

# **OPERATIONS REPORT**

## BARKLY

AIRBORNE MAGNETIC AND RADIOMETRIC SURVEY



TESLA AIRBORNE GEOSCIENCE PTY LTD NOVEMBER 2001



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#### 1. INTRODUCTION

This report provides details of the Barkly airborne geophysical survey flown in the Northern Territory during 2001. The survey was commissioned by the Northern Territory Department of Mines and Energy and flown by Tesla Airborne Geoscience Pty Ltd.

#### 2. SURVEY DETAILS

#### 2.1 Project Identification

Area Name:	Barkly
Contractor:	Tesla Airborne Geoscience Pty Ltd
Tesla Job No.:	TA2764

#### 2.2 Survey Location

The survey location is shown in Figure 1. Final flight paths are provided in ERMapper format in the "Flight\_Path" directory of this final report CDROM. Figures 2 and 3 are maps of the flight path at a reduced scale.

Survey boundaries in WGS84 coordinates are:

Eastings	Northings
560137 mE	8119141 mN
657813 mE	8119847 mN
657813 mE	8084657 mN
694384 mE	8084673 mN
694430 mE	8078364 mN
749814 mE	8078314 mN
749836 mE	8097579 mN
727276 mE	8097619 mN
727254 mE	8105258 mN
707882 mE	8105240 mN
707885 mE	8105572 mN
680002 mE	8105612 mN
680026 mE	8108379 mN
	/cont.

Survey boundaries in WGS84 coordinates, cont.

Eastings	Northings
672788 mE	8108330 mN
672772 mE	8106448 mN
657815 mE	8106457 mN
657815 mE	8119847 mN
819452 mE	8117998 mN
819363 mE	8098391 mN
809886 mE	8098425 mN
806294 mE	8093162 mN
806294 mE	8093162 mN
801186 mE	8093237 mN
800636 mE	8092027 mN
800628 mE	8091473 mN
800626 mE	8091363 mN
795409 mE	8091217 mN
795183 mE	8090334 mN
795173 mE	8089670 mN
791554 mE	8089610 mN
791502 mE	8085956 mN
789162 mE	8085989 mN
789162 mE	8082000 mN
785500 mE	8082000 mN
785500 mE	8067826 mN
819307 mE	8067595 mN
817706 mE	8007242 mN
741600 mE	8007500 mN
741600 mE	7939000 mN
816800 mE	7939000 mN
816800 mE	7932600 mN
800800 mE	7932600 mN
800800 mE	7929600 mN
792000 mE	7929600 mN

792000 mE	7926500 mN	
		/cont.
Eastings	Northings	
783400 mE	7926500 mN	
783400 mE	7923000 mN	
761600 mE	7923000 mN	
761600 mE	7927000 mN	
755600 mE	7927000 mN	
755600 mE	7924000 mN	
754000 mE	7924000 mN	
754000 mE	7932800 mN	
736600 mE	7932800 mN	
736600 mE	8008000 mN	
706400 mE	8008000 mN	
706400 mE	8045000 mN	
705000 mE	8045000 mN	
705000 mE	8064259 mN	
606267 mE	8064851 mN	
606268 mE	8085432 mN	
595216 mE	8085486 mN	
584056 mE	8085424 mN	
580776 mE	8088867 mN	
568871 mE	8088911 mN	
568796 mE	8098094 mN	
568478 mE	8098537 mN	
567202 mE	8098542 mN	
565926 mE	8098546 mN	
562400 mE	8101875 mN	
562400 mE	8113634 mN	
560137 mE	8113634 mN	
500000 mE	8120000 mN	
508000 mE	8120000 mN	
508000 mE	8120000 mN	

/cont.

Survey boundaries in WGS84 coordinates, cont.

