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EXPLORATION

WESTERN CANADA

NTS: 105G/7

COMBINED HELICOPTER-BORNE MAGNETIC AND ELECTROMAGNETIC SURVEY ON THE COBB CLAIMS, PELLY MOUNTAIN PROJECT, YUKON TERRITORY

- ASSESSMENT REPORT -

WORK PERIOD: JULY 22 - AUGUST 23, 1995

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- ASSESSMENT REPORT -

1. INTRODUCTION

This report describes an airborne geophysical survey flown for Cominco Exploration by Aerodat Inc. (Aerodat) under a contract dated April 18, 1995. Principal geophysical sensors include a five-frequency electromagnetic system and a high sensitivity cesium vapour magnetometer. Ancillary equipment consists of a colour video tracking camera, a Global Positioning (GPS) for navigation, a radar altimeter and a base station magnetometer.

The COBB claims involve one claim block located near the Robert Campbell Highway, 200 kilometres NW of Watson Lake, within NTS Reference Map 105G/7.

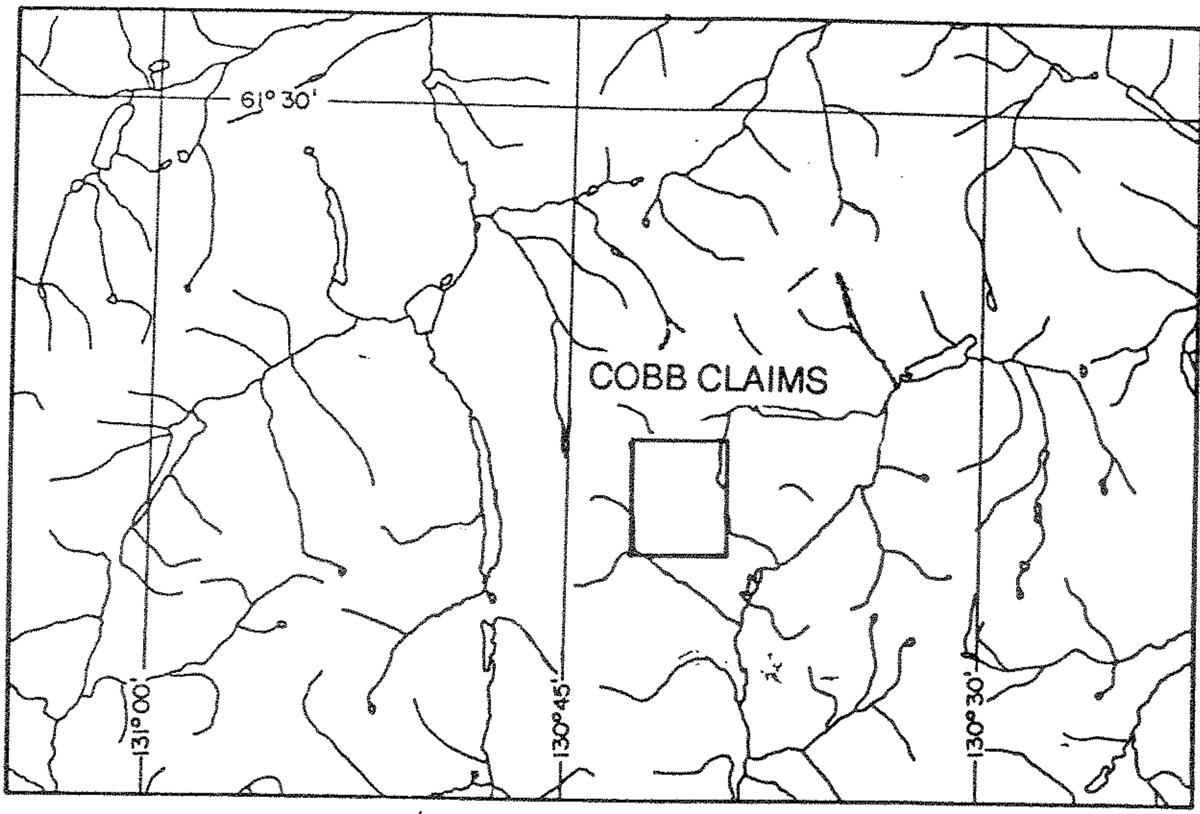
The flight line spacing is 300 m. The Aerodat Job Number is J9525. This report is a version of that more extensive report supplied by Aerodat ("Operational Report On a Combined Helicopter-borne Magnetic and Electromagnetic Survey, Pelly Mountain Extension, Yukon Territory, for Cominco Exploration" by Sandra A. Takata, Nov. 10, 1995), and describes the survey, the data processing, data presen-tation and electromagnetic anomaly selection.

2. SURVEY AREA

The survey area is located 200 kilometres NW of Watson Lake. The airborne survey on the COBB claims involves a total of 76 line kms of a larger AEM/Mag program.

Topography is shown on the 1:50,000 scale NTS map sheet listed above. Local relief is generally rugged.

INDEX MAP



The survey area is shown on the following index map that includes local topography and latitude-longitude coordinates.

3. SURVEY PROCEDURES

The survey was completed in the period from July 22 to August 23, 1995 with the flying over the COBB claims involving only a small portion of this time. Principal personnel are listed in Appendix II. Aircraft ground speed is maintained at approx. 60 knots (30 metres per second). The nominal EM sensor height is 30 metres (100 feet), consistent with the safety of the aircraft and crew.

A global positioning system (GPS) consisting of a Magnavox MX 9212 operated in differential mode guides aircraft navigation and flight line control. Field processing of the differential GPS data in the field utilizies a PC using software supplied by the manufacturer. One system is installed in the survey helicopter. This involves mounting the receiver antenna on the tail boom. A second system acts as the base station.

The published NTS maps provide the UTM coordinates of the survey area corners. These coordinates program the navigation system. A test flight confirms if area coverage is correct. Thereafter, the navigation system guides the pilot along the survey traverse lines marked on the topographic map. The operator also enters manual fiducials over prominent topographic features. Survey lines showing excessive deviation are re-flown.

Aircraft position is registered by the navigation system. The operator calibrates the geophysical systems at the start, middle (if required) and end of every survey flight. During calibration the aircraft is flown away from ground effects to record electro-magnetic zero levels.

4. PRESENTATION

A claim map of the COBB area is presented on a topo base, at a scale of 1:10,000. The EM and magnetic data are overlain for easy interpretation in this report and include the 4600 Hz coaxial, electromagnetic profiles and interpretation on a coloured total field magnetic background, at a scale of 1:10,000. On a separate plate is a total field magnetic contour map, also at a scale of 1:10,000.

5. AIRCRAFT AND EQUIPMENT

5.1 Aircraft

The survey aircraft was an Aerospatiale AS316B helicopter (C-FPWH), piloted by G. Suthern and B. Stone, owned and operated by Turbowest Helicopters. P. Moisan and J. Cunningham of Aerodat acted as navigator and equipment operator. Aerodat performed the installation of the geophysical and ancillary equipment. The survey aircraft flies at a mean terrain clearance of 60 metres (200 feet).

