AERODATA a division of
WORLD GEOSCIENCE CORPORATION LTD

REPORT ON THE

BATTEN TROUGH

AEROMAGNETIC AND RADIOMETRIC SURVEY

on behalf of

NORTHERN TERRITORY OF AUSTRALIA
DEPARTMENT OF MINES AND ENERGY
GEOLOGICAL SURVEY

GS 89/24

CONTENTS

1. INTRODUCTION

On the 18 August 1989 (Order No.224880) Aerodata of 17 Emerald Terrace, West Perth, was contracted by the Northern Territory Geological Survey (NTGS) to carry out an aeromagnetic and radiometric survey over Mt Young, Rosie Creek, Mantungula (part) Tawallah Range, Bing Bong, Batten Trough and Booroloola (part) 1:100,000 scale sheets in the Northern Territory. The survey was named the BATTEN TROUGH survey.

Flying commenced on the 26 September 1989 the survey was completed on the 5 November 1989.

Data processing was carried out at our Perth office.

2. GENERAL SURVEY SPECIFICATIONS

FLYING SPECIFICATIONS

Flight Line Direction	- 090°-270°
Tie Line Direction	- 000°-180°
Flight Line Spacing	- 500 metres
Tie Line Spacing	- 5,000 metres
Sensor Height	- 100 metres
Magnetometer Cycle Rate	- 0.2 second
Spectrometer Cycle Rate	- 1.0 second
Magnetometer Sample Interval	- 14 metres
Spectrometer Sample Interval	- 70 metres
Aircraft Ground Speed	- 130 knots
Magnetometer Resolution	- 0.04 nT
Magnetometer Noise Envelope	- 0.20nT

3. EQUIPMENT USED FOR FLYING SURVEY

3.1 AIRCRAFT

A Rockwell Shrike Commander 500S.

3.2 MAGNETOMETER

The magnetometer system is based on the Scintrex V-201 cesium vapour magnetometer. The system consists of a tail stinger mounted Scintrex VIW 2321 HG single cell split beam cesium magnetometer sensor with associated sensor electronics. This system outputs a continuous sinusoidal signal which has a frequency proportional to the total magnetic field at the sensor. The frequency of the Lamore signal is counted by an Aerodata designed system which is connected to the acquisition system computer by an HPIB interface. The rate at which the Lamore frequency is determined (ie. the cycle rate) can be set from 0.1 second to 1.5 seconds in 0.1 second steps. This magnetometer cycle rate was set at 0.2 seconds.

3.3 CRYSTAL AND SPECTROMETER SYSTEM

Two Geometrics DET 1024 NaI slab crystal packs with a total volume of 33.56 litres were used. The crystals were connected to a Geometrics GR800 256 channel spectrometer through a GR900 crystal controller. The spectrometer was used in such a manner that although 256 channels were available for spectral plotting not all were used in normal survey acquisition. Groups of channels were summed to provide outputs (analog and digital) for Potassium, Uranium and Thorium windows. All channels were summed to give the Total Count. See section 7.2 for energy level settings of the various windows.

3.4 RADAR ALTIMETER

A Sperry AA100A Radar Altimeter was used. The altimeter provided a visual display of height above terrain to the pilot and also supplied a voltage proportional to height. This voltage was fed to the chart recorders and the acquisition system such that the altimeter was digitally recorded. The output of the altimeter was linear up to 500'.

3.5 TRACKING SYSTEM

A Vinten MKIII 16mm tracking camera was used for aircraft location. This camera was fired by the acquisition system which also generated 10's and 100's marks on the appropriate frames to aid in film editing.
Decca Doppler and TANS Navigation System data were digitally recorded to infill flight path between recovered points.

3.6 ANALOG RECORDER

A Watanabe 10" 8 channel recorder was used to record the analog data. Two channels were used for the magnetics, one at 100 nT full scale and the other at 1,000 nT full scale. As the cesium vapour magnetometer has no analog output the magnetic analogs were derived from the digital value of the magnetics that was sent to the acquisition computer.

