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INTERPRETATION REPORT

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AIRBORNE ELECTROMAGNETIC SURVEY
BARRINGER 'INPUT' SYSTEM

OF THE

RIANA, HIGHCLERE AND LOONGANA AREAS
8/77 4/77 36/79
TASMANIA

FOR

THE SHELL COMPANY OF AUSTRALIA LIMITED

BY

GEOTERREX PTY. LIMITED

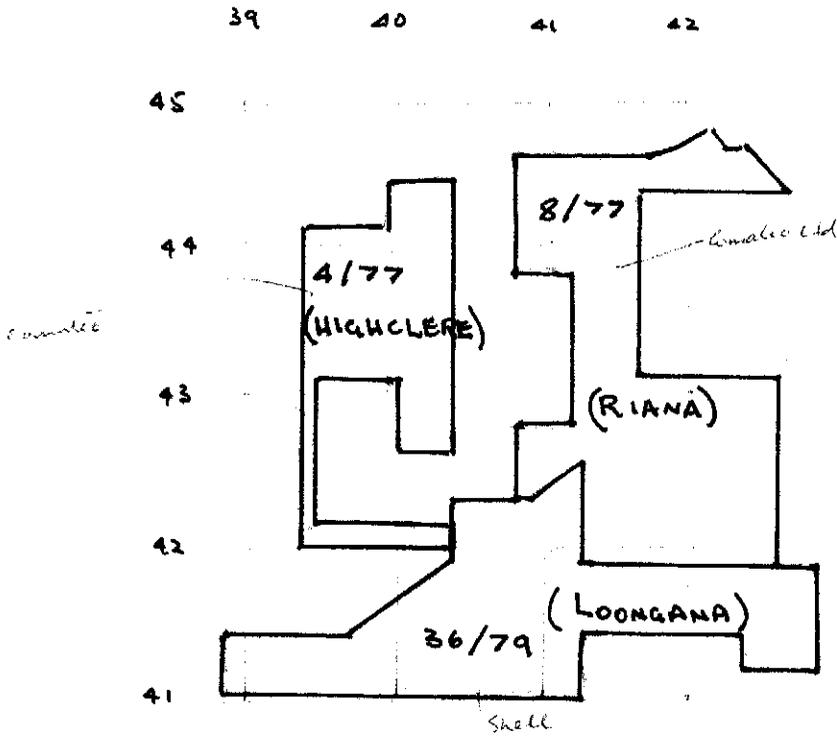
(83-548)

Sydney, Australia

April, 1982

M. Schneider

Geophysicist



INDEX OF EM ANOMALY
MAP TRANSPARENCIES

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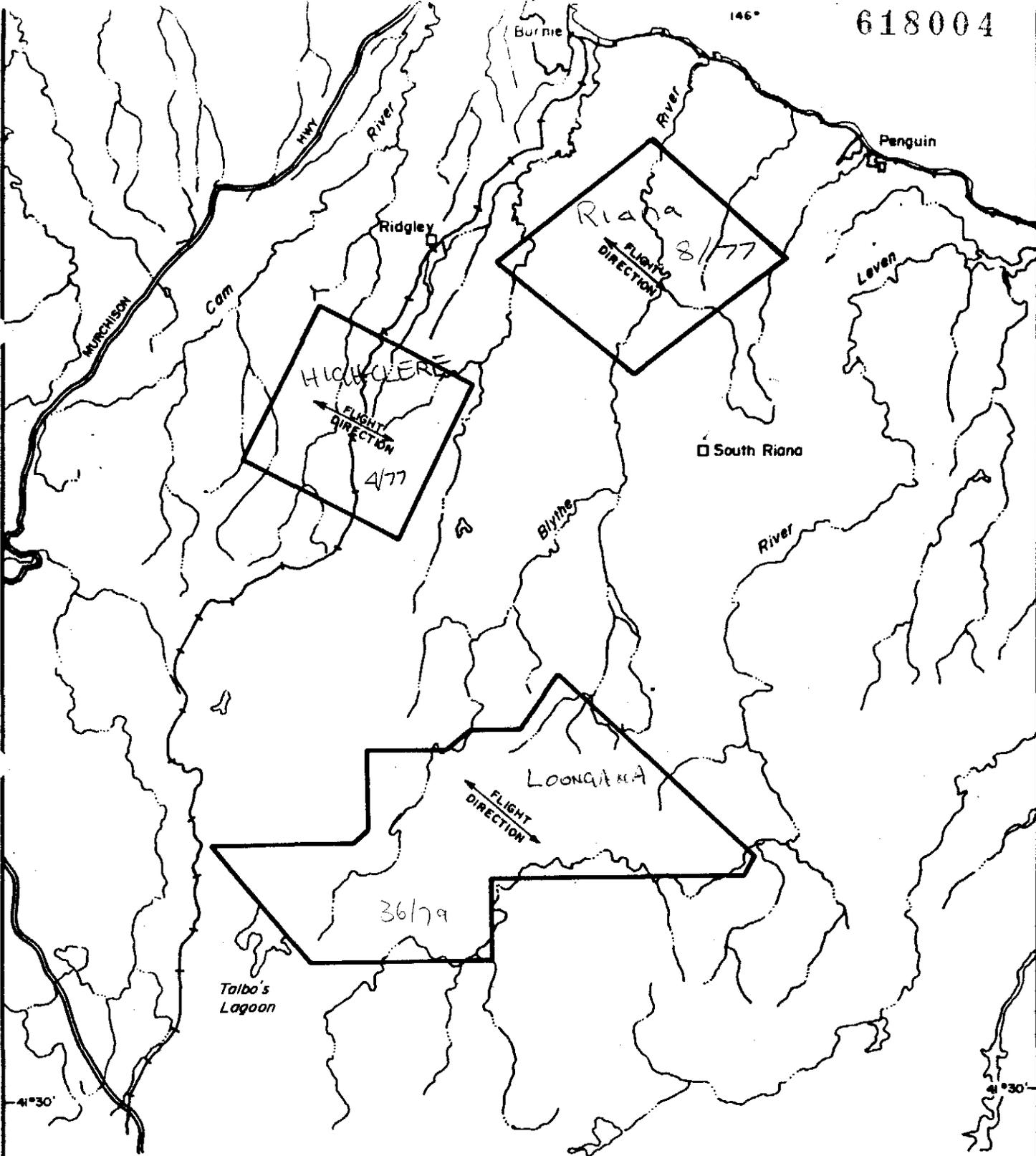
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TRANSPARENCIES IN VERTIPLAN - All report No 83-1929

E.M. ANOMALY MAPS - RIANA	<u>E.L.</u> 8/77	REPORT NO. 82-1784
	HIGHCLERE 4/77	
	LOONGANA 36/79	

See
map
fol



5 cm

SURVEY AREA LOCATION MAP

SCALE 1:250 000



1. INTRODUCTION

During the period January 7th to January 11th, 1982, Geoterrex Pty. Limited flew a combined electromagnetic and magnetic survey over the Riana, Highclere and Loongana areas of Tasmania on behalf of the Shell Company of Australia Limited. The base for the duration of the survey was Burnie.

A total of 248.0 kilometres was flown at a flight line spacing of 300 metres in a north west direction in the Riana area, 216.0 kilometres were flown at a flight line spacing of 300 metres in a north west direction in the Highclere area, 996.1 kilometres were flown at a flight line spacing of 300 metres in a north west direction in the Loongana area.

The project was conducted with the Super Canso PBY-5A under registration VH-EXG, which is operated by H.C. Sleigh Aviation for Geoterrex Pty. Limited and was equipped with :-

- a Barringer Mark V Input EM System
- a Geometrics G803 nuclear precession magnetometer
- a Geoterrex 'Madacs' digital acquisition system
- a Sperry RT220 radar altimeter
- a 50 Hz monitor
- a Geocam 705 35mm continuous strip tracking camera
- a Honeywell 1912 visicorder

Navigation was by visual means from black and white government photography enlarged to a scale of 1:20,000. The aircraft was operated at a mean terrain clearance of 120 metres.

II. PERSONNEL

The following Geoterrex personnel participated on the field phase of the survey

J. Edwards	Pilot
D. Bowen	Co-Pilot
W. Mitchell	Aircraft Mechanic
L. Williams	Senior Electronics Technician
S. Kiss	Electronics Technician
M. Curtis	Data compiler
G. Butt	Senior Geophysicist ?
M. Schneider	Geophysicist ?

{ what is geophysics? }

The entire project was planned and supervised by G. Butt of Geoterrex Pty. Limited in conjunction with N. Hungerford representing the Shell Company of Australia Limited.

Digital data processing was carried out at Engineering Computer Services Pty. Limited of Bowral, New South Wales.

Drafting was by Geodrafting Pty. Limited of Sydney.

III. DATA PRESENTATION.

The geophysical data is presented in the following form and all maps are at a scale of 1:20,000.

- EM Anomaly Map (overlay to topographic sheet)
- Original Input analogues
- Flight path plotted on Tasmanian 1:20,000 cadastral sheets.

EM ANOMALY MAP

The EM Anomaly Maps which overlay each 1:20,000 cadastral sheet show the INPUT anomalies from the high resolution channels.

The anomalies are plotted in their correct lateral positions (i.e. the 2.0 second lag between the six HRC INPUT* responses and the true ground position has been accounted for) on the flight lines and grouped according to similarity of amplitude and shape from line to line. The boundaries of these anomalous zones are determined from the half peak amplitude width on Channel 3. A diamond symbol indicates the anomaly peak and hence whether the anomaly is symmetrical or not. The number at the upper left of the diamond is the ratio of Channel 2 to Channel 5 in 10ths of inches chart deflection. The number at the upper right is the aircraft altitude in metres. Any significant association between an INPUT and magnetic anomaly is indicated by plotting the amplitude of the magnetic response beneath the diamond. If there is any offset between these peak responses an arrow indicating the direction of offset is drawn beneath the amplitude of the magnetic response.

During the course of data evaluation, groups of anomalies are outlined to show our interpretation of the extent of the geologically conductive zones. If any doubt exists, the outlines are dashed. Conductors of

interest are numbered to facilitate reference to the report.

* For the Highclere area only the slow time constant channels were used for picking and plotting anomalies due to the undue amount of 50Hz and cultural interference on the HRC responses. The lag used to plot these anomalies was 40 seconds. Otherwise the procedure was the same as outlined above.

THE RECOVERED FLIGHT PATH is presented on both the recovery photo-mosaic and the 1:20,000 cadastral sheets for each area. The flight path on the cadastral sheets was used as the base for all processing on EM anomaly maps.

The original visicorder records of the raw INPUT, altitude and magnetic data are presented bound in line number order. All calibration data is included and a copy of the analogue format is shown in Figure 3 of Appendix A.

The 4 rolls of negative 35mm continuous strip tracking film are delivered and labelled according to their flight number.

The aerial photography, bearing all the points, along with the tracking film is provided for accurate location of any followup investigation.

The flight logs which contain all relevant information regarding the collection of geophysical data are presented bound in flight order.

The data was processed at Engineering Computer Services Pty. Limited

in Bowral, New South Wales. Compilation and interpretation of the data was performed in Sydney.

The survey was conducted in consultation with N. Hungerford, representing the Shell Company of Australia Limited.

IV. INTERPRETATION - General

Commonly used interpretation techniques rely mainly on qualitative review of data and refer to anomaly shape, symmetry, strike extent and variability within conductive zones. The apparent conductivity, as determined by the amplitude and rate of decay of the INPUT response, is an important criterion in our analysis of conductors.

Other important factors taken into account include:-

- the shape and size of the INPUT anomalies,
- the strike length and degree of isolation of the conductor,
- the form of conductors particularly with respect to direction and dip of geological and cultural structures,
- the associated geophysical parameters such as aeromagnetics,
- variation of response characteristics within a given conductor,
- the geological environment and the response of the system to known mineralization.

Conductors delineated by an EM survey can be separated into categories based on their probable origins, namely bedrock, surficial and cultural.

The term cultural is used for those conductors thought to be due to any man-made construction. These are responses due to fences, telephone and powerlines etc.

Surficial conductors refer to sources in the overburden, in the weathered portion of the bedrock or in those formations not usually considered as host material for sulphide orebodies. In the context of this report the word surficial should not be used in the geological sense but rather as a geophysical term.

fails if there is little or no difference between overburden and target body. This method (Verma 1975*) is useful in areas of extensive high conductivity.

- b) Curve matching to theoretical homogeneous half-space response (HHS) curves. Sets of HHS response curves of various transmitter-conductor altitudes are stored in computers for matching the field data. A degree of fit measurement is made. Apparent resistivity and apparent depth are calculated. The mechanism of parameter calculation and plotting are described in the appendix concerning quantitative interpretation of the data.
- c) Consideration of average response amplitude, as defined by Dyck et al, 1974**, and decay time constant can yield a broad definition of the two-layer case solution. It is possible to distinguish between thin and thick layer cases in certain controlled environments.

INPUT CLASSIFICATION

All conductors of interest are classified according to the following priority system:-

Priority 1 zones satisfy most of the criteria associated with a bedrock source which could be due to massive sulphides. They contain responses indicating a highly conductive source, and may be isolated or extensive, bearing in mind the expected size of sulphide deposits in this region.

* Verma. S.K. 1975.
Resolution of responses due to conductive overburden and orebody, through time-domain EM measurements; a field example; G.P. 23 No. 2: 292-299.

** Dyck. A.V., Becker. A., Collett. L.S. : 1974.
Surficial conductivity mapping with the airborne INPUT system. CIM Bulletin, page 104-109, April, 1974.

Priority 2 zones also satisfy most of the criteria associated with bedrock structures but anomalies display characteristics such as faster rate of decay or broader width which preclude them being listed as Priority 1.

Zones which are rated as Priority 3 targets are almost certainly of surficial origin, but a small degree of uncertainty is present.

Priorities assigned to zones are made primarily on the merits of the INPUT responses, with some influence from the magnetic data. Geological information must be further analysed to determine the ultimate priority for followup.

The priority rating system refers to the probability that the conductive source of given zones is related to massive sulphide mineralization.

V. INTERPRETATION OF HIGHCLERE SURVEY DATA

a) General

Inspection of the geological and geophysical maps from the region shows that the majority of the survey area is covered by Tertiary Basalts. The previously flown aeromagnetic survey indicates that the basalt has the form of a large tabular structure with many localized inhomogeneities due to thickening and changing rock chemistry (magnetic susceptibility). To a large extent, the airborne electromagnetic (INPUT) data reflects this distribution in terms of a general background of conductivity with localized increases (or concentrations) in conductivity corresponding to either changes in the character of the basalt (i.e. associated clay horizons) or possible massive sulphide occurrences. Whilst the total conductivity distribution has been presented in map form (EM Anomaly Map) only the localized conductivity "concentrations" are zoned, numbered and described in detail in this section.

The most readily identifiable responses in the area are due to flat lying near surface bodies commonly labelled as "surficial responses". The heavily barred section in the central south (Line 2011 - 2101) exhibits a dual peaked response which compares almost identically to the numerically modelled responses of a flat lying plate of finite X and Z

dimensions. The very noticeable flight direction dependent offsets in the boundary position of each conductor is further evidence of tabular geometry (see Appendix 3 Figure 1).

Since it is unlikely that the basalt itself gives rise to the INPUT response we must look to an associated geological feature that may explain why this part of the "basalt cover" should stand out against the general background of conductivity. If the response is due to conductive clay horizons within the basalt (presumably the clay layers would represent the weathered surface of one particular flow which makes up the basalt sequence) it is difficult to imagine what ancient topographic control or variation of basalt chemistry would produce such an enhancement. Perhaps a more reasonable explanation would be that the EM response emanates from a conductive weathered layer at the basal contact of the basalt flow. In such a case, a different lithology below the basalt contact may selectively weather to form a more conductive horizon than the surrounds. The existence of this selective weathering, and hence the determination of different lithologies beneath the basalt cover may be important in the search for sulphide systems at some depth. Since it appears that we are dealing with horizontally layered situations, a combination of DC and EM sounding techniques may improve the understanding of what is causing the INPUT response and what significance (if any) this may have in the evaluation of data from this type of environment.

A cautionary note must be sounded concerning the reliability of some of the boundary positions of some of the "surficial" zones in the vicinity of the large powerline. In many cases the conductor outline is dashed because it is not possible to determine whether the channel responses decay to zero (or sometimes negative) due to powerline effects or real geological reasons. Further, the proximity of some zones (e.g. 20/3943/IH2) to this severe 50 Hertz interference detracts from their importance since it is known that high frequency noise on the High Resolution channels can be aliased by the slower time constant channels to produce "phantom anomalies" with many characteristics similar to conductive bedrock sources.

ZONE 20/3943/IH2PRIORITY 3

Line 2271 Fiducial 546040 Ratio 16.0 / 2.0
Line 2231 Fiducial^{to} 533112 Ratio 22.5 / 3.0

Anomalies: Shape : Symmetric and narrow.
 Amplitude : Moderate - large.
 Decay Rate : Moderate - slow.
 Cultural Signs : None obvious.
 Mag Association: Discrete offset association on Line 2251 only.

Conductor: Dimensions : 1.5 kilometres long, 500 metres wide.
 Strike : North-east.

Location:

Fields.

Remarks:

The validity of this zone is under question due to the interference effects of some ground based noise source on the high resolution channels. The slow time constant channels appear to have aliased this noise to produce anomalies which have many desirable characteristics.

This aliasing has most effect on the late channels where the signal to noise is poorest and hence any "phantom response" added to the generally quiet background activity will enhance the favourability of an otherwise ordinary response. (Observe how the channel 1 response on the HRC is responding to the geology compared to channel 6 which is grossly affected by the noise source). The isolated anomaly on Line 2204, Fid 527436 appears to have the same character as this zone. The noise source appears to be the very large power-line which runs through the whole area.

Recommendations:

Some comparison between the INPUT zone and known geology should be made in order to better determine the source of this response.

ZONE 20/3943/IH2APRIORITY 2

Line 2231

Fiducial 540400

Ratio 19.0 / 3.0

Anomalies: Shape : Inflective peak on the edge of a larger response.
 Amplitude : Moderate - small.
 Decay Rate : Slow.
 Cultural Signs : None.
 Mag Association: 60nT anomaly offset 60 metres (1 second) to the east.

Conductor: Dimensions : 300 metres wide.
 Strike : Nil

Location:

Field.

Remarks:

Although this anomaly is part of the questionable 20/3943/IH2 zone, the double peaking on this line (not evident on any of the other responses in zone IH2) may be indicative of another source apart from the noise. The magnetic association may be more fortunate than discrete but there are sufficient meritorous features of the airborne geophysical responses to isolate this zone.

Recommendations:

Ground followup is recommended to establish the source of the INFUT response.

ZONE 20/3943/IH5PRIORITY 2

Line 2211	Fiducial 529860	Ratio 15.0 / 2.0
	to	
Line 2191	Fiducial 419940	Ratio 10.0 / 1.0

Anomalies: Shape : Narrow and symmetric.
Amplitude : Small - moderate.
Decay Rate : Slow.
Cultural Signs : Near a large powerline.
Mag Association: None.

Conductor: Dimensions : 250 metres wide, 1.0 kilometres long.
Strike : North-east.

Location:

In the middle of a wooded section.

Remarks:

This zone occurs in an area where the powerline interference has completely obliterated the true character of the HR channels especially on the late channels. Again it is uncertain whether the slow time constant channels have aliased the noise to produce "phantom anomalies" or whether the anomalies exist as true ground responses.

Recommendations:

Supporting geological/geochemical evidence would be desirable to establish the true merits of this zone.

