APPENDIX 1

GEOTEM$_{DEEP}$ Logistics Report

CR#27764

LOGISTICS REPORT FOR A GEOTEM$_{DEEP}$ AIRBORNE ELECTROMAGNETIC SURVEY OVER

SIX AREAS NEAR MOUNT ISA, QUEENSLAND

FOR

BHP MINERALS PTY LTD.

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JOB NO. 2-734

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GEOTERREX PTY. LTD.
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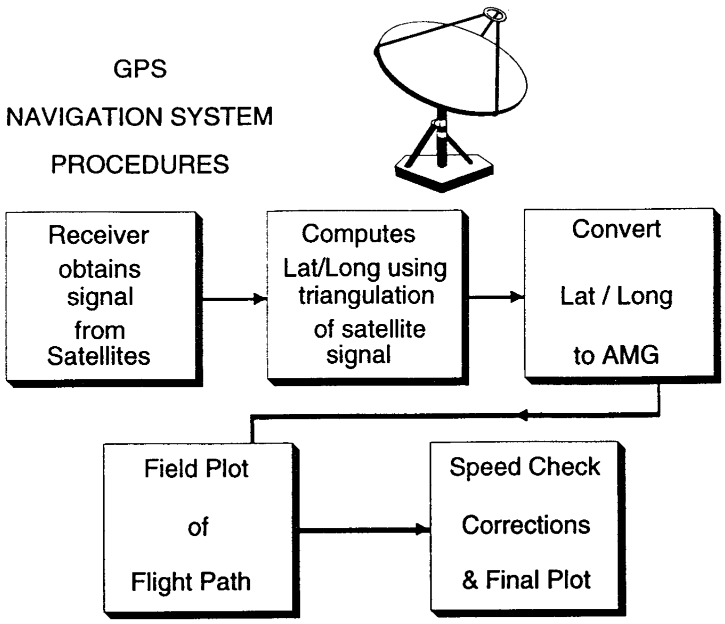
2. FLIGHT PATH RECOVERY



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The GPS receiver mounted in the aircraft determines which satellites are in operation and uses 3D triangulation of the satellite response to calculate position in real time as well as providing steering information. The GPS information is stored digitally as Latitudes and Longitudes (Lat / Longs) and later converted to Australian Map Grid (AMG) co-ordinates.

The Doppler system is a radar velocity sensor that determines the three components of aircraft velocity from measurements of the Doppler frequency shift in radar energy transmitted toward, and received back from the ground.

To obtain the optimum level of positioning accuracy the Doppler velocity information is combined with the GPS coordinates using least squares techniques. The integrated solution has greater accuracy and repeatability than either of the individual components. The integrated aircraft track was plotted on a daily basis at 1:50,000 scale to ensure data quality and to determine any necessary reflights.

Before the first survey areas were started, the accuracy of the navigation system was checked in a test flight over an easily identifiable target. The difference of the recorded coordinates and the map coordinates of the target was well within contract specifications.

3. GEOTEM ELECTROMAGNETIC SYSTEM

3.1 EQUIPMENT SPECIFICATIONS

TABLE 4: EQUIPMENT SPECIFICATIONS

Specifications		Values
Model		**GEOTEM$_{DEEP}$**
Geometry	Transmitter Height (m) (above ground level (agl))	105
	Receiver Bird Height (agl, m)	60
	Tx-Rx horizontal separation (m)	120
Transmitter	Coil Axis	Vertical
	Signal	Half sine wave current pulse
	Base frequency (Hz)	25
	Repetition rate (pulses per second)	40
	Pulse width (microseconds)	4 108
	Loop area (square metres)	231
	Number of turns	6
	Peak Current (amps)	480
	Tx loop dipole moment (Am^2)	6.65×10^5
Receiver	Fundamental Coil Axis	Horizontal, parallel to flight direction (X component)
	Auxiliary Coil Axis	Vertical (Z component)
	Sample Interval (seconds)	0.25 (Fundamental X), 0.5 (Auxiliary Z)
	Channel times	Shown in Table 5

