

PASMINCO EXPLORATION

**INTERPRETATION OF HELICOPTER-BORNE
ELECTROMAGNETIC SURVEY DATA
ACQUIRED OVER THE
DUNDAS REGION
WESTERN TASMANIA
MAY 1999**

EL 21/96

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Date: October 2000

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Submitted By:

Accepted By:

Melbourne Report No: VC339

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1. SUMMARY

A high resolution helicopter-borne frequency domain electromagnetic (HEM) and magnetic survey was conducted in April 1999 over the Dundas exploration licence EL 21/96, located in Western Tasmania. The survey was flown by Geo Instruments Pty Ltd for Pasmenco Exploration who are currently exploring the ground for Rosebery and Farrell style Pb-Zn-Ag-Au mineralisation. The aim of the survey was to detect anomalous conductive response in the EM data that could be directly targeted for base-metals mineralisation. It is conceptual that massive sulphide mineralisation within a base-metals mineralised system would comprise a sufficient quantity (with suitable geometrical distribution) of conductive sulphide minerals (eg galena, pyrite, pyrrhotite, and chalcopyrite) to produce a recognisable EM response. An additional aim of the survey was to facilitate geological mapping of the region to assist with defining prospective horizons on which to focus more detailed exploration using alternative techniques.

The survey was flown using the Hummingbird 5 frequency EM system developed by Geotech Pty Ltd. The system consists of two vertical coaxial coil pairs (980Hz and 7001Hz) and three coplaner coil pairs (385Hz, 6606Hz, and 34133Hz). The EM coils are mounted in an 8m long boom (bird) which is towed below the helicopter via a 30m cable. The magnetometer is also located in the boom. Minor noise was introduced into the magnetic readings by the 385Hz EM coil operation. Otherwise survey data quality was acceptable apart from unavoidable cultural noise presented by power-lines and other culture in the NE of the survey region.

The region features rugged topography and several cultural anomalies (power-lines) which impeded the logistical aspects of data acquisition. A total of 987 line kilometres were flown at 100m line spacing and 30m nominal terrain clearance. Data were sampled at 0.1 seconds equating to 1-4 metres interval dependent on the helicopter ground speed. Total cost for data acquisition and processing was \$87,000 equating to \$88/line kilometre. Mobilisation/demobilisation costs equated to approximately \$7,000. Located data and grids of apparent resistivity and total magnetic intensity data were provided by the contractor along with stacked profiles of raw EM response.

A suite of anomalous EM responses were delineated in images produced of the computed resistivity data. These anomalies were checked against stacked profiles of the actual located line data. Analysis of stacked profiles provided the most suitable means of anomaly prioritisation. A majority of the low resistivity responses were determined to be dominantly high frequency quadrature responses (poor conductors). A significant EM response was delineated coincident with the known Collbrook Hill skarn mineralisation. A total of 13 other HEM responses have been determined to be worthy of ground follow-up. Most of these anomalies have had some degree of previous work conducted on them. Images of the EM and magnetic data have been produced and provide the basis for future structural and lithological interpretation.

2. INTRODUCTION

A high resolution helicopter-borne frequency domain electromagnetic (HEM) and magnetic survey was conducted in April 1999 over the Dundas EL 21/96 in Western Tasmania. The Dundas EL is situated less than 1 kilometre to the west of the town of Rosebery (Figure 1). The survey was flown by Geo Instruments Pty Ltd for Pasmenco Exploration who are currently exploring the ground for Rosebery style Pb-Zn-Ag-Au mineralisation. The aim of the survey was to detect anomalous conductive response in the EM data that could be directly targeted for base-metals mineralisation. It is conceptual that massive sulphide mineralisation within a base-metals mineralised system would comprise a sufficient quantity (with suitable geometrical distribution) of conductive sulphide minerals (eg galena, pyrite, pyrrhotite, and chalcopyrite) to produce a recognisable EM response. An additional aim of the survey was to facilitate geological mapping of the region to assist with defining prospective horizons on which to focus more detailed exploration using alternative techniques.

The survey was flown using the Hummingbird 5 frequency EM system developed by Geotech Pty Ltd. The system consists of two vertical coaxial coil pairs (980Hz and 7001Hz) and three coplaner coil pairs (385Hz, 6606Hz, and 34133Hz). The EM coils are mounted in an 8m long boom (bird) which is towed below the helicopter via a 30m cable. The magnetometer is also located in the boom. This report presents the results of this survey and provides recommendations for follow-up work.

3. GEOLOGY

This geological summary is extracted directly from the annual report by Parfrey and Simpson (1999).

The Dundas region is a geologically complex part of the Central Mount Read Volcanic Belt characterised by intercollated fault bounded lithologies. The region largely comprises lithologies of the Dundas Group. These include a mixture of epiclastic and minor volcanoclastic sediments. The volcanosedimentary sequence is dominantly comprised of turbiditic to shallow water sediments containing immature conglomerates, monotonous siltstones and shales. At the top of the sequence felsic to intermediate tuffs, related volcanoclastic sediments, and minor lava flows occur.

Pre-Cambrian Oonah Formation is present within EL 21/96 as a fault bounded block of schists, thinly bedded mudstones and siltstones and minor shale and sandstone. Shallow water deposits of the Success Creek Group outcrop in the NW of the Dundas area near the Renison Bell Tin Mine. The package includes laminated siltstone and shale, with interbedded sandstone and conglomerate. The Crimson Creek Formation (also outcropping in the NW of the EL) comprises a sequence of turbiditic volcanoclastic

epiclastic lithic wackes, massive siltstones, mudstones and basaltic lava flows. Highly magnetic ultramafic complexes are also evident in the western part of the survey region.

The main implications for HEM surveying are the presence of glacial cover and discrete areas of Permian sediments that give rise to high frequency quadrature EM responses. These are quite readily distinguishable from basement responses due to the spatial and frequency responses observed. Also is the fact that flying a coil EM sensor through a high gradient magnetic field (such as that situated over the ultramafic complexes) results in induction of a response that is not due to ground conductivity but due to the magnetic characteristics of the rocks.

4. SURVEY SPECIFICATIONS

Survey specifications for the helicopter borne aeromagnetic and electromagnetic data are summarised as follows (full survey specifications and logistics are outlined in the Operations Report of Appendix 1):

Date of Survey:	March 1999
Contractor:	Geo Instruments Pty Ltd
Aircraft:	Aerospatiale AS350BA "Squirrel"
Magnetometer:	Geometrics G822A (within the towed bird)
EM System:	GeoTech Hummingbird 5-frequency
Co-Axial Coil Freq.:	980 Hz and 7001 Hz
Co-Planar Coil Freq.:	385 Hz, 6606 Hz, and 34133 Hz
Recording Interval:	0.1 second (approx. 1-4 m)
Helicopter Clearance:	60 metres
Towed Bird Clearance:	30 metres
Line Spacing:	100 metres
Line Direction:	090-270°
Tie Line Spacing:	1000 metres
Tie Line Direction:	000-180°
Navigation:	Real Time GPS
GPS Receiver:	Novatel 951R
Altimeter:	Sperry AA210
Acquisition System:	Geo Instruments G2002
Processing By:	Geo Instruments Pty Ltd
Total Line km's:	987

5. PROCESSING AND MODELLING PARAMETERS

Processing parameters are provided below (these are for the purpose of any future work):

EM data were levelled using high altitude EM zero levels (according to the contractors logistics report). It is the understanding of the author that tie line levelling of survey data was not attempted due to problems associated with maintaining survey altitude in the rugged terrain. It was also the understanding of the author that levelling of EM data using high altitude calibration runs was similarly not used due to rapid changes in temperature with height making these calibrations unreliable. In the end the EM survey data were levelled by taking background from areas of low EM relief. Apparent resistivity data were computed for the coplanar coil data.

Raw magnetic data exhibited a low amplitude high frequency noise component induced by the 385 Hz EM coil. This was removed using a 5 point low-pass filter. Subsequent processing included diurnal subtraction, system parallax removal, IGRF removal, and micro-levelling.

A flight path map is presented in Plan 1.

6. DISCUSSION AND RESULTS

Data are discussed on an individual basis and integrated where considered necessary.