5.2 Electromagnetic System

The electromagnetic system is an Aerodat five-frequency configuration. Two vertical coaxial coil pairs operate at frequency ranges of 935 Hz and 4600 Hz and three horizontal coplanar coil pairs at frequency ranges of 865 Hz, 4175 Hz and 33 kHz. Actual frequencies used depend on the particular bird configuration. Presently, Aerodat have eight bird systems. This survey utilized the Hornet bird which has frequencies of 917 Hz and 4507 Hz for the coaxial pairs and 867 Hz, 4127 Hz and 32330 Hz for the coplanar coil pairs. Transmitter-receiver separation is seven metres. In-phase and quadrature signals are measured simultaneously for the five frequencies with a time constant of 0.1 seconds. The HEM bird is towed 30 metres (100 feet) below the helicopter.

5.3 Magnetometer

A Scintrex H88 Cesium, optically pumped magnetometer sensor, measures the earth's magnetic field. The sensitivity of this instrument is 0.001 nT at a sampling rate of 0.2 second. The sensor is towed in a bird 15 metres (50 feet) below the helicopter, 45 metres (150 feet) above the ground.

5.4 Ancillary Systems

Base Station Magnetometer

A GSM-19 Cesium magnetometer is set up at the base of operations to record diurnal variations of the earth's magnetic field. Synchronization of the clock of the base station with that of the airborne system is checked each day to ensure diurnal corrections will be accurate. Recording resolution is 1 nT with an update rate of four seconds. The data is saved to disk.

Radar Altimeter

A King KRA-10 radar altimeter records terrain clearance. The output from the instrument is a linear function of altitude. The radar altimeter is pre-calibrated by the manufacturer and is checked after installation using an internal calibration procedure.

Tracking Camera

A Sony colour video camera records the flight path on VHS video tape. The camera operates in continuous mode. The video tape also shows the flight number, 24-hour clock time (to .01 second), and manual fiducial number.

Global Positioning System (GPS)

The Global Positioning System is a U.S. Department of Defence program that provides worldwide, 24 hour, all-weather position determinations. GPS consists of three segments:

- a constallation of satellites
- ground stations that control satellites
- a receiver

The receiver takes in coded data from satellites in view and thereafter calculates the range to each satellite. The coded data must therefore include the instantaneous position of the satellite relative to some agreed earth-fixed coordinate system. The satellite constellation consists of 24 satellites with a proportion of the satellites acting as standby spares.

Analog Recorder

An RMS dot matrix recorder displays the data during the survey.

Digital Recorder

A DGR-33 data system records the digital survey data on magnetic media. Contents and update rates are as follows:

DATA TYPE	RECORDING INTERVAL	RECORDING RESOLUTION
Magnetometer	0.2 s	0.001 nT
HEM (8 channels)	0.1 s	
coaxial		0.03 ppm
coplanar - 865 Hz/4175 Hz		0.06 ppm

coplanar - 33 kHz		0.125 ppm
Position (2 channels)	0.2 s	0.1 m
Altimeter	0.2 s	0.05 m
Power Line Monitor	0.2 s	-
Manual Fiducial		
Clock Time		

6. DATA PROCESSING AND PRESENTATION

6.1 Base Map

The base map is taken from digital NTS topographic maps. A UTM reference grid and the survey area boundary are added.

6.2 Flight Path Data

Global Positioning System

The GPS receiver takes in coded data from satellites in view and thereafter include the instantaneous position of the satellite relative to some agreed earth-fixed coordinate system.

A further calculation using ranges to a number of satellites gives the position of the receiver in that coordinate system (e.g., UTM, lat./long.). The elevation of the reciver is given with respect to a model ellip-soidal earth.

Normally the receiver must see 3 satellites for a full positional determination (3-space coordinates and time). If the elevation is known in advance, only 3 satellites are needed. These are termed 3D and 2D solutions.

The position of the receiver is updated every second. The accuracy of any 1 second position determination is described by the Circular Error Probability (CEP). Ninety-five percent of all position determinations will fall within a circle of a certain radius. If the horizontal position accuracy is 25 m CEP for example, 95% of all trials will fall within a circle of 25 m radius centered on the mean. The system may be degraded for civilian use and the autonomous accuracy is then 100 m CEP. This situation is called selective availability (SA). Much of this error (due principally to satellite position/time errors and atmospheric delays) can be removed using two GPS receivers operating simultaneously. One receiver acting as the base station, is located at a known position. The second remote receiver is in the unknown position. Differential corrections determined for the base station may then be applied to the remote station.

Differential positions are accurate to 5 m CEP (for a one second example). Averaging will reduce this error further.

The flight path is drawn using linear interpolation between x,y positions from the navigation system. These positions are updated every second (or about 1.5 mm on a scale of 1:20,000). These positions are expressed as UTM eastings (x) and UTM northings (y).

Occasional dropouts may occur when the optimum number of satellites are not available for the GPS to make accurate positional determinations. Interpolation is used to cover short flight path gaps. The navigator's flight path and/or the flight path recovered from the video tape may be stitched in to cover larger gaps. Such gaps may be recognized by the distinct straight line character of the flight path.

The manual fiducials are shown as a small circle and labelled by fiducial number. The 24-hour clock time is shown as a small square, plotted every 30 seconds. Small tick marks are plotted every 2 seconds. Larger tick marks are plotted every 10 seconds. The line and flight numbers are given at the start and end of each survey line.

The flight path is merged with the base map by matching UTM coordinates from the base maps and the flight path record. The match is confirmed by checking the position of prominent topographic features as recorded by manual fiducial marks or as seen on the flight path video record.

6.3 Electromagnetic Survey Data

The electromagnetic data are recorded digitally at a sample rate of 10 per second with a time constant of 0.1 seconds. A two-stage digital filtering process rejects major sferic events and reduces system noise.

Local sferic activity can produce sharp, large amplitude events that 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 searchs our and rejects the major sferic events. The signal to noise ratio is further enhanced by the application of a low pass digital filter. This filter 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 gives minimal profile distortion.

Following the filtering process, a base level correction is made using EM zero levels determined during high altitude calibration sequences. The correction applied is a linear function of time that ensures the corrected amplitude of the various in-phase and quadrature compo-nents is zero when no conductive or permeable source is present.

6.4 Total Field Magnetics

The aeromagnetic data are corrected for diurnal vari-ations by adjustment with the recorded base station magnetic values. No corrections for regional variations are applied. The corrected profile data are interpolated on a regular grid using an Akima spline technique. The grid provided the basis for threading the presented contours. The minimum contour interval is 2 nT. The grid cell is 50 m.

7. ELECTROMAGNETIC ANOMALY SELECTION

The main purpose of EM anomaly selection is to identify thin sheet bedrock conductors, somewhat regardless of conductance. If the source conductance is not large, such anomalies may not register on the apparent resistivity maps as a distinctive resistivity low.

The response type expected from a vertical thin sheet conductor is a positive anomaly in the coaxial EM channels with a coincident low in the coplanar channels of the same frequency. Characteristic EM responses to a number of simple conductor types are attached.

