83-#454 - 11659

HELICOPTER INPUT E.M. SURVEY

SILVER QUEEN MINE

OWEN LAKE AREA, BRITISH COLUMBIA

93L/2E 54°05'N 126°44'W

FILE NO: 24H36 AUGUST, 1983

Part 2 of 2

Questor Surveys Limited, 6380 Viscount Road, Mississauga, Ontario L4V 1H3

CONTENTS

INTRODUCTION

This report contains the results of a Helicopter MARK VI INPUT E.M. Survey flown in the Owen Lake Area, 34 kilometres south-southwest of Houston, British Columbia on June 30; 1982.

A brief description of the survey procedure is included.

The survey mileage was approximately 17.8 line kilometres and the survey was performed by QUESTOR SURVEYS LIMITED. The survey aircraft was a Bell 205 Helicopter C-GLMC and the operating base was Houston, British Columbia.

The area outline is shown on a 1:250,000 map at the end of this report. This is part of the National Topographical Series, Sheet Number 93L.

The following were the personnel involved with the airborne survey:

Pilot	- Dan Davis
Navigator	- Bill Smith
Operator	- Keith Higgenbottom
Engineer	- Laughin Currie
Geophysicist	- Robert deCarle

SURVEY PROCEDURE

Terrain clearance was maintained as close to 122 metres as possible, with the E.M. Bird at approximately 45 metres above the ground. Rough terrain could be a factor for the helicopter not being at 122 metres. A normal S-pattern flight path using approximately one half kilometre turns was used. Consecutive lines were flown in alternate directions for the sole purpose of interpreting dipping conductors. This phenomenon will be dealt with later.

A variable line spacing was used over the test survey area in order to cover a number of the known mineralized sulphide veins.

The equipment operator logged the flight details and monitored the instruments. It was the responsibility of the geophysicist to maintain and check the ground magnetic station, Geometrics G-826, which was recording the daily diurnal changes. The results of these recordings have been included in the final shipment.

MAP COMPILATION

The base maps used for navigation and flight path recovery were photographic transparencies at an approximate scale of 1:25,000 which were made from 1979, 1:60,322 photographs obtained from the Ministry of Environment, MAPS B.C. The final maps were reproduced at a scale of 1:10,000 on stable transparent film from which white prints can be made. A copy of the map layout is located on the map sheet using topographical reference numbers.

Flight path recovery was accomplished by comparison of the 35mm. half frame film with the mosaic in order to locate the fiducial points. Most picked points are between 300 and 600 metres depending on the difficulty of the area, some picked points are much in excess of this figure.

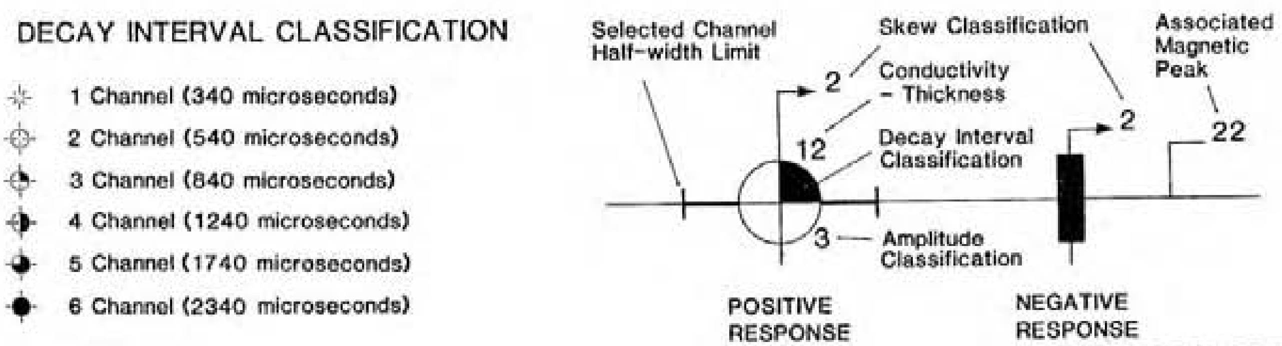
DATA PRESENTATION

The results of the INPUT survey are presented to the client in the following manner:

- 1 photographic base showing combined INPUT anomalies, half peak width of channel 2, skew classification, selected targets, interpretation and flight lines at a scale of 1:10,000.

See Appendix for a comprehensive description of the interpretation approach used in helicopter INPUT surveys.

QUESTOR's conventional form for presenting the helicopter INPUT data on a base map is as follows and is self-explanatory:



AREA LOCATION

The survey block is located approximately 34 kilometres south-southwest of Houston, British Columbia. The mine workings are located on the east shore of Owen Lake and access to the area can be made via the Morice River and Owen Lake gravel roads.

GEOLOGY

In the immediate vicinity of the survey block and the mine workings, the major rock units are coarse volcanic breccia and volcanic tuff. However, in contact with the mineralized zones is generally a microdiorite with a number of bladed feldspar porphyry and aphanitic pulaskite dykes. Quartz porphyry has also been mapped in the vicinity of the Ruby Extension.

"A regional geological survey in the Owen Lake, Parrott Lakes, and Goosly Lake areas has augmented speculation on the origin of the veins and ore-bearing solutions. A line of syenomonzonite intrusions was discovered extending in projection from Nadina's Silver Queen Mine, 25 miles northeast to Equity Silver's copper-silver discovery near Goosly Lake. The replacement sulphide deposit on the Equity Silver property is immediately adjacent to a syenomonzonite stock considered to be the source of mineralizing solutions.

The general impression is that the Nadina veins were emplaced at roughly the same time as a set of feldspar porphyry dykes. Also a deep magma similar in composition to the Goosly stock is thought to be the source for both the dykes and mineralizing solutions. It is further speculated that the Nadina vein system may change in form and mineralogy with depth eventually passing into a Goosly-type massive sulphide replacement orebody."

CONDUCTIVE ENVIRONMENT

There were a number of INPUT anomalies intercepted within this block during the course of flying the survey. Most responses are relatively weak, probably reflecting the nature of the make-up of the sulphides within the vein systems. The writer interprets most responses to be due to the sulphides and the weakness of amplitudes probably is a direct relationship with the amount of sphalerite.

As will be shown later, there seems to be good correlation between the INPUT responses and the various vein systems involved in this area. However, three areas may be of interest and should be considered in any future ground follow-up. These are intercept 30010A (ZONE E), intercepts 30031C and 30050D (ZONE F) and intercept 30050E (ZONE G).

SKEWNESS AND DIP OF CONDUCTORS

The two aspects are definitely related, in that, the direction of skew or the stagger of channel peaks indicates the direction of dip. Sometimes the stagger will only show on the early channels while at other times, all 6 channels are affected. As well as affecting the 6 channels in a downward direction (positive), the skew will also be seen in the negative direction (upward). The amount of skew is based on the offset between channels 2 and 4. This interpretational aspect applies to both positive and negative responses. There seems to be a relationship between the amount of skew and the amount of dip. In other words, a skew of 4 would represent a conductor which is dipping between 0° and 20°, a skew of 3 between 20° and 45°, a skew of 2 between 45^{0} and 70°, and a skew of 1 between 70° and 90°. Further model studying is being carried out in this office on this very subject, in order to arrive at a much clearer picture of INPUT responses resulting from dipping conductors.

Good examples of positive skewness are as follows:

Intercepts 30050D

30041D

30031C

Good examples of the negative skewness are as follows: (negative response follows the positive response)

Intercepts 30020A

30050A

Skewness may be obtained in either an up-dip direction or down-dip direction. In the up-dip direction, however, the skewness is more noticeable in the negative response while in the down-dip direction, the skewness is most noticeable in the positive response. These interpretational features have been plotted on the final E.M. interpretation maps.

SELECTED TARGETS

ZONE A Extremely poor electromagnetic responses correlating with a relatively high intensity magnetic feature, in the order of 600-1000 gammas. Intercept 30020B displays a broad E.M. response which may indicate that conductive overburden is the cause.

