



**Mt. Cobalt, Widgee, Elginvale & BanBan Project  
Queensland, Australia  
for  
D'Aguilar Gold Ltd**

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**Survey flown in April, 2007**

**Project A154  
July, 2007**

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# REPORT ON A HELICOPTER-BORNE TIME DOMAIN ELECTROMAGNETIC SURVEY

Mt. Cobalt, Widgee, Elginvale & BanBan Project, Australia

## Executive Summary

As part of the agreement between Geotech Airborne Ltd. and D'Aguilar Gold Ltd, a helicopter borne geophysical survey has been completed over the Mt. Cobalt, Widgee, Elginvale & BanBan project areas of Australia. The survey was carried out during the period from April 10th to April 26th, 2007.

Principal geophysical sensors included Geotech's versatile time domain electromagnetic system (VTEM) and a cesium magnetometer. Ancillary equipment included a GPS navigation system and a radar altimeter. A total of 1113.51 line-km were flown in an area of approximately 152.62 km<sup>2</sup>. In-field data processing involved quality control and compilation of data collected during the acquisition stage, using the in-field processing centre established at Gympie, Australia. Final data processing, including generation of final digital data products were done at the office of Geotech Airborne Limited in Pretoria, South Africa.

The processed survey results are presented as total magnetic field and stacked time domain electromagnetic profiles.

Digital data include all electromagnetic and magnetic products, as well as positional, altitude and raw data.

# 1. INTRODUCTION

## 1.1 *General Considerations*

These services are the result of the agreement signed between Geotech Airborne Ltd. and D'Aguilar Gold Ltd. to perform a helicopter-borne geophysical survey over the Mt. Cobalt, Widgee, Elginvale & BanBan project areas of Australia.

Nick Mather acted on behalf of D'Aguilar Gold Ltd. during data acquisition phases of this project. The survey blocks are as shown in Appendix A. The crew was based in Gympie for the acquisition phase of survey, as shown in Section 2 of this report.

The helicopter was based at Gympie for the duration of the survey. Survey flying was completed by April 26th, 2007. Preliminary data processing was carried out daily during the acquisition phase of the project. Final data presentation and data archiving was completed in the Pretoria office of Geotech Airborne Ltd. by July, 2007.

## 1.2. *Survey and System Specifications*

The survey was flown at nominal traverse line spacing of 200 metres (Mt Cobalt, Widgee and Elginvale) and 100 metres (Ban Ban) in directions N 90° E (Mt. Cobalt), N 150° E (Widgee) and N 0° E (Elginvale and Ban Ban). Tie lines were flown perpendicular to traverse lines at nominal tie line spacing of 2000 metres (Mt Cobalt), 1900 metres (Widgee) and 1000 metres (Elginvale and Ban Ban). The helicopter maintained a mean terrain clearance of 80 metres which translated into an average height of 28 metres above ground for the bird-mounted VTEM system and 68 metres above ground for the magnetic sensor.

The survey was completed using an AS350-B3 helicopter, registration VH-OUF, operated by Heli-Aust. Details of the survey specifications are found in Section 2 of this report.

## 1.3. *Data Processing and Final Products*

Data compilation and processing were carried out by the application of Geosoft OASIS Montaj and programs proprietary to Geotech Airborne Ltd. Digital databases, grids and maps of final products were presented to D'Aguilar Gold Ltd. The survey report describes the procedures for data acquisition, processing, final image presentation and the specifications for the digital data set.

## 2. DATA ACQUISITION

### 2.1. Survey Area

The survey block (see location map, Appendix A) and general flight specifications are as follows:

| Blocks    | Line spacing (m) | Area (Km <sup>2</sup> ) | Line Distance (km) | Flight direction | Line number                  |
|-----------|------------------|-------------------------|--------------------|------------------|------------------------------|
| Mt Cobalt | 200              | 11.47                   | 65.20              | N 90°E           | L1010 - 1190<br>T1910 - 1920 |
| Widgee    | 200              | 41.28                   | 229.62             | N150°E           | L2010 – 2260<br>T2910 - 2950 |
| Elginvale | 200              | 57.49                   | 341.35             | N 0°E            | L3010 – 3440<br>T9010 - 9100 |
| Ban Ban   | 100              | 42.38                   | 477.34             | N 0°E            | L4010 – 4710<br>T4910 - 4970 |

Table 1 – Survey block

Survey block boundary co-ordinates are provided in Appendix B.

### 2.2. Survey Operations

Survey operations were based at Gympie for the acquisition phase of the survey.

The following table shows the timing of the survey.