Aeromagnetic Data

An image and contours of the total magnetic intensity is presented in Plan 2. These data exhibit a relatively subdued magnetic character in the eastern part of the survey region (Dundas Group sediments which are typically non-magnetic) in contrast to the extremely high magnetic relief in the western regions characteristically due to the ultramafic complexes (up to several 1000's on nanoTesla's). Structural information are clearly evident within the data and can be enhanced by viewing high-pass filtered data and image derived derivatives. The skarn mineralisation at Collbrook Hill has an identifiable magnetic anomaly – interpreted to be due to associated magnetic pyrrhotite. For the purpose of base-metals mineralisation detection perhaps the most applicable use of the magnetic image is for correlation with the EM resistivity maps (particularly at 34KHz and 6KHz) for the purpose of identifying those responses caused by high magnetic gradients rather than conductive sources.

Electromagnetic Data

An image and contours of the computed apparent resistivity at 34133 Hz, 6606 Hz, and 385 Hz are presented in Plan 3, Plan 4, and Plan 5 respectively. These images were scanned and a suite of anomalies identified for further investigation. A first pass comparison of the apparent

resistivity images with the mapped geology and the total magnetic intensity image immediately discounts most of the anomalies as being caused by Permian sediments, glacial cover, or high magnetic gradients. A total of 15 other anomalies were identified as being interesting and profile HEM data analysed for each. Each of these responses is summarised in the table below:

Anomaly	Easting AMG	Northing AMG	Interpreted Source	Recommended Followup
D1	374900	5373600	Shale / mineralisation	Historical data + ground check
D2	376500	5373400	Shale / mineralisation	Historical data + ground check
D3	374100	5373200	Culture?	Historical data + ground check
D4	374350	5372200	Shale / mineralisation	Historical data + ground check
D5	375000	5371500	Collbrook Hill	Historical data + ground check
D6	375750	5370900	Shale / mineralisation	Historical data + ground check
D7	372750	5367400	Shale / mineralisation	Historical data + ground check
D8	370150	5367800	Po veining	Historical data + ground check
D9	370900	5367900	Po veining	Historical data + ground check
D10	370300	5366200	Shale / mineralisation	Historical data + ground check
D11	373000	5365300	Shale / mineralisation	Historical data + ground check
D12	373850	5365000	Glacials	None
D13	371500	5364800	Shale / mineralisation	Historical data + ground check
D14	372950	5364000	Shale / mineralisation	Historical data + ground check
D15	371750	5361900	Shale / mineralisation	Historical data + ground check

Of these anomalies 14 have been recommended for ground follow-up and the remainder interpreted as either shale responses, cultural, or conductive cover. The most anomalous response is that produced by the Collbrook Hill mineralised skarn system. This mineralisation has previously been identified and has been the site of numerous historical ground geophysical and geochemical surveys.

No modelling has been conducted on the EM data. The aim of the survey was to identify anomalies for further investigation (ie “bump finding”) hence modelling would likely only prove an academic (and thus costly) exercise. It is estimated that all the above identified EM response are situated within the top 100-200m from surface. Therefore is it most likely that

ground follow-up with geochemistry, further geophysics or simply geological mapping should be sufficient to determine whether drill testing is warranted.

The anomalies are further discussed below:

D1

This anomaly looks to be the northern extension of the Collbrook Hill mineralised trend. There are no

D2

D2 is covered by the Renison GAO grid. The anomaly is N-S striking for 800m and is perhaps the most prospective of all responses for Pb-Zn mineralisation. The results of the Renison GOA grid should be followed up.

D3

D3 is a single line anomaly on the wall of a wall and is quite possibly cultural in origin (although the wavelength of the anomaly does not really support this). The fact that the response is a single line only means no follow-up is recommended.

D4

D4 is a small N-S striking anomaly lying to the NW of Collbrook Hill. The anomaly has the same characteristics as the Collbrook Hill Mineralisation. It has been traversed by a single line of the Collbrook Hill grid.

D5

D5 is the anomaly caused by mineralisation at the Collbrook Hill. It has been traversed by the Collbrook Hill grid. The anomaly has several separate sources, shows great depth potential and appears to plunge to the south. The type of mineralisation and extent of existing drilling would need to be assessed in order to determine whether follow-up was warranted.

D6

D6 appears like a parallel repetition to the Collbrook Hill mineralisation. It has been recommended for followup. The Rosebery Lodes grid traverses this anomaly (which appears deeper than the Collbrook Hill mineralisation).

D7

D7 is a N-S to NE-SW striking EM anomaly with a length of 2.5km. The large strike extent suggests a lithological source however follow-up should be conducted to confirm this assumption. The anomaly is traversed on several lines by the Godkin Minopps/Comstaff grid (Reference TR 92-3358).

D8

D8 is situated near the Renison Mine Lease and is characteristic of a narrow pyrrhotite style body. There are no grids that cover this response and the response has not been closed off to the north.

D9

D9 is situated near the Renison Mine Lease and is characteristic of a narrow pyrrhotite style body. There are no grids that cover this response and the response has not been closed off to the north.

D10

The D10 anomaly is a sharp discrete anomaly extending N-S for a strike length of 300m. The anomaly has very sharp edges suggesting a shallow source. The discrete nature of the response makes it worthy of follow-up. A single grid line from the Carbine RGC grid (reference TR 92-3358) crosses this anomaly.

D11

The D11 anomaly is a suite of 4 separate EM sources. It is likely that the same system (either mineralised or shales) is the source of these responses. The response is covered by the Montezuma EZ/CSR grid reference TR92-3358. Follow-up is strongly recommended. The anomaly has the second highest amplitude (after Collbrook Hill) in the survey.

D12

D12 is a single line anomaly that on closer inspection resembles glacial cover and is not recommended for follow-up.

D13

This anomaly straddles the northern margin of the Pre-Cambrian – Dundas contact. It extends east-west for a strike length of approximately 1.4 km and is covered by the Carbine-CSR ground grid reference TR92-3358.

D14

This anomaly straddles the eastern margin of the Pre-Cambrian – Dundas contact. It extends for a strike length of approximately 1.4 km and is covered by the Montezuma ground grid reference TR92-3358. The broadness and the sharp edges of this anomaly suggest a lithological source (such as a shale package) however follow-up is recommended to confirm this interpretation.

D15

This ovoid HEM anomaly is situated on the contact between Pre-Cambrian and undifferentiated Dundas Group. There are no correlating nearby workings. The anomaly is traversed by the Dundas Grid reference TR92-3358.

7. RECOMMENDATIONS

A total of 14 anomalies have been recommended for ground follow-up. A possible program for follow-up would include the following:

1. Look at existing ground data (drilling, geology, geophysics, and geochemistry) to determine whether the response has been tested. Most of the delineated anomalies have had some degree of previous work conducted on them.
2. Locate the centre of each remaining anomaly on the ground and determine whether the anomaly is situated in prospective lithologies (or whether there are just black shales present!).
3. Conduct geochemistry and a ground fixed loop EM survey over remaining anomalies and drill test those that are anomalous.

