S.L.

3. AIRCRAFT AND EQUIPMENT

3.1 Aircraft

An Aerospatiale SA315B Lama helicopter, (C-GPHQ), owned and operated by Peace Helicopter Ltd., was used for the survey. Installation of the geophysical and ancillary equipment was carried out by Aerodat. The survey aircraft was flown at a mean terrain clearance of 60 metres.

3.2 Equipment

3.2.1 Electromagnetic System

The electromagnetic system was an Aerodat 4-frequency system. Two vertical coaxial coil pairs were operated at 935 Hz and 4600 Hz and two horizontal coplanar coil pairs at 4175 Hz and 32 kHz. The transmitter-receiver separation was 7 metres. Inphase and quadrature signals were measured simultaneously for the 4 frequencies with a time constant of 0.1 seconds. The electromagnetic bird was towed 30 metres below the helicopter.

3.2.2 VLF-EM System

The VLF-EM System was a Herz Totem 2A. This instrument measures the total field and quadrature components of two selected transmitters, preferably oriented at right angles to one another. The sensor was towed in a bird 15 metres below the helicopter.

The VLF transmitters monitored were NLK, Jim Creek, Washington broadcasting at 24.8 kHz. for the Line Station and NPM, Laulualei, Hawaii broadcasting at 23.4 kHz. for the Orthogonal Station.

3.2.3 Magnetometer

The magnetometer employed was a Scintrex Model VIW-2321 H8 cesium, optically pumped magnetometer sensor. The sensitivity of this instrument was 0.1 nanoTeslas at a 0.1 second sampling rate. The sensor was towed in a bird 15 metres below the helicopter.

3.2.4 Magnetic Base Station

A IFG (GSM-8) proton precession magnetometer was operated at the base of operations near Bob Quinn Lake, B. C., to record diurnal variations of the earth's magnetic field. The clock of the base station was synchronized with that of the airborne system to facilitate later correlation.

3.2.5 Radar Altimeter

A King Air KRA-10 radar altimeter was used to record terrain clearance. The output from the instrument is a linear function of altitude for maximum accuracy.

3.2.6 Tracking Camera

A Panasonic video tracking camera was used to record flight path on VHS video tape. The camera was operated in continuous mode with the fiducial numbers and time marks for cross reference to the analog and digital data encoded on the video tape.

3.2.7 Analog Recorder

An RMS dot-matrix recorder was used to display the data during the survey. In addition to manual and time fiducials, the following data were recorded:

Channel	Input	Scale
CXI1	935 Hz Coaxial Inphase	2.5 ppm/mm
CXQ1	935 Hz Coaxial Quadrature	2.5 ppm/mm
CXI2	4600 Hz Coaxial Inphase	2.5 ppm/mm
CXQ2	4600 Hz Coaxial Quadrature	2.5 ppm/mm
CPI1	4175 Hz Coplanar Inphase	10 ppm/mm
CPQ1	4175 Hz Coplanar Quadrature	10 ppm/mm
CPI2	32 kHz Coplanar Inphase	20 ppm/mm
CPQ2	32 kHz Coplanar Quadrature	20 ppm/mm
PWRL	Power Line	60 Hz
VLT	VLF-EM Total Field, Line	2.5%/mm
VLQ	VLF-EM Quadrature, Line	2.5%/mm
VOT	VLF-EM Total Field, Ortho	2.5%/mm
VOQ	VLF-EM Quadrature, Ortho	2.5%/mm
RALT	Radar Altimeter	10 ft/mm
MAGF	Magnetometer, fine	2.5 nT/mm
MAGC	Magnetometer, coarse	25 nT/mm

3.2.8 Digital Recorder

A DGR 33 data system recorded the survey on magnetic tape. Information recorded was as follows:

Equipment	Recording Interval
EM System	0.1 seconds
VLF-EM	0.2 seconds
Magnetometer	0.1 seconds
Radar Altimeter	0.5 seconds

3.2.9 Digital Recorder

A DGR 33:16 data system recorded the survey on magnetic tape. Information recorded was as follows:

Equipment	Recording Interval
EM System	0.10 seconds
VLF-EM	0.20 seconds
Magnetometer	0.20 seconds
Altimeter	0.20 seconds
Nav System	0.20 seconds

4. DATA PRESENTATION

4.1 Base Map

An orthophoto mosaic base map at a scale of 1:10,000 was prepared from a published 1:20,000 map, showing a 2000 metre UTM grid and co-ordinates and presented on a Cronaflex mylar base map.

4.2 Flight Path Map

The flight path for the survey area was recovered from the VHS video tracking tapes by transferring the time at which the helicopter passed a recognizable feature onto the photo mosaic. These co-ordinates were then digitized into the database and formed the basis of the flight path data.

The flight lines show the line and flight numbers as well as the time, and the navigator's manual fiducials for cross reference to both analog and digital data.

4.3 Airborne Electromagnetic Survey Interpretation Map

The electromagnetic data were recorded digitally at a sample rate of 10 per second with a time constant of 0.1 seconds. A two stage digital filtering process was carried out to reject major sferic events and to reduce system noise.

Local sferic activity can produce sharp, large amplitude events which cannot be removed by conventional filtering procedures. Smoothing or stacking will reduce their amplitude, but leave a broader residual response that can be confused with geological phenomena. To avoid this possibility, a computer algorithm searches out and rejects the major sferic events.

The signal to noise ratio was further enhanced by the application of a low pass digital filter. It has zero phase shift which prevents any lag or peak displacement from occurring, and it suppresses only variations with a wavelength less than about 0.25 seconds. This low effective time constant permits maximum profile shape resolution.