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FIGURE 2 GEOTEM SYSTEM GEOMETRY AND WAVEFORM

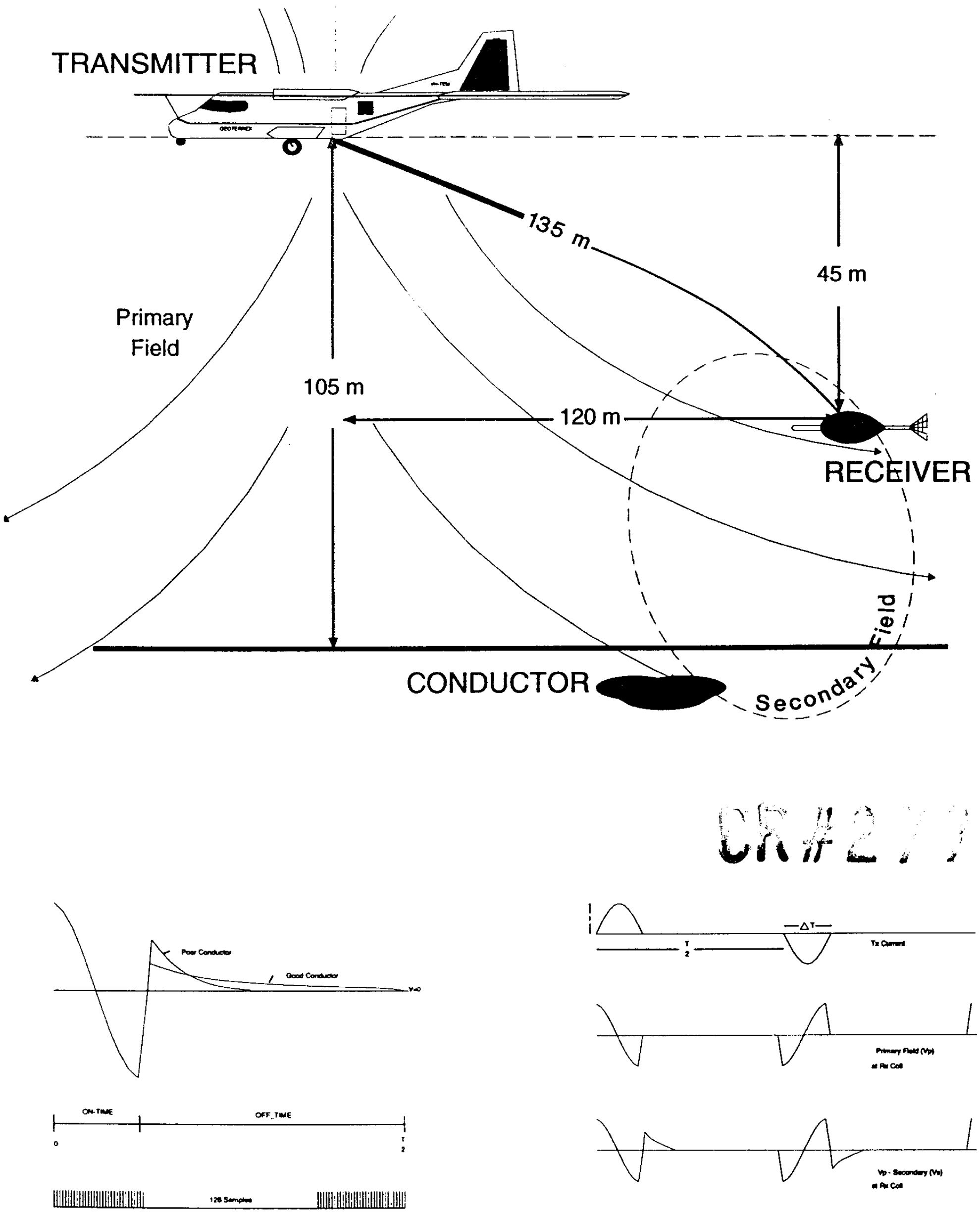
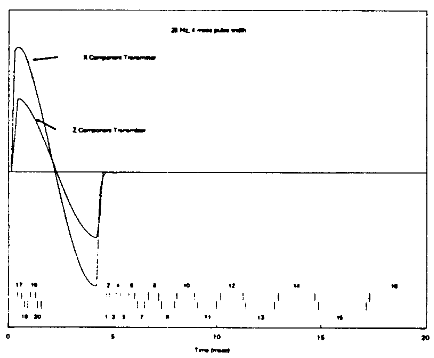