8. KEYWORDS AND LOCALITY

Keywords

anomaly, Dundas, electromagnetics, EM, glacials, heli, magnetics, resistivity

Locality

1:250K SI/55-SW

1:100K Pieman 7914

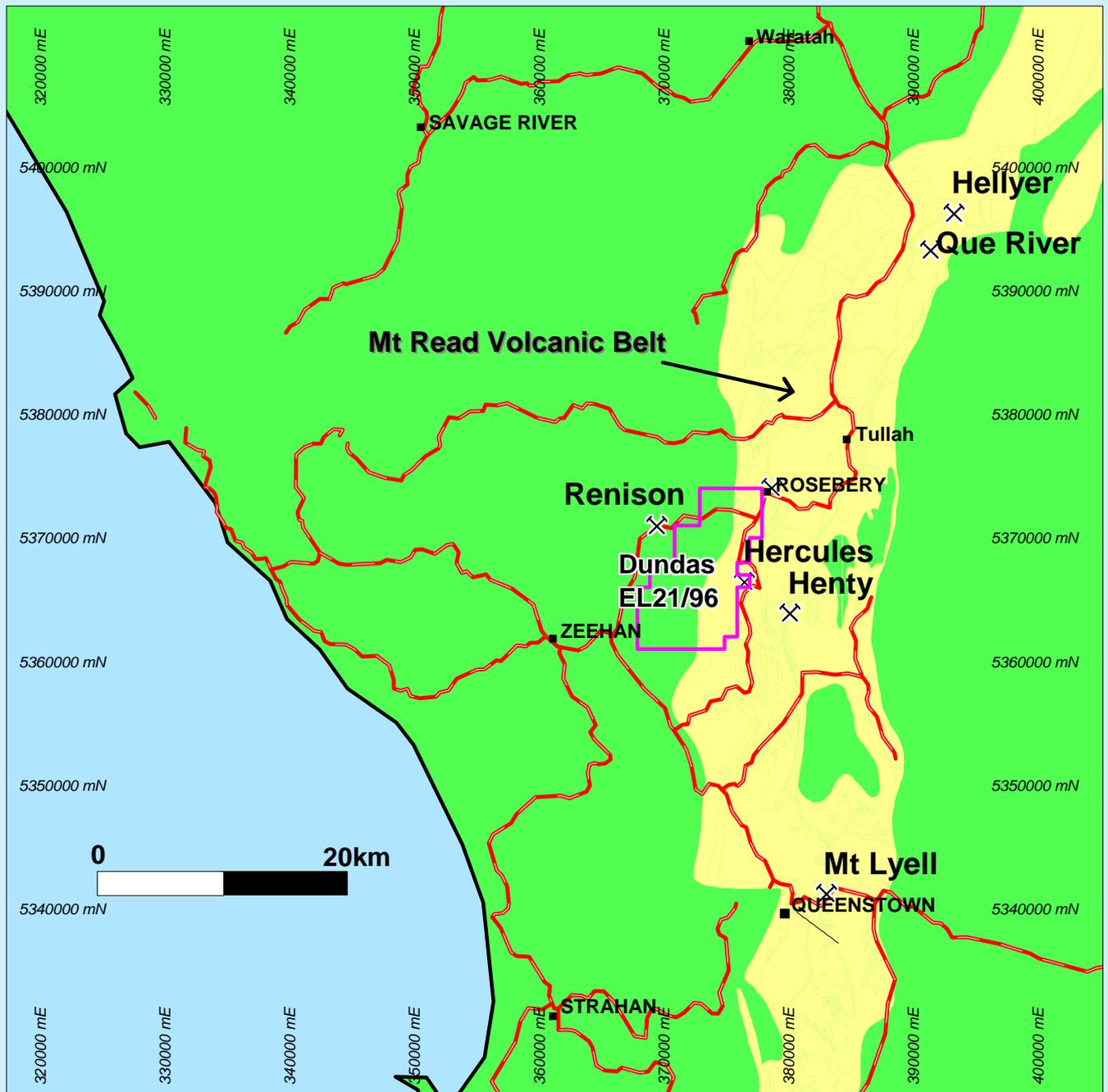
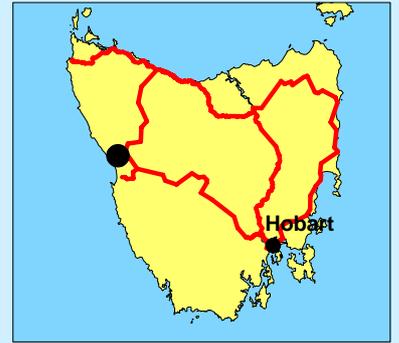
REFERENCES

Parfrey, O., and Simpson, K. L., 1999, Dundas EL 21/96 Annual Report for the period November 1998 to November 1999, Pasminco Exploration Report No. VC284



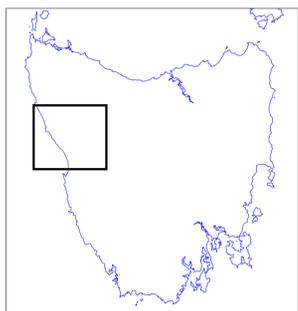
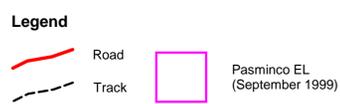
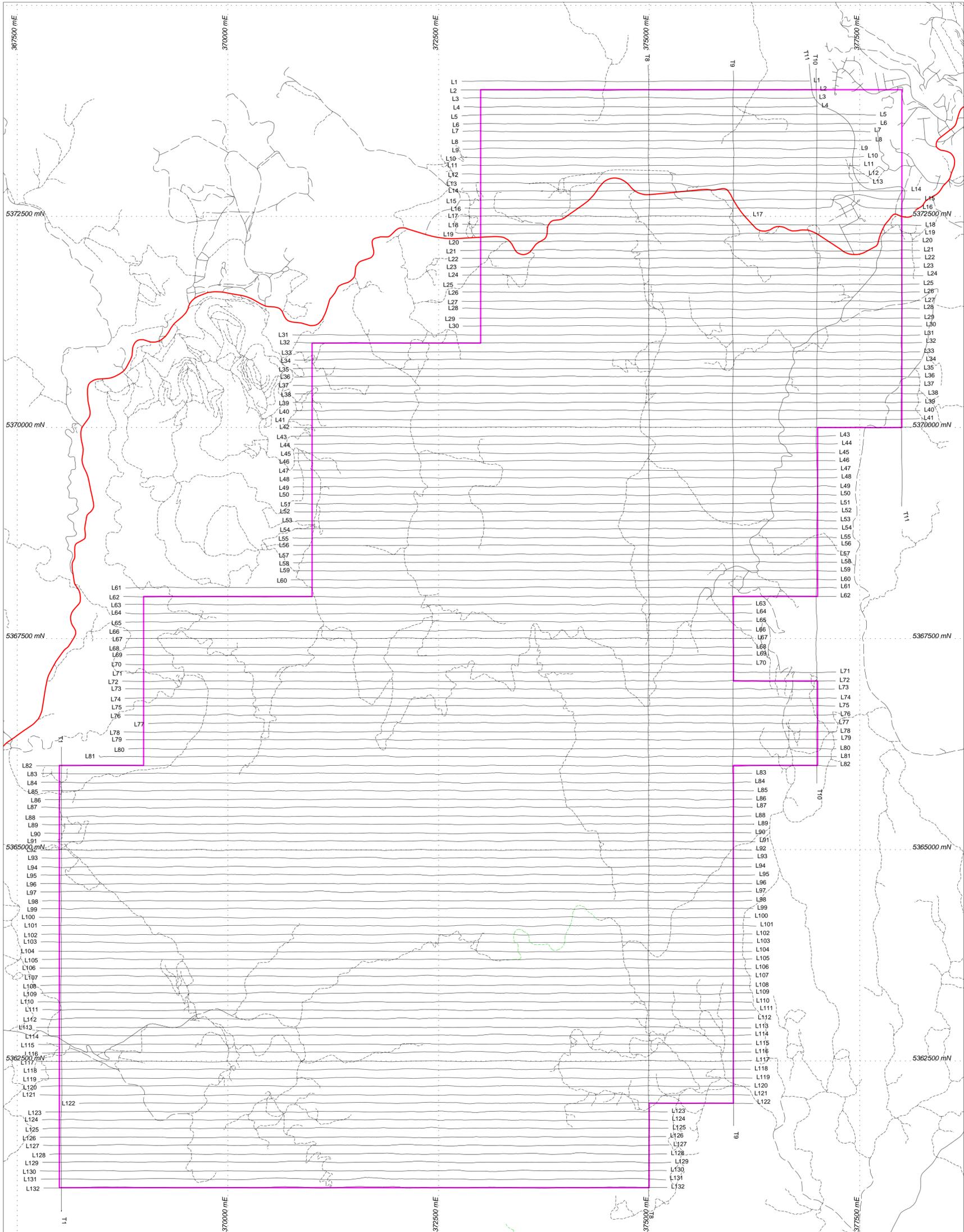
PASMINGO
EXPLORATION