ZONE B This very weak conductive trend would appear to be correlating with what is referred to be the No. 3 Vein. Here the zone is known to contain fair sphalerite-galena values but rather low in chalcopyrite. There is also pyrite involved here which may be the cause of these two very weak anomalies.

ZONE C As was the case for ZONE B, these anomalies represent very weak electromagnetic responses which, invariably, are due to very weak mineralization. Referring to a topographic base of the area which was produced by Nadina Exploration Co., it would appear that this weak conductor coincides with No. 1 Vein. There is a weak magnetic anomaly of 12-16 gammas correlating with the conductor suggesting that pyrrhotite may be the source.

The writer is unaware of the mineralization involved within the No. 1 Vein. In any event, the INPUT response is very weak indicating a poor conductor.

ZONE D This zone displays a little better electromagnetic response than the first three zones and the sharpness of the response, especially intercept 30080A, would seem to indicate that it is a bedrock conductor. There is no magnetic association. Trenches or excavations located to the south of the zone have been worked on but the writer is unaware to what extent.

Along strike to the east, the trend may, in fact, cross the road.

ZONE E The negative effect after intercept 30020A would seem to indicate a southerly dip to the conductor, although a published geology map by Nadina interprets the dip to be to the north. The writer refers to No. 5 Vein. In fact, the conductor or No. 5 Vein is interpreted to extend to at least intercept 30010A. The latter displays a good electromagnetic response and is certainly worthy of further ground follow-up.

A considerable amount of trenching has been done in the vicinity of intercept 30060B as well as intercept 30090A.

First priority for this zone should be to investigate intercept 30010A.

<u>ZONE F</u> Intercepts 30070C and 30090B, towards the north end of the conductor, may, in fact, be due to cultural effects. That is, they may be caused by buildings, overhead wires or possibly railway tracks (tramway). This part of the zone should be checked out on the ground for this possible interference. Otherwise, they represent fair E.M. responses.

Proceeding to the south, one will note the negative effect on line 30080. If one refers to the analog charts just ahead of this negative effect, it will be seen that there is a probable INPUT anomaly just off the end of the line. The writer interprets this as being a southerly extension of the zone and, in fact, may have a southwesterly dip. Continuing along strike, intercepts 30031C and 30050D also suggest a southwesterly dip.

Further work is recommended for this zone with any preliminary work to be initiated in the vicinity of intercept 30050D.

ZONE G Because this is an isolated anomaly without any possibilities of knowing the existence of any correlation, interpretation, both along strike and laterally is impossible. The lone intercept displays a weak electromagnetic response and does not have any magnetic association but the writer feels it is certainly due to a bedrock source.

Follow-up work is suggested.

ZONE H All three intercepts display fair electromagnetic responses but have no magnetic association. Pyrite may be the source. Located just to the north of the conductor looks to be a tailings pond although the writer is not suggesting that this has any effect.

It is suggested that any further work on this trend should be initiated in the vicinity of intercept 30041B.

ZONE J The short trend displays a very weak E.M. response and has no magnetic association. Referring to the photo mosaic base map, it will be noted that there is a clearing which the writer assumes is a trench or excavation. It can be assumed that there are sulphides located here because of the coincident INPUT anomaly.

ZONE K The only positive response along this trend is intercept 30050B, whereas there are two negative responses. The latter indicates to the writer that there may be a southerly dip to this conductor. Excavations or trenches in the vicinity of the outlined conductor suggest that the INPUT responses are probably related to mineralization which has been detected from the trenching.

ZONE L Intercepts 30030A and 30031A appear to coincide with No. 4 Vein while intercepts 30040B and 30041D may be related to the Ruby Extension. The first two anomalies (No. 4 Vein) display very weak E.M. responses and are due to poorly mineralized conductors. The Ruby Extension anomalies, however, display somewhat better responses and would appear to be a little more attractive for reconnaissance surveying at this time. However, because of the previous work that has been done on this zone in the past, this particular area may not be all that attractive.

Pyrite would seem to be the source for all four anomalies.

Respectfully submitted
QUESTOR SURVEYS LIMITED

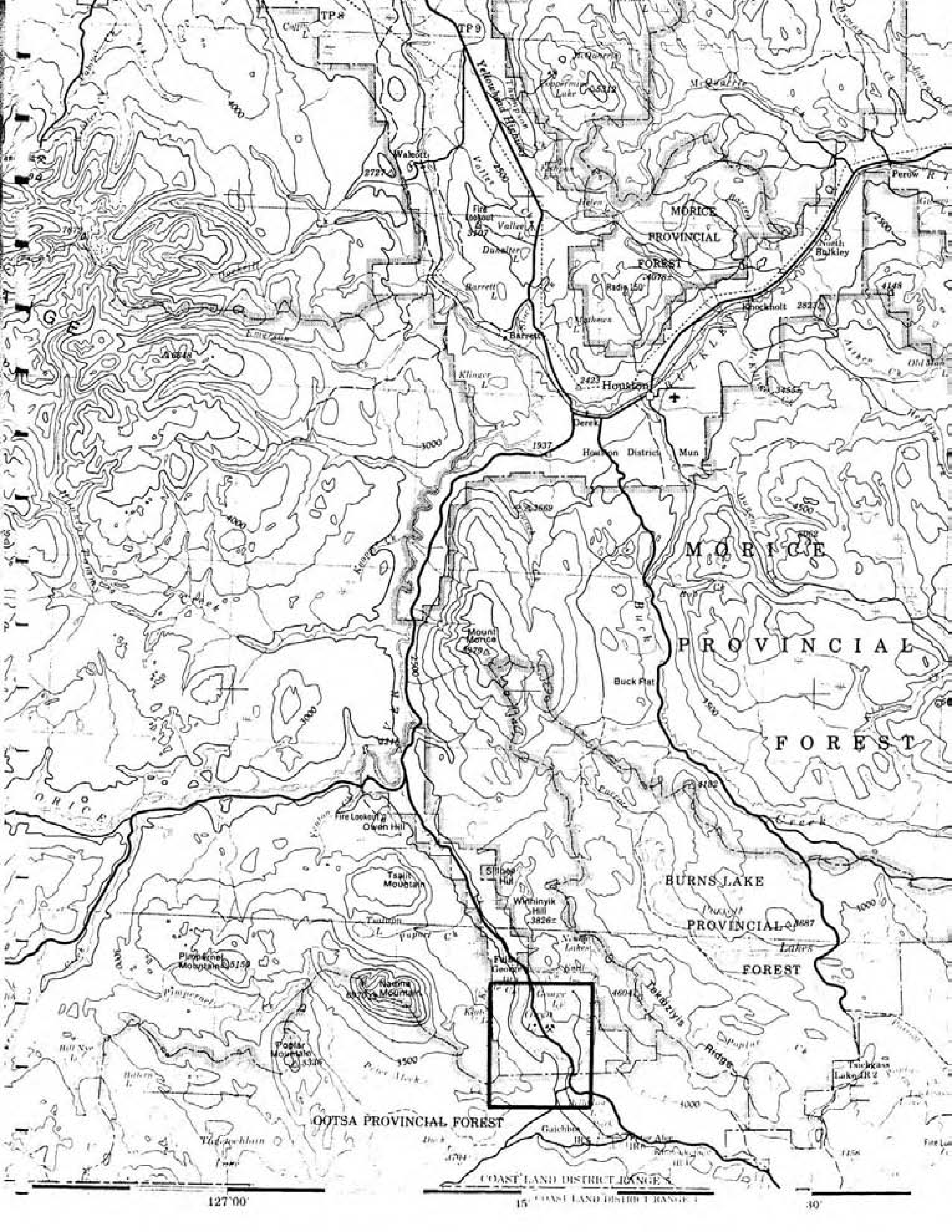
R. J. de Carle

R. J. deCarle,
Chief Geophysicist

SELECTED REFERENCES

Geology, Exploration and Mining in British Columbia, Department of Mines and Petroleum Resources, 1970, Page 134;

Geology, Exploration and Mining in British Columbia, Department of Mines and Petroleum Resources, 1972, Page 370.