ZONE 20/4043/IH9Priority 3

Line	203.1	Fiducial	373604	Ratio	40.0/4.0
Line	204.1	Fiducial	376972	Ratio	22.0/3.5
Line	205.1	Fiducial	381660	Ratio	20.0/2.6
Line	206.1	Fiducial	383058	Ratio	27.0/2.6
Line	207.1	Fiducial	387468	Ratio	12.0/0.5
Line	208.1	Fiducial	388580	Ratio	10.0/0.6

Anomalies:

- Shape : Broad
- Amplitude : Large - moderate, decreases southward
- Decay Rate : Moderate - fast
- Cultural Signs : None
- Mag Association: Large dipolar response

Conductor:

- Dimensions : 400 to 800 metres wide, 1.5 kilometres long.
- Strike : Northeast

Location:

Not plotted on EM anomaly maps since it is outside the flight path recovery limits and could not be plotted accurately.

Remarks:

Response is generally broad and has only weak late channel persistence. On lines 204.1 and 205.1 the response is similar to that of the heavily barred zone in the central south of the survey area which closely resembles the then horizontal plate model studies from the University of Toronto. From line 206.1 to 208.1 the anomaly becomes single peaked and broader with amplitudes decreasing on all channels and no visible late channel response. Also, there is an increase in the extent and amplitude of background conductivity on these lines which results in the anomaly being less well defined.

Recommendations:

The source of this anomalous response may well be within or at the base of the basalt cover. The geometry of the source appears to be horizontal rather than vertical and its conductivity thickness decreases northward. The ultimate importance of the zone may be established by further knowledge of conductive sources within or at the base of the basalt cover by electrical lagging of boreholes in similar geological conditions in the area (if any exist) and then by ground geophysical followup with a deep penetration, discriminatory system.

VI. TABLE 1 - SUMMARY OF SELECTED CONDUCTORS - HIGHCLERE AREA

<u>Priority 1</u>	<u>Priority 2</u>	<u>Priority 3</u>
20/3943/IH4	20/3943/IH2A	20/3943/IH1
	20/3943/IH5	20/3943/IH2
	20/4043/IH7	20/4043/IH3
	20/3943/IH8	20/3943/IH6
		20/4043/IH9

VII. INTERPRETATION OF RIANA SURVEY DATA

The INPUT data from the Riana survey shows a mixture of responses, including extensive broad regions of high conductivity, large highly conductive bedrock features with identifiable structure, potential massive sulphide occurrences and many cultural responses.

As for the Highclere area, geology and aeromagnetic maps indicate that the majority of the area is covered by tertiary basalts. The INPUT data reflects this, as can be seen by the broad conductive areas which extend from the southern to the northern boundary. Within these areas, some of the strongest (and hence most conductive) 6 channel responses have been delineated and discussed (eg zone 20/4144/IR1). Again it must be stressed that no assumption regarding the possible association of sulphides with the most conductive response has been made (as can be seen from the priority usually given to these zones), but should further geological/geochemical evidence be acquired these zones may assume a greater importance.

Unfortunately, there are many cultural responses which interfere with the ground response to an extent where anomaly boundaries become uncertain (eg: 20/4044/IR3) and any source geometry information becomes disguised. Also there are responses which are characteristic of culture but occur just a little to far away from obvious culture on the tracking film to be dismissed outright (eg: 20/4043/IRS).

Zone 20/4044/IR2 is a very interesting area due to its high conductivity and structure inferred from the INPUT data. Whilst INPUT data is certainly not definitive about the absolute magnitude

of conductor dip, it is often possible to gain a firm impression of the dip direction. In the case of this zone it is certain that the conductor has some dip and the inferred directions suggest it may be part of a synformal structure. The major implication of this interpretation is to reduce the likelihood of massive sulphides being the source of the response and to suggest a very conductive unit being responsible such as carbonaceous material.

ZONE 20/4044/IR2Priority 2

Line 108.1	Fiducial 575928	Ratio 30.0/9.0
	Fiducial 575890 to	Ratio 29.0/8.0
Line 102.1	Fiducial 559800	Ratio 10.0/1.5

Anomalies: Shape : Dependent on flight direction
 Amplitude : Moderate
 Decay Rate : Slow
 Cultural Signs : None
 Mag Association : None

Conductor: Dimensions : 2.4 kilometres long, horseshoe
 shaped
 Strike : North East

Location: Cultivated Plateau

Remarks:

The shape and position of the INPUT anomalies indicates that the source of this zone has discernable structure, which has significant implications when considering the geological nature of the source. The dependence of the plotted peak position upon flight direction (a phenomena well displayed from lines 104 to 106) indicates that both limbs of the zone are dipping. The direction of dip may be found from the channel 1 to 6 peak effect on individual anomalies. The most westerly limb shows strong channel 1 to 6 peak offsets on lines 104.1NW, 106.1 NW and 108.1 NW which suggests that these lines were flown up dip. Lines 107.1SE, 106.2SE, 104.2SE and 103.1SE shows no such peak offsets, suggesting these lines were flown down dip. However, Line 105.1SE has peak offsets akin to an updip response and 105.2NW has no offsets as shown on the other downdip lines.

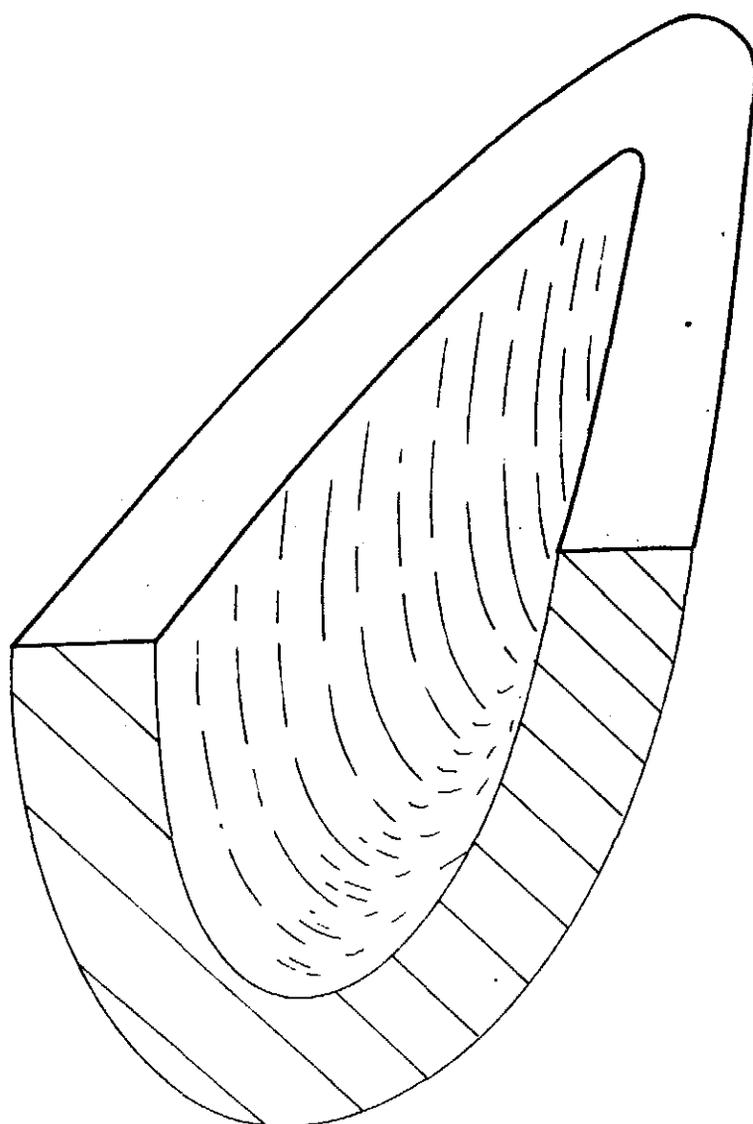
The easterly limb exhibits very little dip information other than the anomaly plotting position being dependent on direction. The responses on Lines 104.1NW, 105.2NW show no channel 1-6 peak offset, implying a down dip response. Lines 105.1SE, 106.2SE and 107.1SE have responses with channel 1-6 peak offsets implying an updip response. Again, there are two lines which don't fit in with this interpretive scheme; Line 104.2SE shows no channel 1-6 peak offset which is inconsistent with the other lines flown. SE and Line 106.1NW which shows peak offsets when you would not expect to see them if the response is from a down dip direction.

Therefore, the INPUT data suggests that the westerly limb dips towards the south east and the easterly limb dips towards the north west. A plausible geological structure consistent with these dips and the ever decreasing distance between limbs to the north east would be a syncline cut an oblique angle as shown in the figure.

The implication of such a structure are to downgrade the importance of this zone as a high priority sulphide target since the structure implies that the same geological unit is the source of both responses. This being the case, the slow decay and high conductivity is more likely to be representative of a carbonaceous unit rather than sulphides.

Recommendations

Ground follow up is recommended to best determine the structure and the form of the source.



- LINE 108-1

- LINE 102-1

Figure 1 - Possible geometry of 20/4043/IR2

ZONE 20/4044/IR4Priority 1

Line 102.1	Fiducial 559652	Ratio 10.0/1.0
	to	
Line 101.1	Fiducial 556310	Ratio 12.5/1.5

Anomalies: Shape : Relatively broad & symmetric
 Amplitude : Small
 Decay Rate : Slow - very slow
 Cultural Signs : None
 Mag Association : Broad dual peaked anomaly

Conductor: Dimensions : 300 metres wide x 800 metres +, long
 Strike : East

Location: River

Remarks:

This zone strikes parallel to zone 20/4044/IR2 and is along strike from the eastern limb of that structure. There is some correlation with a broad dual peaked magnetic anomaly which becomes less apparent north of line 102.1. The very slow decay rate and small amplitude of the INPUT response would suggest that the conductive source is quite deep as is the source of the magnetic anomaly, but it is unlikely that the same source gives rise to both anomalous geophysical quantities.

Recommendations:

Ground follow up is recommended.

ZONE 20/4043/IR5Priority 3

Line 1042

Fiducial 354240

Ratio 12.51

Anomalies: Shape : Very narrow & symmetric
Amplitude : Moderate
Decay Rate : Moderate - Fast
Cultural Signs : Farm houses
Mag Association : None

Conductor: Dimensions : 200 metres wide
Strike : --

Location: Farmhouses and paddocks

Remarks:

This anomaly appears to be cultural, yet examination of the tracking film places the peak some 100 metres away from the evident culture (houses etc). For this reason there is some doubt as to the source of the anomaly. There does not appear to be any similar anomaly on line 104.1 (which crosses 104.2 near the fiducial range we are looking at.)

Recommendations:

Follow up is required to determine whether the culture is the only source present.

VIII. TABLE 2. SUMMARY OF SELECTED CONDUCTORS - RIANA AREA

<u>Priority 1</u>	<u>Priority 2</u>	<u>Priority 3</u>
20/4044/IR3	20/4044/IR2	20/4144/IR1
20/4044/IR4	20/4044/IR6	20/4043/IR5

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IX. INTERPRETATION OF LOONGANA SURVEY DATA

The INPUT data from the Loongana survey distinguishes a number of broad conductive zones extending the entire length of the survey area. These responses are related to the extensive basalt cover in the region established from geological mapping and aeromagnetics. However, a comparison between the EM anomaly map and the geology and aeromagnetics shows that the INPUT system has more clearly defined the boundaries of the paleovalleys filled with basalt. The typical INPUT response from these features are broad 'surficial' * responses, some of which bear a close resemblance to modelling data over flat lying horizontal plates performed at the University of Toronto.

The separation of true bedrock responses from within "surficial conductors" has not been realisable in practice but zones of enhanced response within the broad responses is certainly an achievable target. However, in the Loongana area, there are no enhancements within the surficial zones which correlate between more than one line. There are a number of peaks within these zones which indicate localised increases in conductivity, but there are no outstanding airborne geophysical parameters which set them apart from any other peak found with the broad responses. The only conceivable way of upgrading their importance would be the addition of geochemical evidence.

Hence there are only three anomalously conductive zones which are described in this section. Peaks from within the broad zones which may become important with the addition of further information are tabulated in Table 3.

* The word surficial is used in a geophysical rather than geological sense here.

ZONE 20/4041/IL1Priority 2

Line 3332 Fiducial 660924 Ratio 8.0/1.0
Line 3322 Fiducial 656110 Ratio 4.0/0.8

Anomalies: Shape : narrow, asymmetric
 Amplitude : small
 Decay Rate : slow
 Cultural Signs : none
 Mag Association : none

Conductor: Dimensions : 1.2 kilometres long x 250 metres wide
 Strike : East

Location: Forested area

Remarks:

This zone is weak and situated on the edge of a broad conductive zone. The best response is on line 333.2 where the decay is very slow and the anomaly shape is well defined. The proximity of this zone to the edge of the broad zone introduces some doubt as to whether a separate source is responsible for this anomaly, but there are sufficient differences between this site and other "edge responses" which enhance the importance of this zone.

Recommendations:

Ground follow up is recommended.

ZONE 20/4041/IL2Priority 3

Line 3191	Fiducial 621860	Ratio 8.0/1.2
Line 3181	Fiducial 620770	Ratio 15.0/1.0

Anomalies: Shape : narrow and symmetric
 Amplitude : moderate - small
 Decay Rate : moderate - slow
 Cultural Signs : none
 Mag Association : 100 - 160nT discrete anomaly

Conductor: Dimensions : 600 metres long x 300 metres wide
 Strike : East

Location:

Remarks:

This discrete zone with magnetic association may be an expression of topography on the airborne geophysical records. The zone has a tenuous extension to the south on the ends of lines 3171 and 3161 where the response is broader and weaker mainly due to increased terrain clearance. The associated magnetic anomalies do not persist to these lines. The anomalies do not indicate a highly conductive source is present.

Recommendations:

Ground follow up is recommended.

λ. TABLE 3 SUMMARY OF SELECTED PEAKS WITHIN SURFICIAL ZONES

<u>Line</u>	<u>Fiducial</u>	<u>Ratio</u>	<u>No. of Channels</u>
3511	489264	8.0/0.5	5.. 4141/114
3411	454620	10.0/1.2	6 4042/113
3271	642270	14.0/2.1	6 4041/116
3251	637740	14.0/1.8	6 4041/117
3111	599924	20.0/3.0	6 4041/118

XI. CONCLUSIONS AND RECOMMENDATIONS

Tables 1-3 summarise the interpretation of the geophysical data and the classification of zones according to their priority in the search for conductive massive sulphides. This categorisation is established primarily on the merits of the INPUT data with the magnetic and other information considered as secondary tools.

The main purpose of the survey was the delineation of discrete massive sulphide conductors, often from beneath the extensive basalt cover. The complex nature of such target conditions places limitations on the separation of true bedrock responses from responses originating from within the overburden (basalt) or at the base of the overburden, due mainly to the poorly understood interactions between "surficial" and bedrock conductors. Consequently there are very few high priority zones listed in this report.

The Highclere area contains 1 Priority 1, 4 Priority 2 and 4 Priority 3 zones, the most outstanding zone being 20/3943/IM4.

The Riana area contains 2 Priority 1, 2 Priority 2 and 2 Priority 3 zones, the most prospective being 20/4044/IR3 and 20/4044/IR⁴₅ which are Priority 1 and 20/4043/IR2 which is Priority 2 but has a very interesting geometry interpreted from the INPUT data.

The Loongana area contains only 2 Priority 2 and 1 Priority 3 zone. In this area the basalt cover was extensive and relatively uniform, there being no trending enhancements within the extensive areas of high conductivity.

Since there are very few zones listed as being possibly caused by a

bedrock source. It is recommended that all zones regardless of priority be followed up. The zones which have been outlined as being anomalously conductive within the generally conductive background would require a deep penetration ground EM system capable of separation of background response from target response at the processing and interpretation stage.

Respectfully submitted,

Martin Schneider

Martin Schneider
Geophysicist

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APPENDIX A

INPUT EQUIPMENT AND PROCEDURES

1. BARRINGER INPUT SYSTEM

a) General:

The INPUT (Induced Pulse Transient) method is based upon the study of the decay of secondary electromagnetic fields created in the ground by short pulses generated from an aircraft. The time-varying characteristics of the decay curve are analysed and interpreted in terms of information concerning the conductivity characteristics of the terrain.

The principle of separation in time between the production of the primary field and the detection of the measured secondary signal gives rise to an excellent signal-to-noise ratio and an increased depth of penetration compared to conventional continuous wave electromagnetic systems. It also makes the INPUT system relatively independent of air turbulence.

At a normal survey altitude of 120 metres above terrain, the typical effective depth penetration is estimated at about 180 metres below surface, depending on the conductivity contrast between the conductive body and surrounding rocks, the size and

attitude of the conductor and the presence or lack of conductive overburden. In optimum conditions a penetration of 210 metres subsurface can be achieved.

One of the major advantages of the INPUT method lies in good differentiation between flat-flying surface conductors and bedrock conductors so that the latter can be detected even under a relatively thick cover. Typical uses involve the search for sedimentary sulphides in thick basins and the search for graphitic lithologies under younger cover.

However, the application of the airborne INPUT electromagnetic method is limited to the solution of problems that are characterized by a reasonable resistivity contrast. The method is not considered to be applicable to the direct search for disseminated mineralization, except where a resistivity contrast exists.

b) Equipment:

The INPUT system was developed by Barringer Research Limited of Toronto, Canada.

The transmitted primary field is discontinuous in nature (Fig. 1A) with each pulse lasting 900 micro-seconds; the pulse repetition rate is 288 per second.

The electromagnetic pulses are created by means of powerful electrical pulses fed into a 3-turn shielded transmitting loop surrounding the survey aircraft and fixed to the nose and tail of the fuselage and to the wing tips.

The secondary field reception is made by means of a receiving coil wound on a ferrite rod and mounted in a "bird" towed behind the aeroplane on a 140 metre co-axial cable. The axis of the pick-up coil is horizontal and parallel to the flight direction and a Faraday shield is used to reduce noise levels. Periods of two and a half milliseconds between successive primary pulses (Fig. 1B) are used for detecting the secondary field and the transient voltage (Fig. 1C) thus produced corresponds in time to the decay of the eddy currents in the ground.

The analysis of the bird signal is made in the INPUT receiver by sampling the decay curve at six points, or gates, the centre and width of which have a fixed relationship with respect to time zero (t_0) corresponding to the termination of the pulses. The centres of the six sampling gates are set at a mean delay of 500, 700, 900, 1200, 1600 and 2100 microseconds after time zero (Fig. 1D).

The signals received at each sampling gate are processed in two multi-channel receivers to give two sets of six continuously varying analogue voltages. Each trace represents the coherent integration of one channel of the transient sample, the time constant of integration being variable. Presently, one set of six channels is recorded at a time constant of 2.5 seconds (Standard Resolution Channels, SRC), the second set at a time constant of 0.5 seconds (High Resolution Channels, HRC).

This integration delay plus the time separation between the receiving bird and tracking camera installed in the aircraft introduces a delay which has to be taken into consideration and corrected prior to correlating the electromagnetic data with the other simultaneously recorded data. This delay is approximately 4 seconds for the normal time constant and 2 seconds for the fast time constant.

c) Compensation Procedure

During primary field transmission eddy currents are induced in the aircraft frame as well as in conductive ground. The airframe eddy currents produce a secondary

field which needs to be cancelled out in order to measure the ground-related effects. To compensate for this effect a special device is used which feeds into each channel of the INPUT receiver a signal equal in amplitude and waveform but opposite in polarity to the signal induced by the airframe eddy current. The compensation signal is derived from the voltage induced in the receiving coil by the primary field; this voltage is constantly proportional to the inverse cube of the distance between the bird and the aircraft. Thus, swinging of the bird and changes of coupling are automatically corrected. The compensation adjustment is a simple procedure carried out during flight at a terrain clearance of 600 metres to eliminate the interference of ground conductors.

d) Time Sharing

In order to operate both the INPUT system and the proton magnetometer system simultaneously, the INPUT transmitter is switched off each second for a time period long enough to allow for a noise free magnetometer reading. The affect of this switching can be seen as a 1 Hertz ripple on the HRC INPUT channels.