Following the filtering process, a base level correction was made. The correction applied is a linear function of time that ensures the corrected amplitude of the various inphase and quadrature components is zero when no conductive or permeable source is present. The filtered and levelled data were used in the interpretation of the electromagnetics. An interpretation map was prepared showing peak locations of anomalies and conductivity thickness ranges along with the Inphase amplitudes (computed from the 4600 Hz coaxial responses). The data are presented on a screened copy of the Cronaflex orthophoto mosaic base map.

4.4 Magnetic Total Field Contours

The aeromagnetic data were corrected for diurnal variations by adjustment with the digitally recorded base station magnetic values. The corrected profile data were interpolated onto a regular grid at a 25 metre true scale interval using an Akima spline technique. The grid provided the basis for threading the presented contours at a 2 nanoTesla interval.

The contoured aeromagnetic data have been presented on a Cronaflex copy of the orthophoto mosaic base map.

4.5 Vertical Magnetic Gradient Contours

The vertical gradient was calculated from the gridded total field magnetic data. Contoured at a 0.025 nT/m interval, the gradient data were presented on a Cronaflex copy of the orthophoto mosaic base map.

4.6 Apparent Resistivity Contours

The electromagnetic information was processed to yield a map of the apparent resistivity of the ground.

The approach taken in computing apparent resistivity was to assume a model of 200 metre thick conductive layer (i.e., effectively a half space) over a resistive bedrock. The computer then generated, from nomograms for this model, the resistivity that would be consistent with the bird elevation and recorded amplitude for both the 4600 Hz coaxial and 32 kHz. coplanar frequencies. The apparent resistivity profile data were interpolated onto a regular grid at a 25 metre true scale interval using a cubic spline technique.

The contoured apparent resistivity data for the 4600 Hz coaxial frequency and the 33 kHz. coplanar frequency were presented on a screened copy of the Cronaflex orthophoto mosaic base map along with the flight lines.

4.7 VLF-EM Total Field Contours

The VLF electromagnetic data derived from Jim Creek, Washington was processed to produce a total field contour map on a 25 metre grid with a 2% contour interval. The VLF data for the Line Station is presented on a screened copy of the Cronaflex orthophoto mosaic base map.

5. INTERPRETATION

5.1 Geology

The limited geological information that the writer had available for the survey area suggests a probable up-thrusted, overturned, thick sequence of metasedimentary and metavolcanic units covering most, it not all, of the survey block. This tectonic activity is believed to be associated with the Columbian Orogeny, which is the result of upward movement from much deeper seated intrusions.

Because of the ruggedness of the mountainous terrain within the region, very little geological information is available for most of the survey block. Also, there is a glacier that covers the southwest corner of the area as well.

However, it is believed that most of the survey block is underlain with Mesozoic Middle Jurassic Salmon River Formation rocks consisting of fragments of andesite and near the top of the sequence, a dark pyritic mudstone and siltstone unit. Very little is known over the eastern half of the survey area but is believed to be underlain with these Salmon River Formation rocks. In contact with the Salmon River Formation are the Dilworth Formation rocks, which contains a rusty weathered sedimentary breccia. At the top of the unit is a thin band of felsic tuff. This unit has been traced for a considerable distance near the western portion of the survey area. Its strike extent has not been established as yet.

To the west of the Dilworth Formation is a wide sequence belonging to the Betty Creek Formation. It seemingly covers only a small portion of the survey block along the western survey boundary. It contains a series of interlayering of andesite breccia, dark mudstone and siltstone, conglomerate and sandstone, maroon volcanic breccia, lapilli tuff with minor limonitic zones.

The overthrusting of the various formations has resulted in the various beds dipping towards the east between 56° and 76°.

It is not known if intrusive rocks outcrop in the region. However, they generally are involved in the later stages of any tectonic activity that has taken place in the area, by migrating upward through major fault structures. If not found on surface, they would certainly exist as deeper seated structures.

Structurally, there has been mentioned of a possible tight fold in Mesozoic rocks in an area towards the northwestern portion of the survey block, just south of Treaty Creek. This feature, if it exists, will be investigated more closely in the next sections of this report.

With respect to mineralization in the region, the only reported showing is located towards the southwest portion of the block, on the west face of a high, linear mountain, a short distance up from a glacier. Anomalous zinc, along with minor chalcopyrite and stibnite, are some of the reported minerals from this showing. Pyrite, of course, has been mentioned previously as disseminated sulphides within a Salmon River Formation sequence.

5.2 Magnetics

The aeromagnetic data presentation exhibits three regions of high magnetic intensity. The largest feature is located towards the extreme northeast corner of the survey area, north of Treaty Creek. It is also a much larger magnetic feature than what is indicated on the survey map and no doubt extends well off the survey area.

The writer is not aware of the source for this anomaly, as access to the geology for this region was not available. However, the magnetic feature is interpreted as being associated with deeper seated intrusive, possibly a quartz monzonite.

Similarly, the two magnetic features that are located along the western survey boundary are also believed to be related to deeper seated sources. In both cases, felsic intrusives are probably the cause. In reference to the geology, that has been indicated for this area, there does not seem to be a particular rock type that one could associate with the magnetics. It is known that there are andesites within the Betty Creek Formation as well as volcanic breccias, but it is not believed that any of these units would exhibit any magnetic susceptibility.

With respect to the tight folding that has apparently taken place within the formations, the magnetics would seem to indicate that there may have been a direct relationship. If one compares the location of the folds with the magnetics, there seems to be good correlation between the "nose" of the folds and the ends of the magnetic features. In fact, the correlation is extremely good.

The writer is unsure of the age of the interpreted intrusives, whether or not they are Jurassic or Tertiary intrusives. At this point in time, there does not appear to be any relationship whatsoever, between the magnetics and the overlying Mesozoic sedimentary and volcanic rock types. It is obvious that the overlying depositional assemblages were basically non-magnetic events. There may be some question as to which intrusive, Jurassic or Tertiary, is spatially related to the mineralization in the area. Is it just with Jurassic intrusives or can the peripheral regions of Tertiary intrusives be as important?