TP 8
TP 9
Yellowhead Highway
Walcott
Fire Lookout
Valley L
Barrett L
Barrett
Klinger L
MORICE PROVINCIAL FOREST
North Bulkley
Knockholt
Perow
Houston
Derek
Houston District Mun
Emerson
Buck Flat
MORICE PROVINCIAL FOREST
Mount Morice
Fire Lookout
Owen Hill
Tsalit Mountain
Siltbee Hill
Whithinyik Hill
BURNS LAKE PROVINCIAL FOREST
Pimpernel Mountain
Nadina Mountain
Poplar Mountain
Tatsutnai Ridge
Poplar
OOTSA PROVINCIAL FOREST
COAST LAND DISTRICT RANGE 5
COAST LAND DISTRICT RANGE 4
127°00'
15'
30'
4000
3000
3500
4500

APPENDIX A

BARRINGER/QUESTOR MARK VI INPUT(R) Helicopter System

The INduced PUlse Transient (INPUT) method is a system whereby measurements are made, in the time domain, of a secondary electromagnetic field while the primary field is between pulses. Currents are induced into the ground by means of a pulsed primary electromagnetic field which is generated from a transmitting loop around the helicopter. By using half-sine wave current pulses (Figure A-1) and a transmitter loop of large turns-area, a high signal-to-noise ratio and the high output power needed for deep penetration, are achieved.

Induced current in a conductor produces a secondary electromagnetic field which is detected and measured after the termination of each primary pulse. Detection of the secondary field is accomplished by means of a receiving coil, wound on a ferrite rod, mounted in a fibreglass shell called a "bird" and towed behind and below the helicopter on 120 metres (400 feet) of coaxial cable. The received signal is processed and recorded by equipment within the helicopter.

The axis of the receiving coil may be vertical or horizontal relative to the flight direction. In rolling or hilly terrain the standard or horizontal coil axis is preferred, although in steep terrain, the vertical axis coil optimizes coupling with horizontal or dipping stratigraphy. The secondary field is in the form of a decaying voltage transient, measured in time, at the termination of the primary transmitted pulse. The amplitude of the transient is proportional to the amount of current induced into the conductor, the conductor dimensions, conductivity and the depth beneath the helicopter.

The rate of decay of the transient is inversely proportional to conductance. By sampling the decay curve at six different time intervals and recording the amplitude of each sample, an estimate of the relative conductance can be obtained. Transients due to strong conductors such as sulphides and graphite, usually exhibit long decay curves and are therefore commonly recorded on all six channels. Sheet-like surface conductive materials, on the other hand, have short decay curves and will normally only show a response in the first two or three channels.

For homogeneous conditions, the transient decay will be exponential and the time constant of decay is equal to the time difference at two successive sampling points divided by the log ratio of the amplitudes at this point.

TRANSMITTER SPECIFICATIONS

Pulse Repetition Rate	211 per sec
Pulse	Half sine
Pulse Width	2.0 millisec
Off Time	2.7 millisec
Output Voltage	60 volts
Output Current Peak	235 amperes
Output Current RMS	106 amperes
Output Current Average	60 amperes
Coil Area	167 $m.^2$ (1,800 $ft.^2$)
Coil Turns	6
Electromagnetic Field Strength (peak)	233,800 amp-turn-$meter^2$

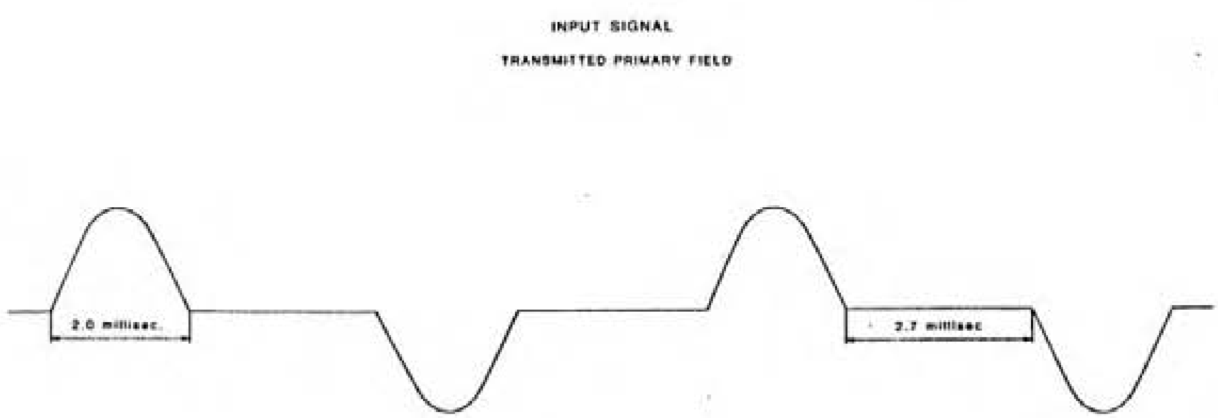


Figure A1

RECEIVER SPECIFICATIONS

Sample Gate	Windows (centre positions)	Widths
CH 1	340 sec	200 sec
CH 2	540	200
CH 3	840	400
CH 4	1240	400
CH 5	1740	600
CH 6	2340	600

Sample Interval	0.5 sec
Integration Time Constant	1.3 sec
Bird Position behind Aircraft (at 40 kt)	19 metres
Bird Position below Aircraft (at 40 kt)	74 metres

Receiver features: Power Monitor 50 or 60 Hz

50 or 60 Hz and Harmonic Filter

VLF Rejection

Spheric Rejection (tweak) Filter

SAMPLING OF INPUT SIGNAL

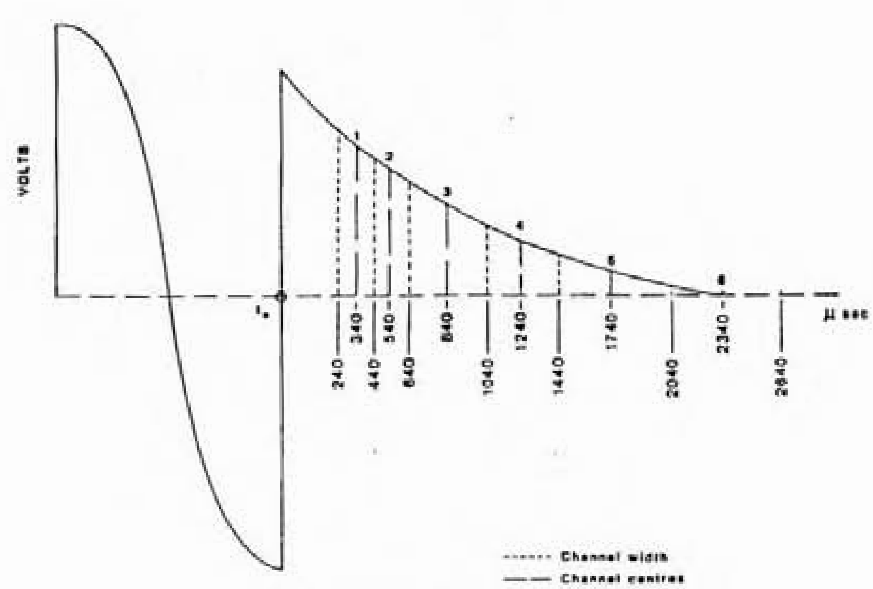


Figure A2

DATA ACQUISITION SYSTEM

Sonotek SDS 1200

9 track 800 BPI ASCII

Includes time base Intervalometer, Fiducial System

CAMERA

Geocam 75 SF

35 mm continuous strip or frame

TAPE DRIVE

Digidata Model 1139

OSCILLOSCOPE

Tektronix Model 305

ANALOG RECORDER

Honeywell Visicorder WS 4010

Kodak Light Sensitive Pape (15cm)

Recording 14 Channels: 50-60 Hz Monitor, 6 INPUT Channels, fine and coarse Magnetics, Altimeter, vertical and horizontal timing lines and fiducial markers.