II. MAGNETOMETER

The magnetometer is a Geometrics G-803 nuclear precession unit especially adapted to operate in conjunction with the INPUT equipment. Readings are taken every 1.0 second with a sensitivity of plus or minus 1 nanotesla and recorded at a full scale of 5 inches for 100 nanoteslas. The coarse trace is recorded at a full scale of 5 inches for 1,000 nanoteslas. The sensing head is mounted at the end of a 3 metre stinger, on the tail of the PBY aircraft.

III. SPECTROMETER (Optional)

A Nuclear Data 256 channel spectrometer is used. Its input is taken from the photomultiplier tubes attached to either 16 or 33 litres of NaI detectors, through an Ortec summing amplifier. Separate amplification is available for each individual detector to allow correct photomultiplier output voltage matching. The detectors are mounted in insulated containers and maintained at a constant temperature above the ambient temperature. The analogue voltage outputs from the photomultiplier tubes, which represent the gamma ray spectrum, are fed to the spectrometer (ADC) and converted into digital signals. These digital signals are then processed by the Madacs acquisition system. The acquisition system also

VI. Hz MONITOR

A Hz monitor tuned to the local domestic power distribution frequency, is employed to assist in the detection of powerlines and their resultant anomalies.

VII. MADACS DIGITAL ACQUISITION SYSTEM

The MADACS is a computer based software system using an Interdata processor, model 6/16 with 32k memory. This computer is linked with a Digi-Data, model 1600 magnetic tape drive with a true read after write feature which allows checking of the recording process as many times as the particular application permits. The checking procedure includes elimination of errors due to bad tape spots. Use of multiple buffers permits recording and processing data simultaneously with acquisition of new data, with no resulting dead time.

The system uses a Cybernex TV monitor to display acquired data and operator messages and is fully interactive with a Cybernex alpha numeric keyboard which can be used remotely for special installations.

The key feature of this system is that all the data collecting, verifying, buffering and recording is software-controlled and thus may be economically

They are then recorded on the flight log by the operator.

- memory storage of spectral data. This data can be plotted at any stage during a flight or at the end of flight, even after the system has been powered down.

A software facility is also provided to enable correction for Compton scattering effects on the analogue data (not the digital data).

IV. TRACKING CAMERA

The tracking camera is a 35mm continuous strip camera equipped with a wide angle lens. The 35mm film is synchronized with the geophysical record by means of fiducial marks printed every 2.0 seconds. These time readings are not from an incrementing counter, they are read from digital information provided by the MADACS system.

V. ALTIMETER

A Sperry radar altimeter is used. This instrument has an accuracy of $\pm 2.5\%$. Data is recorded in units of feet.

measures "live-time" which is the total time per sample period in which the ADC is processing incoming analogue signals.

The equivalent energy values for the various channel positions are noted in Appendix C.

For calibration purposes software routines are employed which allow:

- calculation and adjustment of both thorium and cesium window positions as a channel number. This channel number is comparable with the expected peak channel location. This check is accurate to .01 of a channel window width (0.12 KeV).

The use of both thorium and cesium peaks ensures the spread of the 256 channels is linear.

- display of the thorium or cesium photopeak on the oscilloscope or on the analogue chart, in order to allow calculation of system resolution. These peaks can be plotted for individual crystals or for the entire crystal array.
- automatic calculation of the various window responses to either a uranium or thorium source. The background values are automatically subtracted from the data recorded in the presence of either source and results are displayed on the television monitor.

INPUT and altitude data are digitally recorded five times each second. Either SRC or HRC data can be recorded on digital tape, but not both. Six channels are recorded plus transmitter current and altitude. Digital INPUT data can be positive or negative depending on the zero level voltage dictated by the compensation circuitry. The output voltages of the INPUT receiver are converted to digital units by analogue-to-digital converters (ADCs) and it is here that gains are adjusted to ensure that in conductive areas large anomaly amplitudes (large output voltages) can be kept within the dynamic range of the ADC's.

Magnetic data are recorded once per second and to an accuracy of 1nT. However the software allocates two decimal places to these readings to allow for future replacement of the G803 with a more sensitive instrument.

Radiometric data is accumulated over one second periods. Channels 1 through to 255 are recorded between thresholds set according to Appendix C. Channel 0 records counts in a higher MeV range which corresponds to cosmic gamma radiation. The counts accumulated within certain energy windows, corresponding to those radioactive isotopes of most interest, are calculated from Channels 0 to 255 by the computer and recorded separately each second. These windows are those commonly used for thorium, uranium, potassium, total count and cosmic, as

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altered to fit almost any requirements. Many critical parameters are automatically monitored during flight, with visual and aural alarms provided.

Survey parameters are displayed during flight in the same units as the basic sensor, making operator comparisons simple. A suite of programs is provided for checking and trouble-shooting the hardware.

The MADACS is used to control and command the operation of all three geophysical systems (INPUT, magnetometer and spectrometer) as well as ancillary equipment such as the camera, altimeter, tape drive, analogue chart recorders and sometimes electronic navigation systems. The basis is a precision clock recording time to 0.1 seconds. Time is digitally recorded in seconds after midnight, so that a six figure number such as 360000 corresponds to a time of ten a.m. Fiducials are generated on digital tape, camera and analogue chart at two second intervals. The fiducial numbers do not increment by units; they are in fact calculated from the time by the computer. Using this method, any data are uniquely defined by their flight number and their time. This system thus does not require digital recording of line numbers, part numbers or direction, thus avoiding a source of digital recording errors.

well as an additional uranium window termed auxiliary uranium.

Spaces are left in the format for frame number (if a frame camera is used) and for navigation information (if an electronic navigation system is used).

Manual information such as start time and flight number are keyed in each morning at the start of the flight.

The MADACS system is provided with 12 digital-to-analogue converters (DAC's) to provide outputs to the analogue recording units. The DAC's can be individually subjected to a software routine which checks that their response to a complete range of digital inputs is linear.

VIII. DIGITAL RECORDING

600 or 1200 foot tapes are written in IBM compatible binary with full parity, cyclic redundancy and longitudinal check characters. Read-after-write checking ensures data is correctly recorded. The recording density is 800 b.p.i. and the recording format is described in Appendix D.

IX. ANALOGUE RECORDING

The MADACS system controls a read-after-write facility whereby most of the analogue channels are read after the data are recorded onto digital tape. Altitude, radiometric and magnetic data are programmed for automatic zero calibration at the start of each flight line.

a) Honeywell Visicorder

This is an optical galvanometer recorder used to record INPUT, magnetic and Hz monitor data. An example of its analogue output is displayed in Figure 2.

The data traces, in order from the top of the chart, are:

- 50 Hz monitor.
- six SRC INPUT channels.
- altimeter (read-after-write).
- total magnetic field (1000nT FSD) (read-after-write).
- total magnetic field (100nT FSD) (read-after-write).
- six HRC INPUT channels (read-after-write).

The fiducial system is used to generate vertical "event" lines on the charts. Lines every 10 seconds are dual, and the dual lines every 50 seconds are labelled with their appropriate time value. Time increases from left to right.

Both SRC INPUT and magnetic data deflect downwards for

positive anomalies. The HRC INPUT data deflects upwards for positive anomalies.

During calibration procedures, a test signal of known strength is used to generate from the INPUT receivers an analogue response of known amplitude on each channel. Generally one of two standard sets of amplifications is used, depending whether the survey is to be flown in a generally conductive or generally resistive area. The actual gains used are noted in Appendix C. It should be noted that the gain set on the HRC receiver is actually 75 % of the gain set on the SkC receiver, due to the relative effects of time sharing on each receiver.

b) Mars 6 Recorder (Optional).

Radiometric, altitude and magnetic data are recorded on this 6 - channel, heat pen recorder. Figure 3 shows the usual arrangement of channels on this recorder. Provision is made in the software for full scale values to be changed for each channel, depending on activity in the area to be surveyed. Time increases from right to left and is indicated by an event mark every 10 seconds. These event marks are annotated at regular intervals with their appropriate time values.

Thorium, uranium, potassium and total count values

increase upwards; terrain clearance and Magnetics increases upwards.

X. PROCEDURES

a) Field Operations:

The flight line spacing is normally in the range of 200 metres to 1 kilometre. During survey flights, the altitude of the aircraft is maintained at approximately 120 metres above the ground with the bird flying about 40 metres above the ground.

The heading of the aircraft is such that two adjacent lines are normally flown in opposite directions. Visual navigation is based on airphoto mosaics or in some cases on topographic maps of suitable scale.

During surveys the calibration of the altimeter is checked by flying straight and level over the runway at a barometric altitude AGL of 120 metres. The compensation adjustment is checked during ferry from the base to the survey area.

b) Calibration

Before each flight the gains and zero levels for each INPUT channel are checked and adjusted if necessary. This is carried out at an altitude of 600 metres, away from ground effects. These items are again monitored

during each flight and at the end of each flight. The information is recorded on digital tape and analogue chart. If the survey area is resistive, the zero levels are best determined from data recorded over the resistive regions at normal survey altitude. While at 600 metre altitude the compensation procedure is followed to ensure effects of airframe transients are cancelled. Any adjustments are made prior to zero level monitoring since compensation adjustments affect zero level voltages.

All checks and adjustments are performed at high altitude where they can be clearly monitored and recorded for subsequent digital processing.

If radiometric data is being collected a test line may be required before and after each flight. Background gamma radiation levels are monitored and recorded at high altitude during the INPUT calibration procedures. Spectrum positioning checks and source checks are performed before and after each flight.

c) Compilation

At the end of each flight, all records and films are developed, edited and all synchronized fiducial marks are checked. Then, the actual flight path recovery is made by picking visible marks common to both 35mm

film and photo mosaics.

Identified points with their time value are plotted on the mosaic. Then, the electromagnetic anomalies are transferred from the records onto a mosaic overlay by interpolation according to their own fiducial number.

The position of the INPUT anomalies must be corrected to take into account the separation between the bird and the aircraft as well as the delay introduced in the integration circuitry. This offset, or lag, is plotted towards the smaller fiducial numbers (to the left on the record). It varies, depending whether the SRC or HRC data is used.

The INPUT anomalies are represented on a map by means of symbols that condense the most significant characteristics:

- i) the location of the centre and half-peak width of the electromagnetic anomaly.
- ii) the number of INPUT channels affected by a noticeable deflection.
- iii) the peak amplitudes of the second and fifth channels.
- iv) the altitudes at which the anomalies were recorded,

- v) the amplitude of any magnetic features which coincide with INPUT anomalies;
- vi) associated response on the Hertz monitor.

The only subjective elements introduced by this processing are in the decision as to whether a deflection corresponds to a genuine anomaly or to a noise source (electrostatic atmospheric discharge, compensation noise, etc.) and in the correlation of the anomalies from line to line to delineate a conductive zone.

To aid in this correlation process various computer products can be utilized. These are profile maps or contour maps of one or more channels, multiplots or printouts showing calculated parameters such as decay time constant or half-space model correlation. These latter parameters can also be contoured or plotted as profile maps.

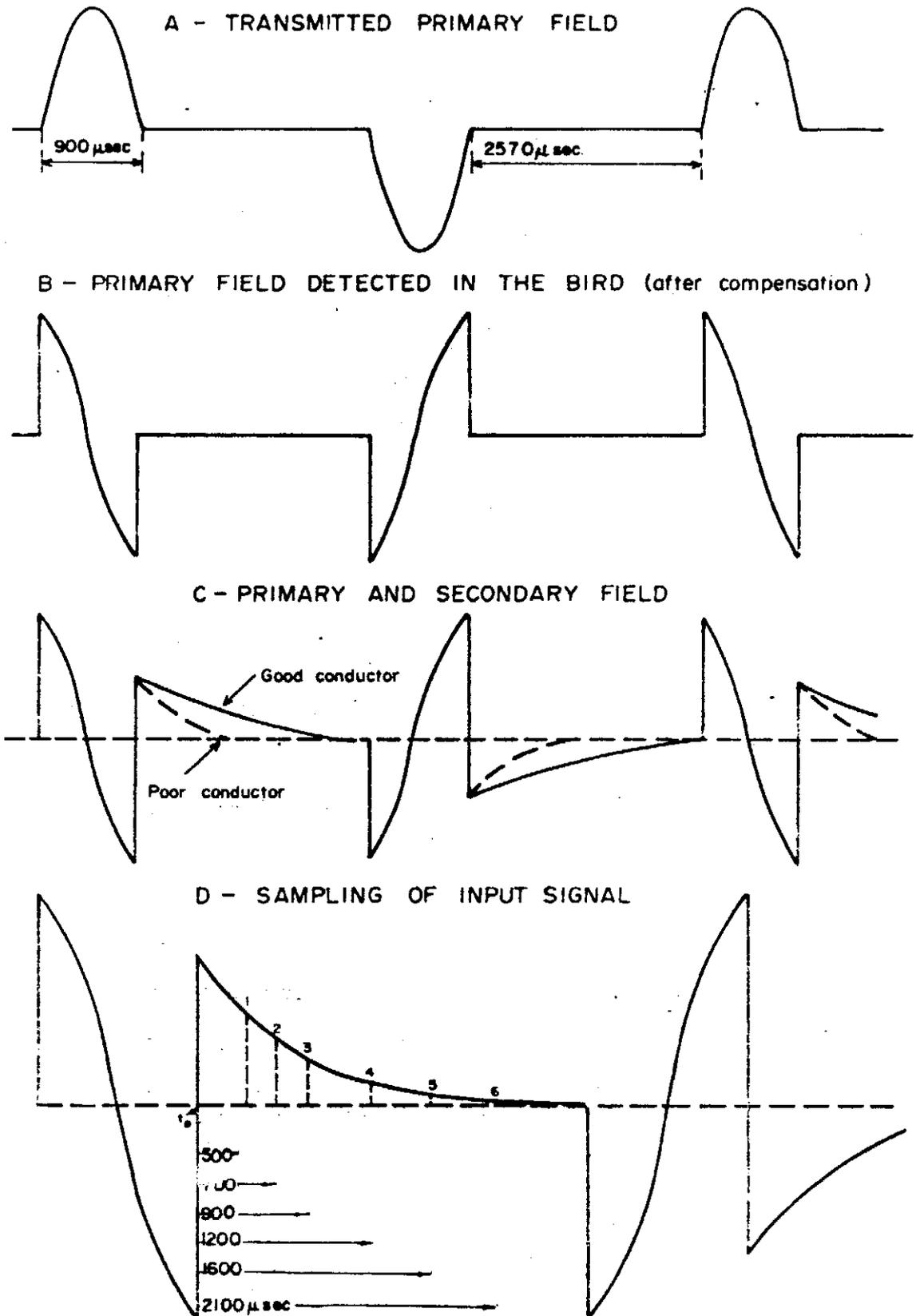
INPUT SIGNAL

FIGURE 1.

TYPICAL INPUT RECORDING

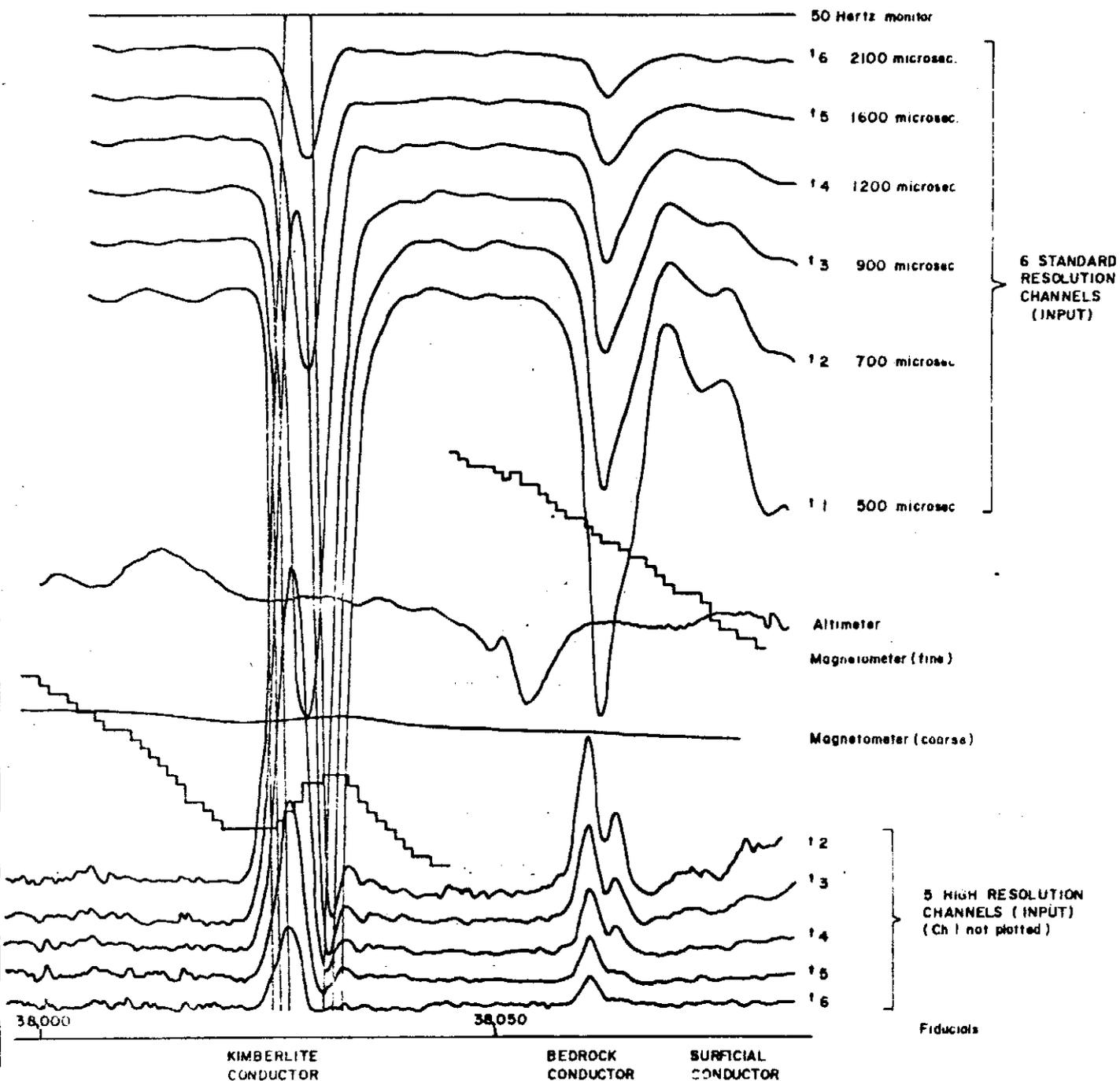
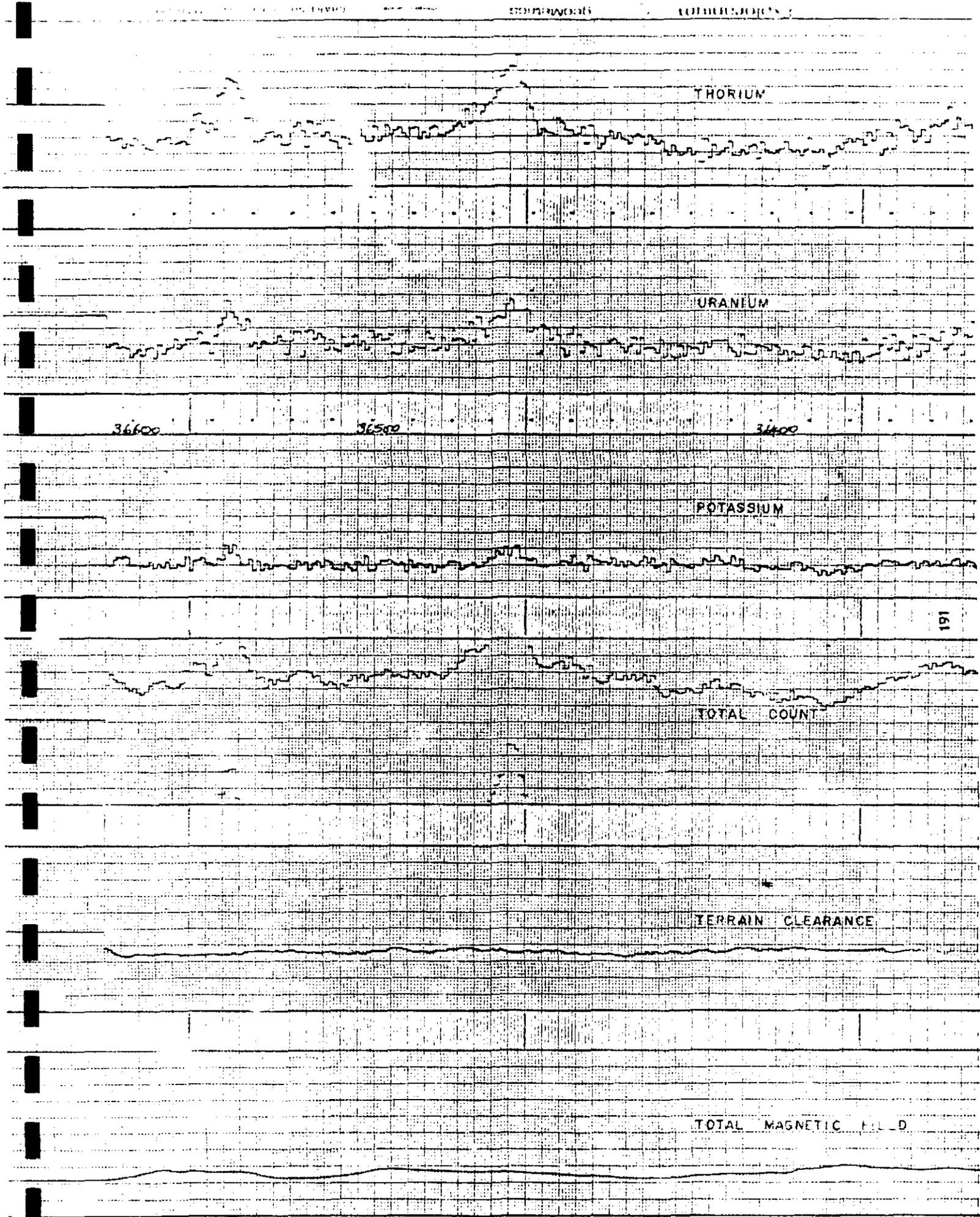