TABLE 5: X and Z COMPONENT CHANNEL POSITIONS

Channel	Channel Centre	Channel Width	BHP Channel
	µsec after Tx turn off	µsec	no.
Inpulse 1	-3 788	313	1
Inpulse 2	-3 476	313	2
Inpulse 3	-3 163	313	3
Inpulse 4	-2 851	313	4
Offtime 1	352	156	5
Offtime 2	509	156	6
Offtime 3	665	156	7
Offtime 4	899	313	8
Offtime 5	1 212	313	9
Offtime 6	1 602	469	10
Offtime 7	2 071	469	11
Offtime 8	2 618	625	12
Offtime 9	3 321	781	13
Offtime 10	4 181	938	14
Offtime 11	5 196	1 094	15
Offtime 12	6 368	1 250	16
Offtime 13	7 774	1 563	17
Offtime 14	9 493	1 875	18
Offtime 15	11 681	2 500	19
Offtime 16	14 337	2 813	20

FIGURE 3 X AND Z COMPONENT CHANNEL POSITIONS



3.2 SYSTEM DESCRIPTION

GEOTEM$_{DEEP}$ is a time domain towed bird electromagnetic system incorporating a high speed EM receiver. The primary electromagnetic pulses are created by a series of discontinuous half-sine current pulses fed into a six turn transmitting loop surrounding the aircraft and fixed to the nose, tail and wing tips. The pulse repetition rate is 25 Hz (40 bipolar pulses per second).

The EM sensor is a pair of orthogonal air cored coils mounted in a "bird", towed behind the aircraft on a long cable. The cable is demagnetised to reduce noise levels. The geometry of the system is displayed in Figure 2. Two coil orientations are available, the X component having an axis which is horizontal and in the direction of flight, and the Z component having a vertical axis. For this survey X was selected as the fundamental component and Z as the auxiliary component

For each primary pulse a secondary magnetic field is produced by decaying eddy currents in the ground (The transmitted and received waveforms are depicted in Figure 2). These in turn induce a voltage in the receiver coil which is in proportion to the electromagnetic field. This voltage is sampled over 20 time channels (for both X and Z components) whose centres and widths are software selectable and which may be placed anywhere within or outside the transmitter pulse.

The time varying EM signals received at the sensor pass through anti-aliasing filters and are then digitised with an A/D converter. The digital data stream from the A/D converter passes into an array processor where all the numerically intensive processing tasks are carried out. The array processor is under control of a multi-tasking minicomputer. The on-board processing sequence is as follows:

Transient Analysis: Transient analysis enables the separation of noise from signal in real time;

Digital Stacking: The stacking of transients to produce 1 recorded reading, of which 4 are recorded every second for the fundamental component and 2 for the auxiliary component;

Windowing of Data: The transient is initially sampled over 128 time windows which are then binned to form 16 final off-time channels, and 4 on-time (inpulse) channels.

3.3 SYSTEM CALIBRATION

All checks and adjustments are performed at high altitude at the start of each flight to allow for automatic compensation and calibration at survey altitude. The calibrations and compensations are as follows:

Compensation: During the flight, the transmitter creates eddy currents within the structure of the aircraft that have measurable effects at the receiver coil. Compensation for this signal is effected numerically within the receiver by a statistical analysis of the signal at the bird in the absence of ground response (by flying at an altitude in excess of 600 m above ground level). The observed signal is used to define a compensation signal that is removed from the observed signal to produce a null and thus effectively buck out any response due to changing geometry between receiver and transmitter (ie between the bird and the aircraft);

Normalisation: All EM response channels are automatically calibrated and reduced to parts per million of the primary field in the receiver.

3.4 DATA PROCESSING

Data collected was loaded onto a UNIX workstation and processed using GMAPS software.

Levelling

Since the **GEOTEM**$_{DEEP}$ receiver constantly normalises and calibrates during data acquisition there is no levelling of data at the post-survey processing stage.

Synchronisation Lag

All **GEOTEM**$_{DEEP}$ and auxiliary geophysical data has been synchronised with the navigation data so that there is no "peak position" offset between the responses obtained from lines flown in opposite directions over a narrow vertical conductor.

Noise Reduction

Noise reduction in the digital data is accomplished by identification of the noise type (atmospheric, system or cultural), analysis of the spectral content of the entire signal (geological + noise) and selective filtering.