The other channels recorded were the radar altimeter and the radiometric data as Total Count, Potassium, Uranium and Thorium. The radiometric data were normalized to counts per second, dead time corrected and recorded in stripped form using internal stripping coefficients generated by hand sample tuning prior to survey flying.
The chart recorder was driven at a constant speed and had event marks placed on it by the acquisition system such that the chart could be suitably edited.

3.7 DIGITAL ACQUISITION AND RECORDING SYSTEM

The system used was designed and built by Aerodata and is based around a Hewlett Packard 300 series Computer and a Kennedy 6470 cartridge tape drive.

The magnetometer's 10MHz temperature controlled, stable oscillator generated accurate system timing.

The system accepts data from the magnetometer directly into the computer and at intervals set by the cycle rate of the system, digital spectrometer data is read from the spectrometer. Digital spectrometer data were read from the spectrometer at a cycle rate of 1.0. seconds.

Analog altimeter data is fed into the acquisition system which then passes this data in digital form to the computer via a HPIB interface. The same HPIB interface also carries commands from the computer to the acquisition system to control the camera, mark the analog charts and output the analogs for the magnetics to the analog recorder.

This HPIB interface is also used to connect the tape drive to the computer. The computer carries as a peripheral a real time clock such that the month, day, hour, minute and second of the start and end time of each line is recorded.

For each fiducial 7 digits of magnetic data were recorded. On every 5th fiducial radar altimeter, Doppler and Total Count, Potassium, Uranium, Thorium and Cosmic data were recorded. The radiometric data were normalized to counts per second and dead time corrected and recorded digitally in unstripped form.

A line header record was also recorded which holds a variety of data along with line number, line

direction, start and end fid number and start and end time of the line.

4. NAVIGATION, PHOTOGRAPHY AND FLIGHT PATH RECOVERY

Aerodata provided new high level photography and supplied 2 sets of 1:25,000 scale enlargements.
Aerodata arranged purchase and preparation of AMG control via AAM Surveying and Mapping Consultants.

One set of enlargements was used for visual navigation and the second set for flight path recovery. Recovery was carried out in the field. In fill lines were flown if flight line separation exceeded 150% of the planned line separation over a distance of 5 kilometres or more.

The Decca Doppler and TANS Navigation System data were used as an aid to visual navigation and as the only navigation aid over the offshore section of the survey.

AMG control supplied by AAM Surveying and Mapping Consultants was transferred to the flight path recovery enlargements.

5. MAGNETIC BASE STATION

5.1 LOCATION OF MAGNETIC BASE STATION

The base station was located at Heartbreak Hotel Airstrip, Northern Territory in an area of low magnetic gradient away from cultural effects.

5.2 DESCRIPTION OF BASE STATION SYSTEM

The heart of the system was a Geometrics G856 proton precession magnetometer with 0.1nT sensitivity and cycled at 10 seconds. At each cycle the magnetic field was sampled and stored in memory along with the time from the magnetometer real time clock. The base station clock was synchronised with the aircraft real

time clock to within 1 second. 12,000 readings can be stored in memory. Data from the memory were downloaded each day into a Hewlett Packard 9845B computer which recorded the data onto magnetic tape and also produced a plot for visual display.

5.3 METHOD IN WHICH BASE STATION DATA WERE USED

The data from the base station were used as a monitor for abnormal diurnal variation. If the magnetic field changed by more than 5 nT in 5 minutes flying, if not already commenced, was cancelled. If during flying, variations greater than 10nT in 5 minutes occurred any airborne data collected during that period were reflown at Aerodata's expense.

The base station data were also used to diurnally level all lines flown during the survey.

6. DATA PROCESSING

The following equipment were installed at the field base to carry out daily quality control checks on all data.

- 1 x Hewlett Packard 9845B computer
- 1 x Kennedy 6470 cartridge tape drive

6.1 DIGITISING OF PHOTOGRAPHY

AMG co-ordinates were generated for each recovered fiducial by digitising the AMG controlled photography. The average interval between recovered points was 2 kilometres.