There is a very good chance that each of these three interpreted intrusives are one and the same and are joined together at depth.

The regions of magnetic lows are contained within areas overlain with Mesozoic rock types, and thus are exhibiting low intensity magnetic signatures.

5.3 Vertical Gradient Magnetics

It is very clear that the areas displaying the higher intensity magnetic features have been broken up into unique trends as a result of the computation of the vertical gradient. These areas would tend to represent the various Jurassic and Tertiary felsic intrusive rocks.

The zero contour interval also coincides directly or is very close to where one should find the contacts of these intrusives on the ground. Because of the nature of the intrusives and their probable near vertical contacts, it means that the zero contour intervals are reasonably close to where they will be found on the ground. If, in fact, the zero contour interval represents the contact of the intrusive, then the area of interest for further exploration should be within an area encompassing approximately 200-300 feet away from the contact. This is considered to be the aureole zone of metamorphism and metasomatism where the alteration processes have absorbed the sulphide mineralization and where one should expect the gold mineralization to be emplaced. On surface, one would expect such an environment to exist as an oxidized gossan zone.

By using known or accurate geological information and combining this data with the vertical gradient data, one can use the presented map as a pseudo-geological map. Obviously, the more that is known about an area geologically, the closer this type of presentation is to what the rock types are. It is believed that most, if not all, of the magnetic features within the survey area are related to either Middle Jurassic or Lower Tertiary felsic stocks or dikes. However, there is still a degree of uncertainty as to whether or not the Tertiary intrusive rocks are magnetic. This should be established in the field; are both Tertiary and Jurassic intrusives magnetic or is it just the Jurassic?

This type of presentation will be an invaluable tool in helping to define complex geology, especially since there are widespread overlying Mesozoic sedimentary and volcanic rocks. It will also be very helpful in interpreting accurately the known felsic plutons, as well as outlying new intrusives. A few smaller bodies in close proximity to the larger intrusions are evident and it is quite possible that some of these smaller intrusives are connected to larger ones at depth.

The writer has indicated a few fault zones on the interpretation map. These are believed to be pre-Tertiary fault structures and may have affected the mineralizing processes. Because of the nature of the computation of the vertical gradient data, magnetic anomalies produced by sub-surface features have been emphasized with respect to those resulting from more deeply buried rock formations. It is suggested that these are inferred fault zones, as opposed to interpreted fault zones. They may be indications of eventual interpreted faults or upon obtaining further information in the field, they may turn out to be actual fault zones. In any event, they are presented to the client for further scrutiny.

It is of general opinion that the underlying felsic intrusive rocks are related to major structural zones that were developed during the Jurassic period and Tertiary period. It is also believed that the migration of mineralization took place during the Jurassic period and also within these same structures. If this was to be the case then serious consideration must be given to those areas within the survey block that display high intensity magnetic features. The important horizons are not only the regions of structural effects, but also in close proximity to the contacts between the Jurassic felsic intrusives and the surrounding Mesozoic rock units. However, as mentioned previously, it must be decided whether or not the Tertiary felsic intrusives are magnetic and if so, have they also played a role in the eventual mineralizing processes within the region.

5.4 Electromagnetics

The electromagnetic data was first checked by a line-by-line examination of the analog data. Record quality was very good with only minor noise levels in areas of difficult flying. However, this was readily removed with an appropriate smoothing filter. There is some evidence of surficial conductivity and is generally seen on the high 32 kHz frequency coplanar coil.

Anomalies were picked off the analog traces of the low and high frequency coaxial responses and then validated on the coplanar profile data. The data were then edited and re-plotted on a copy of the profile map. This procedure ensured that every anomalous response spotted on the analog data was plotted on the final map and allowed for the rejection - or inclusion if warranted - of obvious surficial conductors. Each conductor or group of conductors was evaluated on the basis of magnetic (and lithologic, where applicable) correlations apparent from the analog data and man-made or surficial features not obvious on the analog charts.

RESULTS

As a result of this airborne survey being carried out, it is very clear that a majority of the survey block is overlain with a rather resistive cover. The obvious phenomena is the extremely resistive background over the glacier towards the southwest corner of the survey. In the areas of ice-field run-off, there does seem to be a moderate to poorly conductive background which is perhaps due, in part, to the local tills and sediments. In low lying regions, including creek bottoms and river bottom silts of Treaty Creek, there is also a certain degree of conductivity being exhibited.

There are a few areas where the electromagnetic traces tend to be "tracking" each other. These features generally indicate regions of wide, flat-lying, sheet like horizons that are sometimes associated with surficial materials, such as river bottom silts. However, there may be such specific geophysical phenomenon that are associated with broad, flat lying mineralized bodies as well. As such, differentiating between two sources can sometimes be difficult. Two such areas are Zones TC2 and TC4. Any association with creek bottoms would obviously not make them attractive targets.

There are a few areas where the responses indicate vertical to near vertical oriented conductors. These types of responses generally display a positive coaxial response coincident with a negative trough on the coplanar trace. One such conductor has been outlined as Zone TC1 on the Interpretation Map. The lone intercept is located just to the north of Treaty Creek and in close proximity to the interpreted felsic intrusive. There is a very good chance that this anomaly is not associated with the river bottom silts of Treaty Creek. In reference to the vertical gradient data presentation, it is noted that the size of the magnetic feature (intrusive) is not as large as it is for the total field. The magnetic intensity, however, is just as strong. A reconnaissance survey is suggested for the area of Zone TC1.

Because of the complexities of the conductive environment surrounding the eastern flank of the southern "intrusive", assigning individual conductor axes would be extremely difficult. One interesting observation with Zone TC3 is that the larger EM amplitudes are located in close proximity to the outer perimeter of the magnetic anomaly. Note how the conductivity "tapers" away towards the southeast, in a similar manner as does the magnetics. There is generally good agreement. It is expected that any areas of economic interest will be located within several hundreds of feet from the contact of the felsic intrusive. Therefore, it is believed that the regions of high amplitude EM responses which are located near the magnetic features will be the areas to be looked at. If sulphides are involved here, then one should expect to see gossan zones on the ground.