These criteria reject EM anomalies due to gradual changes in over-burden thickness or resistivity. For such anomalies, the coaxial and coplanar channels (either in-phase or quadrature) for the same operating frequency move together and no separation is seen.

A second type of EM anomaly is a negative in-phase response due to a near-surface concentration of magnetite (or pyrrhotite). For a halfspace with a uniform weight percent magnetite (W_m) and an EM sensor clearance of 30 metres, the coaxial in-phase response (R) is approximately:

$$R = -2.5 * W_m ppm.$$

A halfspace of 1% by weight magnetite produces a coaxial in-phase response of -2.5 ppm (and a coplanar in-phase response of -10 ppm). This is independent of operating frequency. It is very sensitive to sensor height.

Because magnetic sources are often wide, sharp negative EM peaks are rare. Broad negatives are more common and "magnetite" anomaly centres are a poor representation of the near-surface distribution of magnetite.

Where broad negative in-phase responses are common, maps of apparent weight percent magnetite are sometimes more appropriate.

In some cases, a negative in-phase anomaly will be accompanied by a positive quadrature response which suggests a source which is both conductive and magnetic (or conductors and magnetic sources which are very close). In rare instances, the coaxial in-phase trace shows a small positive peak superimposed on larger negative responses in both coaxial and coplanar channels. Such anomalies are often of special exploration interest.

ANOMALY SELECTION

EM anomalies are manually picked from the offset profiles. The selection process is as follows:

1. The digital records of the power line monitor for all survey lines were scanned for the average, maximum and minimum values. No power line responses occur in the COBB claims area.

2. Pick all negative in-phase responses on the 935/865 Hz offset profiles. Unlike bedrock conductors, magnetic sources may be wide and therefore may not generate a clear anomaly pick. Negative in-phase anomalies are labelled as such regardless of any coincident quadrature response (which is commonly present but rarely shows a thin sheet source). In those rare cases, where the in-phase results support both sources which are both magnetic and conductive, both types of EM anomaly - i.e., magnetic and normal - are shown side by side over the source.

3. Pick all thin sheet type anomalies on the 935/865 Hz offset profiles (not provided in this report). Pick all in-phase anomalies which show the tradi-tional response to a dipping thin sheet conductor. Horizontal conductors are identified by EM anomalies at their edges.

4. Transfer all anomaly picks from Steps 1, 2 and 3 to the 4600/ 4175 Hz offset profiles. Check that anomaly picks show reasonable fit with the middle frequency data. Add in-phase anomalies which were not picked from the low frequency data. EM anomalies which are only expressed in the 4600/4175 Hz quadrature channels are not picked.

   In some areas, the mid frequency responses are extreme and individual anomalies are difficult to identify. In these cases, the low frequency picks are used with little modifi-cation.

   Weak and uncertain anomalies are probably picked if they show line to line correlation. They will probably be ignored if there are no similar responses on neighbouring lines.

ANALYSIS

The picked anomalies are digitized by location and type (normal, magnetite or power line). The 4600 Hz in-phase and quadrature anomaly amplitudes are recovered for the locations given. Normal anomalies are modelled as a vertical thin sheet conductor using an automated version of the attached phasor diagram. Inversion returns estimates of source conductance and depth of burial. Anomaly centres showing the conductance range and in-phase response are plotted on selected map products.

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Distribution:

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REFERENCE

Takata, Sandra S., 1995 **"Operational Report On a Combined Helicopter-borne Magnetic and Electromagnetic Survey, Pelly Mountain Extension, Yukon Territory"** for Cominco Exploration

APPENDIX 1

GENERAL INTERPRETIVE CONSIDERATIONS

Electromagnetic

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

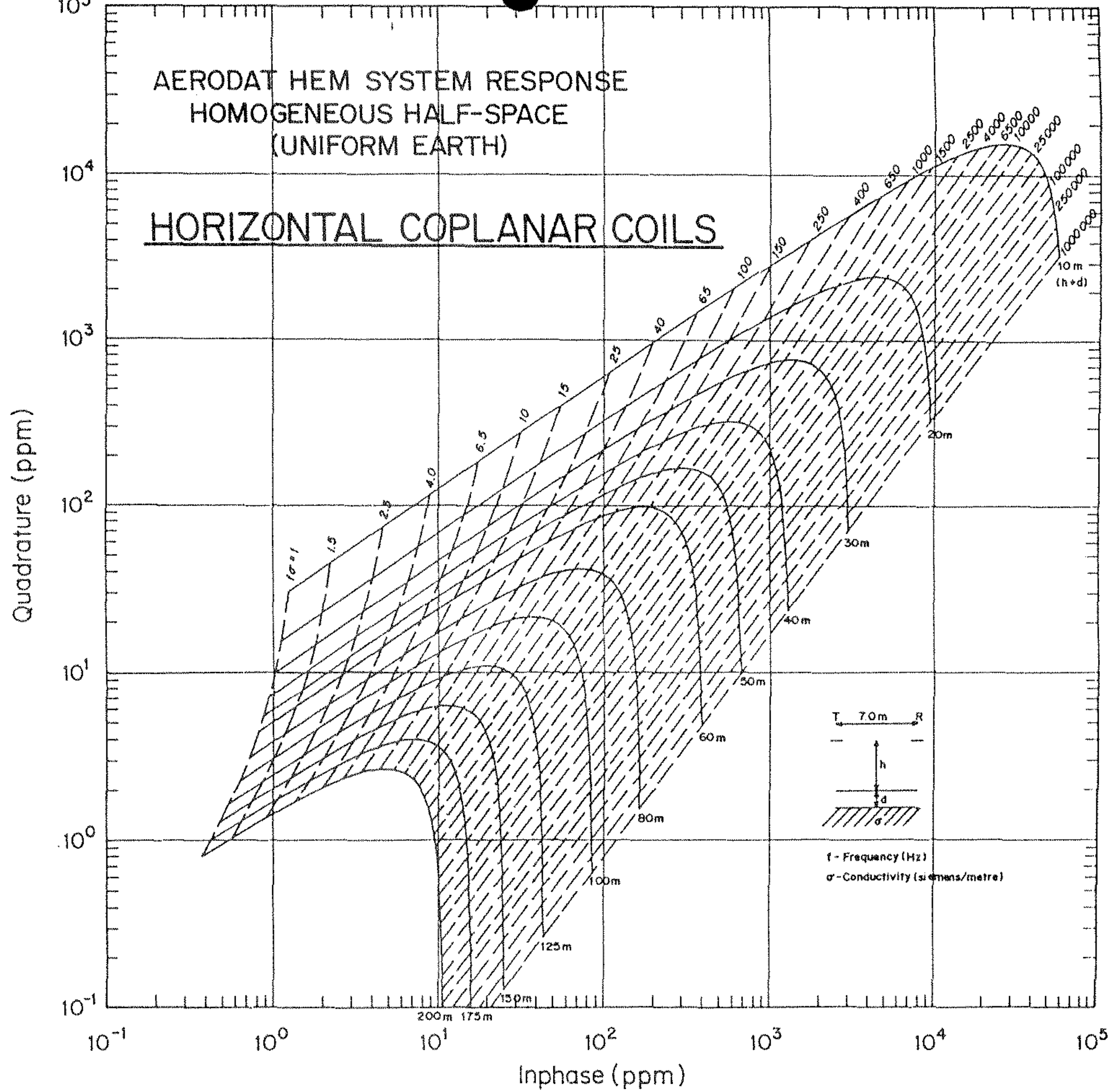
The electromagnetic response measured by the helicopter system is a function of the "electrical" and "geometrical" properties of the conductor. The "electrical" property of a conductor is determined largely by its electrical conductivity, magnetic susceptibility and its size and shape; the "geometrical" 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 and half space models on the accompanying phasor diagrams. 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 anomaly listings included in the survey report and the conductance and inphase amplitude are presented in symbolized form on the map presentation.