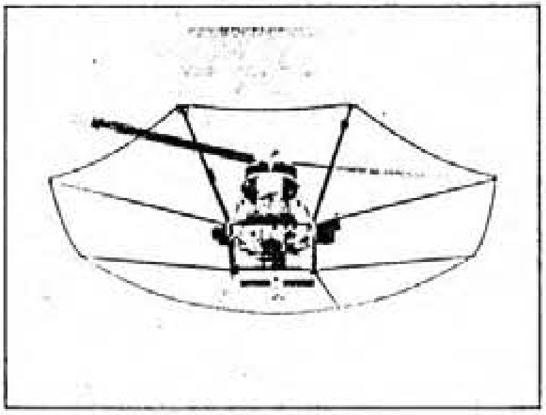
ALTIMETER

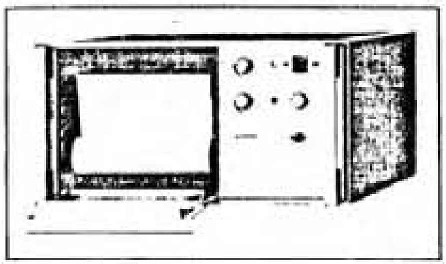
Sperry Radar Altimeter

SONOTEK P.M.H. 5010 PROTON MAGNETOMETER

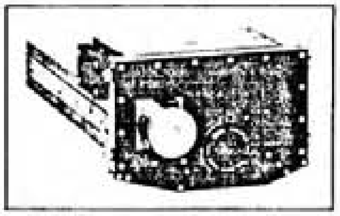
The airborne magnetometer is a proton free precession sensor, which operates on the principle of nuclear magnetic resonance to produce a measurement of the total magnetic intensitity. It has a sensitivity of 1 gamma and an operating range of 20,000 gammas to 100,000 gammas. The sensor is a solenoid type, oriented to optimize results in a low ambient magnetic field. The sensor housing is mounted on the tip of the nose boom supporting the INPUT transmitter cable loop. A 3-term compensating coil and perma-alloy strips are adjusted to counteract the effects of permanent and induced magnetic fields in the aircraft.

Because of the high intensity electromagnetic field produced by the INPUT transmitter, the magnetometer and INPUT results are sampled on a time-share basis. The magnetometer head is energized while the transmitter is on, but a measurement is only obtained during a short period when the transmitter is off. Using this technique, the sensor head is energized for 0.80 seconds and subsequently the precession frequency is recorded and converted to gammas during the following 0.20 seconds when no current pulses are induced into the transmitter coil.

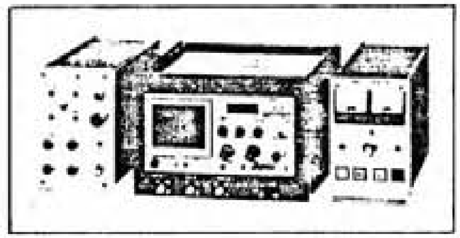




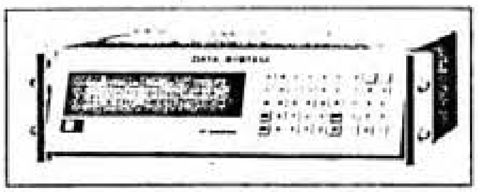
HONEYWELL ANALOGUE CHART RECORDER



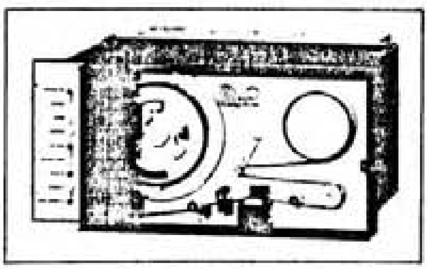
35mm TRACKING CAMERA



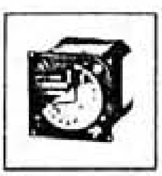
INTERFACE, OSCILLOSCOPE & T.C.U.



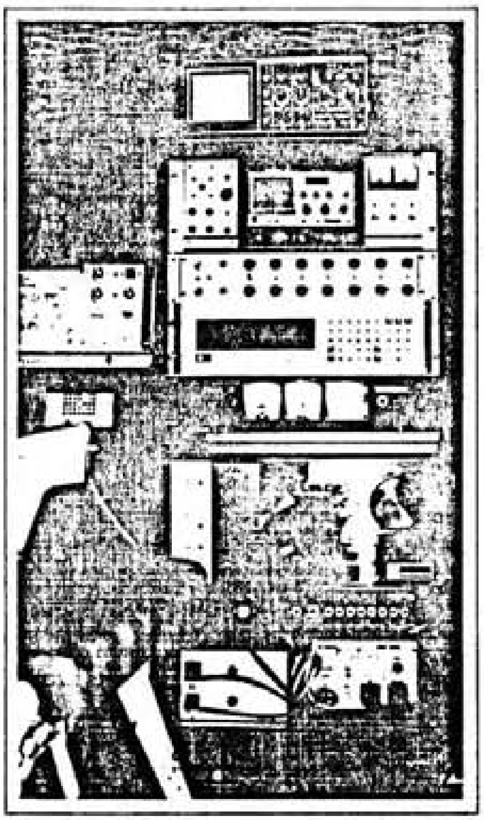
SONOTEK DATA SYSTEM



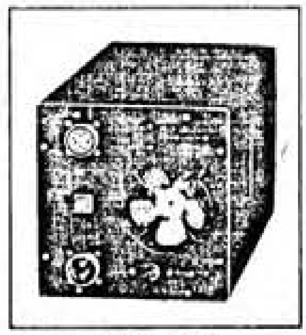
9 TRACK TAPE RECORDER



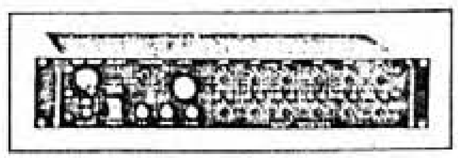
RADAR ALTIMETER



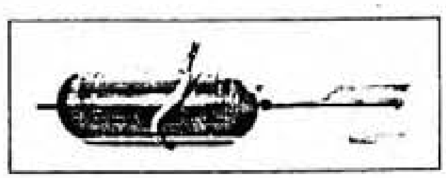
INPUT® EQUIPMENT INSTALLATION



TRANSMITTER



MK VI INPUT® RECEIVER



TOWED "BIRD" ASSEMBLY

QUESTOR/BARRINGER MARK VI "INPUT"® SYSTEM EQUIPMENT

APPENDIX B

The Survey Helicopter

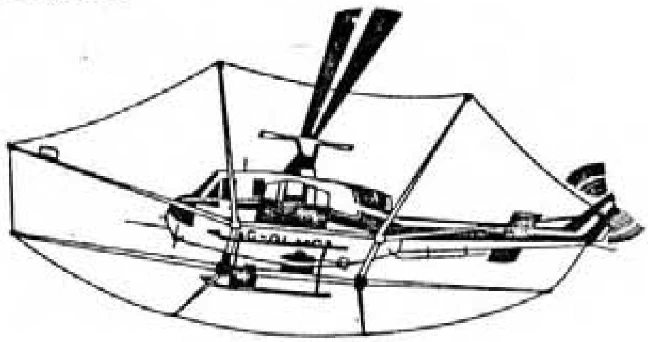


Figure B1

Manufacturer	Bell Helicopter Company
Type	205A-1
Canadian Registration	C-GLMC - present installation
Date of INPUT Installation	May 1982

Modifications:

1) Cradle and wing booms for transmitter coil mounting
2) Camera and altimeter mounting
3) Modified gasoline driven generator system

Any BELL 205-212 airframe can support the QUESTOR Helicopter INPUT system. The 205 is powered by one low maintenance turbine engine. The configuration of the helicopter provides for easy installation of equipment, which can be dissasembled and crated to the survey base. Reassembly takes less than two days. These factors have proven the helicopter to be a reliable and efficient geophysical survey system in areas not suitable for fixed-wing operation.