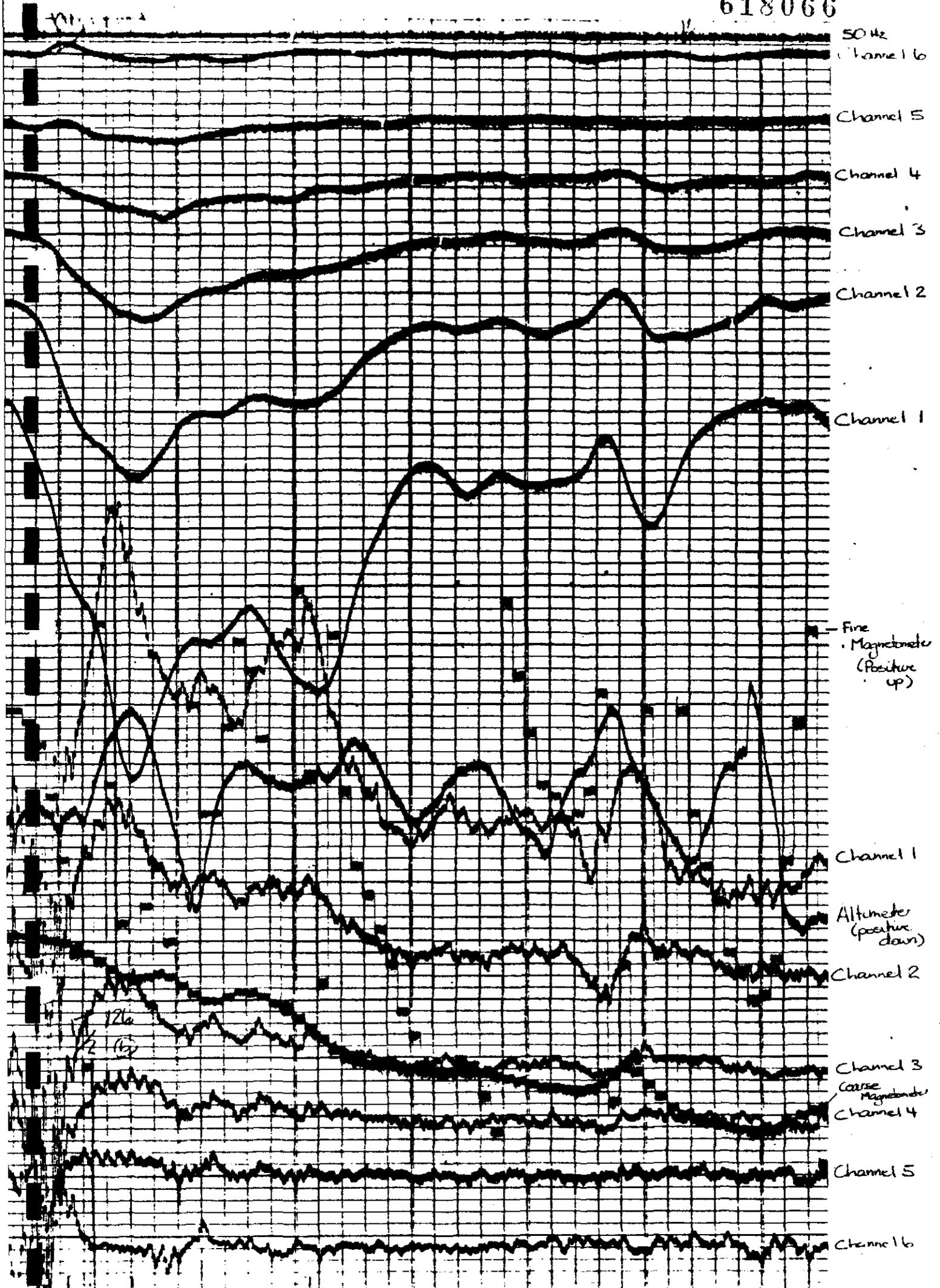
FIGURE 2



5 XPIORUMUM GEOMETRUS CHART NO 30 601-001 MARS-6 RECORDER

FIGURE 3

618066



APPENDIX BINPUT INTERPRETATIONI. INTRODUCTION

Although the approach to interpretation varies from one survey to another depending upon local conditions, the following generalizations may provide the reader with some helpful background information.

The main purpose of the interpretation is to determine the probable origin of the conductors detected during the survey and to suggest recommendations for a further exploration programme by taking into account a limited amount of available geophysical data. This is possible through an objective analysis of all characteristics of the different types of conductors and correlating magnetics, if any. Then, the maps of electromagnetic results are compared to the available geological maps. A certitude is seldom reached, but a high probability is obtained in the appreciation of the conductive causes in most cases. One of the most important problems is usually the differentiation between non-economic surface conductors and bedrock conductors.

II. TYPES OF CONDUCTORS

a) Bedrock Conductors:

The different types of bedrock conductors that are normally encountered are the following:

1. Graphites (including a large variety of carbonaceous rocks) occur in the sedimentary formations of the Precambrian as well as in volcanic tuffs, often concentrated in shear zones. They correspond generally to long, multiple conductors often lying in parallel bands. They are not magnetic unless associated with pyrrhotite or magnetite. Their conductivity is variable but generally high.
2. Massive sulphides Syngenetic sulphides often correspond to long multiple conductors and their conductivity, which varies considerably, may be very high, as for graphites. Pyrrhotite, often associated with other sulphides may be the cause of coincident magnetic anomalies. Generally, sulphides are not as frequently encountered as is graphite.

Isolated orebodies of massive sulphides give rise to short conductors of high conductivity. They quite often present a direct magnetic anomaly and are easily recognized. However, some sulphide

orebodies are not magnetic, some are not very conductive (discontinuous mineralization), and they can be located among formational conductors so that one must not be too dogmatic in the selection of the prospects.

Sedimentary sulphide orebodies often give rise to conductors with large dimensions, often without the narrow anomaly usually associated with volcanogenic sulphides. They may be found in large pyritic basins which also display high conductivity. They are often flat lying or gently dipping.

3. Magnetite and some serpentized ultra-basic rocks are conductive and very magnetic.
4. Manganese oxides may give a weak electromagnetic response.

b) Surface Conductors:

1. Clayey alluvium or residual soils, some swamps and brackish groundwater are usually poorly conductive to moderately conductive.
2. In unglaciated areas lateritic formations, residual soils and the weathered layer of the bedrock often cause surface anomalous zones, the conductivity of

which is generally low to medium but can be very high. Their presence is often related to the lithology of the underlying bedrock and can be used as a guide in exploration for such targets as kimberlite pipes. The latter lithology is very friable and can weather to a thick, highly conductive clay.

c) Man-made Conductors (Cultural):

1. Power Lines These frequently produce a conductive type response on the INPUT record. In the case of direct radiation of their field, the anomaly shows phase changes with the different channels which are recognized easily, in the case of a grounded wire, or steel pylon, the anomaly may look very much like a bedrock conductor.
2. Grounded fences or pipelines These will invariably produce responses much like a bedrock conductor. Whenever they cannot be identified positively a ground check is recommended.
3. General Culture Metal barns or houses, tailings ponds, dumps, etc., may produce INPUT anomalies. However, their instances are rare and can generally be verified by identification on the path recovery film.

III. ANALYSIS OF THE CONDUCTORS

The apparent conductivity alone is not generally a decisive criterion in the diagnosis, and other factors are also very important:

- the pattern of conductors
- the shape and size, both with respect to the direction of flight
- the associated geophysical parameter (aeromagnetics, radiometrics)
- the position with respect to the direction of structures
- the geological environment
- the local variations of characteristics within conductive zones.

A first objective of the interpretation is to classify each zone under one of these three categories, according to its most likely origin. The characteristics of each of the three major classifications are discussed below in subsections a, b and c.

For any particular anomaly or zone the criteria used to analyze it are applied as rigorously and consistently as possible in order to establish the correct classification. In the majority of zones finally selected, the evidence is never totally conclusive.

Consequently, the ultimate priority or classification is the one which appears to be the most probable, bearing in mind that every zone which is discussed in detail has some chance of being a bedrock conductor. In the case of targets such as kimberlite pipes, certain types of surficial conductors will take the highest priority.

The experience of handling a large amount of INPUT data and observing the ground followup results over a large portion of this data has confirmed the validity of our interpretational criteria.

a) Bedrock Conductors

This category is comprised of those anomalies which do not fit the criteria laid down for classifications b and c. It is difficult to assign a specific set of values which signify bedrock conductivity because any individual zone or anomaly might exhibit some, but not all, of these values and still be a bedrock conductor.

The criteria considered as favourable pointers to a bedrock conductor are:

1. Intermediate to high conductivity. Channels five

and six are generally affected. Where the conductivity drops (i.e. second to fifth channel ratios greater than 15) it is difficult to distinguish narrow surficial conductors from bedrock ones.

2. Good anomaly shape: Narrow, relatively symmetrical, anomalies with well defined peaks are preferred to wider anomalies with rounded peaks. The leading flank should show a gradual increasing response with no abrupt change in slope or tendency to go negative, the latter is often associated with cultural conductors.
3. No serious displacement of anomaly peak position with line direction, i.e.; edge effect. Some displacement can be expected from a wide bedrock source or banded bedrock source which is not resolved into more than a single peak. However, major displacements in peak position appears to be associated with surficial conductors only. (Note the possible exception of flat lying sedimentary sulphides).
4. Small to intermediate amplitude. Large amplitudes do occur but generally, the amplitude of the response is smaller than for thick, extensive surficial

conductors. The amplitude varies to the depth of the source.

5. A degree of continuity. Maintenance of any, or all, of characteristic 1, 2, 3 and 4 is strong evidence in favour of a bedrock conductor.
6. Associated magnetic response with similar strike. A related magnetic response is usually interpreted as signifying a lithologic unit carrying the magnetic and conductive material. However this criteria is often not significant in sedimentary sulphide exploration.

However, as discussed in subsection b, some basic rocks which weather to produce a conductive upper layer will possess this magnetic association. In the absence of characteristics 1, 2, 3 or 4, the related magnetic response does not help to distinguish between surficial conductivity related to a bedrock feature and genuine bedrock conductivity.

Interference, then, with conductive overburden can make the identification of a bedrock conductor somewhat difficult but a careful and consistent

comparison of residual responses to the above criteria results in a better level of success. The use of quantitative analysis of amplitude decay can improve the success rate in areas of conductive overburden.

Residual anomalies, basically, are those which, in comparison to other deflections, appear to be located "on" rather than "part of" the already deflected traces.

Most obvious bedrock conductors occur in long, relatively monotonous, sometimes multiple zones following formational strike. Graphitic material is usually the most probable source. Massive syngenetic sulphides running for many miles are known in nature but, in general, they are not common.

Other sources of bedrock conductivity are massive magnetite and serpentine. We rely heavily on the amplitude and dimensions of the associated magnetic activity plus the geological setting of the conductor to distinguish these cases.

The criteria used for the selection of a bedrock conductor which is considered to have a good chance of being a massive sulphide are:

- high conductivity,
- good anomaly shape,
- small to intermediate amplitude,
- characteristic anomaly decay,
- isolation,
- short strike length,
- preferably a localized, small amplitude magnetic anomaly of the same width.

If the magnetic anomaly has similar lateral dimensions, with an amplitude up to 400 gammas, and correlates directly with the EM response, there is a strong possibility of pyrrhotite being present.

We must consider, however, the possibility of localized occurrences of massive sulphides within or near formational conductors. The selection of targets from within these extensive belts is a difficult problem. They are singled out primarily on the basis of a marked local increase in conductivity and/or amplitude or some evidence for a relatively localized occurrence. Variations within the conductive formations themselves can account for these characteristics, so the reliability of this type of selection is considered to be low.

Localized magnetic correlations within long formational

conductors can be taken as evidence of pyrrhotite. In some environments, however, this criterion is very difficult to apply due to the prevalent association of conductors to magnetically active rock types. The compilation of the magnetic data into isomagnetic contour maps assists this type of selection.

b) Surficial Conductors

This term is used for geological conductors in the overburden, either glacial or residual, and in the weathered layer of the bedrock. Most surficial conductors are probably caused by clay minerals. In some environments, salty deposits give rise to highly conductive surficial features.

Other possible electrolytic conductors are residual soils, swamps, brackish groundwater and lake or river-bottom deposits.

Many conductive surficial features have low or intermediate conductivity so they are not usually mistaken for highly conducting bedrock features. Many of them are very broad features and their anomaly shapes are typical of broad horizontal sheets. However, in some areas surficial conductivity can be extreme and flying is not recommended in areas where this problem is well established, unless the type of survey target can be

located from the varying thickness of its conductive cover e.g. basement depressions, channels.

When the conductivity is higher, it is often still possible to identify a flat-lying surficial conductor, thanks to a typical asymmetry in the INPUT responses observed on both edges of the conductor (edge effect) when flying adjacent lines in opposite directions (Figure 1). Flying from A to B, the coupling between the transmitting coil and the flat-lying conductor AB is maximum when the coil is over the leading edge A and minimum when the coil is over the edge B. The INPUT response appears stronger over Point A than over Point B. The phenomenon is reversed when flying from B to A. The actual limits of the conductive zone correspond, in fact, to the envelope of the leading edges of staggered anomalies. In practice there are many variations on this basic pattern caused by variations in width, thickness and conductivity. For an understanding of the variability of transmitter-conductor-receiver coupling refer to Figure 2 and 3.

Other surficial conductors may be recognized by analysing the radio-altimeter trace, e.g. conductive deposits in the valleys or increased thickness of the weathered zone on top of the hills. Also, a comparison to the altimeter profile is essential when flying over a

surface layer of apparently high conductivity where a sudden dip of short duration (or small hill) can cause an apparent sharp anomaly.

However, the existence of surficial conductors related to bedrock lithology does introduce ambiguities into the interpretation. There are instances where we cannot distinguish between weakly conductive serpentine or poorly developed graphite within the bedrock and weakly conducting soils or a weathered layer above the bedrock. This does not generally detract from the prime purpose of the survey, which is the location of highly conducting massive sulphides, but it does complicate the overall analysis of the data.

If the anomaly shapes show a dependence on line direction, a surficial or flat-lying bedrock is probable; if they show multiple peaking and a lack of dependence on line direction a bedrock source is probable; but with the weaker anomalies the shape is often insufficiently clear for a reliable interpretation.

Formational surficial conductors seem to be most commonly related to rocks of intermediate to basic composition, as they tend to follow magnetic highs. (This is also true of most of the formational bedrock

conductors.) However, there are also examples of formational surficial conductors in acidic environments.

A surficial response of direct economic interest is that recorded over the weathered part of kimberlite pipes. These responses are usually isolated and often very strong, especially in tropical areas where extensive weathering may occur.

Surficial conductors are not completely portrayed on the EM Map because weaker INPUT responses are not usually plotted. Sometimes, the distribution of this type of conductor is indicated by the stronger sections which are plotted and by the conductor outline which delineates the entire zone. Alternatively, when the amplitude of one of the early channels is contoured, these weak zones are delineated.

Any outlined conductive zones which are not assigned an identification number can be taken as interpreted surficial features. Similarly, any isolated anomalies which bear no zone number and no "C" designation are interpreted as surficial.

(c) Cultural Conductors

The majority of cultural anomalies occur along roads

and are accompanied by a 50 Hz response. Power lines are clearly the most common source. Although some power lines are recognised immediately on the records by virtue of phase reversals or an abnormal rate of decay, many yield INPUT anomalies of a normal "high conductivity" character which could be mistaken for bedrock responses. There are also many power lines which cause no INPUT response whatsoever.

Fences, pipelines, communication lines, railways and other man-made conductors can give rise to INPUT responses, the strength of which will obviously depend on the grounding of these objects.

Our analysis of suspected cultural anomalies is helped a great deal by the 50 Hz monitor. It is important to note, however, that the 50 Hz response must be sharply peaked in order to be a reliable indicator and it is equally noteworthy that the 50 Hz response along a power line will occasionally vanish on one or more lines.

The exact location of an INPUT anomaly with respect to the associated 50 Hz response is important. In cases where a definite cultural conductor is known, the lag between the monitor and INPUT responses is

consistent from line to line. Any departure of the lag interval from the "normal" would raise suspicion of an additional conductor being present.

The direction of the power line must also be considered, as the inductive response diminishes, sometimes markedly, with reduced coupling when the power line makes a shallow angle iwth the flight line. In other cases, the shallow angle results in a broadening of the anomaly shape and of the 50 Hz response.

Geological conductors often carry this 50 Hz response in the vicinity of power lines but these anomalies usually have the appearance of broad swells on the monitor record rather than sharp peaks.

Invariably, there are a few borderline cases, hence the nomenclature "Hz?" appears occasionally on the EM maps.

It is also necessary to utilize the tracking film. . . The exact positions of all anomalies, with the exception of the obvious broad surficial features, are checked on the film and possible cultural sources or the lack thereof, are noted on the work sheets. In this way, cultural features which may not be apparent on the planimetric maps are located. In the same way

small offsets of plotted EM anomalies from cultural features can be very significant in the interpretation of the data.