**Figure 1.
Dundas EL 21/96
Location Diagram**

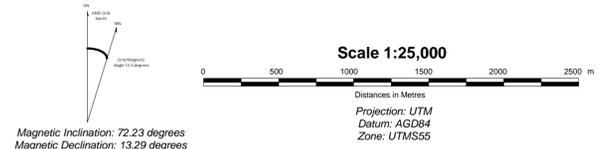


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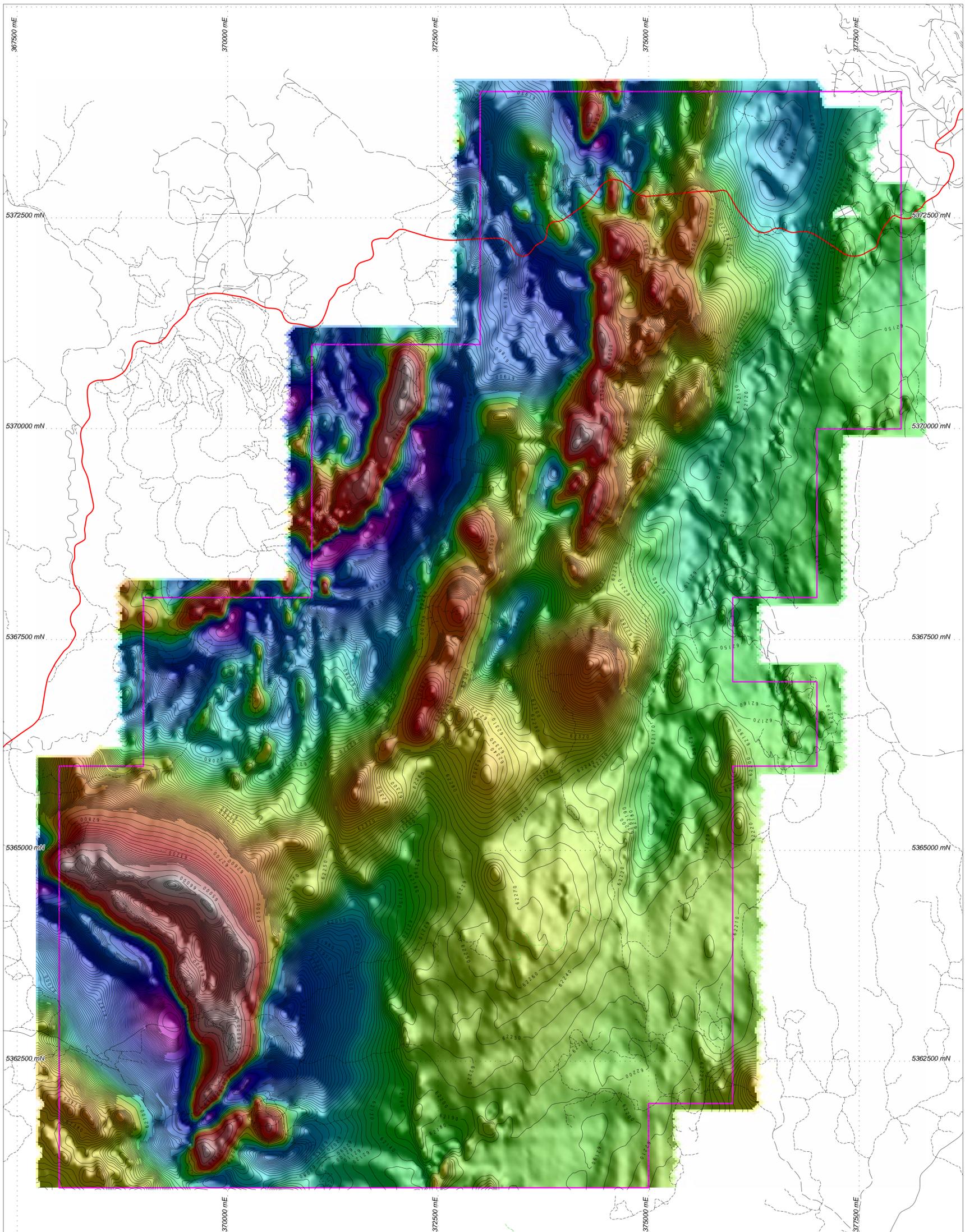
Compiled by C Dauth July 2000



Survey Specifications
 Survey Date: March 1999
 Contractor: Geo Instruments Pty Ltd
 Line Spacing: 100m
 Line Direction: 090-270 degrees
 Sample Interval: 0.1 sec (1-4 m)
 Terrain Clearance: Nominal 60m
 Bird Clearance: Nominal 30m
 Magnetometer: Geometrics G822A
 EM System: Geotech Hummingbird
 Frequencies: 34K, 7001Hz, 6606Hz, 980Hz, and 385Hz
 Flight Path Recovery: Real Time GPS
 GPS: Novatel 951R GPS Receiver
 Radar Altimeter: Sperry AA210
 GPS Base Station: Fugro Melbourne
 Aircraft: Squirrel



		PASMINCO EXPLORATION ETS Melbourne	
		TASMANIA	
Date: Nov 1999 Author: C Dauth Office: ETS Ref:		DUNDAS EL21/96 Heliborne Electromagnetic Survey Flight Path Diagram	
Scale: 1:25,000	Projection: SUTM55 AGD84	PLAN: 1	



Legend

— Road
 - - - Track
 □ Pasmenco EL (September 1999)

Survey Specifications

Survey Date: March 1999
 Contractor: Geo Instruments Pty Ltd
 Line Spacing: 100m
 Line Direction: 090-270 degrees
 Sample Interval: 0.1 sec (1-4 m)
 Terrain Clearance: Nominal 60m
 Bird Clearance: Nominal 30m
 Magnetometer: Geometrics G822A
 EM System: Geotech Hummingbird
 Frequencies: 34K, 7001Hz, 6606Hz, 980Hz, and 385Hz
 Flight Path Recovery: Real Time GPS
 GPS: Novatel 951R GPS Receiver
 Radar Altimeter: Sperry AA210
 GPS Base Station: Fugro Melbourne
 Aircraft: Squirrel

Processing Details

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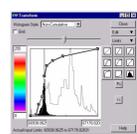
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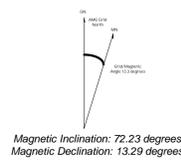
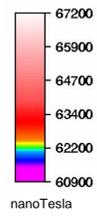
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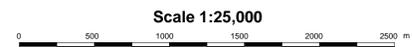
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 Sunangle: NE at 45 degrees



TMI colour histogram transform

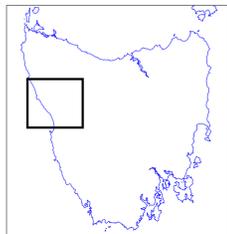


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 Magnetic Declination: 13.29 degrees

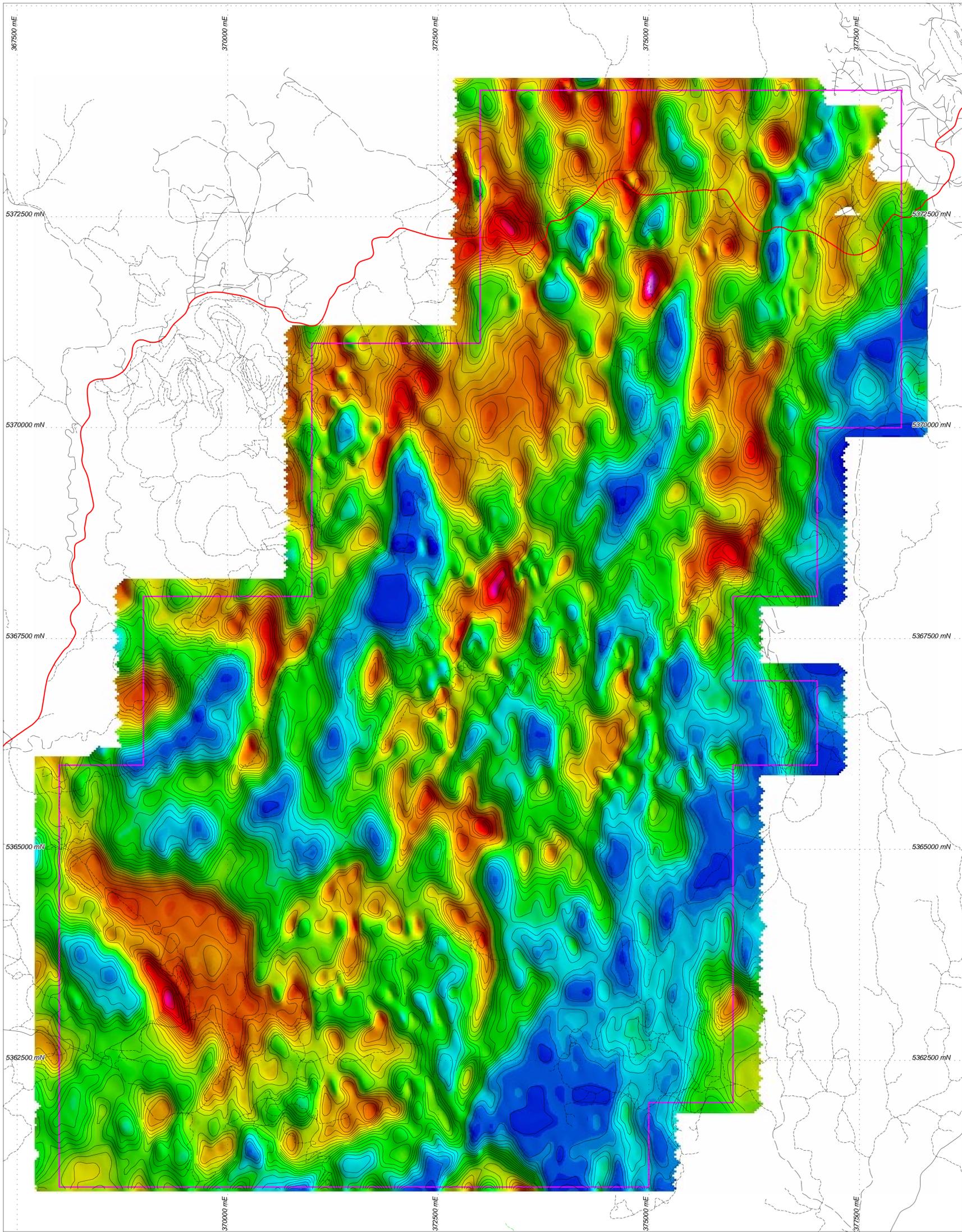


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Distances in Meters
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 Zone: UTM55