The conductance estimate is most reliable when anomaly amplitudes are large and background resistivities are high. Where the anomaly is of low amplitude and background resistivities are low, the conductance estimates are much less reliable. In such situations, the conductance estimate is often quite low regardless of the true nature of the conductor. This is due to the elevated background response levels in the quadrature channel. In an extreme case, the conductance estimate should be discounted and should not prejudice target selection.


AERODAT HEM SYSTEM RESPONSE
HOMOGENEOUS HALF-SPACE
(UNIFORM EARTH)
HORIZONTAL COPLANAR COILS
Quadrature (ppm)
Inphase (ppm)
10 m (h+d)
20m
30m
40m
50m
60m
80m
100m
125m
150m
175m
200m
T 7.0m R
h
d
σ
f - Frequency (Hz)
σ - Conductivity (siemens/metre)

The conductance and depth vales 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.

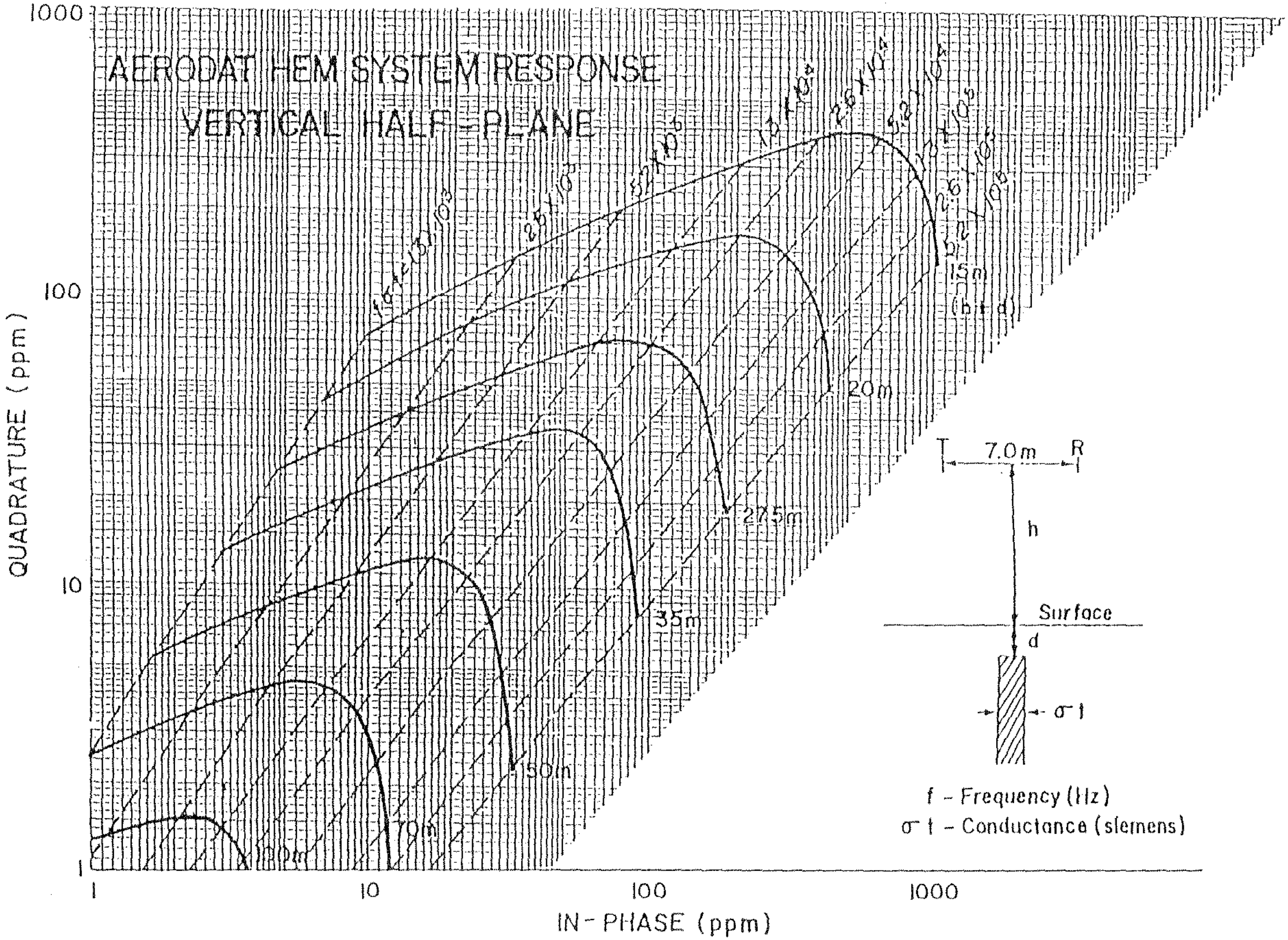
The higher ranges of conductance, greater than 2-4 mhos, indicate that a significant fraction of the electrical conduction is electronic rather than electrolytic in nature. Materials that conduct electronically are limited to certain metallic sulphides and to graphite. High conductance anomalies, roughly 10 mhos or greater, are generally limited to massive sulphides or graphites.

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 concentrations in association with minor conductive sulphides, and the electromagnetic response will 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. Minor accessory sulphide mineralization may however provide a useful indirect indication.