Another facet of this analysis is the line-to-line comparison of anomaly character along suspected man-made conductors. In general, cultural anomalies should be very narrow, sometimes exhibiting small negatives on their leading edge, and the lag for plotting is often slightly greater than for geological conductors. The INPUT amplitude, the rate of decay, and the anomaly width should not vary a great deal along any one man-made conductor. A marked departure from the average response character along any given feature gives rise to the possibility of a second conductor. A further characteristic of cultural anomalies is that the HRC response amplitude will often be larger than that of the SRC response due to the extreme narrowness of the target.

Any monotonous string of narrow anomalies along a road with a sharp 50 Hz response can be discarded immediately. Even the more localized narrow anomalies can usually be eliminated if a potential cultural source is evident on the tracking film and there is a sharp 50 Hz response. A response over a farm or a farm track can be eliminated with confidence if the

source of power to the farm is obvious. Similarly, an apparently isolated response along a road can often be discarded by checking for feeble, unplotted anomalies on adjacent lines or for 50 Hz responses with no INPUT anomalies.

Anomalies identified as cultural with a very high degree of reliability (designated by "C") can be ignored in the followup programme. In those cases where any reasonable element of doubt remains as to the type of source and/or where the anomalies have sufficiently favourable character to be considered sulphide prospects, a "C?" is shown and the conductive zone is outlined and a ground check is usually recommended.

In most cases a visual examination of the site will suffice as it is only necessary to verify the presence of a man-made conductor. In a few instances we know already that one cultural conductor is present and the object of the ground check is to determine if there is a second cultural source, a variation in the construction of the single source, a change in the grounding conditions, or perhaps a bedrock source. This type of check is obviously more difficult to accomplish.

EDGE EFFECT

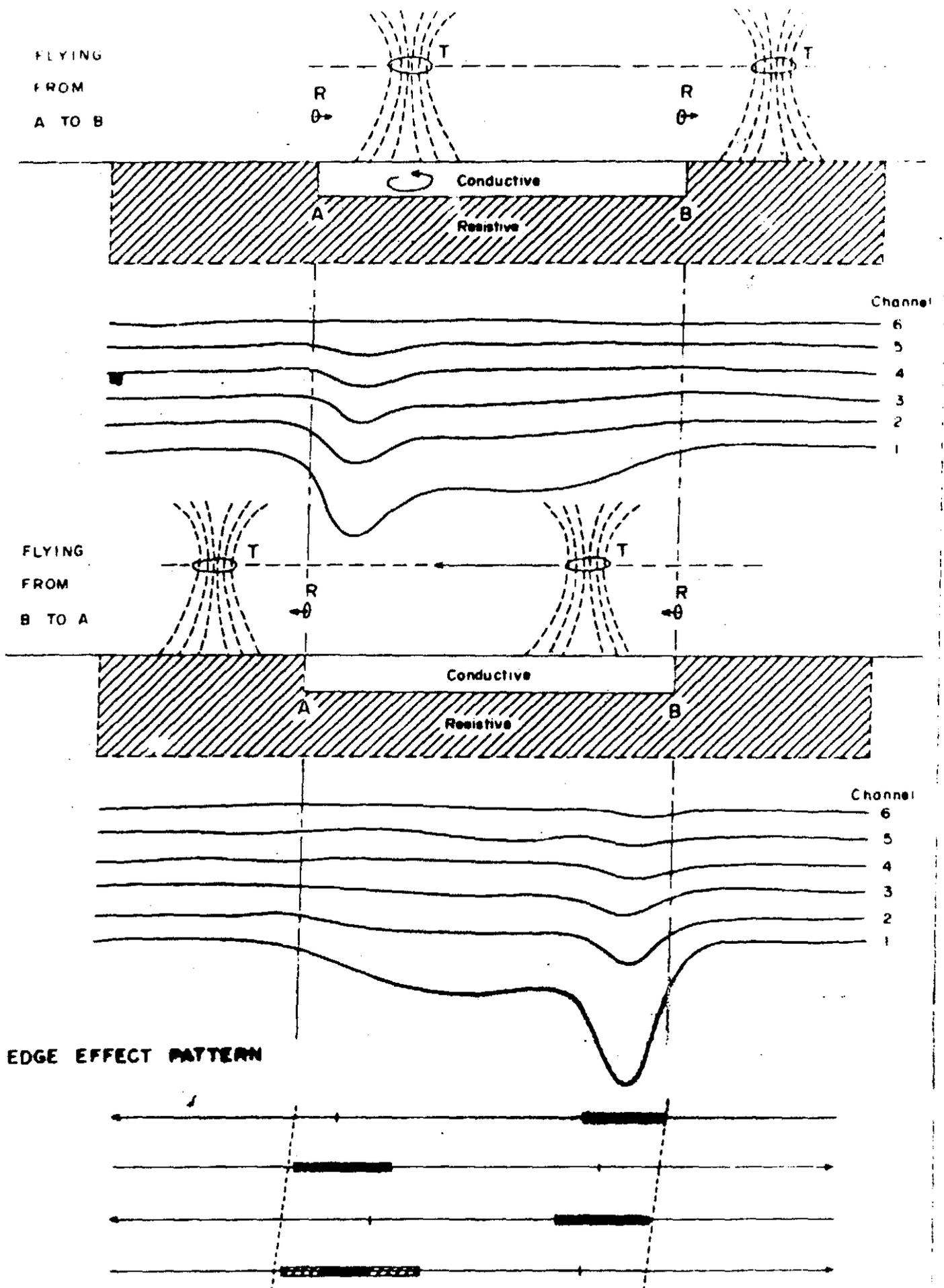
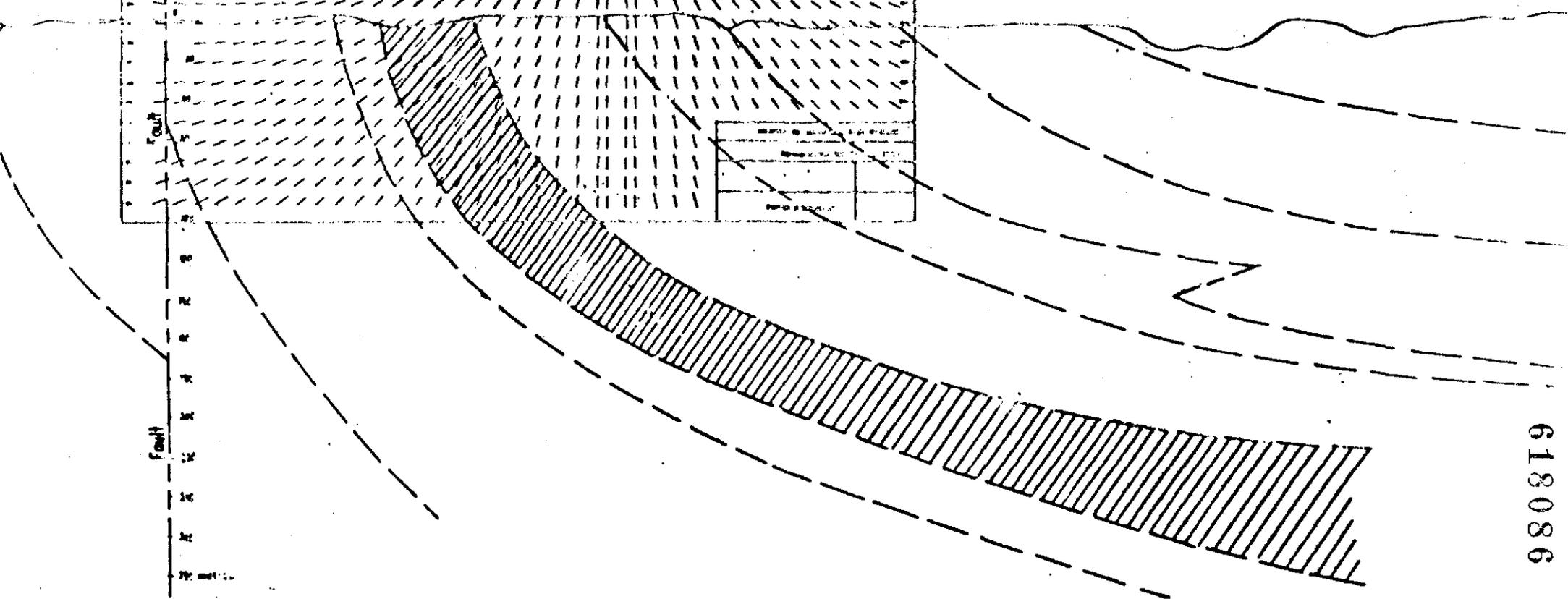
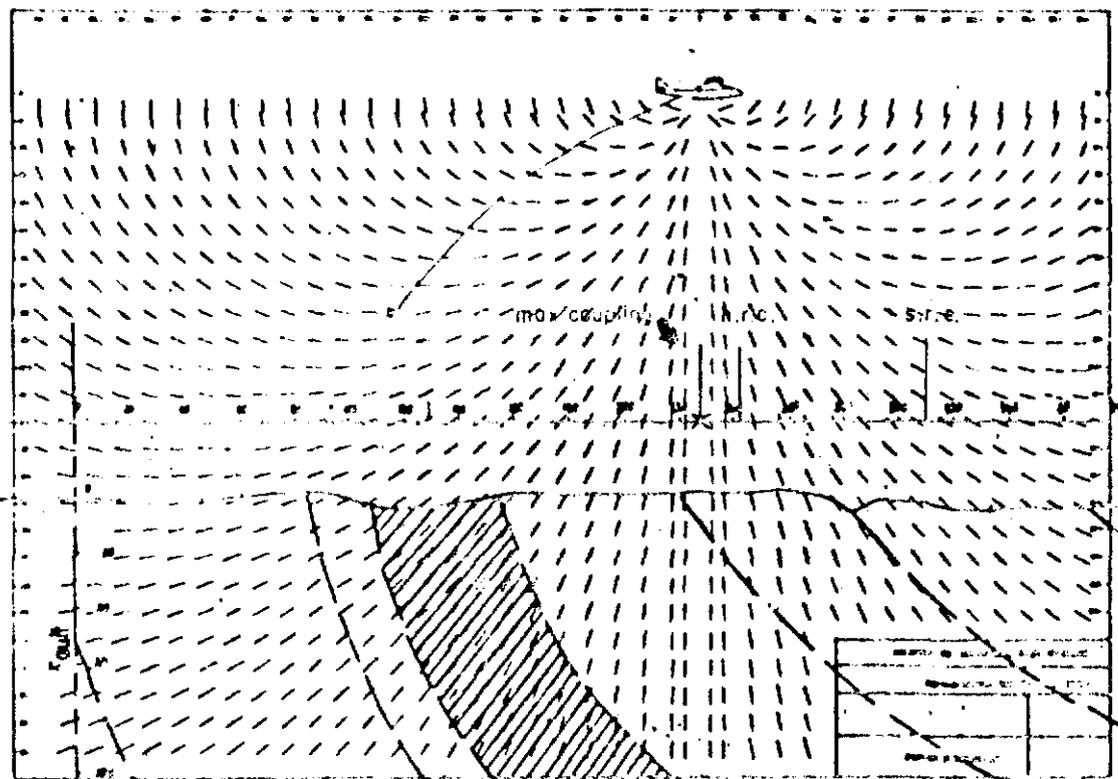


FIGURE I.

FIG. 2

PLATE
DEFECT

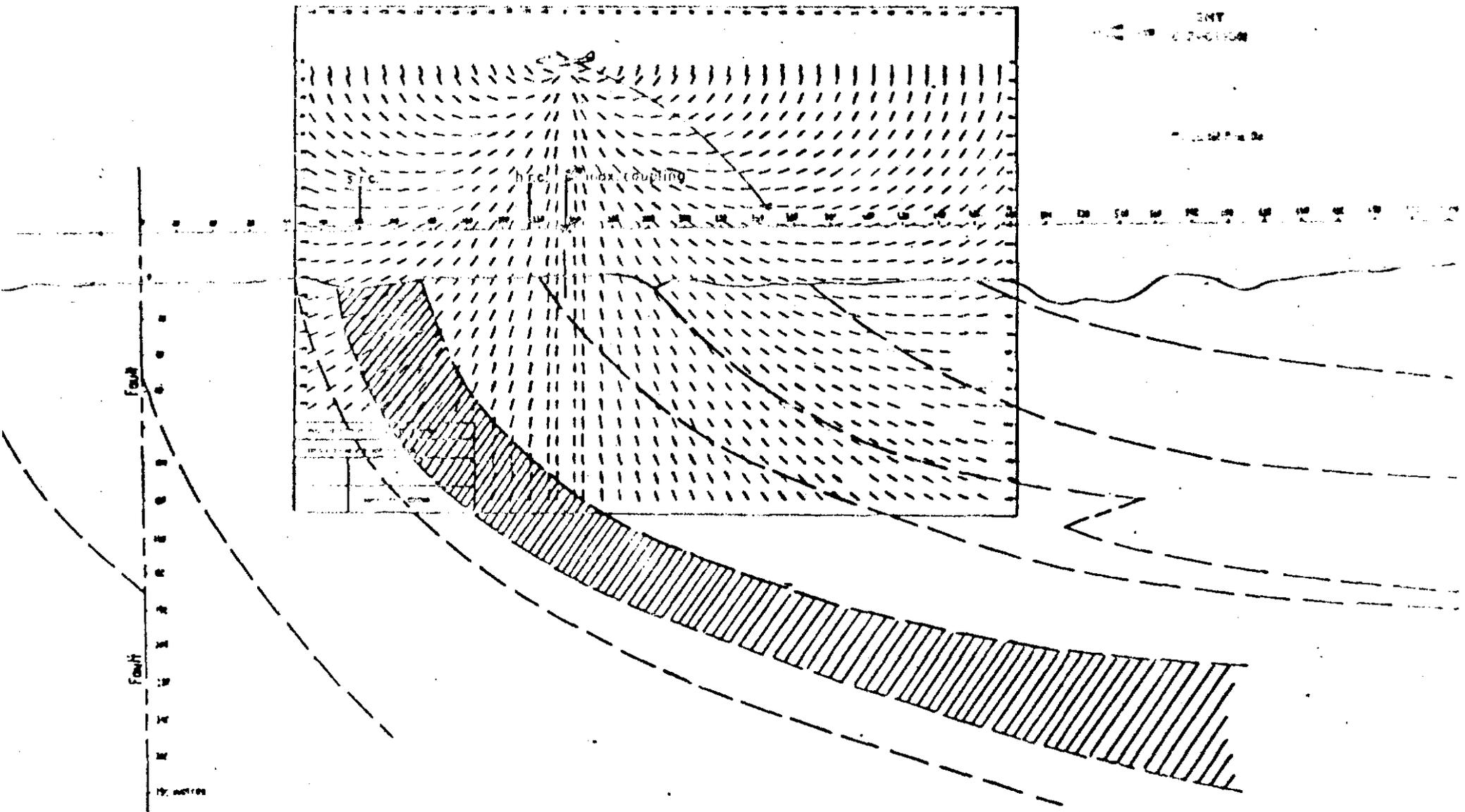
DEFECT



618086

FIG. 3

ENT
SECTION



APPENDIX CINSTRUMENT SPECIFICATIONS AND CALIBRATIONS1. INPUT MARK V

Transmitter : Half-sine wave current pulse system
Frequency: 288 cycles per second.

Receiver	:	Channel	1	2	3	4	5	6
Delay time (centre)			500	700	900	1200	1600	2100 usec.
Channel width			200	200	400	400	600	600 usec.

Primary signal at receiver (in normal bird position): 1.05

Defn 1 million ppm = $\frac{1}{2}$ peak-peak primary signal at receiver = 525MV

a) Standard Resolution Channels

Receiver calibration: 2mV test signal: 3.0" chart deflection

Sensitivity: 0.1" = 165 ppm of primary field
(with time sharing)

b) High Resolution Channels

Receiver calibration: 2mV test signal: 2.0" chart deflection

Sensitivity - analogue: 0.1" = 182 ppm of primary field
digital : 300 digital units = 2mV
1 digital units = 12.7 ppm of
primary field

Synchronisation lag: 2.0 seconds (for vertical surface conductors)

c) Digital Recording (per second)

- 5 HPC INPUT readings
- 1 magnetometer reading

2. MAGNETOMETER

Geometrics G803 Proton Precession

Stinger mounted

Sensor height: 120 m

Sample interval: 1.0 second

Sensitivity: 1.0nT (G)

Full scale chart deflection 100 nT (G) - fine scale
2000 nT (G) - coarse scale

3. ANALOGUE RECORDER

I. - Honeywell visicorder : 50 Hz monitor
Top 6 SRC INPUT traces (positive down)
Terrain clearance (positive down)
Magnetic field (fine + coarse) (positive up)
6 HRC INPUT traces (read after write)
(positive up)

Bottom Fiducial numbers (SCAN TIMES)

Chart speed 6" per minute.

MADACS FORMAT

The tape structure used on this survey is set to record INPUT, magnetic and radiometric data.

The following is the tape decision for a single physical block. Each physical block or record is composed of a 358 byte "header" representing values incremented every second followed by five sequential 16 byte "scans" of INPUT data representing data sampled five times per second, to give a total record length of 438 bytes.

Field Tape Description

Tape density	9-track, 800 bpi
Block size	438 bytes
Recording mode	binary (IBM compatible)

Tape Structure

<u>Byte Position(s)</u>	<u>Number of Bytes</u>	<u>Description</u>
1-4	4	Block number
5-6	2	Flight number
7-8	2	Spare halfword
9-10	2	Spare halfword
11-12	2	Spare halfword
13-16	4	Magnetometer *
17-18	2	(Thorium)
19-20	2	(Uranium)
21-22	2	(Auxilliary Uranium)
23-24	2	(Potassium)
25-26	2	(Total count)
27-28	2	(Cosmic sum)
29-30	2	(Live time in milli-seconds)
31-34	4	Scan Time: tenths of a second past midnight
35-36	2	Fiducial number
37-38	2	For doppler track
39-158	120	(Channels 0-59; two bytes/channel)
159-354	196	(Channels 60-255; one byte/channel)
355-356	2	(Doppler along distance**)
357-358	2	(Doppler across distance**)
359-374	16	INPUT Scan 2
375-390	16	INPUT Scan 4
391-406	16	INPUT Scan 6
407-422	16	INPUT Scan 8
423-438	16	INPUT Scan 0

* The magnetic values represent the earth's total magnetic field. These values are recorded in 1/100th of gammas.

** The positions shown in parenthesis are not required for this survey. The digital print out contains zero values.

Contents of : Single INPUT Scan

<u>Byte Positions(s)</u>	<u>Number of Bytes</u>	<u>Description</u>
1-2	2	INPUT Channel 1
3-4	2	INPUT Channel 2
5-6	2	INPUT Channel 3
7-8	2	INPUT Channel 4
9-10	2	INPUT Channel 5
11-12	2	INPUT Channel 6
13-14	2	Hz Monitor
15-16	2	Radar altimeter in feet

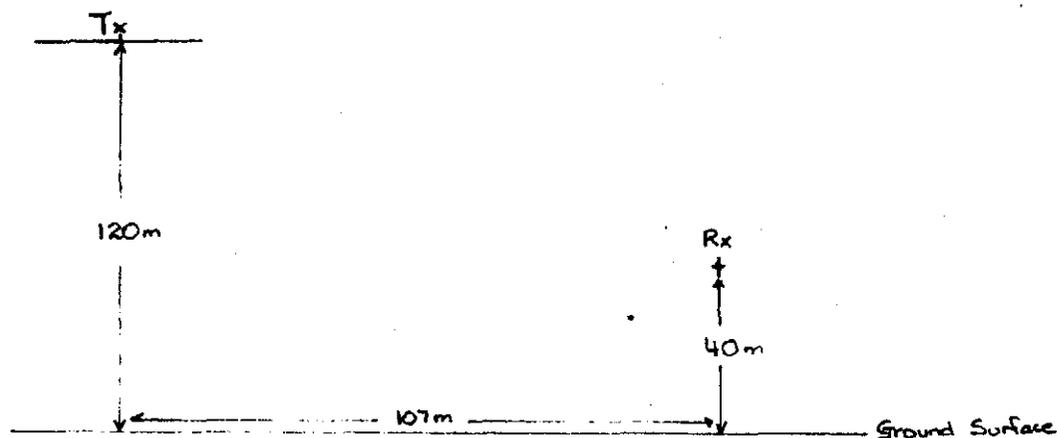
5. RADAR ALTIMETER

Sperrt RT-220 : Scale 1" = 30m

APPENDIX D - COMPUTER PROCESSING METHODS1. CONVENTIONS

The working units used for all computations are Parts for Million of the primary field. 10^6 ppm is defined to be half of the peak to peak voltage induced in the receiver bird in the 'normal' system configuration during the on-time of the primary pulse (Fig. 1). This definition is in accordance with the convention adopted by workers at the University of Toronto.