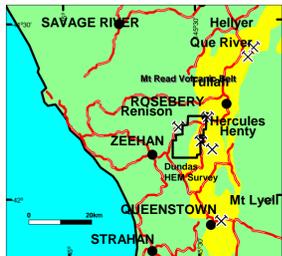
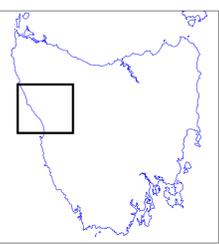


	PASMINCO EXPLORATION ETS Melbourne	
	TASMANIA	
Date: Nov 1999	DUNDAS EL21/96 Heliborne Electromagnetic Survey TMI Image and Contours	
Author: C Dauth		
Office: ETS		
Ref:		
Scale: 1:25,000	Projection: SUTM55 AGD84	PLAN: 2



Legend

- Road
- Track
- Pasmenco EL (September 1999)



Survey Specifications

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 Line Spacing: 100m
 Line Direction: 090-270 degrees
 Sample Interval: 0.1 sec (1-4 m)
 Terrain Clearance: Nominal 60m
 Bird Clearance: Nominal 30m
 Magnetometer: Geometrics G822A
 EM System: Geotech Hummingbird
 Frequencies: 34K, 7001Hz, 6606Hz, 980Hz, and 385Hz
 Flight Path Recovery: Real Time GPS
 GPS: Novatel 951R GPS Receiver
 Radar Altimeter: Sperry AA210
 GPS Base Station: Fugro Melbourne
 Aircraft: Squirrel

Image Specifications

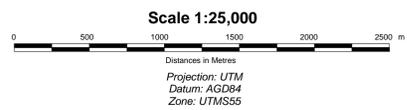
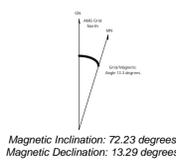
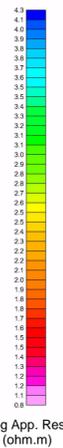
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Contour Specifications

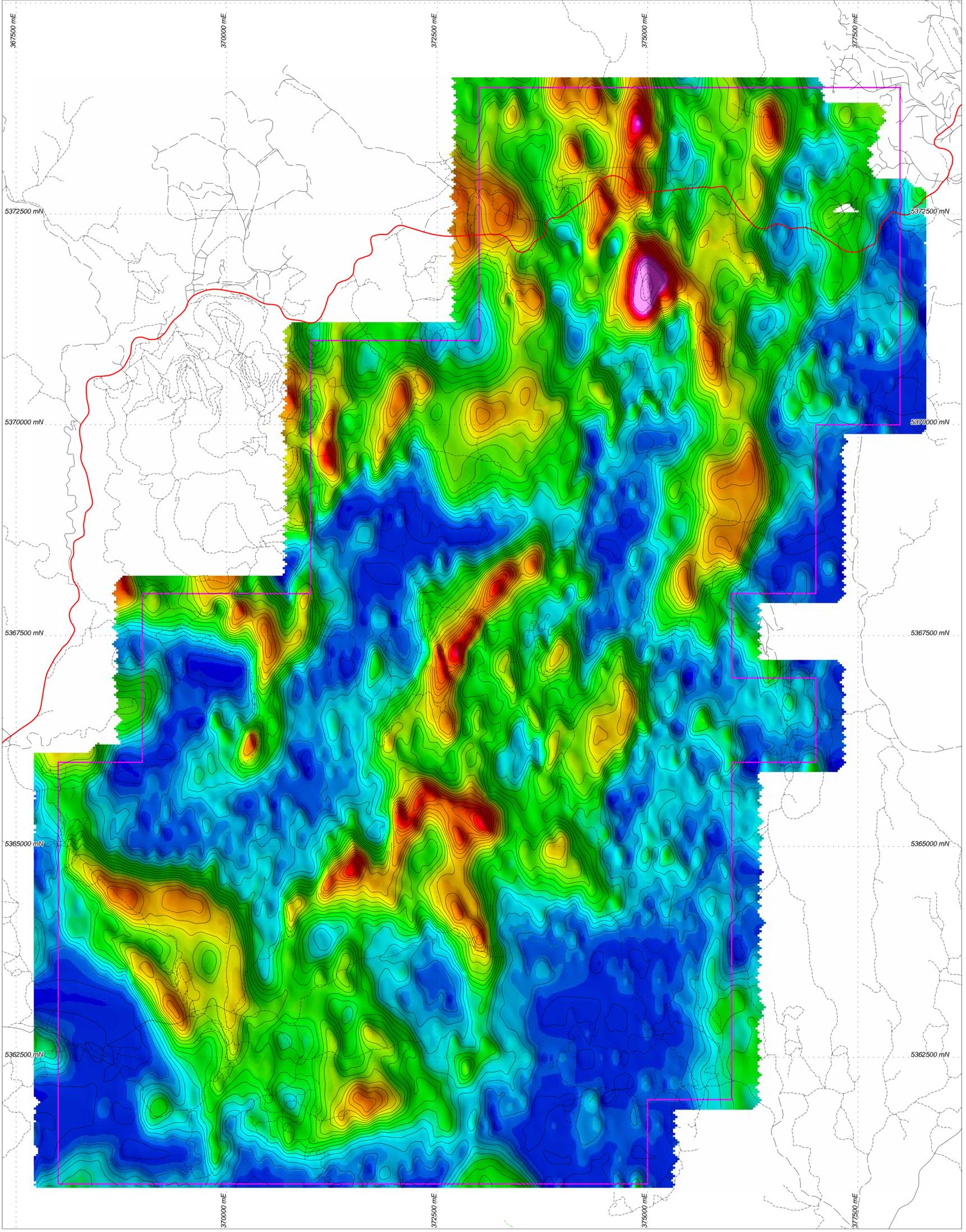
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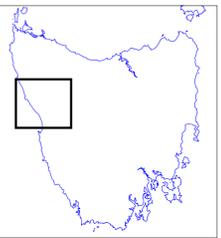


	PASMINCO EXPLORATION ETS Melbourne	
	TASMANIA	
Date: Nov 1999	DUNDAS EL21/96 Heliborne Electromagnetic Survey Image of Apparent Resistivity Coplaner Coils at 34133 Hz	
Author: C Dauth		
Office: ETS		
Ref:		
Scale: 1:25,000	Projection: SUTM55 AGD84	PLAN: 3



Legend

- Road
- Track
- Pasmenco EL (September 1999)



Survey Specifications

Survey Date: March 1999
 Contractor: Geo Instruments Pty Ltd
 Line Spacing: 100m
 Line Direction: 090-270 degrees
 Sample Interval: 0.1 sec (1.4 m)
 Terrain Clearance: Nominal 60m
 Bird Clearance: Nominal 30m
 Magnetometer: Geometrics G822A
 EM System: Geotech Hummingbird
 Frequencies: 34K, 7001Hz, 6606Hz, 980Hz, and 385Hz
 Flight Path Recovery: Real Time GPS
 GPS: Novatel 951R GPS Receiver
 Radar: Altimeter: Sperry AA210
 GPS Base Station: Fugro Melbourne
 Aircraft: Squirrel

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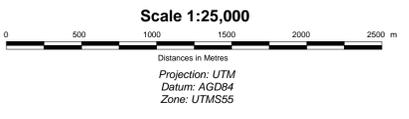
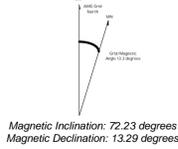
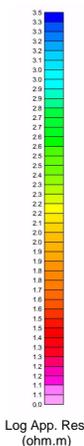
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Contour Specifications