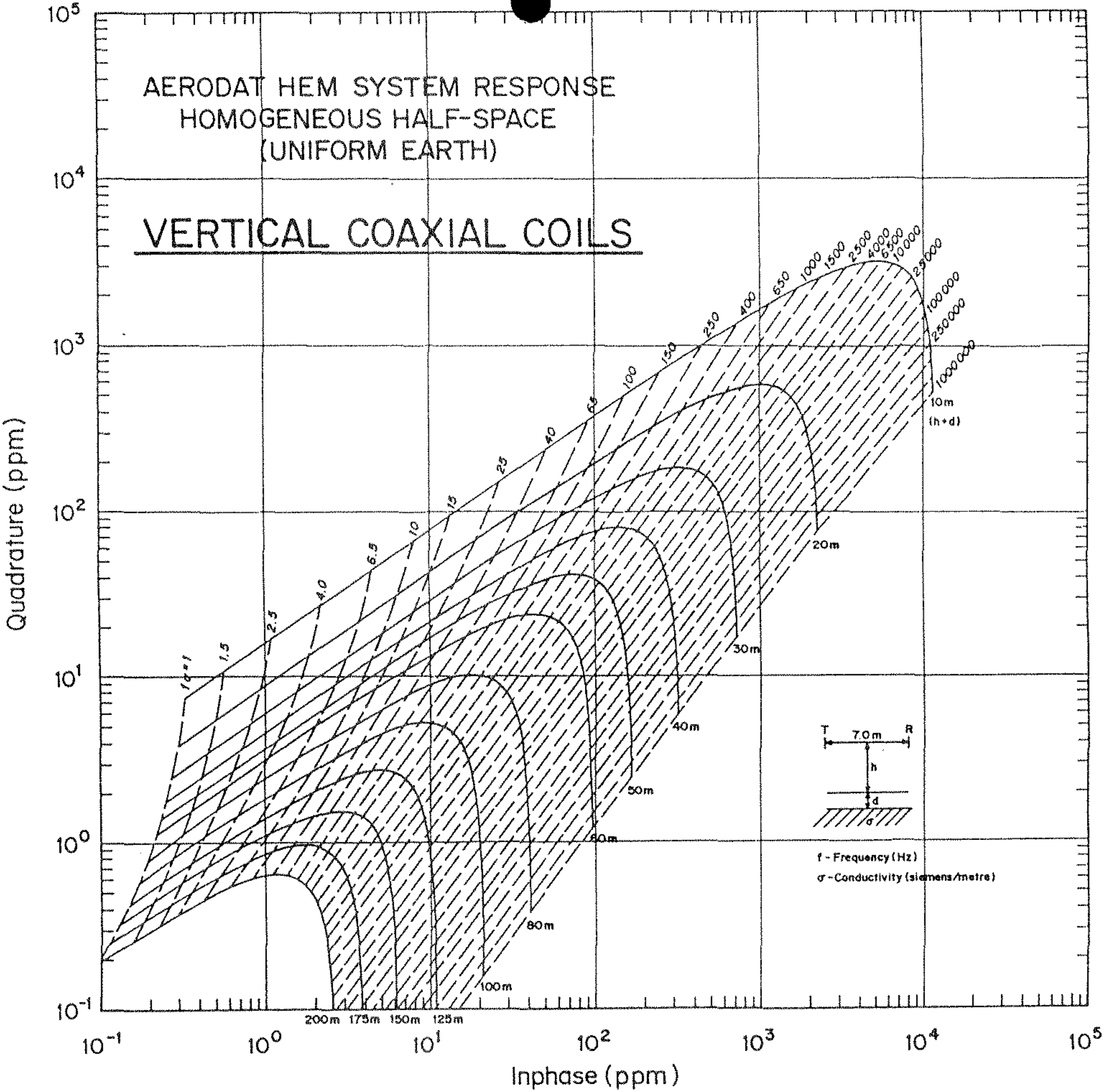
In summary, the estimated conductance of a conductor can provide a relatively positive identification of significant sulphide or graphite mineralization. A moderate to low conductance value does not rule out the possibility of significant economic mineralization.

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. The accompanying figure shows a selection of HEM response profile shapes from nine idealized targets. Response profiles are labelled A through I. These labels are used in the discussion which follows.



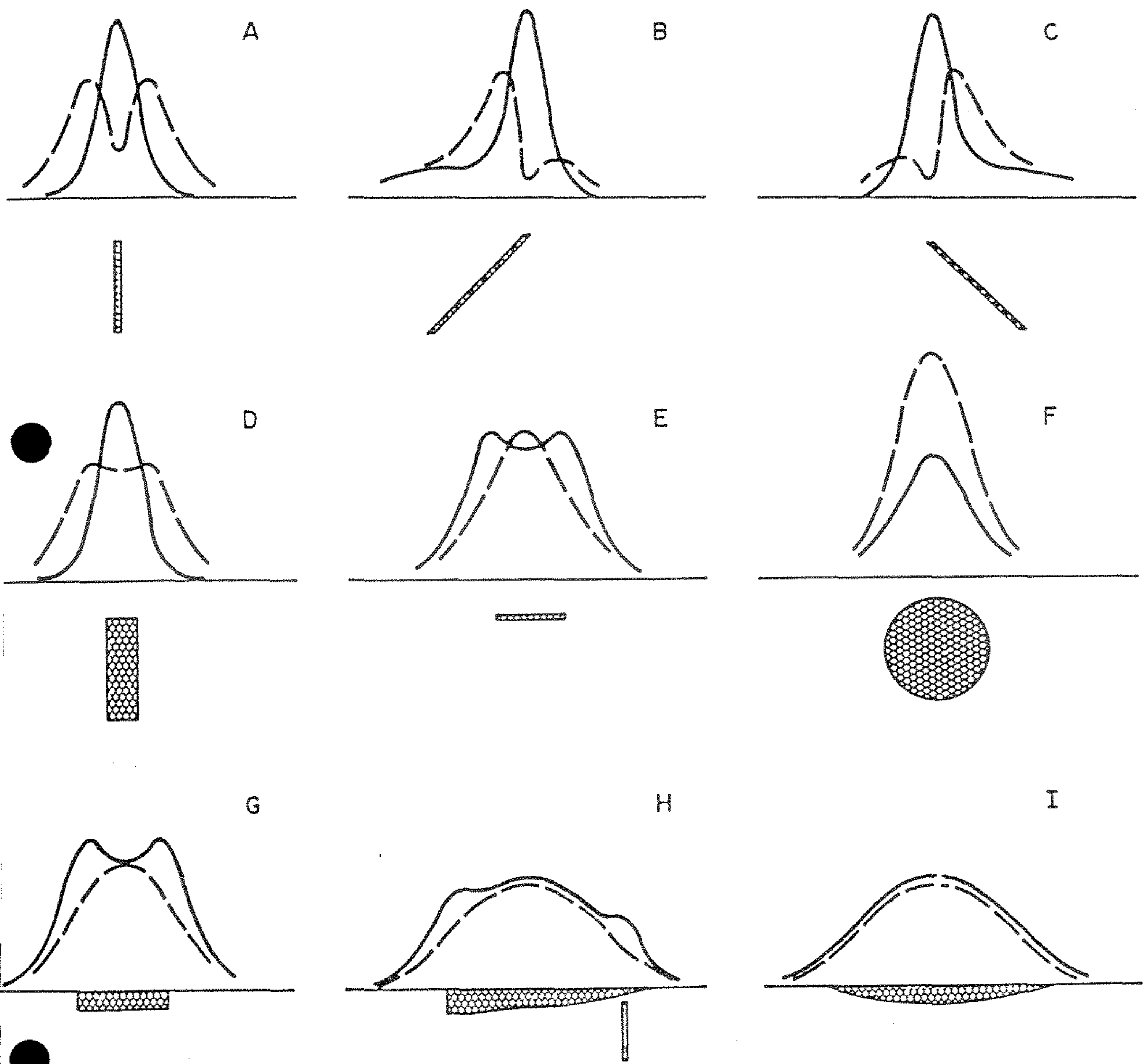
AERODAT HEM SYSTEM RESPONSE
VERTICAL HALF-PLANE
QUADRATURE (ppm)
IN-PHASE (ppm)
1000
100
10
1
1
10
100
1000
15m
20m
27.5m
35m
50m
70m
7.0m
T
R
h
Surface
d
σ t
f - Frequency (Hz)
σ t - Conductance (siemens)



AERODAT HEM SYSTEM RESPONSE
HOMOGENEOUS HALF-SPACE
(UNIFORM EARTH)
VERTICAL COAXIAL COILS
Quadrature (ppm)
Inphase (ppm)
10m (h+d)
20m
30m
40m
50m
60m
80m
100m
125m
150m
175m
200m
7.0 m
T
R
h
d
σ
f - Frequency (Hz)
σ - Conductivity (siemens/metre)

HEM RESPONSE PROFILE SHAPE AS AN INDICATOR OF CONDUCTOR GEOMETRY

COAXIAL vertical scale 1 ppm/unit
COPLANAR vertical scale 4 ppm/unit



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 (Profile A). As the dip of the conductor decrease 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 (Profiles B and C).