Figure 1

2. CALIBRATIONS

The 6 channels of raw INPUT data are recorded in arbitrary units (referred to as digital units), so some reference calibration is required to relate digital units to ppm. A 2mV step function is fed into the receiver upon activation from the console by the operator and the gains in the receiver are set such that the response to the 2mV signal is equal to 300 digital units. The peak to peak voltage (referred to as the bird signal) induced in the bird during the primary pulse is recorded and is normally stable at 1.05 volts. Then using the relation :

$$\text{Ppm} = \text{DU} \times \left[\left(\frac{2\text{mV}}{525\text{mV}} \times 10^6 \right) + \text{CAL} \right]$$

where DU = digital units

CAL = response in digital units to the 2mV test signal

we can convert from our arbitrary units to a meaningful scale. This calibration is performed at an altitude in excess of 2000 ft to ensure that ground response does not affect the calibration signals.

3. ZERO LEVEL DETERMINATION

Since the 6 channels of INPUT data are recorded in arbitrary units, the zero level is also arbitrary, that is to say 0 digital units is not necessarily equal to zero ppm. This means that before we can convert digital units to ppm as outlined in section 2 we must establish the true zero level. Presently this is done manually by first replotting the digital data on an electrostatic plotter and drawing on a base (zero) line. The position of this zero line may be determined from the high altitude background test lines flown at the beginning and end of each flight and by identification of resistive sections on line where the channels have decayed to a true zero level. This procedure is carried out for every flight line so that the true datum is established for all data before proceeding to the interpretation stage.

4. LAG

There is a known system lag (due to the rise time of the electronic circuits) of 2.0 seconds between the time at which the INPUT responses are recorded and their true ground position. Before any interpretation is attempted the raw data is lagged to its true position.

5. FILTERING

Prior to interpretation, the INPUT data is filtered using a frequency filter with a wavelength of 25 samples (or 5 seconds) to remove high frequency noise and atmospheric.

6. INTERPRETATION

(I) Time constants

The transient decay curve can be approximated by an exponential curve of the form

$$A_j = A_0 e^{-t_j/\tau}$$

where A_0 = amplitude at initial time

A_j = " " time position j

t_j = time after initial time

τ = time constant

thus for two delay times t_j and t_k (where $t_k > t_j$, t = centre of channel)

$$A_j = A_0 e^{-t_j/\tau}$$

and

$$A_k = A_0 e^{-t_k/\tau}$$

if we take the ratios of the amplitudes A_k and A_j we get

$$\frac{A_j}{A_k} = e^{(t_k - t_j)/\tau}$$

and solving for τ we get

$$\tau_{jk} = \frac{t_k - t_j}{\text{Loge} (A_j/A_k)}$$

thus the time constant between channels 2 and 3 denoted by τ_{23} would be given by :

$$\tau_{23} = \frac{t_3 - t_2}{\text{Loge} (A_2/A_3)}$$

We may also take the average of successive time constants and we define the average to be:

$$\tau_{36} = \frac{\tau_{34} + \tau_{35} + \tau_{56}}{3}$$

$$\tau_{25} = \frac{\tau_{23} + \tau_{34} + \tau_{45}}{3}$$

Presently, all successive time constants ie τ_{12} , τ_{23} , τ_{34} , τ_{45} , τ_{56} may be calculated and stores, and τ_{36} and τ_{25} are also calculated.

NOTE: The 6 channels of INPUT data used in the time constant calculations are all from the same unique time position (fiducial or scan time). When the ratio of amplitudes $A_j/A_k < 1.01$ no calculation is made and no calculation is attempted when the signal level in the channel involved is less than 50 ppm.

(II) Average amplitude

Dyck et al ** have shown that a quantity called average amplitude (which is really the area beneath the decay curve) can be diagnostic of electrical layering especially when used in conjunction with time constant. It is defined to be:

$$AA = \sum_i^{i=j} \left[\frac{(A_n + A_{n+1}) (t_n - t_{n-1})}{\sum_i^{i=j} \Delta t_n} \right]$$

where A_n = amplitude of the nth channel - ppm

A_{n-1} = " " " nth-1 channel - ppm

t_n = centre of the nth channel - microseconds

t_{n-1} = " " " nth-1 " - microseconds

t_n = width of the nth channel - "

(i = first channel to be used for the calculation

*

(j = last " " " " " " " "

(III) Ratio

The ratio of any two channels may be calculated. Presently we use the ratio of channel 2/channel 5 as this is the ratio that is plotted in the field and on the EM anomaly maps.

No calculation is attempted when the signal level is either of the channels decreases to less than 50 ppm.

* under ideal conditions all six channels would be used in the calculation but if there is zero response on the late channels or if channel 1 exceeds its dynamic range (maximum recordable value after A/O^o conversion is 2048 du) these situations would adversely affect the calculation and render it meaningless.

Presently we are calculating two Average Amplitudes, one using all channels - AA16, and one using only channels 2 to 6 - AA26.

No calculations are attempted when the signal level in any of the channels is less than 50 ppm.

** Dyck. A.V., Becker. A., Collett. L.S. : 1974.
Surficial conductivity mapping with the airborne INPUT system.
CIM Bulletin, page 104-109, April, 1974.

(IV) Apparent Half Space Resistivity

The response of the INPUT system to a half space of any particular conductivity can be numerically modelled on a computer and the results stored in a tabular form (Figure 2), each table of values corresponding to a particular altitude of the system above the surface of the half space. Thus an "apparent half space resistivity" can be determined by searching through the master tables until a satisfactory match between the field and theoretical data is achieved. Presently we have 6 master tables of half space responses, one each for 120 metres, 150 metres, 200 metres, 300 metres, 400 metres and 500 metres aircraft altitude. Each table contains the theoretical response for the system configuration described in Appendix C spanning 4 decades of conductivity from .005 mhos to 5.0 mhos with 9 data points per decade. As the curves are smoothly variant this is an adequate definition of their shape.

The method of determining an "apparent half space resistivity" is as follows :-

- firstly the aircraft altitude is checked so that only the master tables for altitudes \geq the recorded altitude are considered for searching. This prevents the occurrence of half space conductors above the ground surface.
- each of the remaining master tables is searched separately until a conductivity value is found which minimises the

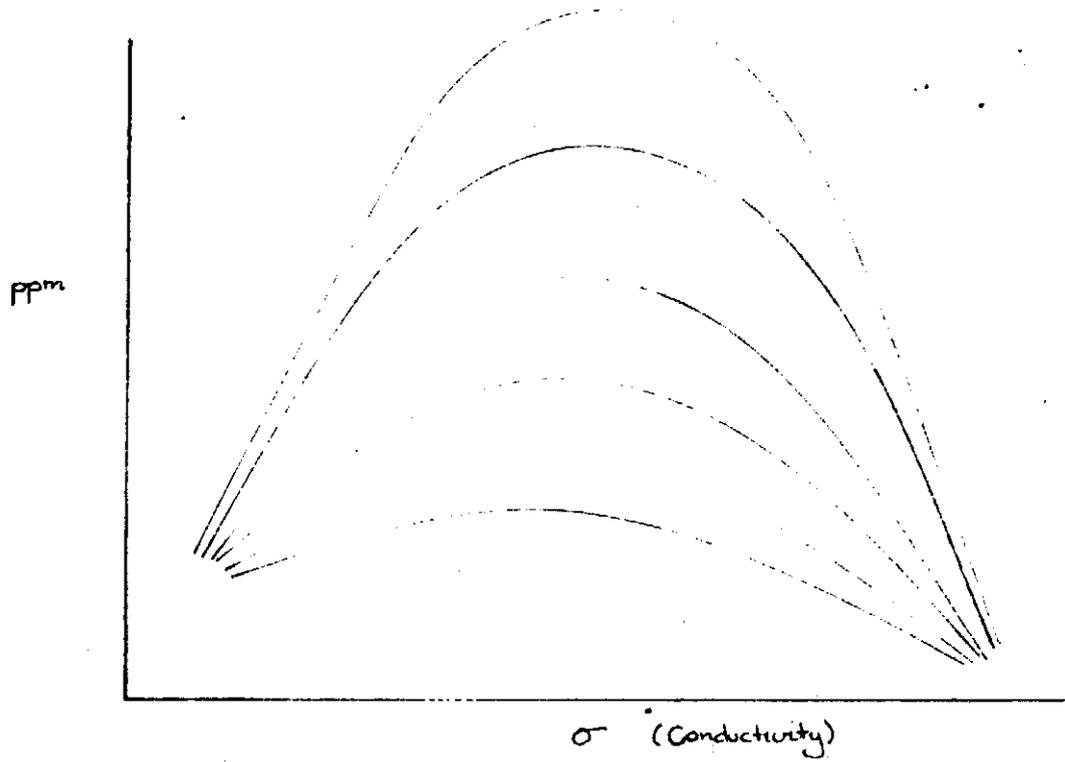


Figure 2

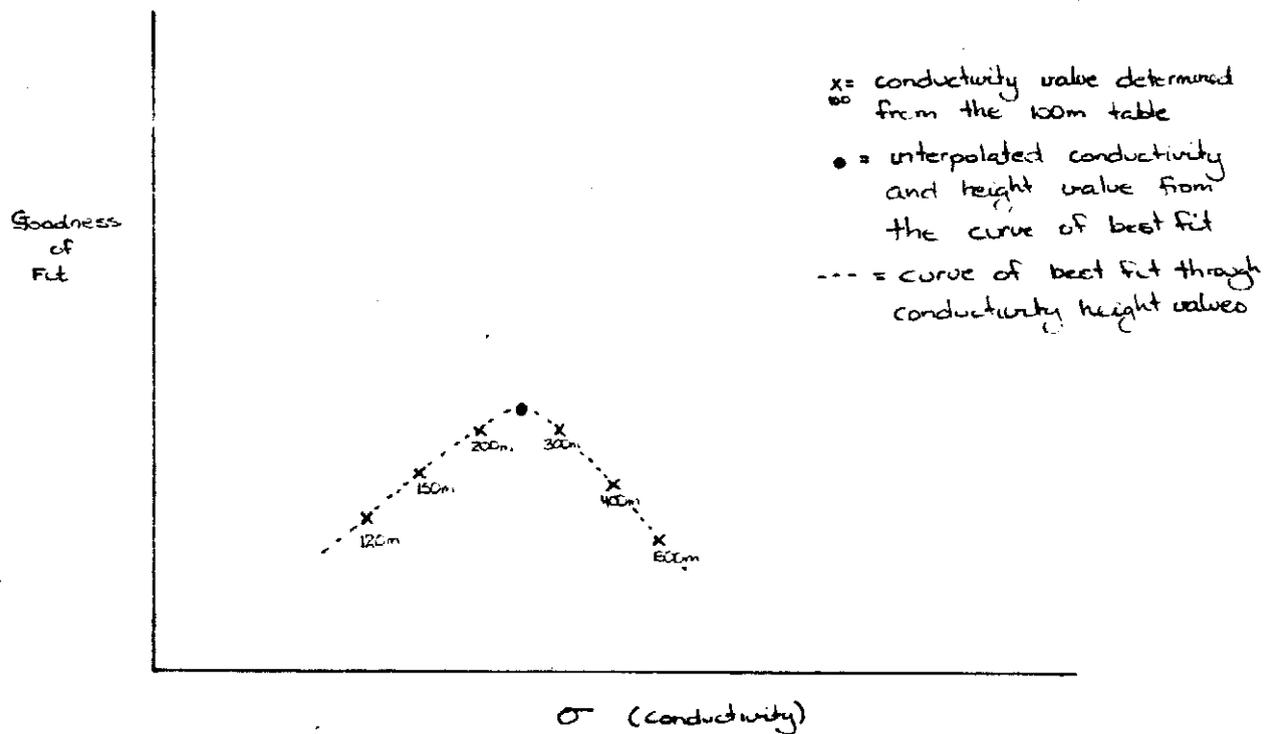


Figure 3

differences (in a least squares fashion) between the theoretical data and the field data. All of the 6 channel valves are used in this curve matching procedure although some of the channels are downweighted since they may have greater noise contributions in their signals. The weighting applicable to each channel is determined by the user, based upon his knowledge of the signal strength (directly related to the conductivity environment), the level of noise present in each channel response and the stability of the channel position. The current weights used for channels 1-6 are 0.75, 1.0, 1.0, 1.0, 0.75, 0.5. The reason for the reduced weighing of channel 1 is that a small fluctuation in gate position at early times creates considerably larger amplitude variations than at late times.

- when the curve matching within each table is complete we are left with a number of conductivity and height values each with a degree of fit determined by the least squares minimisation fitting. We now determine the best fitting curve through these conductivity height versus degree of fit values and interpolate the best fit conductivity, height and degree of fit (figure 3). The conductivity is inverted to give a resistivity value, the aircraft altitude is subtracted from the height to give a depth below ground surface to the top of the half space conductor and the goodness of fit is converted to a percentage number.
- This process is performed only at every 5th data point and not for every data point as for all other calculations.

7. PRESENTATION

Assuming that most or all of the quantities outlined in the interpretation section have been calculated, numerous presentation options are available, the most comprehensive being the multi-channel profile or "multiplot". The present multiplot format, plotted at suitable vertical scales and on a true geographic co-ordinate X- axis is listed below. Recovered fiducials are also plotted and labelled.

Channel	Sense	Scale
Aircraft altitude	positive down	Linear
Coarse Magnetometer)	positive up	"
Fine Magnetometer)	"	"
INPUT Channel 1)	"	"
" " 2)	"	"
INPUT Channel 3)	"	"
INPUT " 4)	"	"
INPUT Channel 5)	"	"
" " 6)	"	"
Average Amplitude 1-6)	"	"
" " 2-5)	"	"
Time constant 36)	"	Logarithmic
" " 25)	"	"
Apparent half space resistivity	"	"
Depth below ground surface to top of half space	positive down	Linear
Channel 2/5 ratio	positive up	Logarithmic
Model Fit	"	Linear

The interpreter is able to examine the multiplots to determine which parameters are most diagnostic of the particular target of interest and subsequently what type of parameter map would assist most in solving his exploration problem. Further, the

) indicates that these channels are on the same axis.

scales and accuracy of the plotted parameters ensure that the multiplot is also extremely useful in a quantitative manner.

It is possible to present any of the raw channels or derived parameters as either contour, stacked profile or perspective maps.

8. LOCATED DATA TAPE FORMAT DESCRIPTION

<u>Columns</u>	<u>Description</u>
1-6	Date in ddmmyy
7	Blank
8-10	Flight number
11-16	Time in seconds
17	Blank
18-23	Line number
24-29	Fiducial
30	Asterisk (*) if recovered point
31-37	Easting coordinate
38	Blank
39-45	Northing coordinate
46	Blank
47-52	MAG (Levelled & IGRF removed)
53-58	MAG (RAW)
59-62	ALTIMETER (METRES)
63-69	P1 (Reduced channel 1 INPUT data-ppm)
70-76	P2 (Reduced channel 2 INPUT data-ppm)
77-83	P3 (Reduced channel 3 INPUT data-ppm)
84-90	P4 (Reduced channel 4 INPUT data-ppm)
91-97	P5 (Reduced channel 5 INPUT data-ppm)
98-104	P6 (Reduced channel 6 INPUT data-ppm)
105-110	TAU12 (Time constant-channels 1-2 - microseconds)
111-116	TAU23 (Time constant-channels 2-3 - microseconds)
117-122	TAU34 (Time constant-channels 3-4 - microseconds)
123-128	TAU45 (Time constant-channels 4-5 - microseconds)
129-134	TAU56 (Time constant-channels 5-6 - microseconds)
135-140	TAU36 (Average Time constant-channels 3-6 - microseconds)
141-146	TAU25 (Average Time constant-channels 2-5 - microseconds)

Contd.

LOCATED DATA TAPE FORMAT DESCRIPTION Contd.