| Date      | Crew Location | Flight # | Km flown | Comments                                    |
|-----------|---------------|----------|----------|---------------------------------------------|
| 10-Apr-07 | Gympie        | 1        | 65.16    | One flight, stopped due to windy conditions |
| 11-Apr-07 | Gympie        | 2        | 73.17    | One flight, stopped due to windy conditions |
| 12-Apr-07 | Gympie        | 0        |          | ferry to Block #3                           |
| 13-Apr-07 | Gympie        | 0        |          | ferry to Block #3                           |
| 14-Apr-07 | Gympie        | 3,4      | 203.0    | Production                                  |

|           |            |                    |        |                           |
|-----------|------------|--------------------|--------|---------------------------|
| 15-Apr-07 | Gympie     | 5                  | 101.1  | Troubleshooting           |
| 16-Apr-07 | Gympie     |                    |        | Troubleshooting           |
| 17-Apr-07 | Gympie     | 6 test             |        | Troubleshooting           |
| 18-Apr-07 | Gympie     | 7 test             |        | Troubleshooting           |
| 19-Apr-07 | Gympie     | 8 test<br>,9,10,11 | 138.6  | Production                |
| 20-Apr-07 | Gympie     | 12                 | 55.0   | Production                |
| 21-Apr-07 | Gympie     | 13 test            |        | Repairs                   |
| 22-Apr-07 | Gympie     |                    |        | Repairs                   |
| 23-Apr-07 | Gympie     |                    |        | Repairs                   |
| 24-Apr-07 | Relocating | 14                 | 12.1   | Relocation and Production |
| 25-Apr-07 | Kilkivan   | 15,16              | 211.05 | Production                |
| 26-Apr-07 | Kilkivan   | 17,18,19           | 254.23 | Production                |

Table 2 – Survey schedule

### **2.3. Flight Specifications**

The nominal EM sensor terrain clearance was 28 m (EM bird height above ground, i.e. helicopter is maintained 80 m above ground). Nominal survey speed was 80 km/hour. The data recording rates of the data acquisition was 0.1 second for electromagnetic and magnetometer, 0.2 second for altimeter and GPS. This translates to a geophysical reading about every 2 metres along flight track. Navigation was assisted by a GPS receiver and data acquisition system, which reports GPS co-ordinates as latitude/longitude and directs the pilot over a pre-programmed survey grid.

The operator was responsible for monitoring of the system integrity. He also maintained a detailed flight log during the survey, tracking the times of the flight as well as any unusual geophysical or topographic feature.

On return of the aircrew to the base camp the survey data was transferred from a compact flash card (PCMCIA) to the data processing computer.

## 2.4. Aircraft and Equipment

### 2.4.1. Survey Aircraft

An AS350-B3 helicopter, registration VH-OUF- owned and operated by Heli-Aust was used. Installation of the geophysical and ancillary equipment was carried out by Geotech Airborne Ltd.

### 2.4.2. Electromagnetic System

The electromagnetic system was Geotech's Versatile Time Domain EM (VTEM) system. The layout is as indicated in Figure 1 below.

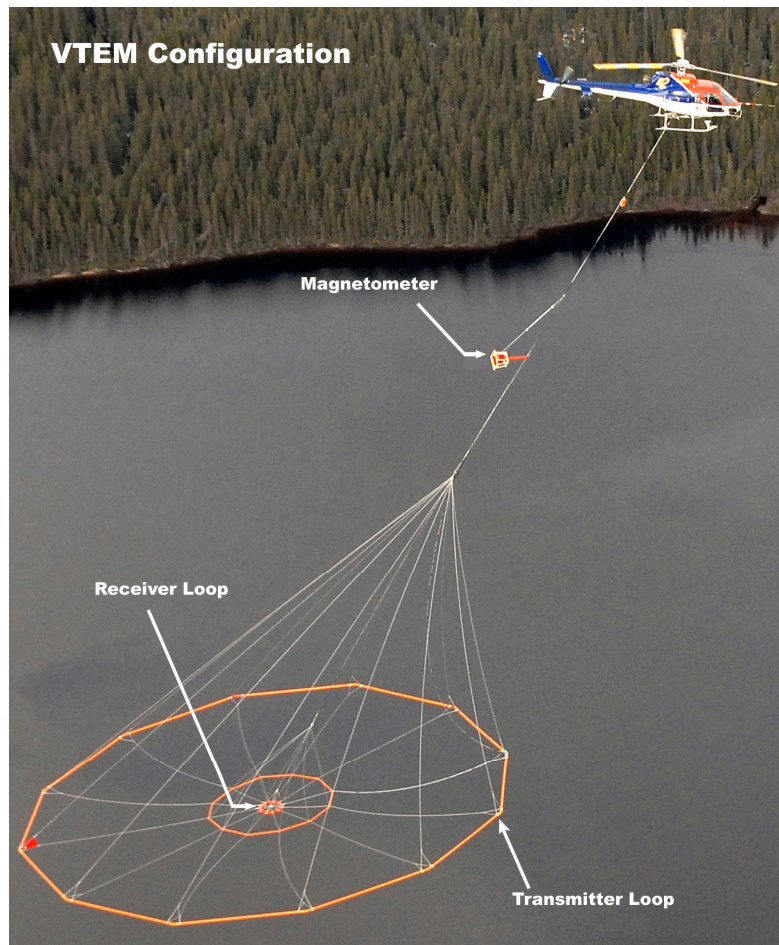


Figure 1 – VTEM configuration

Receiver and transmitter coils are concentric and Z-direction oriented.

The receiver decay recording scheme is shown diagrammatically in Figure 2.