6.2 SPEED CHECKING

All flight path co-ordinates were subjected to an analysis that listed the speed of the aircraft in metres/second such that any flight path recovery or digitising errors became obvious. For each line a list was produced of the average speed of the aircraft, the standard deviation of the aircraft's speed, the average distance per reading and the length of the line.

6.3 MERGED DATA

9510 line kilometres of previously acquired final quality B.H.P. data were merged and were included in all final maps.

6.4 FLIGHT PATH MAPS

Final flight path maps were plotted at a scale of 1:100,000 on standard 1:100,000 sheets. Lines were labelled at each side of the sheet, a straight line joined each recovered point. Fiducials were plotted at intervals of not greater than 3 kilometres with every 5th plotted fiducial numbered oblique to the flight line.

The sheets showed the latitude and longitude at the corners and 5 minute intervals and AMG 10 kilometre grid ticks.

6.5 TOTAL FIELD MAGNETIC STACKED PROFILES

Final stacked profiles were produced at a scale of 1:100,000 to overlay the flight path maps. Two sets were produced, one with every line plotted and one with every 4th line plotted at an enlarged vertical scale.

A constant residual base level of 1100nT was used. The vertical scales in nT/cm for the two sets were:

Every Line 20
Every 4th Line 10

6.6 MAGNETIC CONTOUR MAPS

Single reading noise spikes were manually removed and the data were corrected for diurnal effects. The regional gradient was removed using the IGRF 1985 and secular variation (1985-1990) models extrapolated to the survey date. A system parallax of 2 fiducials and a heading error correction of 0nT were applied to the

data which were then tie line levelled and micro-levelled. These data were used to produce total magnetic intensity contour maps at a scale of 1:100,000 and and contour interval of 2nT for all sheets. The grid cell size was 150 metres. Sheet layout was as per item 6.4.

6.7 RADIOMETRIC DATA

The Total Count, Potassium, Uranium and Thorium radiometric channels were corrected and levelled for sheets Batten Trough and Booroloola (part) were provided with the cosmic channel data in raw form on the final located data tape described under section 6.8. Radiometric data for the remaining sheets were not corrected nor levelled and were provided in raw form on the final located data tape.

6.8 LOCATED DATA TAPES

All data were recorded onto 9 track tape in the form of located data.

Three copies of these tapes in ASCII code, ASEG-GDF format at 1600 bpi were provided containing the following:

XY record of all edited raw field data on a line by line basis

XY record of corrected data on a line by line basis

because of their small size, sheets 6065 and 6165 were included on the same tape. Likewise sheets 6067 and 6167. All other tapes contained only data from a single 1:100,000 map sheet plus a 1.5km wide border around the edge of the sheet.

6.9 IMAGE PROCESSING

Image processing was requested for the 4 radiometric channels of the combined Batten Trough and Booroloola 1:100,000 sheets. The following images were produced as slides:-

RADIOMETRIC SLIDES

COLOUR/B&W	FILTER TYPE
colour	Red Gun - K
	Green Gun - Th
	Blue Gun - U
colour	Total Count - Raw Data
colour	Total Count - East Gradient
colour	Colour - Total Count
	Intensity - East Gradient Magnetics

COLOUR/B&W	FILTER TYPE
colour	Potassium - Raw Data
colour	Potassium - East Gradient
colour	Colour - Potassium
	Intensity - East Gradient Magnetics
colour	Thorium - Raw Data
colour	Thorium - East Gradient
colour	Colour - Thorium
	Intensity - East Gradient Magnetics
colour	Uranium - Raw Data
colour	Uranium - East Gradient
colour	Intensity - East Gradient Magnetics
colour	Potassium/Thorium Ratio - Raw Data
colour	Potassium/Thorium - E Gradient
colour	Colour - Potassium/Thorium Ratio
	Intensity - E Gradient Magnetics

From the slides the following images were selected to be produced as 1:100,000 Hardcopy:-

1. R,G,B composite K, Th, U
2. Total Count - E Gradient (colour)
3. Potassium - E Gradient (colour)
4. Thorium - E Gradient (colour)
5. Uranium - E Gradient (colour)

7. SYSTEM CALIBRATION AND CHECKS

7.1 MAGNETIC HEADING ERRORS

The aircraft was statically compensated for magnetic heading error on the ground in an area of low magnetic gradient before the survey.