Eastings	Northings
508000 mE	8050000 mN
508000 mE	8050000 mN
508000 mE	8050000 mN
500000 mE	8050000 mN
500000 mE	8050000 mN
500000 mE	8120000 mN
578700 mE	7843675 mN
683652 mE	7842910 mN
683081 mE	7787562 mN
709243 mE	7787269 mN
708234 mE	7704232 mN
656164 mE	7704795 mN
656921 mE	7787816 mN
578455 mE	7788343 mN
500000 mE	7899172 mN
500000 mE	8013014 mN
520117 mE	8013012 mN
534182 mE	8064880 mN
540764 mE	8064868 mN
540521 mE	7899128 mN

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### 2.2 SURVEY SPECIFICATIONS

:	87905 kilometres	/	Comment [T1]: One decimal place only
:	8852 kilometres		Comment [T2]: One decimal place only
:	96757 kilometres		Comment [T3]: One decimal place only
:	400 metres		
:	WGS84 Grid East/West		
:	1608		
:	4000 metres		
:	WGS84 Grid North/South		
:	150		
:	80 metres		
midity	10Hz (approx. 7m) 1Hz (approx. 70m) 1Hz 10Hz 1Hz 0.5Hz 33.6Lt		
	: : : : : : : nidity	:       87905 kilometres         :       8852 kilometres         :       96757 kilometres         :       96757 kilometres         :       400 metres         :       1608         :       1608         :       4000 metres         :       1608         :       4000 metres         :       150         :       80 metres         iiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiii	<ul> <li>87905 kilometres</li> <li>8852 kilometres</li> <li>96757 kilometres</li> <li>96757 kilometres</li> <li>400 metres</li> <li>1608</li> <li>4000 metres</li> <li>4000 metres</li> <li>WGS84 Grid North/South</li> <li>150</li> <li>80 metres</li> <li>10Hz (approx. 7m) 1Hz (approx. 70m) 1Hz 10Hz</li> <li>nidity</li> <li>1Hz 0.5Hz 33.6Lt</li> </ul>

### 3. <u>PROJECT PERSONNEL</u>

PROJECT SUPERVISION	Rod Pullin – data acquisition Andrea Wieman – data processing
SURVEY PILOTS	Adam Mustapha Daniel Pidic Luke McCarthy
SURVEY OPERATORS	Rob Sharp Matthew Lovell
DATA PROCESSING	Andrea Wieman Joe Kita
N.T. D.M.E CONTACT	Richard Brescianini

### 4. ACQUISITION

### 4.1 Aircraft and Equipment

#### 4.1.1 VH-MOK

Model	Cessna 210R
Acquisition System Model Software Version	Tesla TAG3 3.710
<i>Total Field Magnetometer</i> Sensor Mounting Sensitivity Serial Number	Scintrex CS-2 Tail Stinger 0.001 nT 9409005
<i>Vector Magnetometer</i> Model Serial Number	Billingsley TFM100-1E 268
<i>Compensator</i> Model Serial Number	RMS Instruments Automatic Aeromagnetic Digital Compensator (AADCII) 9409661
Gamma-ray Spectrometer Model Serial Number	Exploranium GR820 8275
<i>Crystals</i> Detectors Serial Numbers	Eight all-viewing NaI crystals Total volume: 33.6 litres 2556 / 2557
<b>Radar Altimeter</b> Model	Collins Alt-55B
<i>Humidity and Temperature T</i> Model Serial Number	ransmitter Vaisala HMD 50Y PO250019
<i>Barometer</i> Model Serial Number	Vaisala PTB 200A S2920020
<i>GPS Receiver</i> Model Real-time Corrections	Novatel 951R Fugro Surveys OmniSTAR

#### 4.1.2 Base Stations

GPS Receiver Model

#### Marconi Allstar OEM CMT-1200

BASE GPS R Barkly	ECORD:		
Job No: Client: Area: Aircraft:	TA2764 N.T. D.M.E. Barkly VH-MOK	Crew Leader: Date: Julian: Completed by:	R. Sharp 23 <sup>rd</sup> June 2001 174 R. Sharp
Calculated Base Station Co-ordinates Ellipsoid Method of Position Determination: Duration of Sample Sample Interval: Location of GPS Antenna:		Latitude Longitude Height WGS84 Averaging 12 hours 1 second Fixed to down Barkly Homes	19° 42' 38.6710" S 135° 49' 36.9627" E 296.475 metres

#### BASE GPS RECORD:

Job No: Client: Area:

Co-ordinates

Kiana

Aircraft: VH-MOK Calculated Base Station

Ellipsoid Method of Position Determination:

TA2764

Kiana

N.T. D.M.E.