<u>Columns</u>	<u>Description</u>
147-152	AV16 (Average amplitude-channels 1-6 - ppm)
153-158	AV26 (Average amplitude-channels 2-6 - ppm)
159-164	R25 (Channel 2/Channel 5 Ratio)
165-170	C (Apparent Half Space Resistivity)
171-176	TCP (Depth below surface of the half space conductor-metres)
177-181	MISR1 (Half space model fit)

BLOCK SIZE : 3864 Bytes

RECORD SIZE : 184 Bytes

CODE : ASCII 1600 BPI

5450000 N

5447500 N

5445000 N

5442500 N

5440000 N

390000 E

392500 E

395000 E

397500 E

400000 E

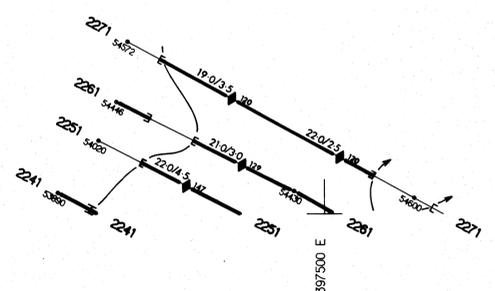
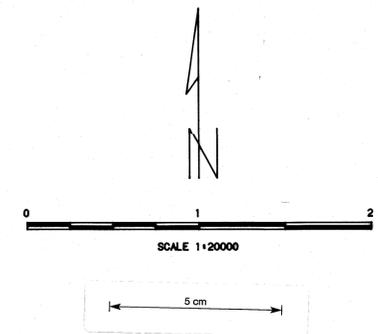
AIRBORNE SURVEY SPECIFICATIONS

EM SYSTEM : INPUT MARK V
 Channel centres 500, 700, 900, 1200,
 1600 and 2100 microseconds after
 transmitter switch off.
 EM RECORDING INTERVAL : 0.2 sec (approx 13 metres)
 MAGNETOMETER : Geotrex G803, sensitivity 1.0nT.
 MAG RECORDING INTERVAL : 1.0 sec (approx 60 metres)
 DATA RECORDING : Geotrex Madacs system, digital to mag tape
 NOMINAL SPEED : mean ground speed 220 km per hour.
 NOMINAL TERRAIN CLEARANCE : Mag and spectrometer in aircraft at 120m.
 EM transmitter in aircraft at 120m.
 EM detector in bird at 40m.
 FLIGHT PATH RECORD : Geocam continuous 35mm tracking camera
 NOMINAL LINE SPACING : Traverses 300m SE-NW, tie lines not flown

E.M. ANOMALY MAP

Sheet 20/3944
 Grid notation refers to Australian Map Grid
 Path recovery digitized from 1:20000 topo maps
 Large 6 channel response 
 6 channel response 
 5 channel response 
 4 channel response 
 3 channel response 
 2nd & 5th channel amplitudes 10/1.0 
 Altitudes (metres) 120 
 Offset magnetic anomaly 22nT 
 Hertz response 
 Zone number 20/3943/IH1
 Conductor boundary 
 Inferred boundary 

20/3944	
20/3943	20/4043

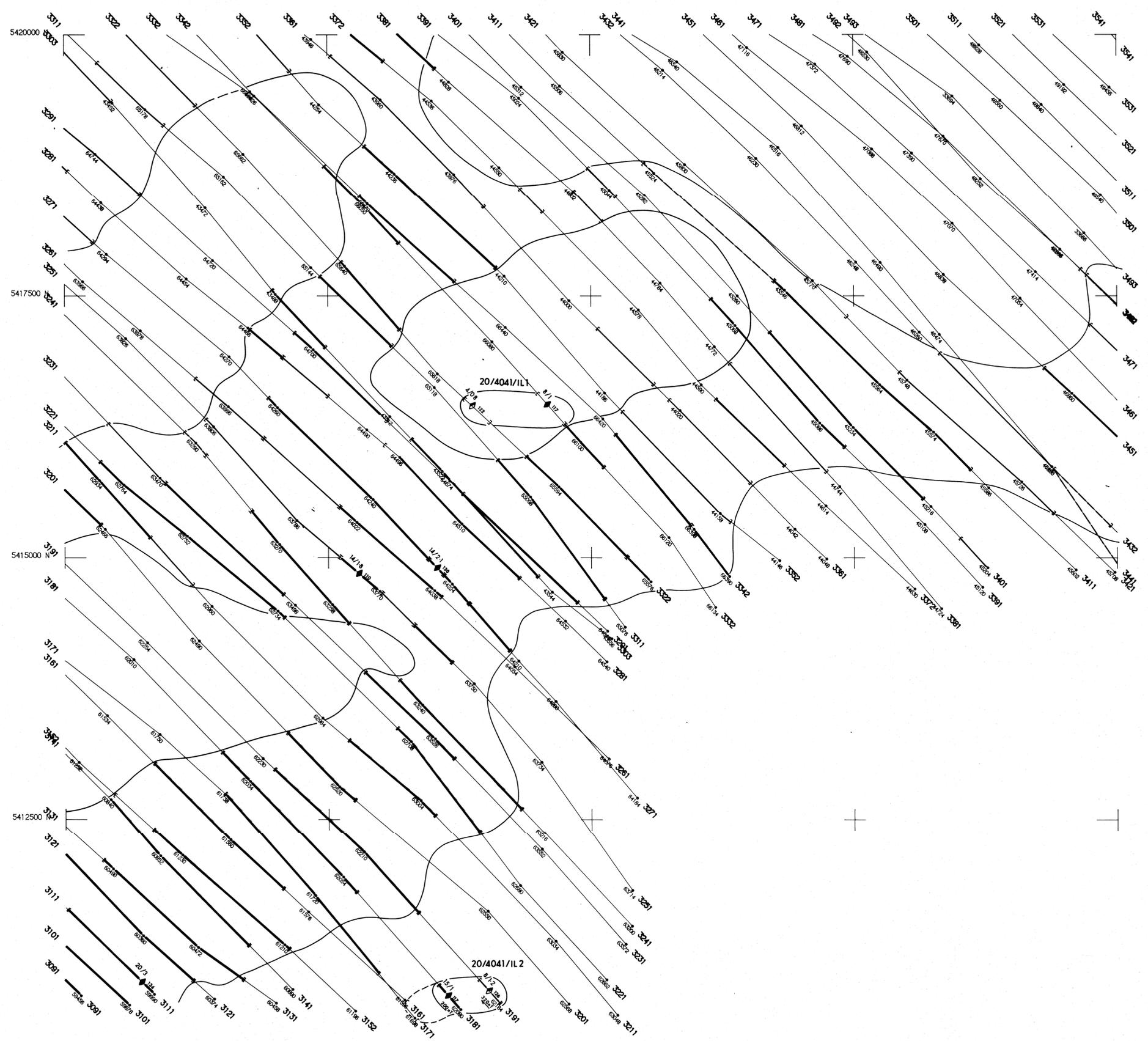


JOB NO : 83-548
 Flown by GEOTERREX PTY LTD : JANUARY 1982
 Compiled by EXPLORATION COMPUTER SERVICES PTY LTD

THE SHELL COMPANY
 OF AUSTRALIA LIMITED

HIGHCLERE, TASMANIA
 E.M. ANOMALY MAP
 SHEET 20/3944

PROJ NO. : DATE : 3-MAR-82



EM SYSTEM : INPUT MARK V
 Channel centres: 500, 700, 900, 1200, 1600 and 2100 microseconds after transmitter switch off.
 EM RECORDING INTERVAL : 0.2 sec (approx 13 metres)
 MAGNETOMETER : Geometrics G803 sensitivity 1.0nT.
 MAG RECORDING INTERVAL : 1.0 sec (approx 60 metres)
 DATA RECORDING : Geotrex Madacs system, digital to mag tape
 NOMINAL SPEED : mean ground speed 220 km per hour.
 NOMINAL TERRAIN CLEARANCE : Mag and spectrometer in aircraft at 120m.
 EM transmitter in aircraft at 120m.
 EM detector in bird at 40m.
 FLIGHT PATH RECORD : Geotrex continuous 35mm tracking camera
 NOMINAL LINE SPACING : Traverses 300m SE-NW, tie lines not flown

E.M. ANOMALY MAP

Sheet 20/4041
 Grid notation refers to Australian Map Grid
 Path recovery digitized from 1:20000 topo maps

Large 6 channel response

6 channel response

5 channel response

4 channel response

3 channel response

2nd & 5th channel amplitudes 10/10

Altitudes (metres)

Offset magnetic anomaly

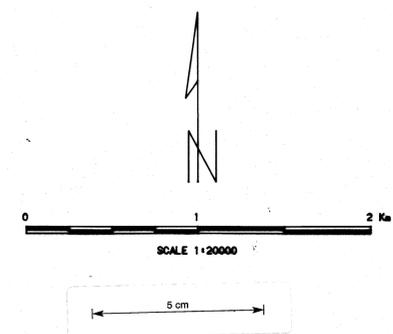
Hertz response

Zone number **20/4041/IL1**

Conductor boundary

Inferred boundary

20/3942	20/4042	20/4142
20/3941	20/4041	20/4141



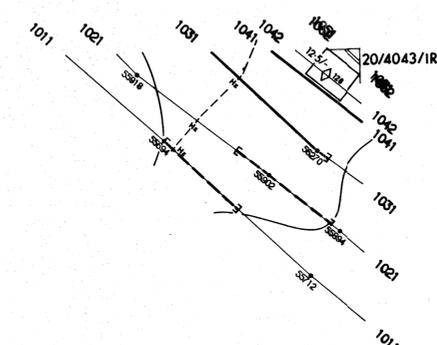
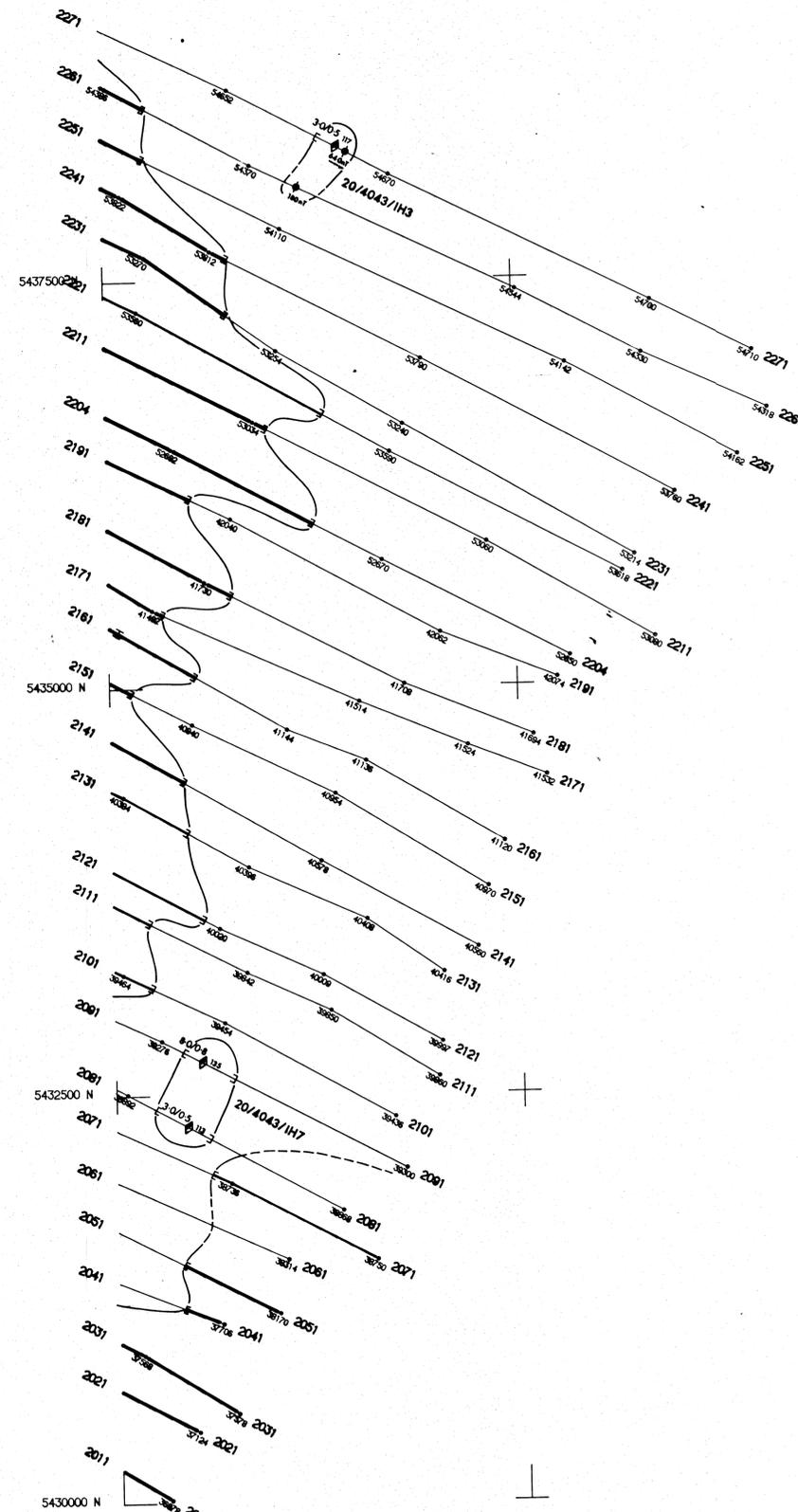
JOB NO : 83-548
 Flown by GEOTREX PTY LTD : JANUARY 1982
 Compiled by EXPLORATION COMPUTER SERVICES PTY LTD

THE SHELL COMPANY OF AUSTRALIA LIMITED

LOONGANA, TASMANIA
 E.M. ANOMALY MAP
 SHEET 20/4041

PROJ NO. DATE: 3-MAR-82

5440000 N



AIRBORNE SURVEY SPECIFICATIONS

EM SYSTEM : INPUT MARK V
 Channel centres 500, 700, 900, 1200, 1600 and 2100 microseconds after transmitter switch off.

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MAGNETOMETER : Geometrics G803, sensitivity 1.0nT.

MAG RECORDING INTERVAL : 1.0 sec (approx 60 metres)

DATA RECORDING : Geotrex Madacs system, digital to mag tape

NOMINAL SPEED : mean ground speed 220 km per hour.

NOMINAL TERRAIN CLEARANCE : Mag and spectrometer in aircraft at 120m.
 EM transmitter in bird at 40m.

FLIGHT PATH RECORD : Geocam continuous 35mm tracking camera

NOMINAL LINE SPACING : Traverses 300m SE-NW, tie lines not flown

E.M. ANOMALY MAP

Sheet 20/4043
 Grid notation refers to Australian Map Grid
 Path recovery digitized from 1:20000 topo maps

Large 6 channel response

6 channel response

5 channel response

4 channel response

3 channel response

2nd & 5th channel amplitudes

Altitudes (metres)

Offset magnetic anomaly

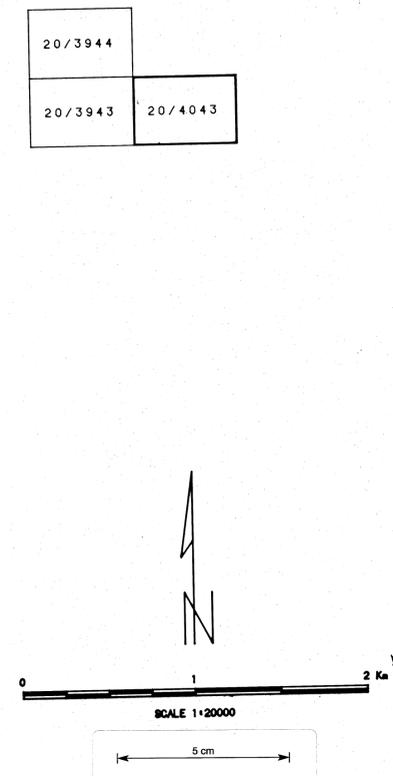
Hertz response

Zone number

Conductor boundary

Inferred boundary

20/3944
 20/3943 20/4043



JOB NO : 83-548
 Flown by GEOTREX PTY LTD : JANUARY 1982
 Compiled by EXPLORATION COMPUTER SERVICES PTY LTD

THE SHELL COMPANY
 OF AUSTRALIA LIMITED

HIGHCLERE, TASMANIA
 E.M. ANOMALY MAP
 SHEET 20/4043

PROJ NO. : DATE : 3-MAR-82

5435000 N
 5432500 N
 5430000 N

400000 E
 402500 E
 405000 E
 407500 E
 410000 E

AIRBORNE SURVEY SPECIFICATIONS

EM SYSTEM : INPUT MARK V
 Channel centres: 500, 700, 900, 1200,
 1600 and 2100 microseconds after
 transmitter switch off.

EM RECORDING INTERVAL : 0.2 sec (approx 13 metres)
 MAGNETOMETER : Geometrics 6803, sensitivity 1.0nT.
 MAG RECORDING INTERVAL : 1.0 sec (approx 60 metres)
 DATA RECORDING : Geotrex Madaga system, digital to mag tape
 NOMINAL SPEED : mean ground speed 220 km per hour.

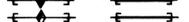
NOMINAL TERRAIN CLEARANCE : Mag and spectrometer in aircraft at 120m.
 EM transmitter in aircraft at 120m.
 EM detector in bird at 40m.

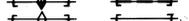
FLIGHT PATH RECORD : Geocam continuous 35mm tracking camera
 NOMINAL LINE SPACING : Traverses 300m SE-NW, tie lines not flown

E.M. ANOMALY MAP

Sheet 20/4044
 Grid notation refers to Australian Map Grid
 Path recovery digitized from 1:20000 topo maps

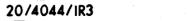
Large 6 channel response 

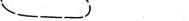
6 channel response 

5 channel response 

4 channel response 

3 channel response 

2nd & 5th channel amplitudes 

Altitudes (metres) 