APPENDIX C

INPUT System Characteristics

a) Geometry

The INPUT system, a time domain airborne electromagnetic system, has the transmitter loop located around the helicopter airframe while the receiver, referred to as the 'bird', typically is towed 19 metres behind and 74 metres below the helicopter at a survey airspeed of 40 knots. The actual spatial position of the bird is dependent on the airspeed of the survey helicopter, as can be seen in Figure C1.

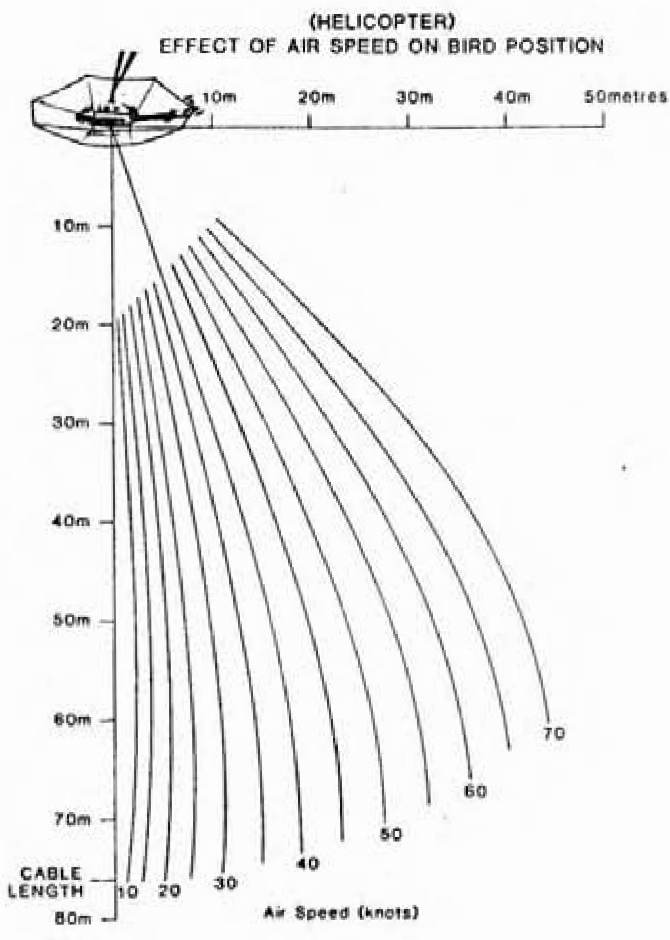


Figure C1

b) The Lag Factor

The bird's spatial position along with the time constant of the system introduces a lag factor (Figure C2) or shift of the response past the actual conductor axis in the direction of the flight line. This is due to fiducial markers being generated and imprinted on the film in real time and then merged with E.M. data which has been delayed due to the two aforementioned parameters. This lag factor necessitates that the receiver response be normalized back to the helicopter's position for the map compilation process. The lag factor can be calculated by considering it in terms of time, plus the elapsed distance of the proposed shift and is given by:us the elapsed distance of the proposed shift and is given by:

$$\text{Lag (seconds)} = \text{time constant} + \frac{\text{bird lag (metres)}}{\text{ground speed (metres/sec)}}$$

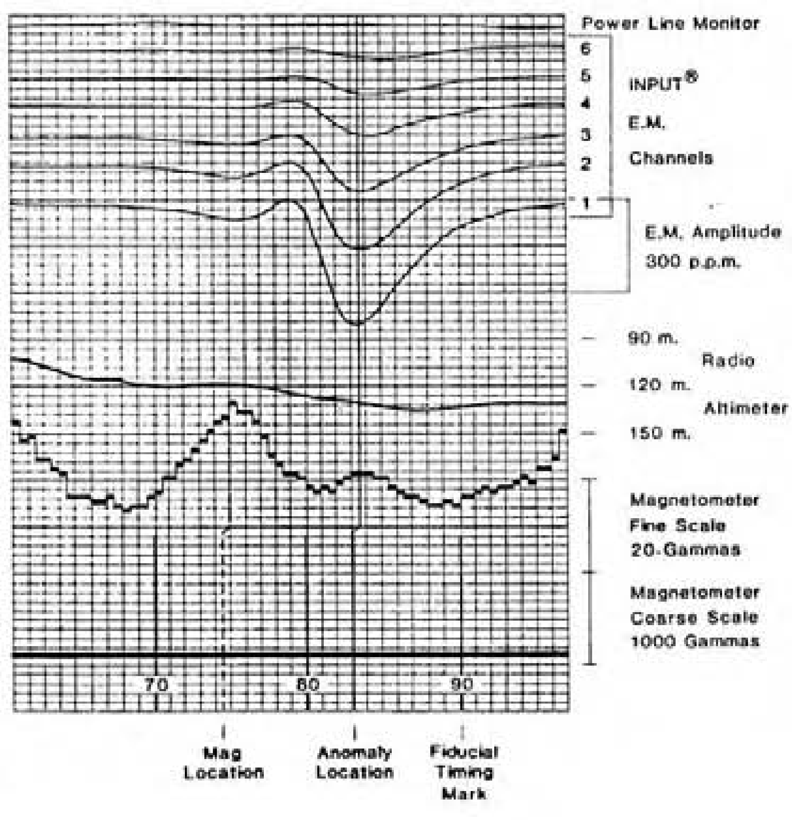


Figure C2

The time constant introduces a 1.3 second lag while, at an aircraft velocity of 40 kt., the 'bird' lag is 1 second. The total lag factor which is to be applied to the INPUT E.M. data at 40 kts. is 2.3 seconds. It must be noted that these two parameters vary within a small range dependent on the helicopter velocity, though they are applied as constants for consistency. As such, the removal of this lag factor will not necessarily position the anomalies in a straight line over the real conductor axis. The offset of a conductor response peak is a function of the system and conductor geometry as well as conductivity.

The magnetic data has a 1.0 second lag factor introduced relative to the real time fiducial positions. This factor is software controlled with the magnetic value recorded relative to the leading edge (left end) of each step 'bar', for both the fine and coarse scales. For example, a magnetic value positioned at fiducial 10.00 on the records would be shifted to fiducial 9.95 along the flight path.

A lag factor of 2 seconds (0.1 fiducial) is introduced to correct 50-60 Hz monitor for the effects of bird position and signal processing. In cases where a 50-60 Hz signal is induced in along formational conductor, a 50-60 Hz secondary electromagnetic transient may be detected as much as 5 km. from the direct source over the conductive horizon.

The altimeter data has no lag introduced as it is recorded in real time relative to the fiducial markings.

c) Calibration

The major advance made during the transition from the INPUT MK V to the INPUT MK VI has been the ability to calibrate the equipment accurately and consistently. Field tests at established test sites are carried out on an average of once every 6 months to check the consistency of the INPUT installations available from QUESTOR.

To calibrate the equipment for a survey operation the following tests are used:

1) "ZERO" the digital and record background E.M. levels;
2) magnetometer scale calibrations;
3) altimeter calibration;
4) calibration of INPUT receiver gain;
5) aircraft compensation;
6) record background E.M. levels at 600 m.;
7) survey flight;
8) record background E.M. levels at 600 m.
9) record full scale INPUT receiver gain;
10) record compensation drift;
11) terminate or repeat from step 4.

This sequence of tests may be repeated in midflight given that the duration of the flight is sufficiently long. Typically, this process is conducted every 2 hours of actual flying time and at the termination of every flight.