<u>Atmospheric Noise</u> The first stage of processing is atmospheric (sferic) noise removal which is achieved by using a method based loosely on cross correlation and non linear filtering, since most sferic events are single reading (impulse response) features which cannot be properly removed by linear filtering.

<u>Cultural noise</u> Cultural noise (which includes sources such as 50 Hz powerlines, electric fences, cathodic protected metal structures) is measured by the 50 Hz monitor. Normally cultural noise is not removed during processing

<u>System noise</u> System noise is removed by filtering using strict amplitude and wavelength thresholds to correctly isolate noise from geological signal. The filter shape and amplitude thresholds are determined on a flight by flight basis from raw data plots of at least 2 flight lines flown in opposite directions at the beginning and end of the flight. This allows customisation of filtering for directional, diurnal and flight noise, ensuring that the minimal amount of filtering is performed so that real signal is not degraded by using a "lowest common denominator" philosophy of applying one filter (usually the maximum) for all noise conditions.

Amplitude-weighted Decay Index (ADI)

To aid interpretation of the data, time constants can be calculated to quantify the rate of decay of the electromagnetic response. The Amplitude Decay Index (ADI) measures this rate of decay and weights it for the relative amplitude of the electromagnetic response. In this respect the Amplitude Decay Index is also a measurement of the area under the decay curve rather than just an estimate of the rate of decay. The index is derived from the best fitting exponential to the decay curve using data from selected **GEOTEM**$_{DEEP}$ channels (minimum of four) as indicated on the multi-parameter profile plots and this index is included on the final located data tape.

Channels 9 to 16 were used in the calculation of ADI in the areas around Mt Isa.

Altitude Correction

In addition to the final processed channels of data, the multi-parameter profile plots also displayed altitude corrected **GEOTEM**$_{DEEP}$ data. This data was presented as dotted lines along the same axes, using the same base lines and scaling applicable for the solid lines which represent the final processed channels of **GEOTEM**$_{DEEP}$ data. This presentation serves to highlight those areas where the electromagnetic response has been affected by variation in aircraft terrain clearance. This aids data interpretation by correcting the data to the mean survey altitude. Unexpectedly large variations in altitude are not corrected so as to avoid drastic distortion of the **GEOTEM**$_{DEEP}$ data and this was achieved by use of tapering functions.

4. MAGNETOMETER SYSTEM

4.1 EQUIPMENT SPECIFICATIONS

Model:	Cesium vapour optical absorption magnetometer
Mounting:	Tail stinger
Sample period:	50 milliseconds
Sample interval:	1.0 seconds *
Sensitivity:	0.01 nanoteslas (nT)

* To operate both the **GEOTEM**$_{DEEP}$ system and the magnetometer system simultaneously, the transmitter is switched off for a period of 200 milliseconds every second to allow for a noise free magnetometer reading.

Base Station

Model:	G856 Proton Procession
Sample interval:	5 seconds
Sensitivity:	0.1 nT

4.2 DATA PROCESSING

Corrections

Diurnal Levelling

The base station data is edited so that all significant spikes, level shifts and null data are eliminated. It is resampled and synchronised to the airborne fiducial system prior to subtraction from the airborne magnetic readings.

Synchronisation Lag

A lag of 2 seconds (120 metres) was applied to synchronise the magnetic data with the navigation data.

5. AUXILIARY EQUIPMENT

5.1 DATA ACQUISITION SYSTEM

Model: Geoterrex Pty Ltd GEODAS

The GEODAS is a computer based software system which runs multiple DOS programs in a multi-tasking environment.

The modular design of the GEODAS allows for reconfiguring the system to record different types of surveys by adding, removing or changing task modules.

In the **GEOTEM**$_{DEEP}$ version of the GEODAS there are seven task modules

1.	Merger:	Merges all incoming data into a buffer which is written to two hard disks (the second as a backup)
2.	Mad_inp:	Multiple-Analogue-Data-Input; acquires analogue data such as radar, barometer and doppler and synchro data. This module also controls the GEODAS system time with an accurate 10mHz clock.
3.	Video:	The video module overlays time and GPS positioning information to the video camera data being recorded to video tape.
4.	GPS:	Records GPS data, recording all raw range data.
5.	RMS:	Plots data in real time on the RMS chart recorder.
6.	OP_IFCE:	Operator commands are entered and processed.
7.	EM:	Acquires the EM data from the HP computer. The HP computer is part of the GEOTEM recording system which includes the analogic array processor and ADC.