The basis of the high conductivity of Zone TC3 is believed to be from sulphides within a region of intense alteration. It is interpreted as being due to a fracture-filled, brecciated zone associated with a contact metamorphic horizon. A certain degree of the conductivity may be a result of other alteration by-products such as alunite.

Note the general absence of any conductivity whatsoever, in the region of the northeast magnetic feature, as well as the west-northwest magnetic feature. This may or may not be the determining factor, in whether or not the underlying intrusives are Middle Jurassic or Tertiary.

The conductive horizon of Zone TC3 displays very strong EM responses in contact with the portion of the magnetic feature that displays the highest intensity. It is believed that this is basically the contact metamorphic zone that has created the aureole pattern. The intensity of the magnetics also decreases in the region where the conductivity levels have also decreased. Wide, banded zones of sulphides (pyrite) within mudstone and siltstone could be the source. Referring to the geology map, Zone TC3 seems to coincide with what is described as the Dilworth Formation and also with an upper sequence of the Salmon River Formation. Note however, how the zone of conductivity is abruptly cut off at the north end by what is interpreted to be a fault zone.

With respect to the white stain that has been reported on the geology map, its location would seem to be on the western face of the mountain and in close contact with the highly conductive zone. The sphalerite showing is apparently located just to the west of this marker horizon, just up from the glacier. There are no airborne EM responses from such a source.

Obviously, a great deal more work will have to be carried out within the survey block before a full understanding of the geological and structural implications are known. The alteration zones or contact metamorphism that may have taken place in the vicinity of Zone TC3 are varied and complex and it is not within the realm of this report to discuss its relationship any further.

5.5 Apparent Resistivity

In presenting the apparent resistivity data for the 4600 Hz. coaxial frequency, the highly conductive region towards the southwest is quite pronounced. It indicates the highly conductive region in close proximity to what is interpreted to be a felsic intrusive, while the region to the east, as well as to the north become gradually more resistive.

The apparent resistivity presentation will not have the same resolution as the EM profile map presentation. As a result, this data set will not show that various banding that seems to exist within either the Dilworth Formation or the upper sequence of the Salmon River Formation. It is obvious from the EM profile map, that several closely spaced conductors exist within Zone TC3. Ground follow-up will be necessary then, to detect the individual horizons.

There are two, small, isolated apparent resistivity anomalies that lie just to the west of the intrusive that may coincide with the sphalerite showing. This should be investigated further, with more detailed geological information.

It is generally found that the resistivity backgrounds for most surficial materials within the survey area are above 1000 ohm - metres and can be as high as 7000 ohm - metres. Within the mineralized zones, the conductivity is quite high, with apparent resistivity readings generally lower than 100 ohm - metres. It will be within regions such as this, where further work should be initiated.

The 32 kHz apparent resistivity data presentation, because of the higher frequency, will tend to be more sensitive to the near surface materials which display very low conductivities. These environments will generally be creek and river bottom silts or glacial debris. This frequency will obviously be sensitive to any near surface mineralized zones as well. However, any evidence of depth to any of these targets, then the 32 kHz. frequency may not respond. This certainly seems to be the case in the region where both the conductivity and the magnetics are tapering off towards the southeast from the felsic intrusive.

This frequency may or may not be outlining the sphalerite showing a little more accurately. This is difficult to know without having an accurate geological compilation of the area.

For both 4600 Hz and 32 kHz. data presentations, it is believed that the area designated to have the white stain on the west face of the mountain, does not have correlating conductive trends. It is suggested that this horizon may be associated with alunite or some other alteration product within the surrounding sedimentary rocks, possibly related to the interpreted contact metamorphic zone.

5.6 VLF-EM Total Field

The VLF data shows no correlation with the magnetics whatsoever, and this is perhaps explainable, as the magnetics are interpreted as being associated with much deeper seated felsic intrusives, as opposed to any overlying rock formations. It is also quite clear that areas where bedrock conductors were intercepted with the 4 frequency EM system, there is no correlation of this data set with the VLF-EM results at all.

In the region of the strong 4 frequency EM responses towards the southwest, there is a coincident VLF response. However, the writer believes that this may be just a coincidence and not a direct correlation at all. In areas where one would expect a VLF response, there was none. It should be pointed out that the airborne VLF has rather poor resolution and depth of penetration. The latter is less than 100 feet at the best of times.

It is suggested that the VLF-EM system has been sensitive to the rough terrain. It will be noted that in a good many areas where there are broad valleys, a VLF low exists, especially if they are on the east side of a high ridge. But once over high terrain, high on the ridges, then a VLF high exists. These particular signatures are thought to be related to the location of the helicopter with respect to the VLF transmitting station.

The quality of the VLF data, in rough terrain such as what one sees within the middle portions of this survey area, is somewhat questionable, especially if one were to use the data to gain further knowledge on structural effects. After further assessment of this data set and along with access to other sources of information, structural events such as fault zones may eventually be interpreted.

In areas of extremely poor conductors, where sulphides are generally thought to be less than 10 %, a ground VLF survey may respond to these types of conductors. As well, fault structures containing poorly conducting gangue material may sometimes give rise to a VLF response. However, in this rugged area, because of the high terrain, this may inhibit the use of the VLF over what appears to be the most interesting portion of the survey block.

5.7 Conclusion and Recommendations

Based on the results of this airborne survey, ground follow-up is recommended for the few selected targets as outlined by the writer on the Interpretation Map. It is felt that these conductors that have been outlined for further work, would be of primary interest for their polymetallic potential within and adjacent to the regions believed to be underlain with felsic intrusives. The importance, in this area, would seem to be the development of these felsic intrusives that are located in close proximity to what are believed to be overlying Mesozoic metasediments and metavolcanics.