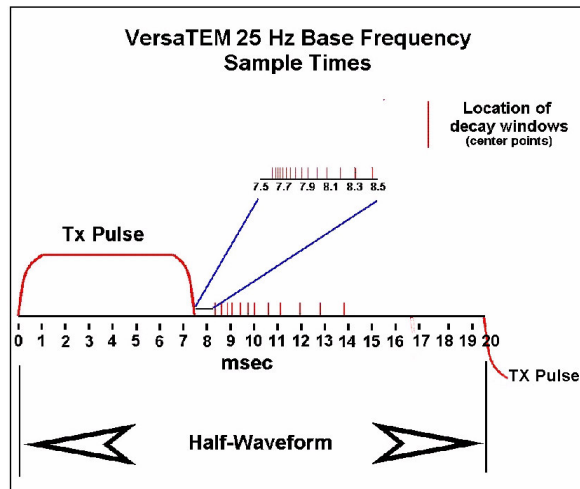


Figure 2 – Sample times

Twenty-seven measurement gates were used in the range from 130  $\mu$ s to 8900  $\mu$ s, as shown in the following table.

| <b>VTEM Decay Sampling scheme (Microseconds)</b> |              |            |              |
|--------------------------------------------------|--------------|------------|--------------|
| <b>Time gate</b>                                 | <b>Start</b> | <b>End</b> | <b>Width</b> |
| 130                                              | 120          | 140        | 20           |
| 150                                              | 140          | 160        | 20           |
| 170                                              | 160          | 180        | 20           |
| 190                                              | 180          | 205        | 25           |
| 220                                              | 205          | 240        | 35           |
| 260                                              | 240          | 280        | 40           |
| 300                                              | 280          | 325        | 45           |
| 350                                              | 325          | 380        | 55           |
| 410                                              | 380          | 445        | 65           |
| 480                                              | 445          | 525        | 80           |
| 570                                              | 525          | 625        | 100          |
| 680                                              | 625          | 745        | 120          |
| 810                                              | 745          | 885        | 140          |
| 960                                              | 885          | 1045       | 160          |
| 1130                                             | 1045         | 1235       | 190          |
| 1340                                             | 1235         | 1470       | 235          |
| 1600                                             | 1470         | 1750       | 280          |
| 1900                                             | 1750         | 2070       | 320          |
| 2240                                             | 2070         | 2450       | 380          |
| 2660                                             | 2450         | 2920       | 470          |
| 3180                                             | 2920         | 3480       | 560          |
| 3780                                             | 3480         | 4120       | 640          |
| 4460                                             | 4120         | 4880       | 760          |
| 5300                                             | 4880         | 5820       | 940          |
| 6340                                             | 5820         | 6860       | 1040         |
| 7540                                             | 6860         | 8220       | 1360         |
| 8900                                             | 8220         | 9740       | 1820         |

Table 3 – VTEM decay sampling scheme.

Transmitter coil diameter was 26 metres; the number of turns was 4.  
Transmitter pulse repetition rate was 25 Hz.  
Peak current was 155 Amp.  
Duty cycle was 46.4%.  
Peak dipole moment was 329,176 NIA.

Receiver coil diameter was 1.2 metre; the number of turns was 100.  
Receiver effective area was 113.1 m<sup>2</sup>  
Wave form – trapezoid.  
Recording sampling rate was 10 samples per second.

The EM bird was towed 52 m below the helicopter.

### **2.4.3. Airborne Magnetometer**

The magnetic sensor utilized for the survey was a Geometrics optically pumped cesium vapor magnetic field sensor, mounted on a separate bird towed 12 m below the helicopter, as shown on figure 1. The sensitivity of the magnetic sensor is 0.02 nanoTesla (nT) at a sampling interval of 0.1 seconds. The magnetometer sends the measured magnetic field strength as nanoTeslas to the data acquisition system via the RS-232 port.

### **2.4.4. Ancillary Systems**

#### **2.4.4.1. Radar Altimeter**

A Terra TRA 3000/TRI 30 radar altimeter was used to record terrain clearance. The antenna was mounted beneath the bubble of the helicopter cockpit.

#### **2.4.4.2. GPS Navigation System**

The navigation system used was a Geotech PC based navigation system utilizing a NovAtel's WAAS enable OEM4-G2-3151W GPS receiver, Geotech navigation software, a full screen display with controls in front of the pilot to direct the flight and an NovAtel GPS antenna mounted on the helicopter tail.

The co-ordinates of the blocks were set-up prior to the survey and the information was fed into the airborne navigation system.

#### 2.4.4.3. Digital Acquisition System

A Geotech data acquisition system recorded the digital survey data on an internal compact flash card. Data is displayed on an LCD screen as traces to allow the operator to monitor the integrity of the system. Contents and update rates were as follows:

| DATA TYPE       | SAMPLING |
|-----------------|----------|
| TDEM            | 0.1 sec  |
| Magnetometer    | 0.1 sec  |
| GPS Position    | 0.2 sec  |
| Radar Altimeter | 0.2 sec  |

Table 4 - Sampling Rates

#### 2.4.5. Base Station

A combined magnetometer/GPS base station was utilized on this project. A Geometrics cesium vapour magnetometer was used as a magnetic sensor with a sensitivity of 0.001 nT. The base station was recording the magnetic field together with the GPS time at 1 Hz on a base station computer. The base station magnetometer sensor was installed where the crew was based, away from electric transmission lines and moving ferrous objects such as motor vehicles. The magnetometer base station's data was backed-up to the data processing computer at the end of each survey day.

### 3. PERSONNEL

The following Geotech personnel were involved in the project

Field Crew Members:

Geophysicist: Anton Rada/ Rafael Coyoli

Operator: Kim Bignell

The survey pilot was employed directly by the helicopter operator – Heli-Aust.