The GEODAS is currently installed on an extremely rugged, totally enclosed, moisture & dust proof system, originally designed for military use. Currently it uses a 486DX CPU on a plug in module card which can be upgraded. Data is recorded on twin hard disks.

Recorded Digital Data:

Each second:	Flight number Time Total magnetic field Altitude (Radar and Barometer) GPS/Doppler positioning information
Each 0.25 secs:	20 Fund. Component GEOTEM Channels 3 Aux. Component GEOTEM Channels Fund. Component Transmitter primary field Power Line Noise Monitor Earth Field Monitor and Earth Field Correction
Each 0.5 secs:	20 Aux. Component GEOTEM channels Power Line Noise Monitor (Aux. component) Aux. component Transmitter primary field Aux. component Earth Field Monitor

5.2 TRACKING CAMERA

Model: Sony DXC101P Video Camera

The tracking camera is equipped with a 4 mm wide-angle lens. The video tape is synchronised with the geophysical record by a digital fiducial display that increments every tenth of a second. These fiducials are recorded on the video tape and displayed on the bottom left of the video screen. Times are recorded from the digital information provided by the GEODAS system.

5.3 ALTIMETER

<u>Barometric Altimeter</u>

Model:	Geoterrex Barometric Altimeter (SENSYM 142SC15A)
Sample Interval:	1.0 seconds
Sensitivity:	0.24 mV/foot (6.5 Mv/mb)

<u>Radar Altimeter</u>

Model:	Sperry Stars AA200 radio altimeter system
Sample interval:	1.0 second
Accuracy:	+/- 3% of indicated altitude.

The Sperry radio altimeter is a high quality instrument whose output is factory calibrated. It is fitted with a test function which checks the calibration of a terrain clearance of 100 feet and altitudes which are multiples of 100 feet.

5.4 ELECTRONIC NAVIGATION

GPS Equipment:	Sercel NR103 GPS receiver and antennae mounted in aircraft and equipped with steering indicators.
Doppler Equipment:	Singer Kearfott AN/ASN 128, Sperry VG-14 Vertical Gyroscope, Sperry C-12 Compass.

5.5 ANALOGUE RECORDER

A sample analogue record is shown in Figure 4.

Model:	RMS GR33 Thermal Dot Matrix Printer
Chart speed:	11 cm/minute; time increases from left to right
Chart width:	30.5 cm
Event marks:	20 second marks are recorded on the bottom of the chart with the associated fiducial numbers being printed at the base of the chart.
GEOTEM Traces:	The scales for the **GEOTEM**$_{DEEP}$ traces are displayed on the analogue charts. The zero line for each channel is separated by 0.5 cm with the latest channel always being plotted closest to the bottom of the page.
Synchronisation:	A lag of approximately 5.0 seconds occurs between the **GEOTEM**$_{DEEP}$ channels and the magnetometer and altimeter traces.
Channels Displayed:	Channel 7 noise monitor Fund. Component (X) Primary Field Monitor Aux. Component (Z) Primary Field Monitor Fund. (X) and Aux. (Z) Component Earth Field Monitors Channel 16 noise monitor Total Magnetic Field - Fine Scale Total Magnetic Field - Coarse Scale Terrain Clearance - Radar Barometer GEOTEM Fund. (X) channels 5-16 GEOTEM Ancillary (X) Channels Powerline Monitor