Because the felsic intrusives have intruded the overlying Mesozoic rock types, contact metamorphism and metasomatic alteration probably surround the pluton and extends several hundred metres into the Mesozoic wall rocks creating an aureole effect of calc-silicate hornfels or skarn. However, the writer believes that only one intrusive has affected the overlying rocks and that is the one located towards the southwest, where sphalerite mineralization has been noted. It is felt that any mineralization may have been developed in the late stages of the intrusive activity. The mineralization would occur almost exclusively within the overlying Middle Jurassic metasediments adjacent to the felsic intrusives.

Major north-south or splay-type faults that pre-date the mineralization probably played an important role as conduits for the mineralizing hydrothermal fluids.

Assessment of each of the data sets for structural information should be carried out. The writer has interpreted a few structures, which have been plotted on the Interpretation Map.

Prospecting and soil geochemical sampling should be carried out in the vicinity of Zone TC3, with any subsequent anomalous areas and interpreted bedrock conductors being prime targets for diamond drilling.

In regards to a ground follow-up geophysical survey, an induced polarization (IP) survey would be more conducive to the type of target being sought in this area. Any thoughts of utilizing a ground EM system should be considered in the vertical mode, as opposed to the horizontal mode, because of the terrain and elevation problems.

It is a matter of using all resources, including geophysics, a geological compilation of the region and gold-soil geochemical sampling that will greatly enhance the chances of discovering a hydrothermal precious metal zone.

Respectfully submitted,

R. J. de Carle

Robert J. de Carle
Consulting Geophysicist
for
AERODAT LIMITED
June 26, 1991

J9126

APPENDIX I

REFERENCE

1986: Exploration in British Columbia, Minerals Exploration Section, page C377.

1991: Millar Western Engineering Limited, personal communication and geological information, June.

APPENDIX II

PERSONNEL

FIELD

Flown	May 19, 1991
Pilots	Eddie Yung
Operators	Steve Arstad

OFFICE

Processing	Ed Hamilton
Report	R.J. de Carle

APPENDIX III

CERTIFICATE OF QUALIFICATIONS

I, ROBERT J. DE CARLE, certify that: -

1. I hold a B. A. Sc. in Applied Geophysics with a minor in geology from Michigan Technological University, having graduated in 1970.

2. I reside at 28 Westview Crescent in the town of Palgrave, Ontario.

3. I have been continuously engaged in both professional and managerial roles in the minerals industry in Canada and abroad for the past twenty years.

4. I have been an active member of the Society of Exploration Geophysicists since 1967 and hold memberships on other professional societies involved in the minerals extraction and exploration industry.

5. The accompanying report was prepared from information published by government agencies, materials supplied by Millar Western Engineering Limited and from a review of the proprietary airborne geophysical survey flown by Aerodat Limited for Millar Western Engineering Ltd. I have not personally visited the property.

6. I have no interest, direct or indirect, in the property described nor do I hold securities in Millar Western Engineering Ltd.

Signed,

R. J. de Carle

Palgrave, Ontario
June 26, 1991

Robert J. de Carle
Consulting Geophysicist
for
AERODAT LIMITED

APPENDIX IV

GENERAL INTERPRETIVE CONSIDERATIONS

Electromagnetic

The Aerodat four frequency system utilizes two different transmitter-receiver coil geometries. The traditional coaxial coil configuration is operated at two widely separated frequencies. The horizontal coplanar coil configuration is similarly operated at two different frequencies where one pair is approximately aligned with one of the coaxial frequencies.

The electromagnetic response measured by the helicopter system is a function of the "electrical" and "geometrical" properties of the conductor. The "electrical" property of a conductor is determined largely by its electrical conductivity, magnetic susceptibility and its size and shape; the "geometrical" property of the response is largely a function of the conductor's shape and orientation with respect to the measuring transmitter and receiver.

Electrical Considerations

For a given conductive body the measure of its conductivity or conductance is closely related to the measured phase shift between the received and transmitted electromagnetic field. A small phase shift indicates a relatively high conductance, a large phase shift lower conductance. A small phase shift results in a large inphase to quadrature ratio and a large phase shift a low ratio. This relationship is shown quantitatively for a non-magnetic vertical half-plane model on the accompanying phasor diagram. Other physical models will show the same trend but different quantitative relationships.

The phasor diagram for the vertical half-plane model, as presented, is for the coaxial coil configuration with the amplitudes in parts per million (ppm) of the primary field as measured at the response peak over the conductor. To assist the interpretation of the survey results the computer is used to identify the apparent conductance and depth at selected anomalies. The results of this calculation are presented in table form in Appendix IV and the conductance and inphase amplitude are presented in symbolized form on the map presentation.

The conductance and depth values as presented are correct only as far as the model approximates the real geological situation. The actual geological source may be of limited length, have significant dip, may be strongly magnetic, its conductivity and thickness may vary with depth and/or strike and adjacent bodies and overburden may have modified the response. In general the conductance estimate is less affected by these limitations than is the depth estimate, but both should be considered as relative rather than absolute guides to the anomaly's properties.

Conductance in mhos is the reciprocal of resistance in ohms and in the case of narrow slab-like bodies is the product of electrical conductivity and thickness.

Most overburden will have an indicated conductance of less than 2 mhos; however, more conductive clays may have an apparent conductance of say 2 to 4 mhos. Also in the low conductance range will be electrolytic conductors in faults and shears.

The higher ranges of conductance, greater than 4 mhos, indicate that a significant fraction of the electrical conduction is electronic rather than electrolytic in nature. Materials that conduct electronically are limited to certain metallic sulphides and to graphite. High conductance anomalies, roughly 10 mhos or greater, are generally limited to sulphide or graphite bearing rocks.