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 (Profile D). 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 a horizontal thin sheet or 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* (Profiles E and G).

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 (Profile F).

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 (Profile I). 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 (Profile H).

* 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.

The interpretation of contoured aeromagnetic data is a subject on its own involving an array of methods and attitudes. The interpretation of source characteristics for example from total field results is often based on some numerical modelling scheme. The vertical gradient data is more legible in some aspects however and useful inferences about source characteristics can often be read off the contoured VG map.

The zero contour lines in contoured VG data are often sited as a good approximation to the outline of the top of the magnetic source. This only applies to wide (relative to depth of burial) near vertical sources at high magnetic latitudes. It will give an incorrect interpretation in most other cases.

Theoretical profiles of total field and vertical gradient anomalies from tabular sources at a variety of magnetic inclinations are shown in the attached figure. Sources are 10, 50 and 200 m wide. The source-sensor separation is 50 m. The thin line is the total field profile. The thick line is the vertical gradient profile.

The following comments about source geometry apply to contoured vertical gradient data for magnetic inclinations of 70 to 80°.

Outline

Where the VG anomaly has a single sharp peak, the source may be a thin near-vertical tabular source. It may be represented as a magnetic axis or as a tabular source of measurable width - the choice is one of geological preference.

Where the VG anomaly has a broad, flat or inclined top, the source may be a thick tabular source. It may be represented as a thick body where the width is taken from the zero contour lines if the body dips to magnetic north. If the source appears to be dipping to the south (i.e. the VG anomaly is asymmetric), the zero contours are less reliable indicators of outline. The southern most zero contour line should be ignored and the outline taken from the northern zero contour line and the extent of the anomaly peak width.

Dip

A symmetrical vertical gradient response is produced by a body dipping to magnetic north. An asymmetrical response is produced by a body which is vertical or dipping to the south. For southern dips, the southern most zero contour line may be several hundred meters south of the source.

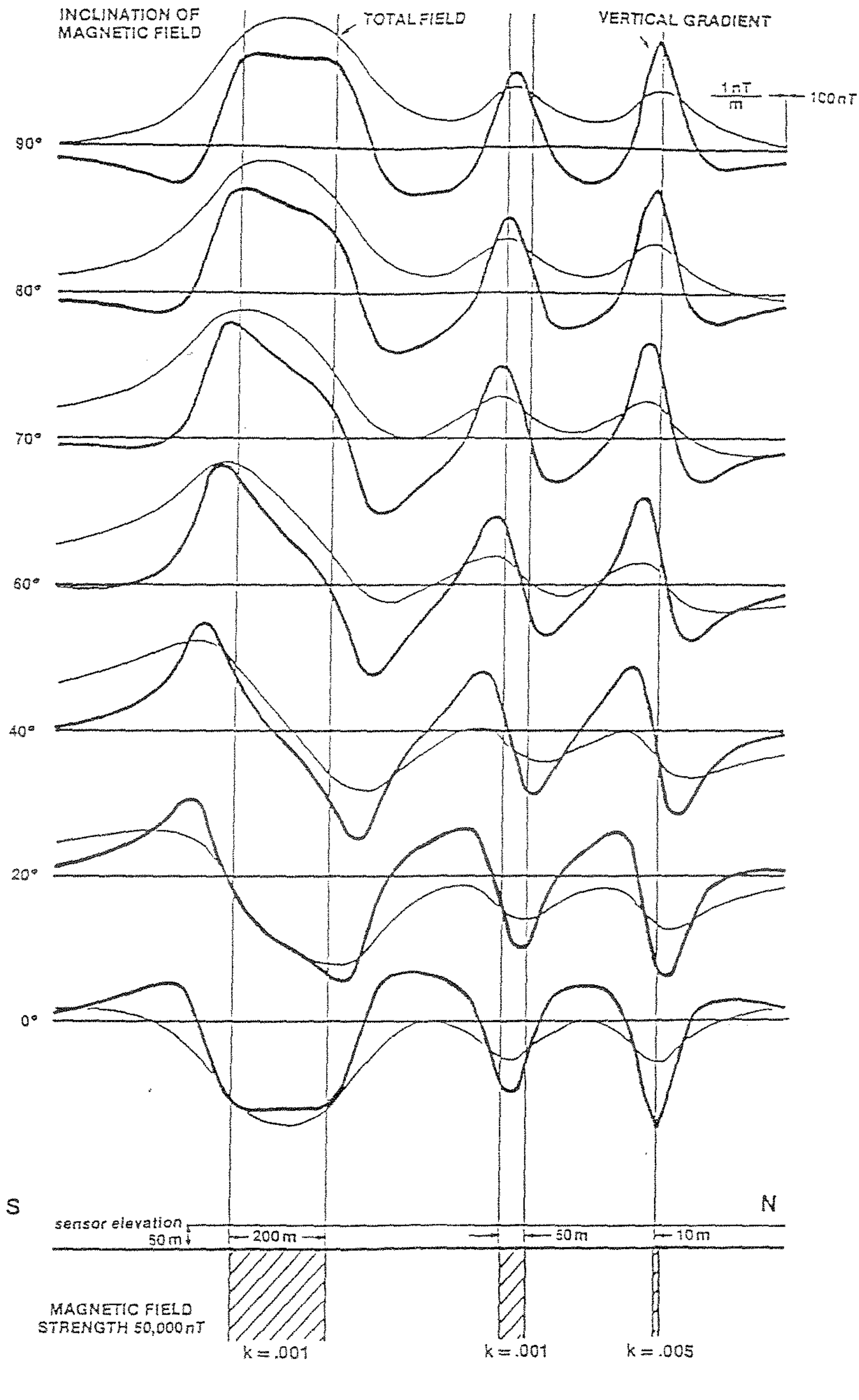
Depth of Burial

The source-sensor separation is about equal to half of the distance between the zero contour lines for thin near-vertical sources. The estimated depth of burial for such sources is this separation minus 50 m. If a variety of VG anomaly widths are seen in an area, use the narrowest width seen to estimate local depths.

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 locally horizontal and normal to a line pointing at the transmitter.