Pilot: Tony Feller

Office:

Preliminary Data Processing: Rafael Coyoli

Final Data Processing / Reporting: Magdel Combrinck

Final data processing at the office of Geotech Airborne Ltd. in Pretoria, South Africa was carried out under the supervision of Magdel Combrinck.

Overall management of the survey was carried out from the Johannesburg office of Geotech Airborne Ltd. by Keith Fisk, Managing Partner and Director.

## 4. DATA PROCESSING AND PRESENTATION

### 4.1. *Flight Path*

The flight path, recorded by the acquisition program as WGS 84 latitude/longitude, was converted into the WGS 84, UTM zone 56S in Oasis Montaj.

The flight path was drawn using linear interpolation between x,y positions from the navigation system. Positions are updated every second and expressed as UTM eastings (x) and UTM northings (y).

### 4.2. *Electromagnetic Data*

A three stage digital filtering process was used to reject major spheric events and to reduce system noise. Local spheric activity can produce sharp, large amplitude events that cannot be removed by conventional filtering procedures. Smoothing or stacking will reduce their amplitude but leave a broader residual response that can be confused with geological phenomena. To avoid this possibility, a computer algorithm searches out and rejects the major spheric events. The filter used was a 16 point non-linear filter.

The signal to noise ratio was further improved by the application of a low pass linear digital filter. This filter has zero phase shift which prevents any lag or peak displacement from occurring, and it suppresses only variations with a wavelength less than about 1 second or 20 metres. This filter is a symmetrical 1 sec linear filter.

The results are presented as stacked profiles of EM voltages for the early as well as late gate times, in linear scale on the preliminary maps and on linear/log scale on the final maps.

Generalized modelling results of the VTEM system, written by Geophysicist Roger Barlow, are shown in Appendix C.

The VTEM output voltage of the receiver coil is shown in Appendix D.

### **4.3. Magnetic Data**

The processing of the magnetic data involved the correction for diurnal variations by using the digitally recorded ground base station magnetic values. The base station magnetometer data was edited and merged into the Geosoft GDB database on a daily basis. The aero magnetic data was corrected for diurnal variations by subtracting the observed magnetic base station deviations.

Tie line levelling was carried out by adjusting intersection points along the traverse lines. A microleveling procedure was then applied. This technique is designed to remove persistent low-amplitude components of flight-line noise remaining after tie line levelling.

The corrected magnetic data from the survey was interpolated between survey lines using a random point gridding method to yield x-y grid values for a standard grid cell size of approximately 0.2 cm at the mapping scale. The Minimum Curvature algorithm was used to interpolate values onto a rectangular regular spaced grid.

## 5. DELIVERABLES

### 5.1. Survey Report

The survey report describes the data acquisition, processing, and final presentation of the survey results.

The survey report is provided in PDF format.

### 5.2. Gridded Data

Total magnetic field grid is provided to D'Aguilar Gold Ltd in Geosoft GRD format.

Grid cell size of 50 and 25 metres was used.

### 5.3. Digital Data

Two copies of CDs were prepared.

There are two (2) main directories for each block,

**Data:** contains databases, grids and maps, as described below.

**Report:** contains a copy of the report and appendixes in PDF format.

- Databases in Geosoft .GDB format containing the following channels, for each survey block:

|          |                                                            |
|----------|------------------------------------------------------------|
| X:       | X positional data (metres – WGS 84, UTM zone 56S)          |
| Y:       | Y positional data (metres – WGS 84, UTM zone 56S)          |
| Long:    | Longitude (WGS 84)                                         |
| Lat:     | Latitude (WGS 84)                                          |
| Z:       | GPS antenna elevation (metres - ASL)                       |
| Gtime1:  | GPS time (seconds of the day)                              |
| Radar:   | Helicopter terrain clearance from radar altimeter (metres) |
| Radarb:  | EM sensor height terrain clearance (metres)                |
| DEM:     | Digital elevation model data (metres)                      |
| Mag1:    | Raw Total Magnetic field data (nT)                         |
| Basemag: | Magnetic diurnal variation data (nT)                       |