Sulphide minerals, with the exception of such ore minerals as sphalerite, cinnabar and stibnite, are good conductors; sulphides may occur in a disseminated manner that inhibits electrical conduction through the rock mass. In this case the apparent conductance can seriously underrate the quality of the conductor in geological terms. In a similar sense the relatively non-conducting sulphide minerals noted above may be present in significant consideration in association with minor conductive sulphides, and the electromagnetic response only relate to the minor associated mineralization. Indicated conductance is also of little direct significance for the identification of gold mineralization. Although gold is highly conductive, it would not be expected to exist in sufficient quantity to create a recognizable anomaly, but minor accessory sulphide mineralization could provide a useful indirect indication.

In summary, the estimated conductance of a conductor can provide a relatively positive identification of significant sulphide or graphite mineralization; however, a moderate to low conductance value does not rule out the possibility of significant economic mineralization.

Geometrical Considerations

Geometrical information about the geologic conductor can often be interpreted from the profile shape of the anomaly. The change in shape is primarily related to the change in inductive coupling among the transmitter, the target, and the receiver.

In the case of a thin, steeply dipping, sheet-like conductor, the coaxial coil pair will yield a near symmetric peak over the conductor. On the other hand, the coplanar coil pair will pass through a null couple relationship and yield a minimum over the conductor, flanked by positive side lobes. As the dip of the conductor decreased from vertical, the coaxial anomaly shape changes only slightly, but in the case of the coplanar coil pair the side lobe on the down dip side strengthens relative to that on the up dip side.

As the thickness of the conductor increases, induced current flow across the thickness of the conductor becomes relatively significant and complete null coupling with the coplanar coils is no longer possible. As a result, the apparent minimum of the coplanar response over the conductor diminishes with increasing thickness, and in the limiting case of a fully 3 dimensional body or a horizontal layer or half-space, the minimum disappears completely.

A horizontal conducting layer such as overburden will produce a response in the coaxial and coplanar coils that is a function of altitude (and conductivity if not uniform). The profile shape will be similar in both coil configurations with an amplitude ratio (coplanar:coaxial) of about 4:1*.

In the case of a spherical conductor, the induced currents are confined to the volume of the sphere, but not relatively restricted to any arbitrary plane as in the case of a sheet-like form. The response of the coplanar coil pair directly over the sphere may be up to 8* times greater than that of the coaxial pair.

In summary, a steeply dipping, sheet-like conductor will display a decrease in the coplanar response coincident with the peak of the coaxial response. The relative strength of this coplanar null is related inversely to the thickness of the conductor; a pronounced null indicates a relatively thin conductor. The dip of such a conductor can be inferred from the relative amplitudes of the side-lobes.

Massive conductors that could be approximated by a conducting sphere will display a simple single peak profile form on both coaxial and coplanar coils, with a ratio between the coplanar to coaxial response amplitudes as high as 8*.

Overburden anomalies often produce broad poorly defined anomaly profiles. In most cases, the response of the coplanar coils closely follows that of the coaxial coils with a relative amplitude ration of 4*.

Occasionally, if the edge of an overburden zone is sharply defined with some significant depth extent, an edge effect will occur in the coaxial coils. In the case of a horizontal conductive ring or ribbon, the coaxial response will consist of two peaks, one over each edge; whereas the coplanar coil will yield a single peak.

* It should be noted at this point that Aerodat's definition of the measured ppm unit is related to the primary field sensed in the receiving coil without normalization to the maximum coupled (coaxial configuration). If such normalization were applied to the Aerodat units, the amplitude of the coplanar coil pair would be halved.

Magnetics

The Total Field Magnetic Map shows contours of the total magnetic field, uncorrected for regional variation. Whether an EM anomaly with a magnetic correlation is more likely to be caused by a sulphide deposit than one without depends on the type of mineralization. An apparent coincidence between an EM and a magnetic anomaly may be caused by a conductor which is also magnetic, or by a conductor which lies in close proximity to a magnetic body. The majority of conductors which are also magnetic are sulphides containing pyrrhotite and/or magnetite. Conductive and magnetic bodies in close association can be, and often are, graphite and magnetite. It is often very difficult to distinguish between these cases. If the conductor is also magnetic, it will usually produce an EM anomaly whose general pattern resembles that of the magnetics. Depending on the magnetic permeability of the conducting body, the amplitude of the inphase EM anomaly will be weakened, and if the conductivity is also weak, the inphase EM anomaly may even be reversed in sign.

VLF Electromagnetics

The VLF-EM method employs the radiation from powerful military radio transmitters as the primary signals. The magnetic field associated with the primary field is elliptically polarized in the vicinity of electrical conductors. The Herz Totem uses three coils in the X, Y, Z configuration to measure the total field and vertical quadrature component of the polarization ellipse.

The relatively high frequency of VLF (15-25) kHz provides high response factors for bodies of low conductance. Relatively "disconnected" sulphide ores have been found to produce measurable VLF signals. For the same reason, poor conductors such as sheared contacts, breccia zones, narrow faults, alteration zones and porous flow tops normally produce VLF anomalies. The method can therefore be used effectively for geological mapping. The only relative disadvantage of the method lies in its sensitivity to conductive overburden. In conductive ground to depth of exploration is severely limited.

The effect of strike direction is important in the sense of the relation of the conductor axis relative to the energizing electromagnetic field. A conductor aligned along a radius drawn from a transmitting station will be in a maximum coupled orientation and thereby produce a stronger response than a similar conductor at a different strike angle. Theoretically, it would be possible for a conductor, oriented tangentially to the transmitter to produce no signal. The most obvious effect of the strike angle consideration is that conductors favourably oriented with respect to the transmitter location and also near perpendicular to the flight direction are most clearly rendered and usually dominate the map presentation.

The total field response is an indicator of the existence and position of a conductivity anomaly.