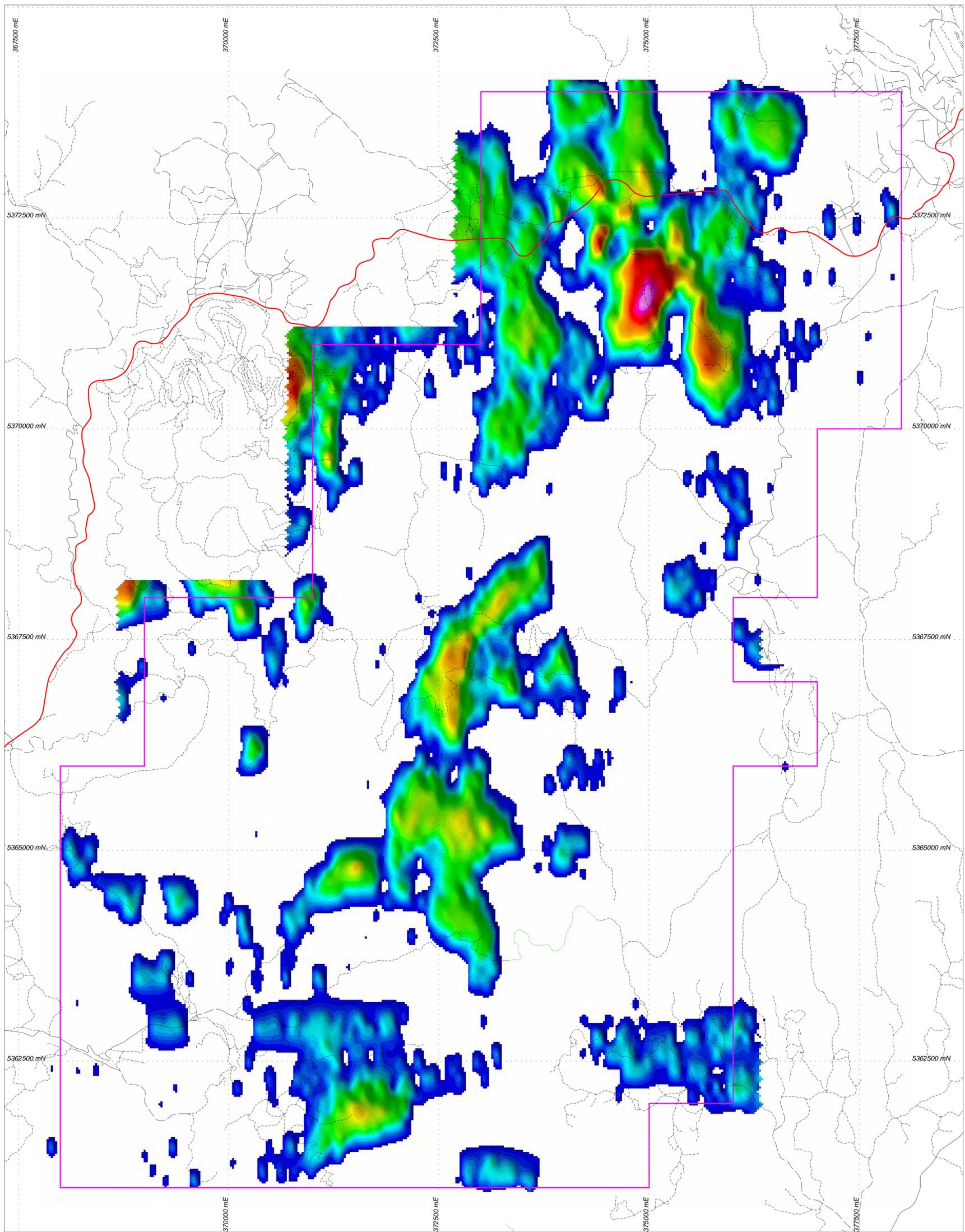
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Processing Details

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 Apparent Resistivity computed for a half-space response.
 Data gridded at 25m cell size.

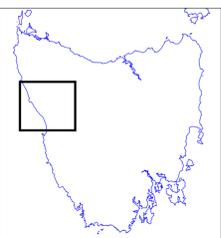


	PASMINCO EXPLORATION ETS Melbourne	
	TASMANIA	
Date: Nov 1999	DUNDAS EL21/96	
Author: C Dauth	Heliborne Electromagnetic Survey	
Office: ETS	Image of Apparent Resistivity	
Ref:	Coplaner Coils at 6606 Hz	
Scale: 1:25,000	Projection: SUTM55 AGD84	PLAN: 4



Legend

— Road
 - - - Track
 □ Pasmenco EL (September 1999)



Survey Specifications

Survey Date: March 1999
 Contractor: Geo Instruments Pty Ltd
 Line Spacing: 100m
 Line Direction: 090-270 degrees
 Sample Interval: 0.1 sec (1-4 m)
 Terrain Clearance: Nominal 60m
 Bird Clearance: Nominal 30m
 Magnetometer: Geometrics G822A
 EM System: Geotech Hummingbird
 Frequencies: 34K, 7001Hz, 6606Hz, 980Hz, and 385Hz
 Flight Path Recovery: Real Time GPS
 GPS: Novatel 951R GPS Receiver
 Radar Altimeter: Sperry AA210
 GPS Base Station: Fugro Melbourne
 Aircraft: Squirrel

Image Specifications

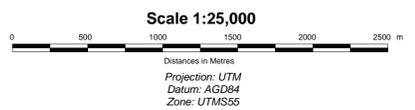
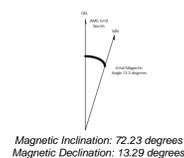
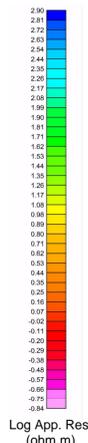
GEOSOF "Colour Shaded Grid"
 Parameter: Log App. Res.
 Colour Table: Colour_Reverse.tbl
 Limits: 100%
 Histogram Transform: Linear
 Sunangle: NE at 45 degrees

Contour Specifications

Parameter: App. Res. at 385Hz
 Interval: 0.1 Log App. Res.
 Dropout: 0.4 mm

Processing Details

Data levelled using background ppm levels.
 Apparent Resistivity computed for a half-space response.
 Data gridded at 25m cell size.



	PASMINCO EXPLORATION ETS Melbourne	
	TASMANIA	
Date: Nov 1999 Author: C Dauth Office: ETS Ref:	DUNDAS EL21/96 Heliborne Electromagnetic Survey Image of Apparent Resistivity Coplaner Coils at 385 Hz	
Scale: 1:25,000	Projection: SUTM55 AGD84	PLAN: 5

Appendix 1

Contractor Logistics and Processing Report

Operations and Processing Report

ON THE 1999 HELICOPTER ELECTROMAGNETIC SURVEY, DUNDAS AND NORTH MURCHISON BLOCKS, ZEEHAN, TASMANIA

March 1999

**Pasminco Australia Limited
ACN 004 074 962
Level 15, 380 St Kilda Road
Melbourne
Victoria 3004
AUSTRALIA**

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AND FLIGHT PLANS

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OPERATORS FLIGHT REPORT

1. INTRODUCTION

This report describes the operations for the Dundas and North Murchison helicopter geophysical surveys conducted at Zeehan, Tasmania, by Geo Instruments Pty Ltd under contract to Pasminco Australia Limited between 13th and 25th March 1999. The survey areas contain volcanic and sedimentary units of the Mt Read Volcanics which are prospective for volcanogenic Pb-Zn-Ag massive sulphide deposits, as well as intrusive rocks which may be associated with other styles of mineralisation.

The survey collected a total of 1,210 line kilometres of electromagnetic, magnetic and elevation data in six days of survey operations. The results of the geophysical survey are presented as colour images of resistivity for three frequencies, magnetics and digital terrain model, plus multi-parameter profiles of each survey line.

2. SURVEY SPECIFICATIONS

The survey comprises airborne geophysical mapping over the Dundas and North Murchison Blocks at Zeehan, Tasmania. Data acquisition totalled 1,210 line kilometres of airborne electromagnetic, magnetic and elevation data.