Prior to commencement of flying and after any maintenance work on the aircraft the heading error was checked and tuned by flying over a common point with very low gradient in a cloverleaf pattern at intervals of 45^{o}.

Pitch and roll tests were also conducted and noise generated in the magnetic data by aircraft manoeuvre was compensated by the adjustment of current in XYZ coils mounted in the stinger. The heading error flying checks were recorded in both digital and analog modes. Heading errors were maintained throughout the survey to a value less than 1nT and manoeuvre noise was limited to a maximum of 0.5nT.

7.2 SPECTROMETER CALIBRATION

The spectrometer was configured to record gamma radiation from the following energy windows:

Total Count	0.321 - 2.995 MeV.
Potassium	1.368 - 1.568 MeV.
Uranium (Bi214)	1.653 - 1.854 MeV.
Thorium (Tl208)	2.393 - 2.795 MeV.

Before and after each day's flying the following tests were carried out:

(a) Ground, hand sample checks were carried out on the spectrometer using samples of Uranium and Thorium. These were preceded and followed by a background check. Each check was given a unique line number with digital and analog records acquired for a period of 120 seconds. The samples were designed to relocate accurately under the aircraft fuselage and evenly irradiate the entire detector array.

Daily averages were calculated for these checks and the operator endeavoured to maintain the total count average for each sample to within 10% of the first check of the survey.

(b) A high level background test line was flown at 850m ground clearance with digital and analog records acquired for a period of 200 seconds.

(c) A fixed test line was flown for 5 kilometres at survey altitude and speed in a constant direction with digital and analog records acquired.

All test lines were recorded both in digital and analog form and were given unique pseudo line numbers. These data were presented on a calibration tape at 1600 bpi in ASCII format. A detailed statistical summary of each line was provided under separate cover with format documentation.

All spectrometer data that were recorded digitally were unstripped, but were normalised to counts/second and dead time corrected. All analog data were normalised to counts/second and dead time corrected and the Potassium and Uranium channels were corrected for Compton Scatter.

Radiometric correction coefficients are:

Compton Scatter:	Alpha	0.316
	Beta	0.372
	Gamma	0.843
	Delta	0.096
Height attenuation:	Total Count	0.006047
	Potassium	0.007439
	Uranium	0.005849
	Thorium	0.005976

Background:	Aircraft	Cosmic
Total Count	249	3.547
Potassium	20	0.208
Uranium	11	0.197
Thorium	3	0.235

8. SURVEY LOGISTICS

8.1 OPERATING BASE

Aircraft Operating Base:

All day to day aircraft operations for this job were carried out from Heartbreak Hotel airstrip, Northern Territory. After each flight the survey aircraft returned to base where mains power was available for maintaining power to the crystal heater overnight and providing auxiliary power to the aircraft for ground running.

8.2 PERSONNEL

The following Aerodata employees were involved with the flying and processing of the data:

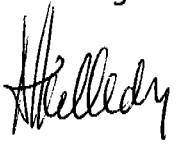
PILOTS:	W Kuech, S Rosenius, P McAuliffe
NAVIGATORS:	P McHugh
TECHNICIAN:	P McAuliffe
FLIGHT PATH RECOVERY:	S Durko
DATA PROCESSING:	P Chambers/ P De Broekert

8.3 PRODUCTION SUMMARY

Flying commenced	26 September 1989
Flying completed	5 May 1989
TOTAL LINE KILOMETRES FLOWN	33,350
AVERAGE PRODUCTION RATE	952kms/day

Final maps and data were delivered progressively however the last delivery was made in April 1990.

REPORT BY: DAVID KELLEDY
Data Manager



26 April 1990