Duration of Sample Sample Interval: Differential Correction Method:

Location of GPS Antenna:

Crew Leader: Date: Julian: Completed by:

R. Sharp 2<sup>nd</sup> August 2001 214 Y: R. Sharp

Latitude17° 14' 37.95229" SLongitude136° 10' 58.40178" EHeight274.002 metresWGS84Differentially processed against averaged, real-time<br/>corrected aircraft position18 hours11 secondReal-time: Fugro OmniSTARPost-flight: Waypoint Consulting Inc. Grafnav V6.01Fixed to tennis court fence pole behind visitors quarters

#### **Magnetometers**

Job No:	TA2764	Aircraft:	VH-MOK	
Client:	N.T D.M.R	Date:	2 <sup>nd</sup> August 2001	
Area:	Barkly	Julian:	214	
Crew Leader:	R. Sharp	Completed by:	R. Sharp	
М	agnetometer A	Ν	Aagnetometer B	
Magnetometer Type:	Scintrex Envi-Mag	Magnetometer Type	e: Scintrex Envi-Mag	
Serial Number:	960766	Serial Number:	9403068	
Location:	Barkly Airstrip	Location:	Barkly Airstrip	
Cycle Rate:	2 seconds	Cycle Rate:	2 seconds	
Sensor Height:	1.5m	Sensor Height:	1.5m	
Area Gradient (nT)		Area Gradient (nT)		
2m North	50761.2	2m North	n 50761.4	
2m South	50760.6	2m South	n 50761.0	
2m East	50761.4	2m East	50760.3	
2m West	50761.0	2m West	50761.4	
Central	50760.8	Central	50761.0	
М	agnetometer C	Magnetometer D		
Magnetometer Type:	Geometrics G823A	Magnetometer Type	e: Scintrex Envi-Mag	
Serial Number:		Serial Number:	9411107	
Location:	Barkly Airstrip	Location:	Brunette Downs	
Cycle Rate:	1 second	Cycle Rate:	2 seconds	
Sensor Height: 2m		Sensor Height:	1.5m	
Area Gradient (nT)		Area Gradient (nT)		
2m North	50760.7	2m North	n 50096.8	
2m South	50761.6	2m South	n 50096.4	
2m East	50761.9	2m East	50097.8	
2m West	50760.3	2m West	50095.1	
Central	50761.5	Central	50097.5	

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#### Magnetometers cont.

Magnetometer A		Magnetometer B		
Magnetometer Type:	Scintrex Envi-Mag	Magnetometer Type:	Scintrex Envi-Mag	
Serial Number:	960766	Serial Number:	9403068	
Location:	Kiana Station	Location:	Kiana Station	
Cycle Rate:	2 seconds	Cycle Rate:	2 seconds	
Sensor Height:	1.5m	Sensor Height:	1.5m	
Area Gradient (nT)		Area Gradient (nT)		
2m North	49246.4	2m North	49122.7	
2m South	49246.4	2m South	49121.9	
2m East	49246.8	2m East	49121.8	
2m West	49245.8	2m West	49122.2	
Central	49246.4	Central	49122.3	

Magnetometer C		
Magnetometer Type:	Geometrics G823A	
Serial Number:		
Location:	Kiana Station	
Cycle Rate:	1 second	
Sensor Height:	2m	
Area Gradient (nT)		
2m North	49086.3	
2m South	49087.1	
2m East	49086.7	
2m West	49086.9	
Central	49086.6	

#### 4.2 Survey Operations

Bases:	Barkly, NT and Kiana, NT
Acquisition Commencement:	19 <sup>th</sup> June 2001
Acquisition Completion:	1 <sup>st</sup> October 2001
Average Production:	970km/day

A full daily operations report is provided as a Microsoft Excel spreadsheet under the "Operations" directory of this final report CDROM. Survey flight logs are also provided as an Excel spreadsheet in this directory.

#### 4.3 <u>Recorded Parameters</u>

All acquired data are recorded digitally. The following parameters are recorded at 10 Hz:

Parameter	Resolution	<u>units</u>
Local time	0.1	s
Fiducial number (time after midnight, local)	1.0	unit
Terrain clearance (radar altimeter)	0.01	m
Uncompensated Total Magnetic Intensity (TMI)	0.001	nT
Fluxgates X, Y & Z	0.01	nT
Fluxgate Total Field	0.01	nT
Uncompensated TMI 4 <sup>th</sup> difference	0.001	nT
Compensated TMI	0.001	nT
-		

The following parameters are recorded at 1 Hz:

<u>Parameter</u>	Resolution	units
GPS time	1.0	s
Latitude	0.0000001	0
Longitude	0.0000001	0
GPS height	0.01	m
Outside air temperature	1.0	°C
Barometric pressure	0.01	hPa
Barometric altitude	0.01	m
Relative humidity	0.001	%
Full 256-channel gamma-ray spectrum	1.0	cps
Spectrometer live time	0.001	s
Resolution	0.1	%
Number of satellites	1.0	
Position dilution of precision (PDOP)	0.1	
HDOP	0.1	

#### 4.4 Calibrations and System Checks

#### 4.4.1 Radiometric Calibrations

Pre-survey radiometric calibrations for the aircraft were completed. Results are summarised in Table 1.