The Herz Totem uses three coils in the X, Y, Z configuration to measure the total field and vertical quadrature component from two VLF stations. These stations are designated Line and Ortho. The line station is ideally in a direction from the survey area at right angles to the flight line direction. Conductors normal to the flight line direction point at the line station and are therefore optimally coupled to VLF magnetic fields and in the best situation to gather secondary VLF currents. The ortho station is ideally 90 degrees in azimuth from the line station.


INCLINATION OF MAGNETIC FIELD
TOTAL FIELD
VERTICAL GRADIENT
1 nT/m
100 nT
90°
80°
70°
60°
40°
20°
0°
S
N
sensor elevation
50 m
200 m
50 m
10 m
MAGNETIC FIELD STRENGTH 50,000 nT
k = .001
k = .001
k = .005

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 anomaly is an indicator of the existence and position of a conductor. 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.

Conversely a negative total field anomaly is often seen over local resistivity highs. This is because the VLF field produces electrical currents which flow towards (or away from) the transmitter. These currents are gathered into a conductor and are taken from resistive bodies. The VLF system sees the currents gathered into the conductor as a total field high. It sees the relative absence of secondary currents in the resistor as a total field low.

As noted, VLF anomaly trends show a strong bias towards the VLF transmitter. Structure which is normal to this direction may have no associated VLF anomaly but may be seen as a break or interruption in VLF anomalies. If these structures are of particular interest, maps of the ortho station data may be worthwhile.

Conductive overburden will obscure VLF responses from bedrock sources and may produce low amplitude, broad anomalies which reflect variations in the resistivity of thickness of the overburden.

Extreme topographic relief will produce VLF anomalies which may bear no relationship to variations in electrical conductivity. Deep gullies which are too narrow to have been surveyed at a uniform sensor height often show up as VLF total field lows. Sharp ridges show up as total field highs.

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 vertical quadrature component is rarely presented. Experience has shown the total field to be more sensitive to bedrock conductors and less affected by variations in conductive overburden.

Apparent Resistivity/Conductivity Maps

Overburden and different types of bedrock may be modelled as a large area horizontal conductor of fixed thickness. A phasor diagram may be constructed, in the same fashion as for the vertical sheet, to convert the measured HEM in-phase and quadrature response to a depth and conductivity value for a horizontal layer. Traditionally if the thickness is large, an infinite half-space, the associated conductivity value is referred to as "apparent conductivity". We have generalized the use of the word "apparent" to include any model where the thickness of the layer is a fixed as opposed to a variable parameter. The units of apparent resisitivity are ohm-m and those of apparent conductivity are the inverse mhos/m or siemen/m. If the chosen model layer thickness is close to the true thickness of the conductor then the apparent conductivity will closely conform to the true value; however, if the thickness is inappropriate the apparent value may be considerably different from the true value.

The benefit of the apparent conductivity mapping is that it provides a simple robust method of converting the HEM in-phase and quadrature response to apparent change in ground conductivity.

A phasor diagram for several apparent resistivity models is presented. The general forms for the various thicknesses is very similar and also closely resembles the diagram for the vertical sheet. The diagrams also show the curves for apparent depth. As with the conductivity value the depth value is meaningful if the model thickness closely resembles the true conductive layer thickness. If the HEM response from a thin conducting layer is applied to a thick layer model the apparent conductivity and depth will be less than the true conductivity and depth.

APPENDIX II

PERSONNEL

FIELD

Flown	July 22 - August 23, 1995
Pilot(s)	B. Stone, G. Suthern
Operator(s)	P. Moisan, J. Cunningham

OFFICE

Processing	Andrei Lambert Ed Hamilton George McDonald
Anomaly Selections	Ian Johnson
Report	Sandra Takata

APPENDIX III

IN THE MATTER OF THE B.C. MINERAL ACT AND THE MATTER OF A GEOPHYSICAL PROGRAM CARRIED OUT ON THE PELLY MTN. PROPERTIES LOCATED 200 KMS NNW OF WATSON LAKE, YUKON IN THE WATSON LAKE MINING DIVISION OF THE YUKON TERRITORY, MORE PARTICULARLY, N.T.S. 105G8

STATEMENT

I, Robert W. Holroyd, of 2752 Dollarton Highway, in the City of North Vancouver, in the Province of British Columbia, make oath and say:

1. THAT I am employed as a geophysicist by Cominco Ltd. and, as such have a personal knowledge of the facts to which I herein after depose;

2. THAT annexed hereto and marked as "Exhibit A" to this state ment is a true copy of geophysical expenditures incurred on the COBB Claims;

3. THAT the said expenditures were incurred during the period July 22 to August 23, 1995, for the purpose of mineral exploration on the COBB claims.

R.W. Holroyd
Senior Geophysicist
Western Canada,
Cominco Ltd.

Dated this 22 day of February, 1996
at Vancouver, B.C.

STATEMENT OF EXPENDITURES

AIRBORNE EM/MAG SURVEY - COBB CLAIMS - JULY 22 to AUG 23, 1995

75 line kms within COBB claims @ $81 per line-km = $6156.00

(cost includes contract costs to Aerodat plus Cominco in-house geophysical consultation and map generation)

TOTAL EXPENSES **$6156.00**

APPENDIX IV

CERTIFICATION OF QUALIFICATIONS

I, ROBERT W. HOLROYD, of 2752 Dollarton Highway, in the City of North Vancouver, in the Province of British Columbia, do hereby certify:

i. THAT I graduated with a Bachelor of Science in Honours Applied Earth Science - Cooperative Programme, from the University of Waterloo in 1977.