2.1 LINE SPECIFICATIONS

Dundas Area (987 Kms)

Traverse Line Direction	090°-270°
Traverse Line Spacing	100 metres
Tie Line Direction	00°-180°
Tie Line Spacing	1000 metres

North Murchison Area (223 Kms)

Traverse Line Direction	115° - 295°
Traverse Line Spacing	100 metres
Tie Line Direction	025° - 205°
Tie Line Spacing	1000 metres

2.2 INSTRUMENTAL SPECIFICATIONS

Electromagnetic	
Sampling Interval	0.1 second
Sensitivity	1 ppm
Coaxial Coil Frequencies	980 and 7001 Hz
Coplanar Coil Frequencies	385, 6606 and 34133 Hz

Magnetics	
Sampling Interval	0.1 second
Total Noise	< 0.05 nT

Base Station Magnetometer	
Sampling Interval	1 second
Noise Level	< 0.2 nT
Resolution	Better than or equal to 0.1 nT

Radar Altimeter	Output 13.1mV/m
-----------------	-----------------

2.3 FLYING SPECIFICATIONS

Electromagnetic and Magnetometer Sensor	
Nominal Terrain Clearance	30 metres (30 metre bird cable)
Flying Speed	40 m/second

3. SURVEY OPERATIONS

3.1 SURVEY BASES

The survey entailed 2 blocks referred to as Dundas and North Murchison. The base for the program was the Heemskirk Motel in Zeehan.

The helicopter survey equipment and party chief arrived in Zeehan on 11th March 1999 and the base magnetometer and base GPS stations were set up on 12th March. The helicopter arrived on site on 13th March and installation and testing were completed that day. Rain and low cloud precluded flying in the survey areas for three days. Surveying of the Dundas Block commenced on 17th March. Heavy rain and strong winds resulted in no production for a further two days. The survey concluded on 24th March.

The quality control (QC) and field data processing were carried out at the Heemskirk Motel. The helicopter was always parked at the same location at the base to ensure consistency in ground calibrations.

3.2 FLIGHT PLANNING

Coordinates of all flight blocks (see maps in Appendix 1), were planned out in separate blocks for each area. Maps of the proposed flight lines and tie lines were reviewed with the client prior to commencement of flying. The presence of both large and small power transmission lines in the survey areas was considered in the overall survey design. Both areas are located in UTM Zone 55.

3.3 FLIGHT PATH CONTROL

A NovAtel 951R receiver was used for navigation and for flight path verification. The position solution from the receiver was obtained using signals from the U.S. Global Positioning System (GPS). Real time corrections were provided by the Fugro Omnistar satellite system. In rare circumstances, the real time differential corrections were not received due to the satellite disappearing below the horizon (ie in valleys) or due to microwave interference. Altitude control is derived from the radar altimeter.

The GPS receiver transmits two data streams to the logging computer. One data stream consists of real time differentially corrected positions at two times per second. The other stream contains the raw range data from all of the satellites being tracked and this is logged once per second.

The positional data are used to calculate the flight path guidance information which is presented to the pilot on both digital and analogue displays mounted in direct view. The radar altimeter display is mounted in close proximity to the guidance displays for easy cross reference.

The GPS base station was a NovAtel 3151R unit.

3.4 SURVEY PLATFORM

Helicopter: Aerospatiale AS350BA "Squirrel" Helicopter
Registration: VH-JWD
Contracted From: Heli-Aust Pty Ltd of Bankstown
Endurance: 3.5 hours fully loaded
Survey Speed: 30 m/sec

3.5 WEATHER DETAILS

The weather was often unfavourable for flying in the rugged terrain within the two survey blocks. Cold fronts with strong wind and heavy rain or low cloud and light rain were encountered on five days resulting in no survey production.

3.6 SAFETY MANAGEMENT

There were no aviation incidents during the implementation of the airborne survey for the aircraft utilised on the project. Safety procedures included strict rotation of pilots, and adherence to daily and scheduled maintenance of the helicopter. The presence of major and minor powerline cables and towers in the survey areas presented a recognised safety hazard. Daily flight plans and radio communication with base camp on completion of each flight line served to predict the position of the helicopter at all times.

3.7 ENVIRONMENTAL MANAGEMENT

The aircraft operations are non-polluting except for noise associated with take-off and landing. All operations were conducted during normal day time and no complaints were received regarding noise. Extreme care was maintained during all refuelling operations to eliminate the risk of fuel spillage or fire.

Ground operations are minor, usually focused around the survey bases. Common sense rules apply to these tasks with particular reference to public facilities, residential areas, stock yards, access paths, etc. Any staff member responsible for damaging property or land is liable for dismissal.

4. PERSONNEL

Survey management and geophysical personnel were provided by Geo Instruments Pty Ltd, Sydney. The helicopter pilot was provided by Heli-Aust Pty Ltd. In field quality control was undertaken at the Heemskirk Motel in Zeehan and data processing, map production were undertaken by Geo Instruments Pty Ltd in Sydney.

Field Operations

Field Project Manager:	Zoltan Beldi
Pilot:	Tony Feller
Operator:	Marc Thomson
Field Processor	Neil Fiset

Data Processing

Data Supervisor:	Neil Fiset
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Client Representative

Field Operations and Data Processing:	Chris Dauth
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5. GEOPHYSICAL EQUIPMENT

5.1 ELECTROMAGNETIC SYSTEM

The electromagnetic system is the Geotech Hummingbird 5-frequency system. It consists of two vertical coaxial coil pairs operating at 980 Hz and 7001 Hz and three horizontal coplanar coil pairs operating at 385 Hz, 6606 Hz, and 34133 Hz housed in a 6.5m long bird together with the magnetometer sensor. The transmitter-receiver separation for each coil pair is 6.2 metres.

The receiver coil responses are converted into their in-phase and out-of-phase (quadrature) components by processors installed in the bird, and are then transmitted as digital data by serial cable to the Geotech processor console in the aircraft. This console retains the calibration coefficients to convert the digital data representing voltages to parts per million. These data are transmitted to the Geo Instruments data acquisition system at 1 second intervals.

The EM system is mounted in a lightweight Kevlar bird which is towed 30 metres below the helicopter. Measurements of the in-phase and out-of-phase signals for each frequency are recorded at the rate of 10 times per second, with a sensitivity of one millionth of the primary field (1 part per million).

5.2 MAGNETOMETER

The Geometrics G822A Magnetometer is a highly sensitive unit incorporating an optically pumped sensor. The constant harmonic frequency from the sensor is proportional to the surrounding scalar magnetic field. This frequency is resolved by the Counter/ Processor which provides the magnetic field to a nominal accuracy of 0.01nT at 10 times per second both in analogue and digital forms. The sensor and pre-amp was mounted in the EM boom which was attached by approximately 30 metres of cable to the helicopter.

5.3 ALTIMETER

A Sperry AA210 radar altimeter system was installed in the helicopter. This controls the pilot's analogue indicator, which provides a terrain clearance display from 0 to 750 metres (0 to 2,500 ft.) above ground level. This is the primary tool used to maintain a consistent terrain clearance. The output of the altimeter is 13.1 mV/m and it can be read to a resolution of 1 mV for 0.076 metres.

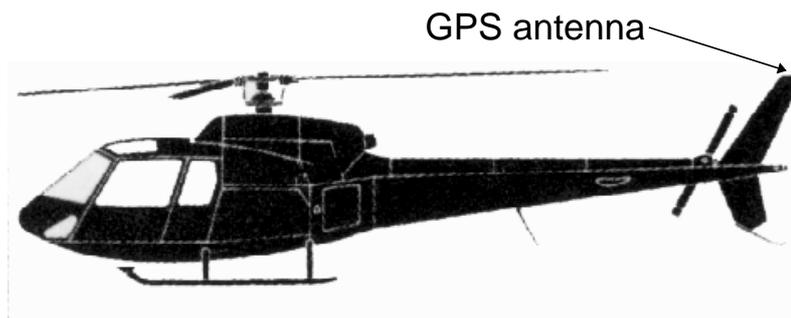
The reference height above the geoid used for data purposes, was derived from the differentially corrected height value provided by the GPS receiver.

Both GPS altitude and the radar terrain clearance were recorded every second by the digital acquisition.

5.4 GPS NAVIGATION SYSTEM

The guidance system for the helicopter was based on the U.S. Global Positioning System. GPS co-ordinates were referenced to the AGD84 spheroid.

A NovAtel 951R receiver mounted on the upper rear fuselage of the helicopter was used for navigation by means of analog and digital displays of the aircraft position located directly in front of the pilot. The corrected position is accurate to 1 metre for X and Y and 5 metres for Z (see Section 3.3).



The GPS base station was a NovAtel 3151R unit, with the antenna mounted on an external wall of the Heemskirk motel.