Offset magnetic anomaly 

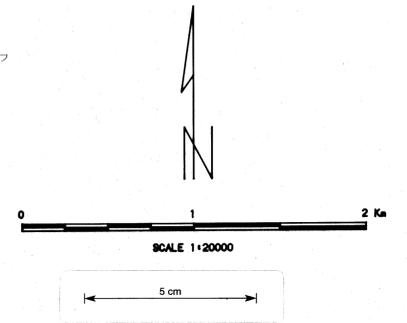
Hertz response 

Zone number **20/4044/IR3**

Conductor boundary 

Inferred boundary 

20/4044	20/4144
20/4043	20/4143

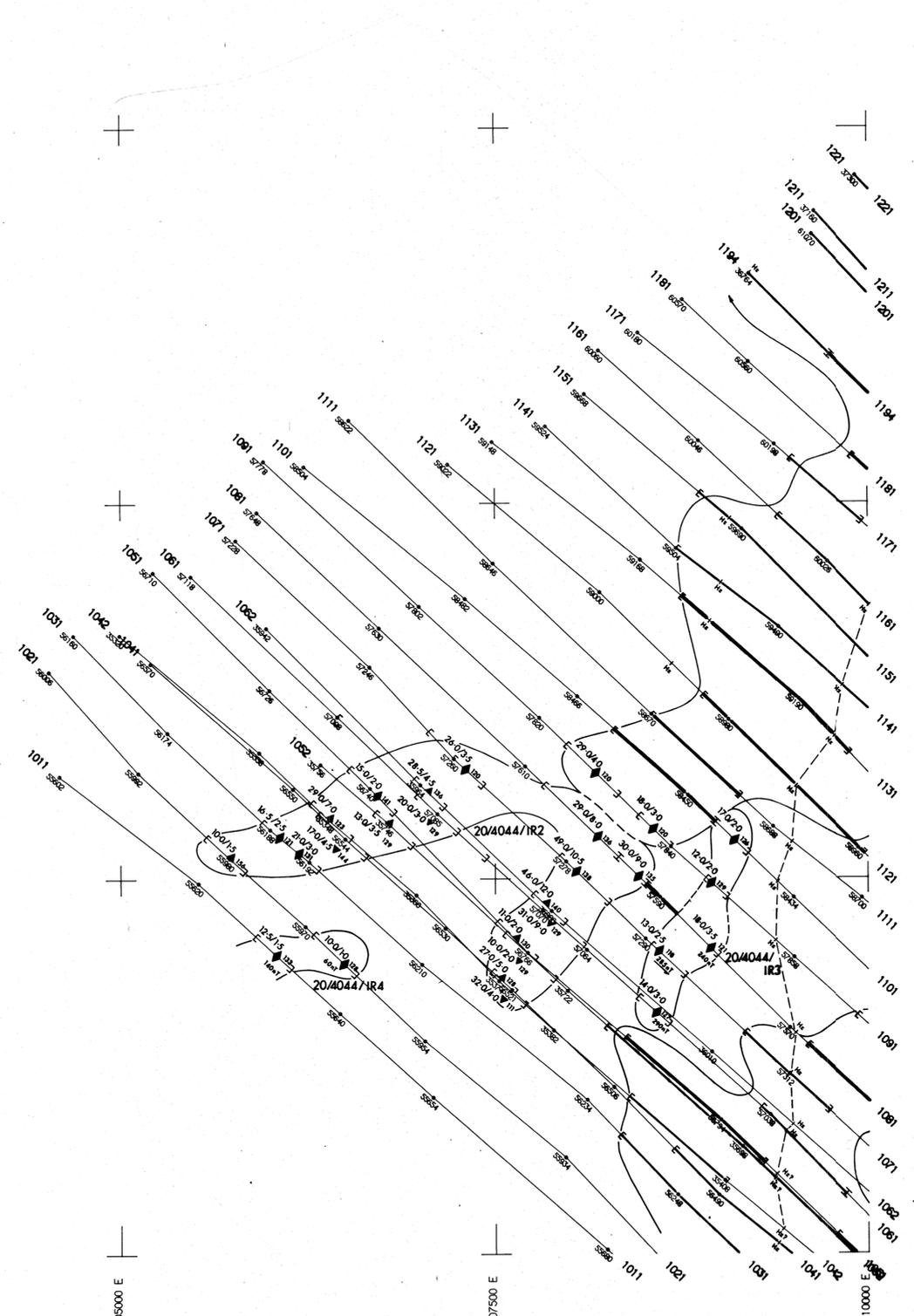


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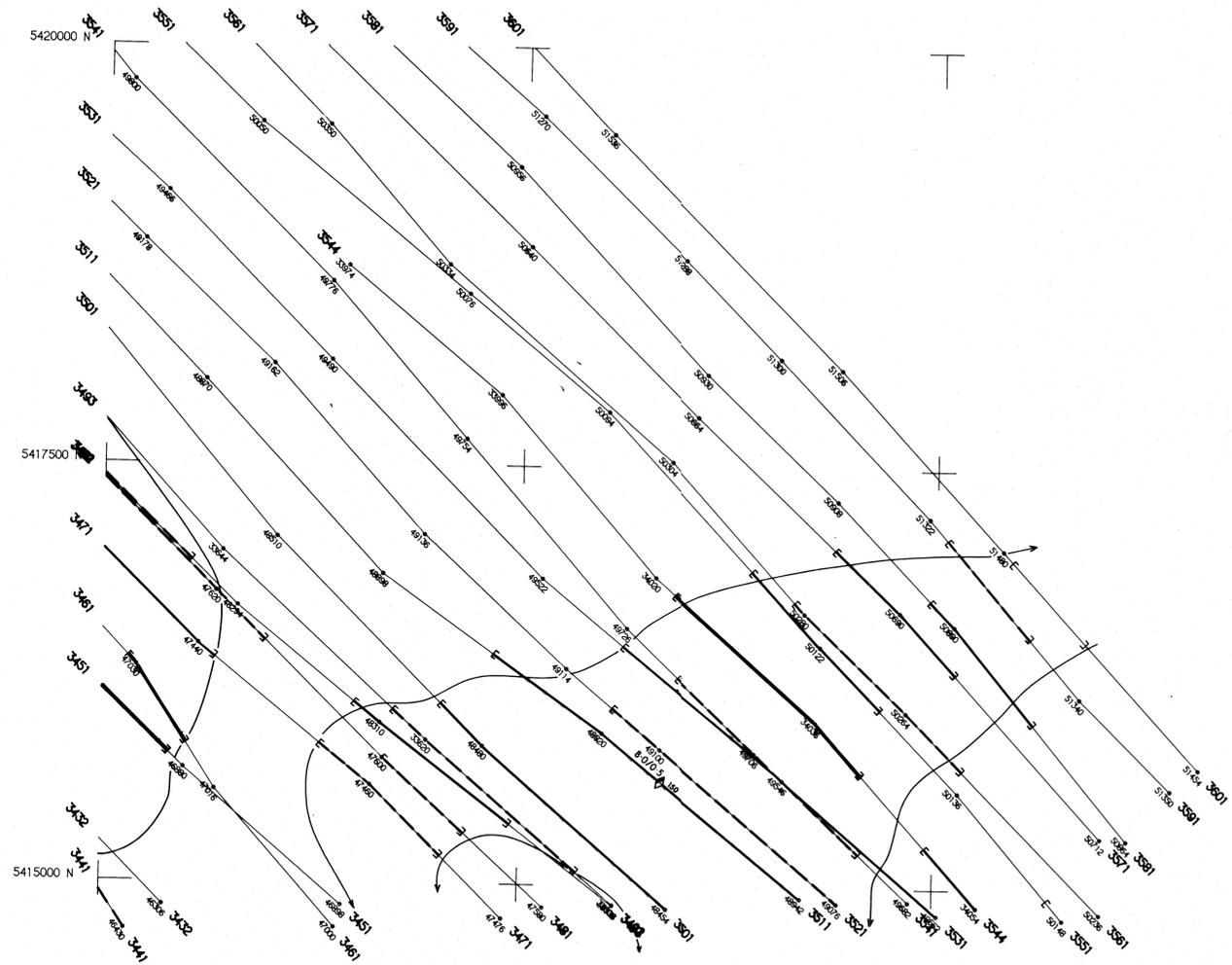
RIANA, TASMANIA
 E.M. ANOMALY MAP
 SHEET 20/4044

PROJ NO. DATE: 3-MAR-82



545000 N
 5447500 N
 5445000 N
 5442500 N
 5440000 N

40000 E
 402500 E
 405000 E
 407500 E
 410000 E



AIRBORNE SURVEY SPECIFICATIONS

EM SYSTEM : INPUT MARK V
 Channel centres: 500, 700, 900, 1200, 1600 and 2100 microseconds after transmitter switch off.

EM RECORDING INTERVAL : 0.2 sec (approx 13 metres)

MAGNETOMETER : Geometrics G803, sensitivity 1.0nT.

MAG RECORDING INTERVAL : 1.0 sec (approx 60 metres)

DATA RECORDING : Geotrex Medaca system, digital to mag tape

NOMINAL SPEED : mean ground speed 220 km per hour.

NOMINAL TERRAIN CLEARANCE : Mag and spectrometer in aircraft at 120m.
 EM transmitter in aircraft at 120m.
 EM detector in bird at 40m.

FLIGHT PATH RECORD : Geocam continuous 35mm tracking camera

NOMINAL LINE SPACING : Traverses 300m SE-NW, tie lines not flown

E.M. ANOMALY MAP
 Sheet 20/4141
 Grid notation refers to Australian Map Grid
 Path recovery digitized from 1:20000 topo maps

Large 6 channel response

6 channel response

5 channel response

4 channel response

3 channel response

2nd & 5th channel amplitudes 10/10

Altitudes (metres)

Offset magnetic anomaly

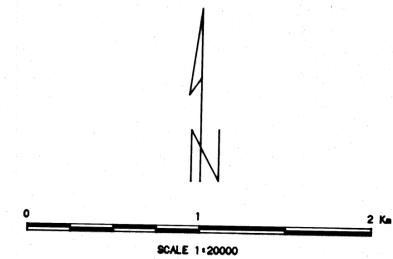
Hertz response

Zone number 20/4041/IL1

Conductor boundary

Inferred boundary

20/3942	20/4042	20/4142
20/3941	20/4041	20/4141

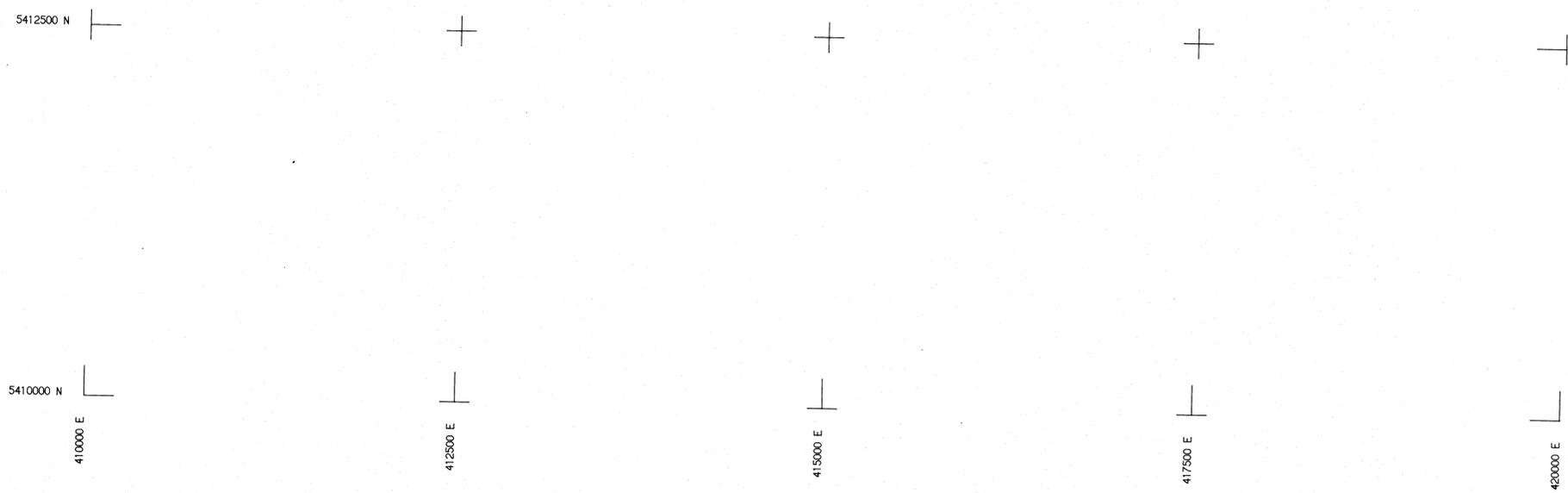


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LOONGANA, TASMANIA
E.M. ANOMALY MAP
SHEET 20/4141

PROJ NO. _____ DATE: _____ 3-MAR-82



AIRBORNE SURVEY SPECIFICATIONS

EM SYSTEM : INPUT MARK V
 Channel centres 500, 700, 900, 1200, 1600 and 2100 microseconds after transmitter switch off.
 EM RECORDING INTERVAL : 0.2 sec (approx 13 metres)
 MAGNETOMETER : Geometrics G803, sensitivity 1.0nT.
 MAG RECORDING INTERVAL : 1.0 sec (approx 60 metres)
 DATA RECORDING : Geotrex Medacs system, digital to mag tape
 NOMINAL SPEED : mean ground speed 220 km per hour.
 NOMINAL TERRAIN CLEARANCE : Mag and spectrometer in aircraft at 120m.
 EM transmitter in aircraft at 120m.
 EM detector in bird at 40m.
 FLIGHT PATH RECORD : Geocom continuous 35mm tracking camera
 NOMINAL LINE SPACING : Traverses 300m SE-NW, tie lines not flown

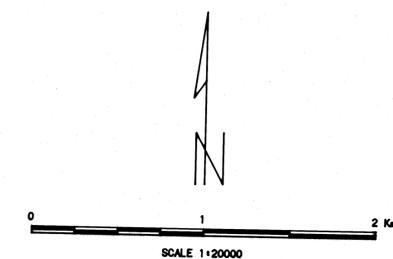
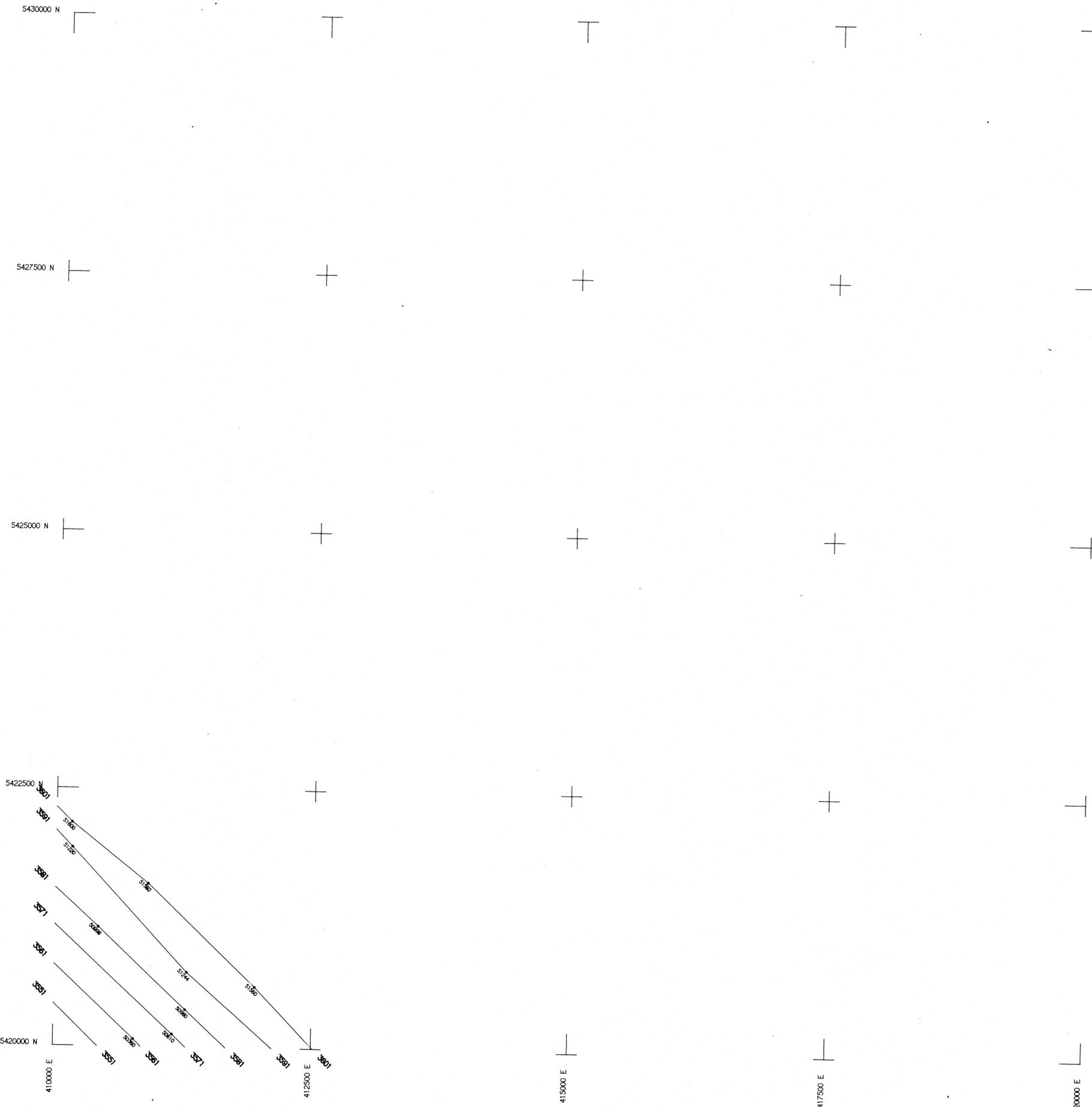
E.M. ANOMALY MAP

Sheet 20/4142
 Grid notation refers to Australian Map Grid
 Path recovery digitized from 1:20000 topo maps

Large 6 channel response 
 6 channel response 
 5 channel response 
 4 channel response 
 3 channel response 
 2nd & 5th channel amplitudes $\frac{10}{10}$ 
 Altitudes (metres) 
 Offset magnetic anomaly 
 Hertz response 

Zone number 20/4041/IL1
 Conductor boundary 
 Inferred boundary 

20/3942	20/4042	20/4142
20/3941	20/4041	20/4141



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LOONGANA, TASMANIA
E.M. ANOMALY MAP
SHEET 20/4142

PROJ NO. _____ DATE: 3-MAR-82

AIRBORNE SURVEY SPECIFICATIONS

EM SYSTEM : INPUT MARK V
 Channel centres 500, 700, 900, 1200, 1600 and 2100 microseconds after transmitter switch off.
 EM RECORDING INTERVAL : 0.2 sec (approx 13 metres)
 MAGNETOMETER : Geometrics G803, sensitivity 1.0nT.
 MAG RECORDING INTERVAL : 1.0 sec (approx 60 metres)
 DATA RECORDING : Geotrex Madacs system, digital to mag tape
 NOMINAL SPEED : mean ground speed 220 km per hour.
 NOMINAL TERRAIN CLEARANCE : Mag and spectrometer in aircraft at 120m.
 EM transmitter in aircraft at 120m.
 EM detector in bird at 40m.
 FLIGHT PATH RECORD : Geocam continuous 35mm tracking camera
 NOMINAL LINE SPACING : Traverses 300m SE-NW, tie lines not flown

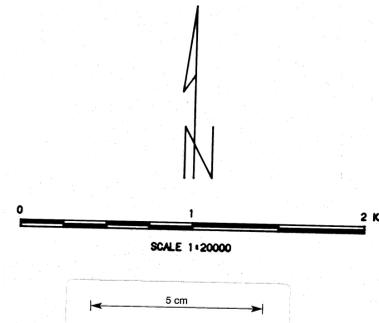
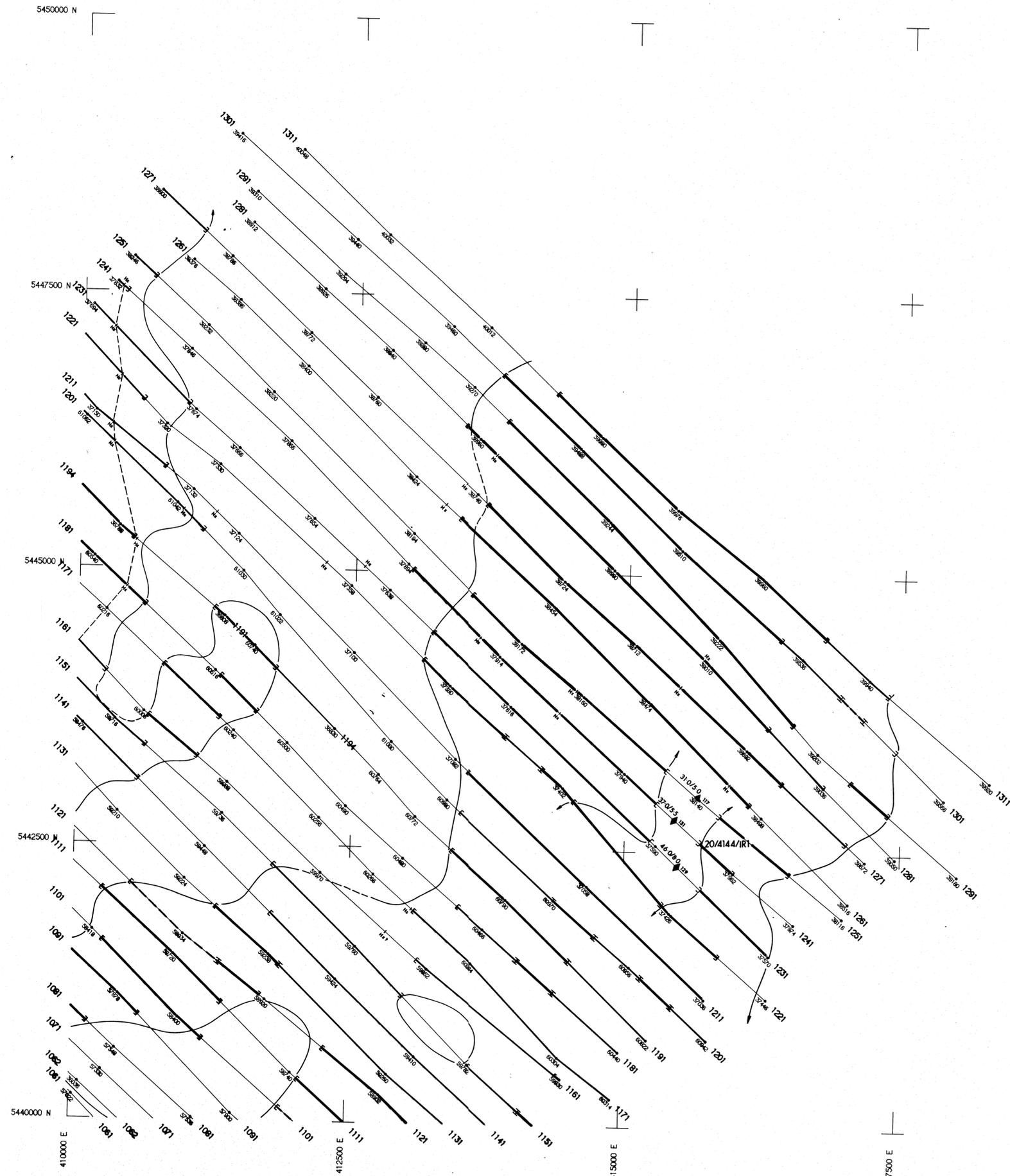
E.M. ANOMALY MAP

Sheet 20/4144
 Grid notation refers to Australian Map Grid
 Path recovery digitized from 1:20000 topo maps

Large 6 channel response		
6 channel response		
5 channel response		
4 channel response		
3 channel response		
2nd & 5th channel amplitudes		
Altitudes (metres)		
Offset magnetic anomaly		
Hertz response		
Zone number		
Conductor boundary		
Inferred boundary		

20/4044/IR3

20/4044	20/4144
20/4043	20/4143



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RIANA, TASMANIA E.M. ANOMALY MAP SHEET 20/4144	
PROJ NO.	DATE:
	3-MAR-82