|         |                                                            |
|---------|------------------------------------------------------------|
| Mag2:   | Total Magnetic field diurnal variation corrected data (nT) |
| Mag3:   | Levelled Total Magnetic field data (nT)                    |
| C130f:  | Raw 130 microsecond time channel (pV/A/m <sup>4</sup> )    |
| C150f:  | Raw 150 microsecond time channel (pV/A/m <sup>4</sup> )    |
| C170f:  | Raw 170 microsecond time channel (pV/A/m <sup>4</sup> )    |
| C190f:  | Raw 190 microsecond time channel (pV/A/m <sup>4</sup> )    |
| C220f:  | Raw 220 microsecond time channel (pV/A/m <sup>4</sup> )    |
| C260f:  | Raw 260 microsecond time channel (pV/A/m <sup>4</sup> )    |
| C300f:  | Raw 300 microsecond time channel (pV/A/m <sup>4</sup> )    |
| C350f:  | Raw 350 microsecond time channel (pV/A/m <sup>4</sup> )    |
| C410f:  | Raw 410 microsecond time channel (pV/A/m <sup>4</sup> )    |
| C480f:  | Raw 480 microsecond time channel (pV/A/m <sup>4</sup> )    |
| C570f:  | Raw 570 microsecond time channel (pV/A/m <sup>4</sup> )    |
| C680f:  | Raw 680 microsecond time channel (pV/A/m <sup>4</sup> )    |
| C810f:  | Raw 810 microsecond time channel (pV/A/m <sup>4</sup> )    |
| C960f:  | Raw 960 microsecond time channel (pV/A/m <sup>4</sup> )    |
| C1130f: | Raw 1130 microsecond time channel (pV/A/m <sup>4</sup> )   |
| C1340f: | Raw 1340 microsecond time channel (pV/A/m <sup>4</sup> )   |
| C1600f: | Raw 1600 microsecond time channel (pV/A/m <sup>4</sup> )   |
| C1900f: | Raw 1900 microsecond time channel (pV/A/m <sup>4</sup> )   |
| C2240f: | Raw 2240 microsecond time channel (pV/A/m <sup>4</sup> )   |
| C2660f: | Raw 2660 microsecond time channel (pV/A/m <sup>4</sup> )   |
| C3180f: | Raw 3180 microsecond time channel (pV/A/m <sup>4</sup> )   |
| C3780f: | Raw 3780 microsecond time channel (pV/A/m <sup>4</sup> )   |
| C4460f: | Raw 4460 microsecond time channel (pV/A/m <sup>4</sup> )   |
| C5300f: | Raw 5300 microsecond time channel (pV/A/m <sup>4</sup> )   |
| C6340f: | Raw 6340 microsecond time channel (pV/A/m <sup>4</sup> )   |
| C7540f: | Raw 7540 microsecond time channel (pV/A/m <sup>4</sup> )   |
| C8900f: | Raw 8900 microsecond time channel (pV/A/m <sup>4</sup> )   |
| PLinef: | Power line monitor                                         |

- **Grids in Geosoft .GRD format, as follow,**

Mag3\_bb: Total magnetic intensity (nT)

A Geosoft .GRD file has a .GI metadata file associated with it, containing grid projection information.

- **Maps in Geosoft .MAP format, as follow,**

A154\_Mag\_bb: Total magnetic intensity contours and colour image

A154\_EM\_Log\_bb: VTEM dB/dt profiles, Time Gates 0.22 - 6.34 ms in linear – logarithmic scale

where bb = BLOCK Name.



- ASCII file **VTEM\_WaveForm.xyz** in Geosoft format contains the following channel:

Volt:           output voltage of the receiver coil  
                  (volts, sampling rate 20 microseconds)

This file is found in the REPORT directory of the CD.

- A *readme.txt* file describing the content of digital data, as described above.

## 6. CONCLUSIONS

A versatile time domain electromagnetic helicopter-borne geophysical survey has been completed over the Mt. Cobalt, Widgee, Elginvale & BanBan project areas of Australia.

The total area coverage is approximately 152.62 km<sup>2</sup>. Total survey line coverage is 1113.51 line kilometres. The principal sensors included a Geotech Versatile Time-Domain EM system and a magnetometer. Results have been presented as colour contour total magnetic field maps and stacked EM profiles at a scale of 1:20,000 and 1:10,000.

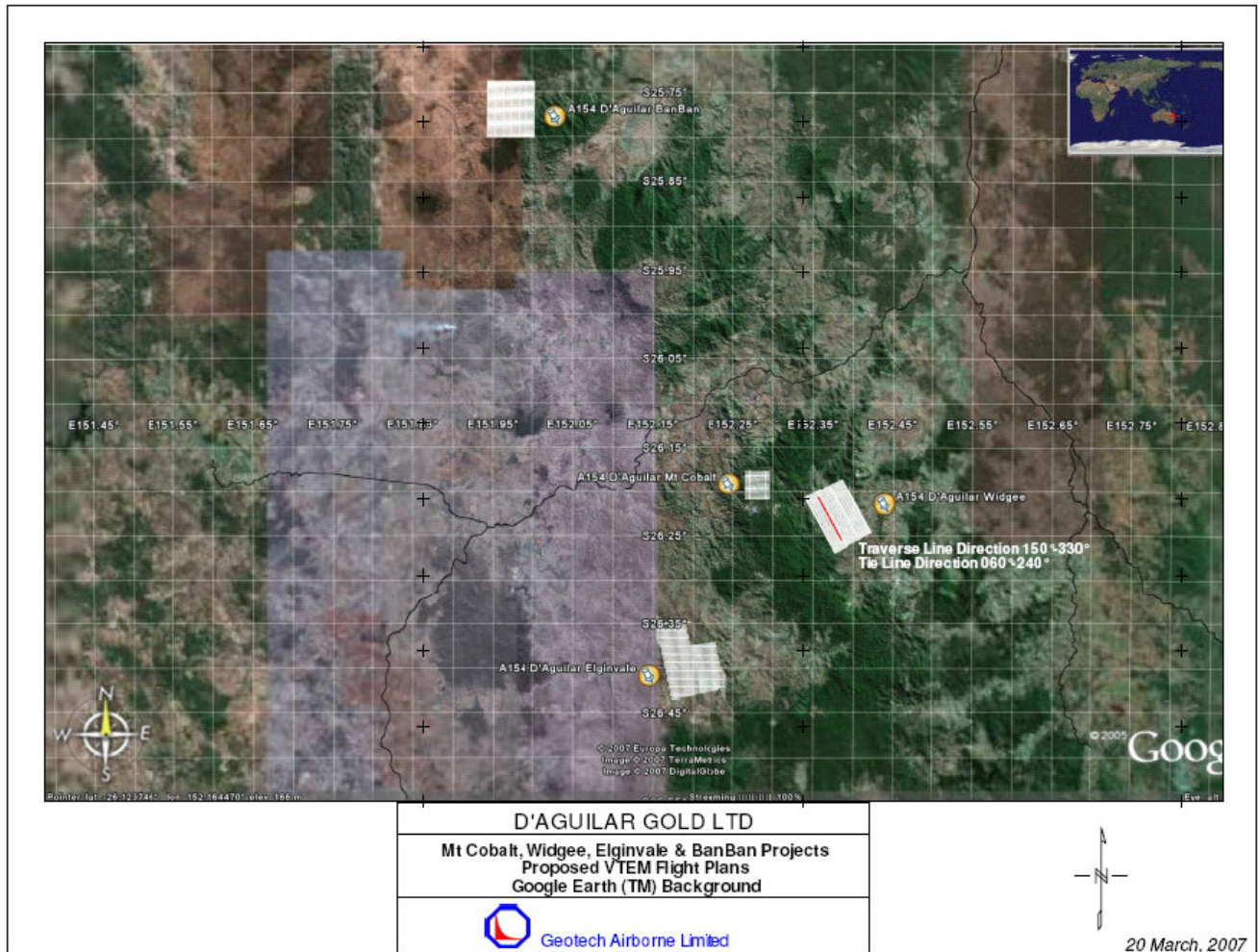
A number of EM anomaly groupings can be identified. Ground follow-up of those anomalies should be carried out if favourably supported by other geoscientific data.