5.5 DATA ACQUISITION SYSTEM

The Geo Instruments G2002 digital acquisition system is based on the IBM PC AT architecture. The system is fitted with several modules tailored to condition the input data from the various sensing instruments. A custom written software package facilitates the following:

- (a) Correct synchronisation of the data streams,
- (b) Formatting of all data received,
- (c) Extended error checking of all parameters,
- (d) Visual data presentation for monitoring purposes,
- (e) Generation and distribution of synchronising fiducial numbers,
- (f) Recording of data to magnetic media,
- (g) Calculation of position and provision of steering display for pilot.

5.6 BASE STATION MAGNETOMETER

A Geometrics Recording Base Station Model G-856 with analog and digital recording was used as a diurnal monitor and run continuously during the survey periods. The sensor of the magnetometer was placed in a low gradient area beyond the region of expected influence of any man-made interference. This base station was located at Zeehan airstrip approximately 1km northeast of Zeehan, and used to record the diurnal variations in the earth's magnetic field every 5 seconds with a resolution of 0.1nT and an accuracy of 0.1nT. The base station was synchronised with the airborne magnetometer.

All diurnal base station magnetometer data form part of the delivered digital information and individual records are not included in this report.

Diurnal activity was classed as quiet throughout the survey and there were no significant diurnal magnetic variations.

6. CALIBRATIONS

6.1 ELECTROMAGNETIC SYSTEM

The electromagnetic response is calibrated using an external Q coil at the commencement of the survey program. Calibration checks are conducted at the beginning and end of each sortie using internal coils, and at the beginning of each day using a ferrite phasing bar. Any drift is monitored by flying out of ground effect (above 350 metres) twice per hour to record electromagnetic zero levels. Prior to the commencement of surveying the EM system is run for at least an hour to stabilise temperatures and the system drift is observed and verified to be less than 5 ppm in 5 minutes.

6.2 MAGNETOMETER

The Geometrics G-822A Caesium vapour magnetometer operates on a split-beam principle with a constant relationship between the earth's magnetic field and the Larmor frequency (the frequency with which gyromagnetic moments precess in a magnetic field). They are therefore not subject to instrumental drift and do not require calibration.

6.3 ALTIMETER

The radar altimeter was calibrated against GPS height by multi-level flights prior to the commencement of the survey.

7. DATA PROCESSING

7.1 IN-FIELD DATA VERIFICATION

In-field quality control (QC) of the survey data entailed two stages of assessment. Firstly the field party leader at the survey base conducted an analysis of the most recently acquired data using both proprietary company software and commercial software (e.g. Geosoft).

At the survey base the post-processed GPS position information was merged with the geophysical data and then subjected to the following checks:

- a) Speed correlation,
- b) Identification of spikes, dropouts and noise bursts in all data streams,
- c) Verification that adequate flight path coverage was achieved,
- d) Checking flight line spacing and terrain clearance tolerances,
- e) Conformity to Contract specifications.

7.2 FINAL PROCESSING

The final data processing was undertaken by Neil Fiset for Geo Instruments Pty Ltd using both Geosoft and Intrepid software. All data had previously been checked for abnormalities by the in-field data verification system described in 7.1 above.

7.2.1 Flight Path Recovery

Processing of the differential GPS location data entailed the following steps:

- a) Post-flight differential GPS corrections using the Ranger differential position processing software where the real time differential GPS data was affected by limited correction satellite visibility (in valleys) or by microwave interference,
- b) No fiducial synchronisation is required as both range data and fiducials are synchronised to GPS time,
- c) Merging of positional data with geophysical data.

7.2.2 Electromagnetic Data Processing

Processing of the in phase and quadrature EM channels entailed:

- a) Filtering to remove major spheric events and reduce system noise;
- b) Base level correction using high altitude EM zero levels;
- c) Calculation of apparent resistivity for the coplanar coils;
- d) Gridding at 25m cell size and micro-levelling

The resistivity formulae are taken from “Geo-Electromagnetism” by James R. Wait, Academic Press, 1982, pp. 108-112. They are standard integrals involving Bessel functions and reflection coefficients for a layered halfspace. For the nomogram look-up, a large number of models over a range of resistivities and depths are calculated, giving in-phase and quadrature results, to produce the nomogram grids (with in-phase and quadrature values on the axes, and the grid variables being resistivity, and depth.) The resistivity for a given value of in-phase and quadrature is then found by interpolating the grid.

7.2.3 Magnetic Processing

Having verified all data in the field, the final processing sequence is reduced to the following steps:

- a) Five point low pass filter,
- b) Diurnal variation removal,
- c) System parallax removal,
- d) IGRF removal,
- e) Micro levelling,
- f) Addition of the mean diurnal value and the IGRF base value,
- g) Gridding at 25m cell size

The helicopter magnetic data have been corrected for regional gradient by subtraction of the IGRF Model for 1998.9 derived from the 1995 secular variation model. The IGRF was calculated at each sample point at the GPS height of the aircraft, adjusted for the geoid-spheroid separation. Diurnal variations and system parallax have been removed. The mean diurnal value and IGRF base value have been added to the data. No filters were applied to the data prior to gridding. The Akima algorithm was used for gridding of the data.

7.2.4 Digital Terrain Model (DTM) Processing

The digital terrain model is computed from the difference in GPS height and radar altitude. The raw GPS range data are recorded internally every one second and corrected using real time factors provided by the Fugro Omnistar satellite system. This yields the position of the aircraft GPS antenna, including longitude, latitude and height relative to the AGD84 reference ellipsoid for each set of range data (every one second).

The radar altimeter provided the aircraft’s ground clearance, the altimeter data being sampled every tenth of a second. The radar altimeter results were lightly smoothed to remove any spikes, spurious reflections or instrument noise.

The raw ground elevation data were then calculated as the difference between the height of the aircraft above the ellipsoid and the height of the aircraft above the ground. These raw elevation data calculated every one second are relative to the AGD84 reference geoid.

The GPS antenna was mounted on the tail fin of the aircraft. The radar altimeter sensor was located under the belly at the front of the aircraft.

The digital terrain model information was gridded at 25m cell size using the Akima gridding algorithm. Decorrugation and microlevelling tools in Intrepid were then applied.

DISCLAIMER NOT TO BE USED FOR NAVIGATION

This digital terrain model (DTM) has been computed from data generated during the course of an airborne geophysical survey flown at a nominal line spacings and data have been interpolated/gridded between such lines. Every effort has been made to make the model a useful general reference. No guarantee can be made that this model is a true representation of height above sea level and it does contain radar altimeter responses from buildings and dense timber. Users of this product should be aware of the topographic limitations mapped here within. **Do not use this DTM for navigation purposes.**

8. DELIVERED ITEMS

Following implementation of all corrections and levelling of the EM, magnetic and DTM fields, ERMapper grid files were generated and subject to further micro-levelling. Preliminary maps and preliminary grid files were delivered for review and approval, then final digital data files were delivered.

Map Products

Flight path map, draft contoured TMI map, draft contoured apparent resistivity maps for 385Hz, 6.6K Hz and 34K Hz.

Multi-parameter plots of EM data plus TMI and DTM.

In-phase and quadrature stacked profiles of EM data.

Digital Data

CD-ROM containing Final Located Data, Gridded Resistivity for each coplanar coil set, Gridded Total Magnetic Intensity and Gridded Digital Terrain Model.

Operations Report

Data delivery included this Operations and Processing Report on the helicopter electromagnetic survey program and data processing.

APPENDIX 1

Maps of Areas Flown and Flight Plans

APPENDIX 2

Data Formats Digital Data Formats

Digital Data Formats

Format for Located Magnetic Data

Column 1 1 - 10 LineNo
Column 2 11 - 14 julian day
Column 3 15 - 22 fid
Column 4 23 - 32 time (decimal hours)
Column 5 33 - 42 easting (NUTM Zone 48, WGS84 +423m)
Column 6 43 - 52 northing (NUTM Zone 48, WGS84 -315m)
Column 7 53 - 62 rawmag (nT)
Column 8 63 - 72 diurnal (nT)
Column 9 73 - 80 gps_alt (metres)
Column 10 81 - 88 radalt (metres)
Column 11 89 - 98 final_mag (nT)
Column 12 99 - 106 final_dtm (metres)
107 - 107 <endline>

Digital Data Formats

Format for Gridded Data

All grids were delivered in Geosoft format.

APPENDIX 3

Flight Index

APPENDIX 4

Operators Flight Report