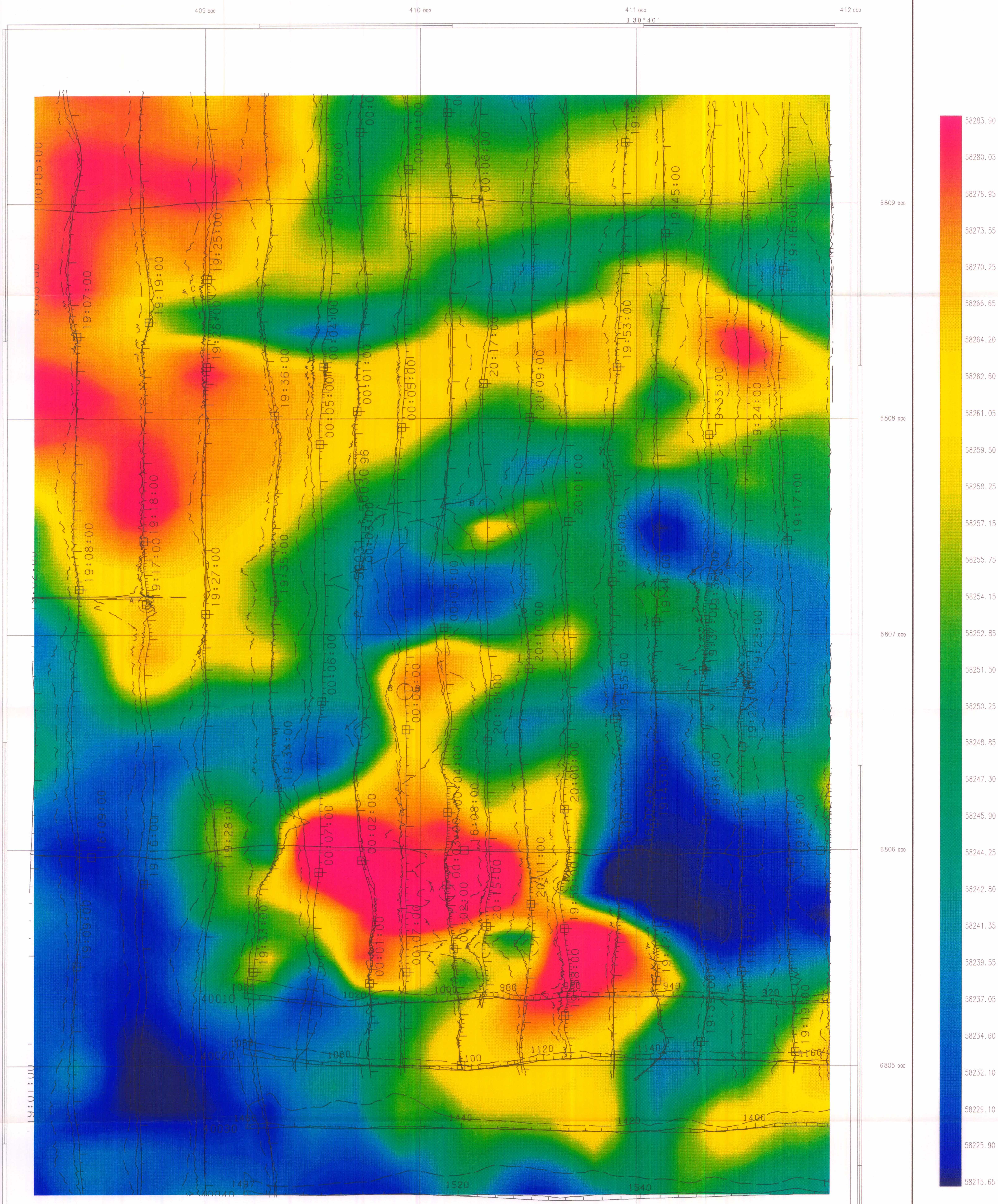
ii. THAT I am a member in good standing of the Association of Professional Engineers and Geoscientists of the Province of British Columbia.

iii. THAT I have been actively practising my profession from 1973 to 1995, and have been an employee of Cominco Ltd. from 1977 to 1995.

Robert W. Holroyd,
B.Sc./P.Geo.

February 1996


COBB PROPERTY
Location and Claim Map
N.T.S. 105O/7
COBB
OVERTIME
DOG
RBI
NORTH LAKES
MAN
PAK
NHL
NORTH RIVER
BIG CAMPBELL CREEK
METRES
093429



COAXIAL EM PROFILES

E-W LINES: DIGHEM 5500 Hz - 2.5ppm/mm

N-S LINES: AERODAT 4600 Hz - 1ppm/mm

(SOLID = IN PHASE; DASHED = OUT OF PHASE)

1 : 10,000

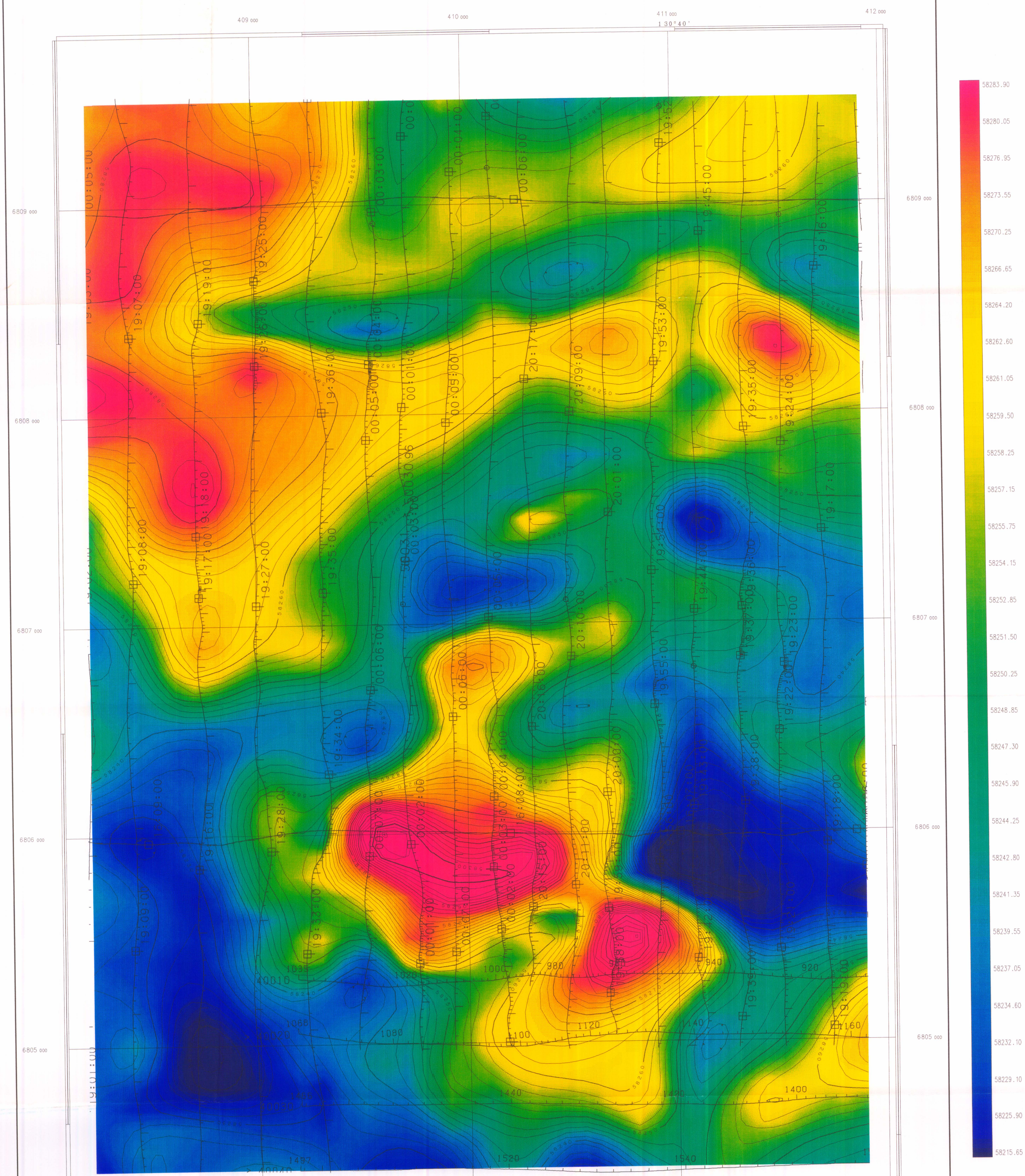
COBB PROPERTY

6804 000

409 000 410 000 130°40' 411 000 412 000

093429

Plate 812-09-C2



TOTAL FIELD MAGNETICS

1:10,000

COBB PROPERTY

093429

Plate 812-09-C3