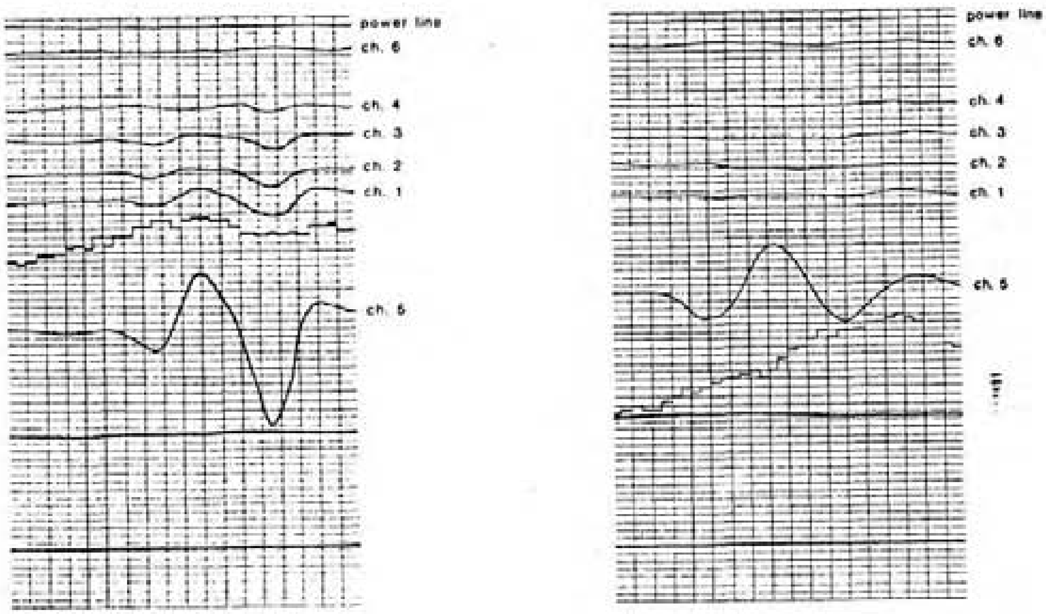
The background levels are recorded and then used to determine the drift that may occur in the E.M. channels during the progression of a survey flight. If drift has occurred, the

E.M. channels are brought back to a levelled position by use of the linear interpolation technique during the data processing.

The primary electromagnetic field generated by the INPUT system induces eddy currents in the frame of the helicopter. This spurious secondary field is a significant source of noise which needs to be taken account of before every survey flight is initiated.

Compensation is the technique by which the effects of this spurious secondary field are eliminated. A reference signal, which is equal in amplitude and waveform but opposite in polarity, is obtained from the primary field voltage in the receiver coil and applied to each channel of the receiver. The compensation signal is not a constant value due to coupling differences induced by 'bird' motion relative to the aircraft. The signal applied is proportional to the inverse cube of the distance between the 'bird' and aircraft. Figure C3 displays the effect of compensation.

Typically, channel 5 is selected for compensation because it is not affected by geological noise due to its sampling location in the transient and then coupling changes are induced by precipitating 'bird' motion. Phase considerations of channel 5, relative to the remaining channels, dictates whether sufficient compensation has been applied. If the remaining channels are in-phase to channel 5 during this procedure, an over-compensated situation is indicated, whereas, out-of-phase would be indicative of an under-compensation case. Normally this adjustment is carried out at an altitude of 600 metres in order to eliminate the influence of external geological and cultural conductors.



Uncompensated Compensated

Figure C3

The magnetometer, altimeter and INPUT receiver gain are also calibrated at the initiation of every survey flight. With the magnetometer, there are two scales, a coarse and a fine scale. The fine scale indicates a 10 gamma change for a 1 cm. change in amplitude (Figure C2). The coarse scale moves 2 mm. (or 1 division) for a 100 gamma change with full scale,2 cm., indicating a 1000 gamma shift.

The altimeter (Figure C4), is calibrated to indicate 400 feet altitude at the seventh major division (7 cm.), read from the bottom of the analog record. This is the nominal flying height of INPUT surveys, wherever relief and aircraft performance are not limiting factors. The eighth major division correlates with 300 feet while the sixth corresponds with 500 feet in altitude.

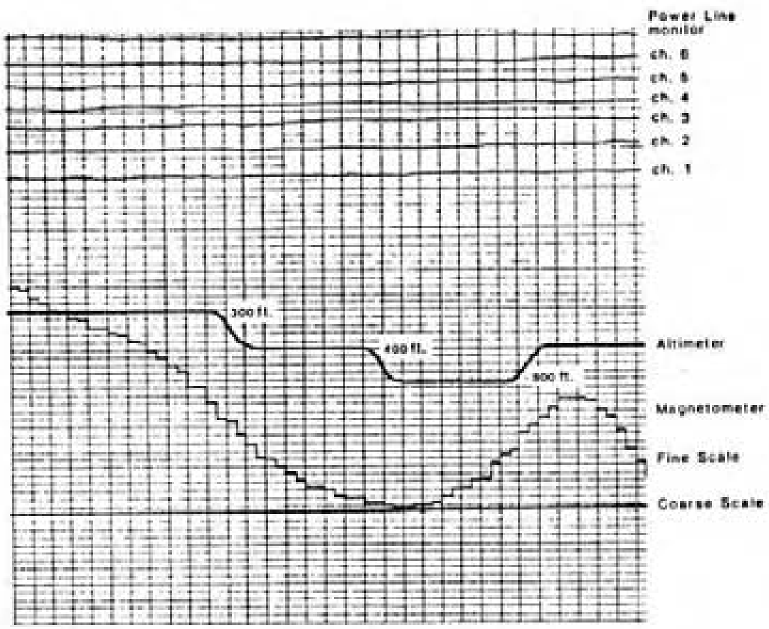


Figure C4

The INPUT receiver gain is expressed in parts per million of the primary field amplitude at the receiver coil. At the 'bird', the primary field strength is 8.5 and 5.8 volts peak-to-peak, for the vertical and horizontal axis coils respectively or 4.2 and 2.9 volts peak amplituded. The calibration signal introduced at the input stage of the receiver is 4.0 mV. Expressed in parts- per-million, this induces a change of:

$$\frac{4 \times 10\text{-}3 \times 10^6}{4.2} = 950 \text{ ppm}$$

These calibration signals (Figure C5) cause an 8 cm. deflection of all 6 traces which translates to a sensitivity of 120 ppm/cm. for the vertical axis receiver coil system.

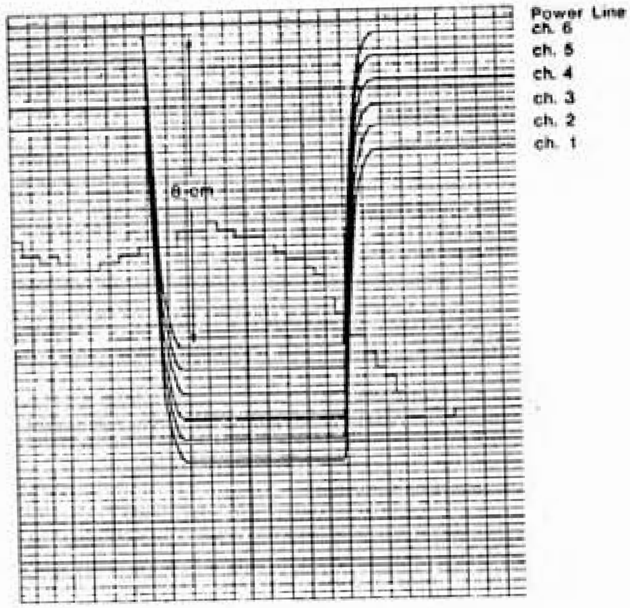


Figure C5

With the chart speed increased from the normal 0.25 cm. to 2.5 cm. per second, the time constant of the system (Figure C6), can be obtained by analysis of the exponential rise of the calibration signal for all 6 traces. The time constant, is defined as the time for the calibrated voltage to build up or decay to 63.2% of its final of initial value. A longer time constant reduces background noise but also has the effect of reducing the amplitude of the signal, especially for near surface responses.