Respectfully submitted,

Magdel Combrinck,  
Geotech Airborne Limited

# APPENDIX A

## SURVEY AREA LOCATION MAP



## APPENDIX B

### MT. COBALT, WIDGEE, ELGINVALE & BANBAN PROJECT AREA COORDINATES (WGS 84, UTM ZONE 56S)

| UTM_X Z56S       | UTM_Y Z56S     |
|------------------|----------------|
| <b>Mt Cobalt</b> |                |
| 426650 7100940   | 426650 7104680 |
| 429670 7104680   | 429670 7100940 |
| 426650 7100940   | 426650 7100940 |
| 426650 7100940   | 426650 7104680 |
| 429670 7104680   | 429670 7100940 |
| 426650 7100940   | 426650 7100940 |
| <b>Widgee</b>    |                |
| 438700 7103600   | 442400 7096900 |
| 437900 7094300   | 434100 7101200 |
| 438700 7103600   | 442400 7096900 |
| 437900 7094300   | 434100 7101200 |
| <b>Elginvale</b> |                |
| 415500 7085100   | 419100 7085800 |
| 419800 7082600   | 423100 7083100 |
| 424400 7077400   | 417600 7075900 |
| 415500 7085100   | 419100 7085800 |
| 419800 7082600   | 423100 7083100 |
| 424400 7077400   | 417600 7075900 |
| <b>Ban Ban</b>   |                |
| 394000 7153000   | 400000 7153000 |
| 400000 7146000   | 394000 7146000 |
| 394000 7153000   | 400000 7153000 |
| 400000 7146000   | 394000 7146000 |

## APPENDIX C

### GENERALIZED MODELING RESULTS OF THE VTEM SYSTEM

#### Introduction

The VTEM system is based on a concentric or central loop design, whereby, the receiver is positioned at the centre of a 26.1 meters diameter transmitter loop that produces a dipole moment up to 625,000 NIA at peak current. The wave form is a bi-polar, modified square wave with a turn-on and turn-off at each end. With a base frequency of 25 Hz, the duration of each pulse is approximately 7.5 milliseconds followed by an off time where no primary field is present.

During turn-on and turn-off, a time varying field is produced (dB/dt) and an electro-motive force (emf) is created as a finite impulse response. A current ring around the transmitter loop moves outward and downward as time progresses. When conductive rocks and mineralization are encountered, a secondary field is created by mutual induction and measured by the receiver at the centre of the transmitter loop.

Measurements are made during the off-time, when only the secondary field (representing the conductive targets encountered in the ground) is present.

Efficient modeling of the results can be carried out on regularly shaped geometries, thus yielding close approximations to the parameters of the measured targets. The following is a description of a series of common models made for the purpose of promoting a general understanding of the measured results.

#### Variation of Plate Depth

Geometries represented by plates of different strike length, depth extent, dip, plunge and depth below surface can be varied with characteristic parameters like conductance of the target, conductance of the host and conductivity/thickness and thickness of the overburden layer.

Diagrammatic models for a vertical plate are shown in figures A and G at two different depths, all other parameters remaining constant. With this transmitter-receiver geometry, the classic **M** shaped response is generated. Figure A shows a plate where the top is near surface. Here, amplitudes of the dual peaks are higher and symmetrical with the zero centre positioned directly above the plate. Most important is the separation distance of the peaks. This distance is small when the plate is near surface and widens with a linear relationship as the plate (depth to top) increases. Figure G shows a much deeper plate where the separation distance of the peaks is much wider and the amplitudes of the channels have decreased.