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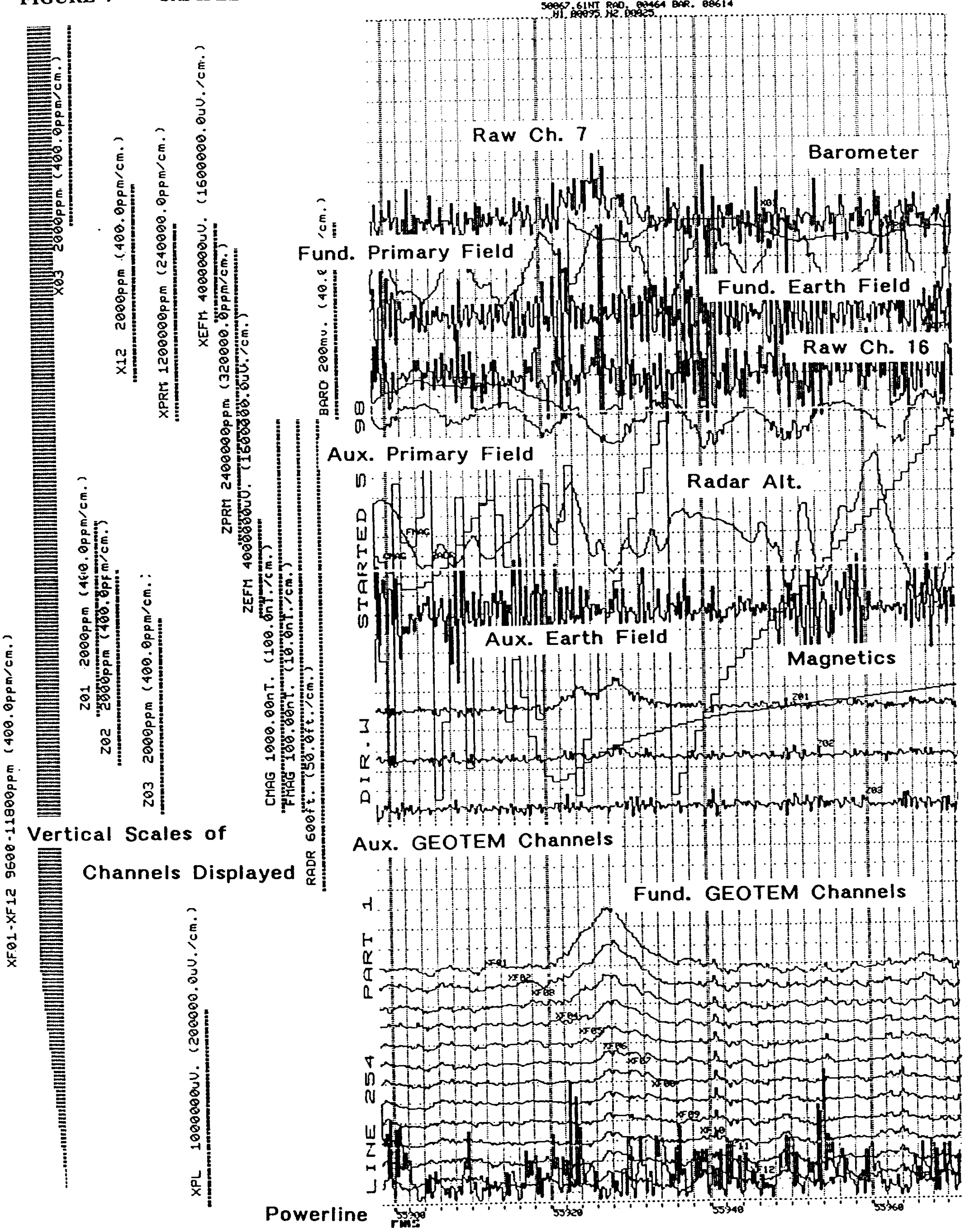
FIGURE 4 SAMPLE ANALOGUE RECORD



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6. SURVEY PRODUCTS

6.1 MULTI-PARAMETER PROFILE PLOTS

The final **GEOTEM**$_{DEEP}$ data (and the altitude corrected **GEOTEM**$_{DEEP}$ data) is presented as multi-parameter profiles plotted at suitable scales from top to bottom, as listed below. The x-axis is fiducially annotated on the bottom plot, while the top plot is annotated with AMG co-ordinates. The scales for the **GEOTEM**$_{DEEP}$ traces vary according to the channel, to allow resolution in late channels, whilst keeping early channels on scale. The base line for each channel is separated by 0.5 cm with the latest channel always being plotted closest to the bottom of the page. These base levels are marked as blue dotted lines. Each plot has a title containing line number, job number, area name, frequency, pulse width and average northing or easting. Scale values were altered from area to area according to the range of responses in each.