The response will be a maximum over the conductor, without any special filtering, and strongly favour the upper edge of the conductor even in the case of a relatively shallow dip.

The vertical quadrature component over steeply dipping sheet-like conductor will be a cross-over type response with the cross-over closely associated with the upper edge of the conductor.

The response is a cross-over type due to the fact that it is the vertical rather than total field quadrature component that is measured. The response shape is due largely to geometrical rather than conductivity considerations and the distance between the maximum and minimum on either side of the cross-over is related to target depth. For a given target geometry, the larger this distance the greater the depth.

The amplitude of the quadrature response, as opposed to shape is function of target conductance and depth as well as the conductivity of the overburden and host rock. As the primary field travels down to the conductor through conductive material it is both attenuated and phase shifted in a negative sense. The secondary field produced by this altered field at the target also has an associated phase shift. This phase shift is positive and is larger for relatively poor conductors. This secondary field is attenuated and phase shifted in a negative sense during return travel to the surface. The net effect of these 3 phase shifts determine the phase of the secondary field sensed at the receiver.

A relatively poor conductor in resistive ground will yield a net positive phase shift. A relatively good conductor in more conductive ground will yield a net negative phase shift. A combination is possible whereby the net phase shift is zero and the response is purely in-phase with no quadrature component.

A net positive phase shift combined with the geometrical cross-over shape will lead to a positive quadrature response on the side of approach and a negative on the side of departure. A net negative phase shift would produce the reverse. A further sign reversal occurs with a 180 degree change in instrument orientation as occurs on reciprocal line headings. During digital processing of the quadrature data for map presentation this is corrected for by normalizing the sign to one of the flight line headings.

APPENDIX V

ANOMALY LIST

MILLAR WESTERN ENGINEERING LTD. - TREATY CREEK AREA

FLIGHT	LINE	ANOMALY	CATEGORY	AMPLITUDE (PPM) INPHASE	QUAD.	CONDUCTOR CTP MHOS	DEPTH MTRS	BIRD HEIGHT MTRS
1	10060	A	0	3.0	19.2	0.0	0	31
1	10060	B	0	1.8	13.8	0.0	5	22
1	10060	C	0	1.9	6.9	0.0	0	45
1	10060	D	0	2.3	5.6	0.1	2	51
1	10080	A	0	2.0	12.1	0.0	0	33
1	10080	B	0	2.7	10.6	0.0	2	35
1	10100	A	0	3.2	11.9	0.0	0	45
1	10100	B	0	3.5	11.1	0.1	0	40
1	10100	C	0	3.4	14.1	0.0	1	31
1	10100	D	0	3.1	8.6	0.1	1	43
1	10130	A	0	3.7	10.4	0.1	4	37
1	10130	B	0	2.5	9.9	0.0	10	28
1	10140	A	0	2.5	8.1	0.0	5	37
1	10140	B	0	1.7	8.2	0.0	0	42
1	10140	C	0	1.7	8.8	0.0	0	42
1	10140	D	0	4.2	8.9	0.2	0	49
1	10160	A	0	2.1	5.4	0.1	15	38
1	10170	A	0	5.5	12.6	0.2	3	37
1	10180	A	0	3.2	5.8	0.2	6	51
1	10190	A	0	4.2	4.8	0.5	0	70
1	10190	B	0	4.5	14.9	0.1	5	30
1	10200	A	0	7.8	10.9	0.5	13	35
1	10200	B	0	7.9	9.7	0.6	9	43
1	10200	C	0	8.7	12.8	0.5	8	37
1	10210	A	0	9.5	21.9	0.3	0	50
1	10210	B	0	7.2	12.2	0.4	0	51
1	10210	C	1	13.4	12.6	1.2	0	51
1	10210	D	1	12.2	10.7	1.3	0	49
1	10210	E	0	5.2	16.0	0.1	0	40
1	10220	A	1	26.3	27.4	1.3	10	27
1	10220	B	0	25.1	61.3	0.4	0	28
1	10220	C	0	20.1	39.3	0.5	9	19
1	10220	D	0	12.9	16.8	0.7	10	32

Estimated depth may be unreliable because the stronger part of the conductor may be deeper or to one side of the flight line, or because of a shallow dip or overburden effects.

MILLAR WESTERN ENGINEERING LTD. - TREATY CREEK AREA

FLIGHT	LINE	ANOMALY	CATEGORY	AMPLITUDE (PPM) INPHASE	QUAD.	CONDUCTOR CTP MHOS	DEPTH MTRS	BIRD HEIGHT MTRS
1	10220	E	0	9.8	34.2	0.1	3	22
1	10230	A	0	12.2	17.0	0.6	6	36
1	10230	B	1	15.1	14.4	1.2	2	44
1	10230	C	2	11.0	6.8	2.0	0	30
1	10230	D	0	3.1	11.2	0.0	7	30
1	10230	E	0	6.7	28.0	0.1	2	24
1	10240	A	0	3.5	8.3	0.1	20	27
1	10240	B	0	6.1	14.1	0.2	14	25
1	10240	C	0	5.0	7.0	0.4	7	49
1	10240	D	0	3.7	5.4	0.3	24	37
1	10240	E	2	33.3	26.0	2.1	4	34
1	10240	F	1	45.1	57.0	1.3	0	33
1	10240	G	0	26.8	57.4	0.5	0	35
1	10260	A	0	3.7	5.4	0.3	9	52
1	10260	B	0	3.9	8.6	0.2	5	42
1	10260	C	2	98.2	76.3	3.1	0	34
1	10260	D	0	21.8	38.0	0.6	0	33
1	10270	A	0	9.7	14.9	0.5	8	34
1	10270	B	2	38.8	31.9	2.1	0	40
1	10270	C	2	54.2	38.3	2.9	0	39
1	10270	D	2	42.2	35.1	2.1	0	39
1	10270	E	2	30.2	18.1	2.9	16	26
1	10270	F	0	3.7	6.1	0.3	8	49
1	10270	G	0	6.0	10.9	0.3	15	31
1	10270	H	0	7.0	9.9	0.5	12	38
1	10280	A	0	5.5	5.1	0.8	10	57
1	10280	B	0	3.8	4.9	0.4	19	46
1	10280	C	0	4.7	6.5	0.4	16	42
1	10280	D	0	4.5	13.4	0.1	9	28
1	10280	E	1	36.6	35.2	1.7	0	41
1	10280	F	2	67.1	55.4	2.5	0	38
1	10280	G	2	75.2	56.3	2.9	0	43
1	10280	H	0	11.5	15.5	0.7	8	34
2	10290	A	1	20.0	16.7	1.6	1	43
2	10290	B	2	74.9	75.5	2.0	0	31
2	10290	C	2	117.3	92.7	3.2	0	25
2	10290	D	1	37.0	37.3	1.6	7	26
2	10290	E	1	19.7	21.9	1.1	6	33
2	10290	F	1	11.4	11.6	1.0	17	33