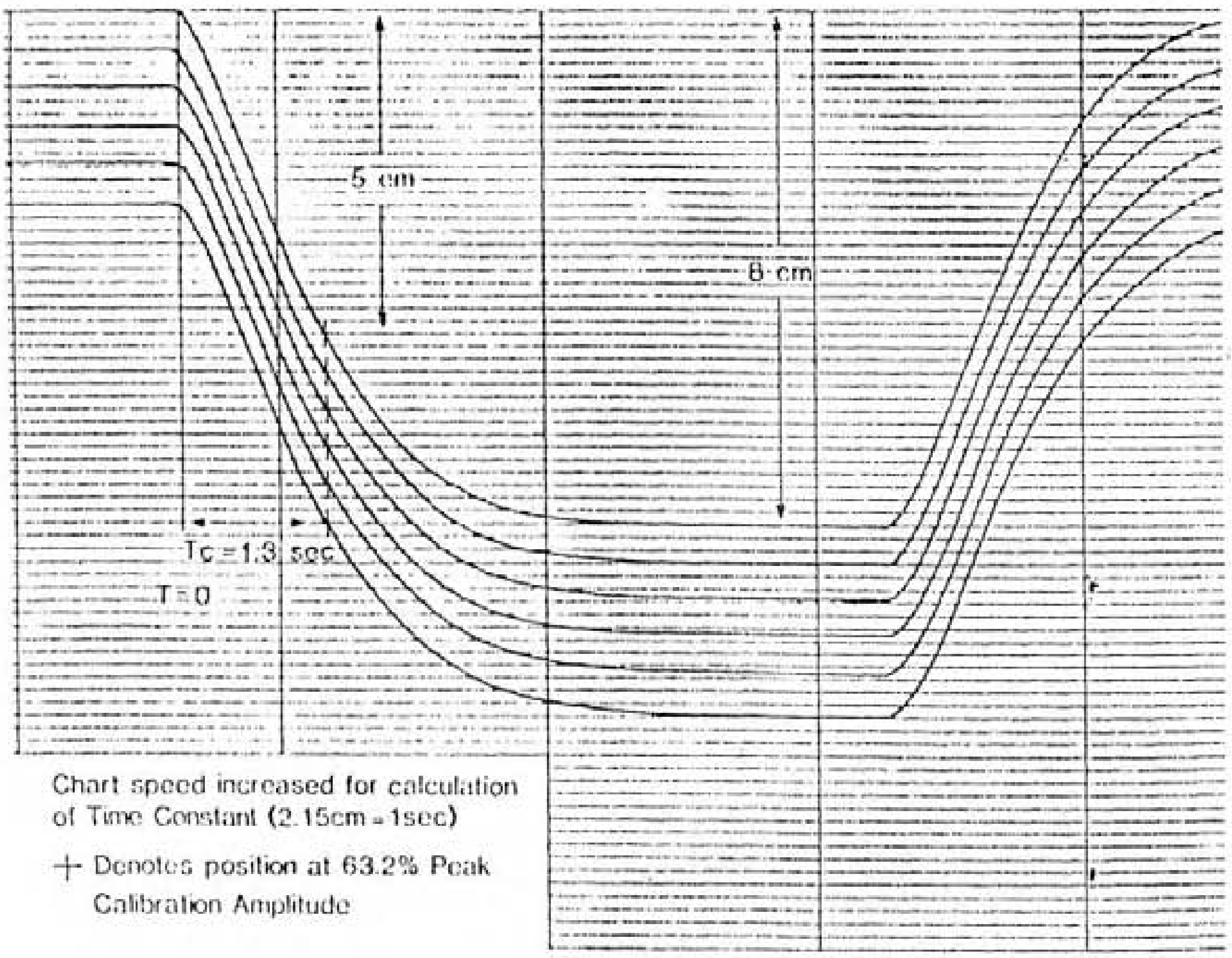


Figure C6 .

This trade-off indicates the importance of selecting an optimum value for the time constant. Experience and years of testing have indicated that a time constant of 1.3 second does not impede interpretation of bedrock source conductors.

d) Depth Penetration Capabilities

There are many factors which effect the depth of penetration. These factors consist of:

1) altitude of the helicopter above the ground;
2) conductivity contrast between conductor and host rock;
3) size and attitude of conductor;
4) type and conductivity of overburden present.

Of these factors, only the first parameter can be controlled. Typically, a survey altitude of 120 metres (400 feet) or less above the terrain is maintained. At this height, the helicopter INPUT MARK VI system has responded to conductors located at a depth of 200 metres (650 feet) below the surface.

APPENDIX D

INPUT Data Processing

The QUESTOR designed and implemented computer software routines for automatic interactive compilation and presentation, may be applied to all QUESTOR INPUT Systems. The software is compatible with the fixed-wing MARK VI INPUT, and the helicopter MARK VI INPUT. The procedures are all common, however, separate subroutines are accessed which contain the unique parameters to each system. Although many of the routines are standard data manipulations such as error detection, editing and levelling, several innovative routines are also optionally available for the reduction of INPUT data. The flow chart on the following page (Figure D1) illustrates some of the possibilities. Software and procedures are constantly under review to take advantage of new developments and to solve interpretational problems.

a) INPUT Data Entry and Verification

During the data entry stage, the digital data range is compared to the analog records and film. The raw data may be viewed on a high-resolution video graphics screen at any desirable scale. This technique is especially helpful in the identification of background level drift and instrument problems.

b) Levelling Electromagnetic Data

Instrument drift, recognized by viewing compressed data from several hours of survey flying, is corrected by an interactive levelling program. Although only two or three calibration sequences are normally recorded, the QUESTOR technique permits the use of multiple non-anomalous background recordings to divide a possible problematic situation into segments. All 6 INPUT channels are levelled simultaneously, yet independently. The sensitivity of the levelling process is normally better than 10 ppm on data with a peak-to-peak noise level of 30 ppm.

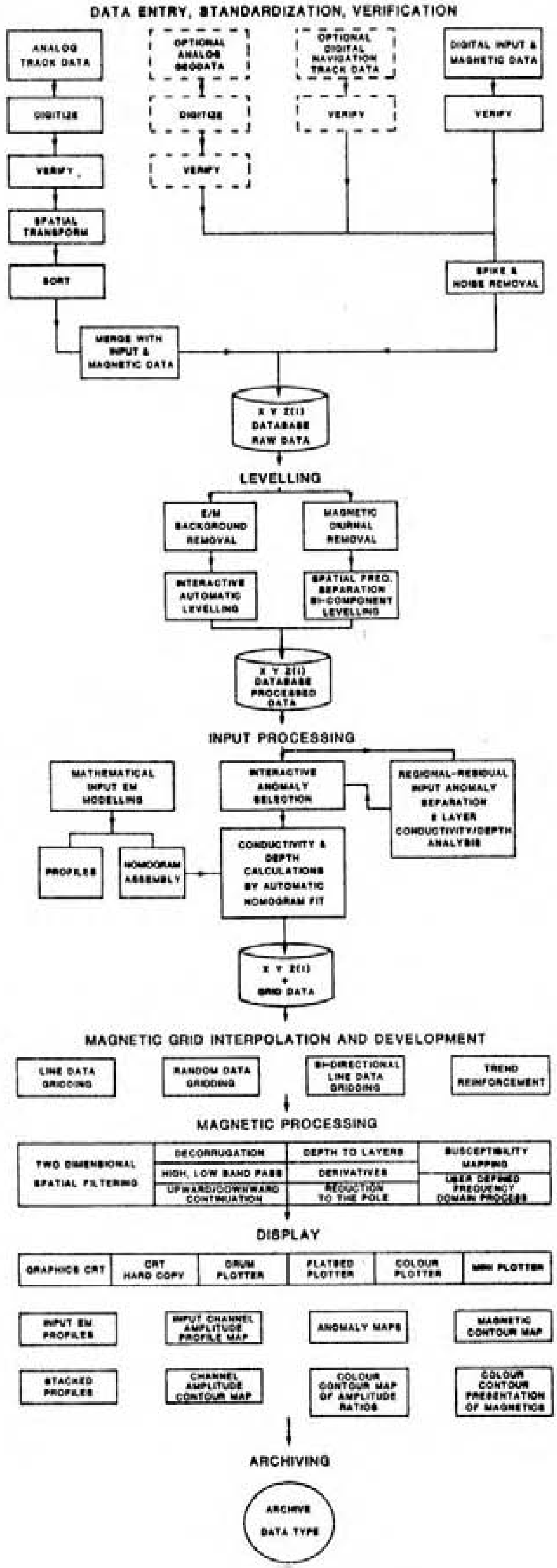
c) Data Enhancement

Normal INPUT processing does not include the filtering of electromagnetic data. The residual high frequency variations often apparent on analog INPUT data, is due almost wholly to "spherics", atmospheric static discharges. In conductive environments, spherics are apparently grounded and effectively filtered. In resistive environments, frequency spectrum analysis and subsequent FFT (Fast Fourier Transform) filters have been applied to data to reduce the noise envelope.

d) Selection of EM Anomalies

The levelled data may be viewed sequentially on a graphics screen for the selection of INPUT anomalies. Anomalies are selected by aligning a cursor to the position of the peaks. Some of the parameters of the response are manually entered during the picking of the response. These include the number of channels above background levels and the type of anomaly, e.g. cultural, bedrock, surficial, up-dip, etc.