TABLE 6: MULTI-PARAMETER PROFILE PLOT SCALES: (1:50,000 horizontal scale)

AXIS	Channel	Trace Colour	Scale
1 (top)	Residual Magnetics Coarse Scale	Red	100, 250 nT/cm
	Residual Magnetics Fine Scale	Green	10, 25, 50 nT/cm
	Barometric Altimeter	Black	50m/cm
	Radar Altimeter	Blue	20m/cm
2	Aux. (Z) Inpulse Channel 1 Aux. (Z) Inpulse Channel 2 Aux. (Z) Inpulse Channel 3 Aux. (Z) Inpulse Channel 4	Black Blue Green Red	5000, 15000 ppm/cm
3	ADI (9-16) Aux. Component (Z)	Red	5000 units/cm
	Aux. (Z) Offtime Channels 1-4 Aux. (Z) Offtime Channels 5-8 Aux. (Z) Offtime Channels 9-11 Aux. (Z) Offtime Channels 12-16 50 Hz Monitor - Fund. Component (X)	Black Blue Green Red Blue	1000 ppm/cm 800 ppm/cm 400, 600 ppm/cm 200, 400 ppm/cm 0.1 volts/cm
4	Fund. (X) Inpulse Channel 1 Fund. (X) Inpulse Channel 2 Fund. (X) Inpulse Channel 3 Fund. (X) Inpulse Channel 4	Black Blue Green Red	5000, 15000 ppm/cm
5 (bottom)	ADI (9-16) Fund. Component (X)	Red	5000 units/cm
	Fund. (X) Offtime Channels 1- 4 Fund. (X) Offtime Channels 5- 8 Fund. (X) Offtime Channels 9-11 Fund.(X) Offtime Channels 12-16 50 Hz Monitor - Fund. Component (X)	Black Blue Green Red Blue	1000 ppm/cm 800 ppm/cm 400, 600 ppm/cm 200, 400 ppm/cm 0.1 volts/cm

```
Header data for BOOM_GEOTEM_AREA1.DAT
Fields are as follows :-

FLIGHT        1-5
LINE          6-18
FID          19-31
X            32-44
Y            45-57
XCH1         58-70
XCH2         71-83
XCH3         84-96
XCH4         97-109
XCH5        110-122
XCH6        123-135
XCH7        136-148
XCH8        149-161
XCH9        162-174
XCH10       175-187
XCH11       188-200
XCH12       201-213
XCH13       214-226
XCH14       227-239
XCH15       240-252
XCH16       253-265
XCH17       266-278
XCH18       279-291
XCH19       292-304
XCH20       305-317
ADI_X       318-330
ZCH1        331-343
ZCH2        344-356
ZCH3        357-369
ZCH4        370-382
ZCH5        383-395
ZCH6        396-408
ZCH7        409-421
ZCH8        422-434
ZCH9        435-447
ZCH10       448-460
ZCH11       461-473
ZCH12       474-486
ZCH13       487-499
ZCH14       500-512
ZCH15       513-525
ZCH16       526-538
ZCH17       539-551
ZCH18       552-564
ZCH19       565-577
ZCH20       578-590
ADI_Z       591-603
MONITOR     604-616
ALT_RADAR   617-622
ALT_BARO    623-631
CORMAG      632-640
```

Header data for BOOM_GEOTEM_AREA2.DAT
Fields are as follows :-

FLIGHT	1-5
LINE	6-18
FID	19-31
X	32-44
Y	45-57
XCH1	58-70
XCH2	71-83
XCH3	84-96
XCH4	97-109
XCH5	110-122
XCH6	123-135
XCH7	136-148
XCH8	149-161
XCH9	162-174
XCH10	175-187
XCH11	188-200
XCH12	201-213
XCH13	214-226
XCH14	227-239
XCH15	240-252
XCH16	253-265
XCH17	266-278
XCH18	279-291
XCH19	292-304
XCH20	305-317
ADI_X	318-330
ZCH1	331-343
ZCH2	344-356
ZCH3	357-369
ZCH4	370-382
ZCH5	383-395
ZCH6	396-408
ZCH7	409-421
ZCH8	422-434
ZCH9	435-447
ZCH10	448-460
ZCH11	461-473
ZCH12	474-486
ZCH13	487-499
ZCH14	500-512
ZCH15	513-525
ZCH16	526-538
ZCH17	539-551
ZCH18	552-564
ZCH19	565-577
ZCH20	578-590
ADI_Z	591-603
MONITOR	604-616
ALT_RADAR	617-622
ALT_BARO	623-631
CORMAG	632-640