Estimated depth may be unreliable because the stronger part of the conductor may be deeper or to one side of the flight line, or because of a shallow dip or overburden effects.

MILLAR WESTERN ENGINEERING LTD. - TREATY CREEK AREA

FLIGHT	LINE	ANOMALY	CATEGORY	AMPLITUDE (PPM) INPHASE	QUAD.	CONDUCTOR CTP MHOS	DEPTH MTRS	BIRD HEIGHT MTRS
2	10290	G	0	6.7	7.9	0.6	14	41
2	10290	H	0	3.3	6.2	0.2	27	28
2	10290	J	0	3.1	6.0	0.2	20	36
2	10290	K	0	4.5	6.6	0.4	16	41
2	10290	M	0	2.7	7.9	0.1	9	35
2	10300	A	0	2.6	12.4	0.0	5	27
2	10300	B	0	3.2	10.7	0.1	11	27
2	10300	C	2	112.7	87.7	3.2	0	36
2	10300	D	2	118.5	99.0	3.0	0	31
2	10310	A	2	23.0	13.0	2.9	0	61
2	10310	B	2	53.0	31.8	3.5	0	42
2	10310	C	2	52.9	46.1	2.2	1	29
2	10310	D	0	7.6	12.5	0.4	20	25
2	10310	E	0	1.8	7.0	0.0	9	34
2	10310	F	0	1.1	4.8	0.0	3	44
2	10310	G	0	2.7	14.2	0.0	3	27
2	10320	A	0	0.2	7.8	0.0	0	30
2	10320	B	0	1.5	33.5	0.0	0	27
2	10320	C	0	3.6	16.5	0.0	0	38
2	10320	D	0	3.5	18.7	0.0	0	27
2	10320	E	1	41.5	44.8	1.5	0	37
2	10320	F	1	48.8	56.9	1.4	0	38
2	10320	G	2	51.2	37.4	2.7	0	47
2	10320	H	2	30.7	24.6	2.0	0	52
2	10330	A	2	8.4	4.0	2.6	15	55
2	10330	B	1	13.4	10.0	1.6	0	56
2	10330	C	1	8.8	5.9	1.6	14	49
2	10330	D	0	5.4	5.3	0.8	20	45
2	10330	E	0	4.7	8.1	0.3	7	44
2	10330	F	0	5.6	10.5	0.3	7	39
2	10330	G	0	5.2	7.8	0.4	20	34
2	10330	H	0	4.8	7.1	0.4	12	43
2	10330	J	0	5.4	8.1	0.4	10	42
2	10330	K	0	5.6	8.8	0.4	1	49
2	10330	L	0	4.2	6.7	0.3	6	49
2	10330	M	0	5.0	16.4	0.1	4	29
2	10340	A	0	0.7	6.3	0.0	0	34
2	10340	B	0	6.9	15.5	0.2	10	28
2	10340	C	0	9.8	20.2	0.3	12	23
2	10340	D	0	9.6	12.3	0.7	0	47

Estimated depth may be unreliable because the stronger part of the conductor may be deeper or to one side of the flight line, or because of a shallow dip or overburden effects.

MILLAR WESTERN ENGINEERING LTD. - TREATY CREEK AREA

FLIGHT	LINE	ANOMALY	CATEGORY	AMPLITUDE (PPM) INPHASE	QUAD.	CONDUCTOR CTP MHOS	DEPTH MTRS	BIRD HEIGHT MTRS
2	10340	E	0	12.6	15.7	0.8	0	47
2	10340	F	0	9.5	13.9	0.5	0	44
2	10340	G	0	4.7	7.2	0.4	9	45
2	10350	A	1	8.9	8.5	1.0	0	62
2	10350	B	0	12.7	14.1	0.9	0	51
2	10350	C	0	13.5	16.1	0.8	11	32
2	10350	D	0	7.8	10.0	0.6	0	52
2	10350	E	0	4.3	8.2	0.2	6	44
2	10360	A	0	8.0	9.8	0.6	0	57
2	10360	B	0	10.6	17.0	0.5	0	58
2	10360	C	0	11.9	12.8	0.9	0	54
2	10360	D	0	9.7	9.8	0.9	0	59
2	10360	E	0	5.9	5.5	0.9	1	64
2	10370	A	0	7.7	12.5	0.4	2	42
2	10370	B	0	12.3	19.2	0.6	8	30
2	10370	C	0	13.6	21.7	0.6	5	32
2	10370	D	0	15.8	27.2	0.5	1	32
2	10370	E	0	12.0	23.0	0.4	0	33
2	10370	F	0	8.6	18.7	0.3	0	40
2	10370	G	0	5.0	9.5	0.3	0	50

Estimated depth may be unreliable because the stronger part of the conductor may be deeper or to one side of the flight line, or because of a shallow dip or overburden effects.