		VH-MOK
Aircraft Background	TC	61.4
	K	15.5
	U	0.9
	Th	1.10
Cosmic Background	TC	0.95
	K	0.05
	U	0.043
	Th	0.04
Height Attenuation	TC	0.007
	K	0.009
	U	0.0093
	Th	0.0073
Stripping	α	0.2668
	β	0.4144
	γ	0.830
	a	0.041
	b	0.000
	с	0.000
Air/Ground	Dose	25.84
	K	84.7
	U	9.62
	Th	5.34

#### 4.4.2 Magnetic Compensation

Magnetic compensation sequences were flown at 10,000 feet above sea level. Resulting coefficients were used for real-time magnetic compensation.

#### 4.4.3 Low-level Test Lines

The low level test line at Barkly was located approximately 7 kilometres north east of the airstrip in a NE/SW direction, approximately 9 kilometres in length. The low level test line was located approximately 3 kilometres to the north of the airstrip in a north-south direction, approximately 8 kilometres in length. The test lines were flown at survey height and in both directions. The start and end points were visually definable positions captured as GPS waypoints for ease of orientation and reference purposes.

Statistics were recorded for the average Potassium, Uranium, Thorium and Total Counts along the test line and the values transferred to a spreadsheet.

The tabulated statistics and a chart showing the average raw Thorium count variation for each test line are provided in Appendix B.

The start and end point co-ordinates of the test line at Barkly were:

Start	(WGS84)	17° 8' 42.529" S	136° 10' 8.429" E
End	(WGS84)	17° 13' 10.747" S	136° 10' 26.870'' E

The start and end point co-ordinates of the test line at Kiana were:

Start	(WGS84)	19° 35' 36.645" S	135° 55' 10.742" E
End	(WGS84)	19° 39' 38.960" S	135° 52' 7.961" E

The test lines were flown in both directions.

Resulting statistics and Th graph are given in the "Calibrations" directory of this CDROM.

#### 4.4.4 Radiometric Button Checks

Crystal stabilisation using Thorium was undertaken prior to each day's acquisition. Radiometric counts were recorded with Thorium samples beneath the aircraft and also with samples removed to determine background radiation.

Calibration statistics and Th graph for these calibrations are given in the "Calibrations" directory of this CDROM.

#### 5. PROCESSING

#### 5.1 Hardware and Software

All data processing was carried out by Tesla10 Pty Ltd in its Perth, WA office.

Hardware	UNIX workstations
	PCs
	HP Designjet 650C Plotter
	HP Designjet 755 Plotter
	Exabyte 8mm tape drive
	Compact Disc writer
	Iomega ZIP drives
Software	Tesla10 Pty Ltd in-house software ERMapper 5.2 and 5.5

#### 5.2 GPS Positioning

#### 5.2.1 Spheroids, Datums and Zones

The acquired GPS positions (latitude, longitude and altitude) were differentially post-processed in the field. These coordinates were then converted to easting and northing grid positions referencing GDA94 in MGA zone 53.

The 1 Hz position data was linearly interpolated to coordinate all 0.1 Hz data.

#### 5.2.2 Quality Control

In addition to Tesla's 'normal' quality control, "100-hourly" reports were produced. These are in the form of ERMapper vector files (.erv) and are provided in the "Quality\_Control" directory of this final report CDROM.

- flight path
- ground speed

#### 5.3 Magnetics

#### 5.3.1 Quality Control

In addition to Tesla's 'normal' quality control, "100-hourly" reports were produced. These are in the form of ERMapper vector files (.erv) and are provided in the "Quality\_Control" directory of this final report CDROM.

- high-pass magnetic noise
- diurnal variation
- radar altimeter

This visual aspect of quality control was aided by the determination of statistics (max., min., mean and s.d.) for all parameters for every line.