INPUT DATA PROCESSING



APPENDIX E

INPUT INTERPRETATION PROCEDURES

The INPUT system is dependent upon a definite resistivity contrast and is most suitable for highly conductive massive sulphides. Differentiation is possible between flat-lying surficial conductors and bedrock conductors.

The selection of anomalies is based on their characteristics and interpretation is sometimes enhanced by analyzing the magnetics. Spherics, due to atmospheric static discharges and lightning storms, are distinguishable from conductive anomalies. In the analysis of each conductor anomaly, the following parameters may be considered: anomaly shape with the conductor pattern, topography, corresponding magnetic features, anomaly decay rate, the number of channels affected, geological environment and strike direction and the interpreted dip relative to structural features.

For each anomaly selected, the following are recorded: location by fiducial, channel amplitudes in parts per million, number of channels, conductivity-thickness in siemens, corresponding magnetic association in gammas, magnetic fiducial location altitude of aircraft above ground in metres and also, the origin of the response (ie. surficial, bedrock, cultural).

Conductive responses are categorized into three main groups. These are bedrock, surficial and cultural.

Bedrock conductors can be sorted into conductive sources which are commonly encountered on INPUT surveys: massive sulphides, graphites, serpentinized peridotites and fault or shear zones. Magnetite and manganese concentrations may also yield INPUT responses in some circumstances. INPUT responses over alkalic intrusives and weathered basic volcanics have been well documented by Macnae (1979) and Palacky (1979).

Massive Sulphides

Massive sulphides occur as both syngenetic and stratified deposits and as vein infilling deposits. Nickel deposits often occur as magmatic injections of massive sulphides. Kuroko-type syngenetic copper-zinc massive sulphides usually occur at an interface of felsic intermediate rocks. In this environment, there are seldom any significant formations of carbonaceous sediments on the same horizon. Often, these deposits are overlain by a silicious zone which may contain stingers of continuous sulphides, which change to disseminated sulphides away from the main deposit. These often give a deposit the appearance of a long strike-length zone which may not fit the explorationist's target model. A careful analysis of conductivities and apparent widths (half-peak-width), will often reveal the geometry and source. Syngenetic deposits of base metal sulphides of up to 2 km strike length are not unknown, although most sizeable deposits have strike lengths between 500 and 1000 m.

The conductivity of most massive sulphide deposits may be attributed to the pyrrhotite and chalcopyrite content, as both minerals form elongated interconnected masses which are most amenable to the induction of electromagnetic secondary fields. Pyrite normally forms cubic crystals which must be interconnected electrically in order to produce a response. Massive pyrite often produces only a moderate response which may be difficult to distinguish from graphite. The in-situ conductivity of massive sulphides, although very high for individual crystals, often falls in the range of 5 to 20 S/m.

Sulphide conductive zones are rare in nature; economic sulphides are even more scarce. Long formational sulphide zones are known, but are not common. More often, sulphide concentrations may occur within formational graphitic zones.

The geometry of many syngenetic and injected sulphide deposits may fall within broad classifications of size, conductivity and magnetization but most of these bodies are anomalous within their local geological environment. There are often changes in dip, conductivity, thickness and magnetization with respect to the regional environment. There are no rules which apply universally to massive sulphide deposits. One observation which has consistently applied to sulphide deposits is that INPUT responses (amplitude and conductivity) are roughly proportional to mineral content.

The INPUT system is capable of detecting disseminated sulphides within zones of resistivity changes. These may have low conductivities and responses will normally be restricted to channels 1 through 4. The response amplitudes will vary with the horizontal and vertical extent of the zone. Gold deposits often fall within this response classification.

The magnetic response of a sulphide deposit is the most deceiving information available to the explorationist. Although many large economic deposits have a strong direct magnetic association, some of the largest base metal deposits have no magnetic association. An isolated magnetic anomaly caused by oxidation conditions at a volcanic vent flanking a conductor, may have more significance than a body which has a uniform magnetic anomaly along its strike length. Differing geochemical environments often results in the zoning of minerals so that non-homogeneous conductivities and magnetic responses may be favourable parameters.

Graphitic Carbonaceous Conductors

Carbonaceous sediments are usually found within the sedimentary facies of Precambrian and Proterozoic greenstone belts. These represent a low energy, sedimentary environment with good bedding planes and little or no structural deformation. Graphites are often located in basins of the sub-aqueous environment, producing the same body shape as sulphide concentrations. Most often however, they form long, homogeneous planar sequences. These may have thicknesses from a metre to hundreds of metres. The recognition of graphites in this setting is normally straightforward.

Conductivities and apparent widths may be very consistent along strike. Strike lengths of tens of kilometres are common for individual horizons.

The conductivity of a graphite unit is a function ot two variables:

a) the quality and quantity of the graphite and

b) the presence of pyrrhotite as an accessory conductive mineral

Pyrite is the most common sulphide mineral which occurs within carbonaceous beds. It does not contribute significantly to the overall conductivity as it will normally be found as disseminated crystals. Greenschist facies metamorphosis will often be sufficient to convert carbonaceous sediments to graphitic beds. Likewise, pyrite will often be transformed to pyrrhotite.

Without pyrrhotite, most graphitic conductors have less than 20 S conductivity-thickness value as detected by the INPUT system or 1 to 10 S/m conductivity from ground geophysical measurements. With pyrrhotite content, there may be little difference from sulphide conductors.

It is not unusual to find local concentrations of sulphides within graphitic sediments. These may be recognized by local increases in apparent width, conductivity or as a conductor offset from the main linear trends.

Graphite has also been noted in fault and shear zones which may cross geological formations at oblique angles.

Serpentinized Peridotites

Serpentinized peridotites are very distinguishable from other anomalies. Their conductivity is low and is caused partially by magnetite. They have a fast decay rates, large amplitudes and strong magnetic correlation.

Magnetite

INPUT anomalies over massive magnetites correlate to the total Fe content. Below 25-30% Fe, little or no response is obtained. However, as the Fe percentage increses, strong anomalies result with a distinguished rate of decay that usually is more pronounced than those for massive sulphides.

Contact zones are often predicted when anomaly trends coincide with lines of maximum gradient along a flanking magnetic anomaly.

Surficial Conductors

Surficial conductors are characterized by fast decay rates and usually have a conductivity-thickness of 1-5 siemens. These values will be much higher in saline conditions. Overburden responses are broad, more so than bedrock conductors. Anomalies due to surficial conductivity are not dependent on flight direction. In profile form, surficial responses are symmetrical from line-to-line with the Helicopter INPUT system, and are characterized by a single response rather than a double peak for dipping and vertical conductors. Conductive deposits such as clay beds, may lie in valleys which can be checked on the altimeter trace and with the base maps topography.

Cultural Conductors

Cultural conductors are identifiable by examining the power line monitor and the film to locate railway tracks, power lines, buidings, fences or pipe lines. Power lines produce INPUT anomalies of high conductivity that are similar to bedrock responses. The strength of cultural anomalies is dependent on the grounding of the source. INPUT anomalies usually lag the power line monitor by 1 second, which should be consistent from line-to-line. If this distance between the INPUT response and the power line monitor differs between lines, then there is the possibility of an additional conductor present. The amplitude and conductivity-thickness of anomalies should be relatively consistent from line-to-line.