#### Variation of Plate Dip

As the plate dips and departs from the vertical position, the peaks become asymmetrical. Figure B

shows a near surface plate dipping 80°. Note that the direction of dip is toward the high shoulder of the response and the top of the plate remains under the centre minimum.

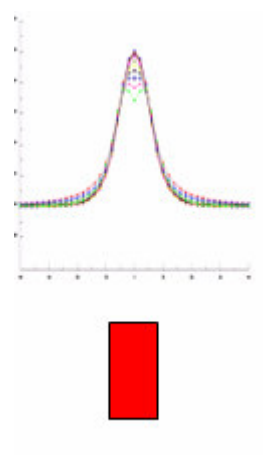
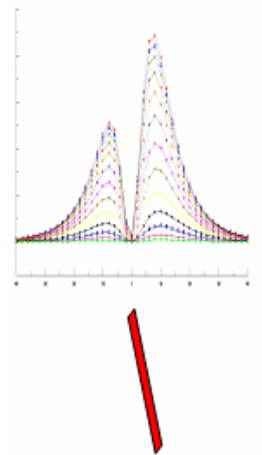
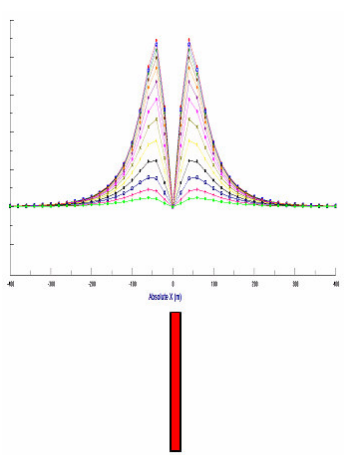
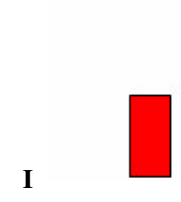
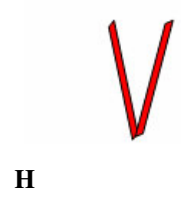
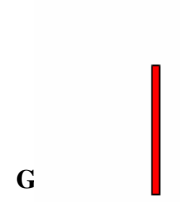
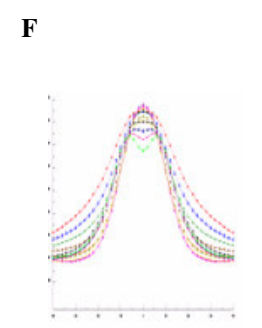
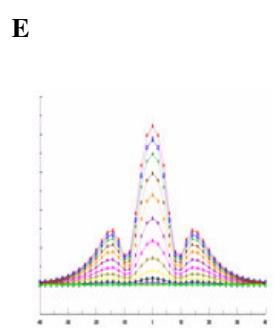
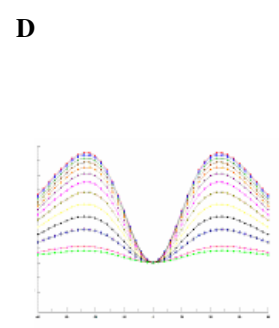
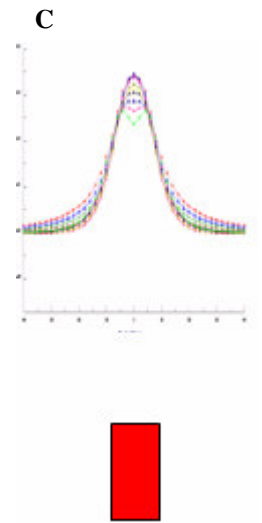
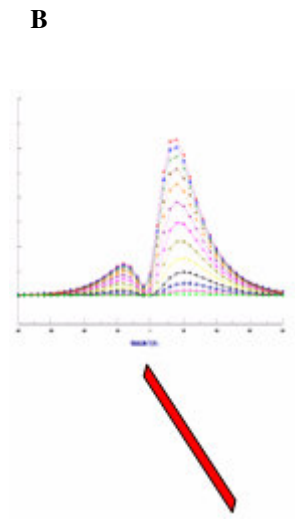
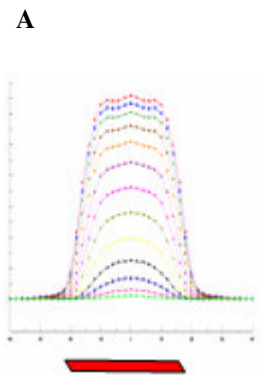
As the dip increases, the aspect ratio (Min/Max) decreases and this aspect ratio can be used as an empirical guide to dip angles from near 90° to about 30°. The method is not sensitive enough where dips are less than about 30°. Figure E shows a plate dipping 45° and, at this angle, the minimum shoulder starts to vanish. In Figure D, a flat lying plate is shown, relatively near surface. Note that the twin peak anomaly has been replaced by a symmetrical shape with large, bell shaped, channel amplitudes which decay relative to the conductance of the plate.

Figure H shows a special case where two plates are positioned to represent a synclinal structure. Note that the main characteristic to remember is the centre amplitudes are higher (approximately double) compared to the high shoulder of a single plate. This model is very representative of tightly folded formations where the conductors were once flat lying.

### **Variation of Prism Depth**

Finally, with prism models, another algorithm is required to represent current on the plate. A plate model is considered to be infinitely thin with respect to thickness and incapable of representing the current in the thickness dimension. A prism model is constructed to deal with this problem, thereby, representing the thickness of the body more accurately.