System spikes were removed from the magnetic data but cultural responses were retained.

#### 5.3.2 Parallax Correction

System parallax adjustments were performed by interpolating the position data to fit the magnetic data. An adjustment of five fiducials was applied.

#### 5.3.3 Diurnal Correction

The magnetic data were corrected for diurnal variations. The correction formula was:

diurnal corrected TMI = compensated TMI minus diurnal plus mean diurnal value

#### 5.3.4 IGRF Correction

The International Geophysical Reference Field (IGRF) was removed from the data using the 2000 model extrapolated to the survey date. The correction formula was:

final corrected TMI = diurnal corrected TMI minus local IGRF plus Base\_Value

#### 5.3.5 Levelling

Tie line levelling and further micro-levelling produced the final levelled magnetics data.

#### 5.3.6 Gridding

A minimum curvature algorithm was used to produce gridded data of 100 metre cell size.

#### 5.3.7 Enhancements

First vertical derivative profiles were calculated on the TMI line data.

The TMI gridded data was reduced to the pole. A first vertical derivative grid was produced from the gridded TMI data. This FVD grid was then enhanced by an Automatic Gain Control process.

#### 5.4 Radiometrics

#### 5.4.1 Quality Control

256 channel spectral plots for all flights and source tests were produced. All data were checked for peak stability and count variation.

Statistics for all channels were calculated and checked. Profiles were produced where required. The data were subsequently checked (images, profiles and statistics) after each stage of processing to ensure continued data integrity.

#### 5.4.2 Calibrations and Coefficients

See Section 4.4.

#### 5.4.3 256-Channel Pre-processing

The raw spectra were firstly smoothed using the NASVD technique. The 256 channel data were then pre-processed to obtain data for Radon gas background removal.

Raw count rates used for final processing were extracted by summing the 256 channel data over the IAEA windows centred on the peak locations, to the nearest channel. The IAEA windows are:

Total Count	0.40 to 2.81 MeV
Potassium	1.37 to 1.57 MeV
Uranium (Bi <sup>214</sup> )	1.66 to 1.86 MeV
Thorium (Tl <sup>208</sup> )	2.41 to 2.81 MeV
Cosmic	>3.0 MeV

#### 5.4.4 Final Processing

Filters were applied to height, temperature, pressure, altitude and the cosmic count.

Cosmic, aircraft and Radon backgrounds were removed.

The Potassium, Uranium and Thorium count rates were corrected for Compton scattering (stripped). The coefficients themselves were corrected to the STP corrected height using theoretical linear corrections for the three primary stripping coefficients.

Corrections to the terrain clearance were made using STP corrected heights and the absorption factors appropriate to the exponentially decreasing count rates with height.

The airborne gamma-ray counts were converted to the equivalent ground radioelement concentrations and the data were then tie line levelled and micro-levelled where required. A minimum curvature algorithm was used to produce gridded data of 100 metre cell size.

#### 5.5 Digital Elevation Model

#### 5.5.1 Processing

The form of the calculation used was:

Digital Terrain = GPS altitude – Radar Altimeter

where,

GPS Altitude is flying height above ellipsoid (WGS84)

Radar Altimeter is flying height above ground

Tie line levelling and further micro-levelling produced the final levelled terrain model.

#### 5.5.2 Australian Height Datum

The terrain surface was subsequently referenced to the AUSLIG 1998 N-values to produce a DTM corrected to the Australian Height Datum.

#### 6. FINAL PRODUCTS

#### 6.1 Final Located Data

Final located data was produced in ASEG GDF2 format. Three products were produced for each area:

- 0.1 second magnetics & digital terrain
- 1.0 second radiometrics (ROI windows)
- 1.0 second 256-channel radiometrics

#### 6.2 Final Gridded Data

Final gridded data was produced in ERMapper format. The grids supplied were:

- Total Magnetic Intensity (TMI)
- TMI Reduced to the Pole (RTP)
- 1<sup>st</sup> Vertical Derivative of TMI (1VD)
- 1<sup>st</sup> Vertical Derivative of RTP (1VD RTP)
- Automatic Gain Control of 1VD TMI (AGC 1VD)
- Total Count (provided as Dose rate, nG/h) (TC)
- Potassium (%) (K)
- Uranium (ppm) (U)
- Thorium (ppm) (Th)
- Composite Potassium, Uranium and Thorium (KThU)
- Digital Elevation Model (DTM)