Figures C, F and I show the same prism at increasing depths. Aside from an expected decrease in amplitude, the side lobes of the anomaly show a widening with deeper prism depths of the bell shaped early time channels.



## General Modeling Concepts

A set of models has been produced for the Geotech VTEM® system with explanation notes (see models A to I above). The reader is encouraged to review these models, so as to get a general understanding of the responses as they apply to survey results. While these models do not begin to cover all possibilities, they give a general perspective on the simple and most commonly encountered anomalies.

When producing these models, a few key points were observed and are worth noting as follows:

- For near vertical and vertical plate models, the top of the conductor is always located directly under the centre low point between the two shoulders in the classic **M** shaped response.
- As the plate is positioned at an increasing depth to the top, the shoulders of the **M** shaped response, have a greater separation distance.
- When faced with choosing between a flat lying plate and a prism model to represent the target (broad response) some ambiguity is present and caution should be exercised.
- With the concentric loop system and Z-component receiver coil, virtually all types of conductors and most geometries are most always well coupled and a response is generated (see model H). Only concentric loop systems can map this type of target.

The modelling program used to generate the responses was prepared by PetRos Eikon Inc. and is one of a very few that can model a wide range of targets in a conductive half space.

## General Interpretation Principals

### Magnetics

The total magnetic intensity responses reflect major changes in the magnetite and/or other magnetic minerals content in the underlying rocks and unconsolidated overburden. Precambrian rocks have often been subjected to intense heat and pressure during structural and metamorphic events in their history. Original signatures imprinted on these rocks at the time of formation have, in most cases, been modified, resulting in low magnetic susceptibility values.

The amplitude of magnetic anomalies, relative to the regional background, helps to assist in identifying specific magnetic and non-magnetic rock units (and conductors) related to, for example, mafic flows, mafic to ultramafic intrusives, felsic intrusives, felsic volcanics and/or sediments etc. Obviously, several geological sources can produce the same magnetic response. These ambiguities can be reduced considerably if basic geological information on the area is available to the geophysical interpreter.



In addition to simple amplitude variations, the shape of the response expressed in the wave length and the symmetry or asymmetry, is used to estimate the depth, geometric parameters and magnetization of the anomaly. For example, long narrow magnetic linears usually reflect mafic flows or intrusive dyke features. Large areas with complex magnetic patterns may be produced by intrusive bodies with significant magnetization, flat lying magnetic sills or sedimentary iron formation. Local isolated circular magnetic patterns often represent plug-like igneous intrusives such as kimberlites, pegmatites or volcanic vent areas.

Because the total magnetic intensity (TMI) responses may represent two or more closely spaced bodies within a response, the second derivative of the TMI response may be helpful for distinguishing these complexities. The second derivative is most useful in mapping near surface linears and other subtle magnetic structures that are partially masked by nearby higher amplitude magnetic features. The broad zones of higher magnetic amplitude, however, are severely attenuated in the vertical derivative results. These higher amplitude zones reflect rock units having strong magnetic susceptibility signatures. For this reason, both the TMI and the second derivative maps should be evaluated together.

Theoretically, the second derivative, zero contour or colour delineates the contacts or limits of large sources with near vertical dip and shallow depth to the top. The vertical gradient map also aids in determining contact zones between rocks with a susceptibility contrast, however, different, more complicated rules of thumb apply.

### **Concentric Loop EM Systems**

Concentric systems with horizontal transmitter and receiver antennae produce much larger responses for flat lying conductors as contrasted with vertical plate-like conductors. The amount of current developing on the flat upper surface of targets having a substantial area in this dimension, are the direct result of the effective coupling angle, between the primary magnetic field and the flat surface area. One therefore, must not compare the amplitude/conductance of responses generated from flat lying bodies with those derived from near vertical plates; their ratios will be quite different for similar conductances.

Determining dip angle is very accurate for plates with dip angles greater than 30°. For angles less than 30° to 0°, the sensitivity is low and dips can not be distinguished accurately in the presence of normal survey noise levels.

A plate like body that has near vertical position will display a two shoulder, classic **M** shaped response with a distinctive separation distance between peaks for a given depth to top.

It is sometimes difficult to distinguish between responses associated with the edge effects of flat lying conductors and poorly conductive bedrock conductors. Poorly conductive bedrock conductors having low dip angles will also exhibit responses that may be interpreted as surficial overburden conductors. In some situations, the conductive response has line to line continuity and some magnetic correlation providing possible evidence that the response is related to an actual bedrock source.

The EM interpretation process used, places considerable emphasis on determining an understanding of the general conductive patterns in the area of interest. Each area has different characteristics and these can effectively guide the detailed process used.

The first stage is to determine which time gates are most descriptive of the overall conductance patterns. Maps of the time gates that represent the range of responses can be very informative.

Next, stacking the relevant channels as profiles on the flight path together with the second vertical derivative of the TMI is very helpful in revealing correlations between the EM and Magnetics.

Next, key lines can be profiled as single lines to emphasize specific characteristics of a conductor or the relationship of one conductor to another on the same line. Resistivity Depth sections can be constructed to show the relationship of conductive overburden or conductive bedrock with the conductive anomaly.

## APPENDIX D

