UTS GEOPHYSICS

Logistics Report

for a

DETAILED AIRBORNE MAGNETIC, RADIOMETRIC AND DIGITAL TERRAIN SURVEY

for the

TENNANT CREEK PROJECT

carried out on behalf of

Australia China Corporation of Coal Geology Engineering Pty Ltd

(UTS Geophysics Job #UT140416)

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1 GENERAL SURVEY INFORMATION

In March and April of 2015, UTS Geophysics conducted a low level airborne geophysical survey for the following company:

Australia China Corporation of Coal Geology Engineering Pty Ltd
54 Ellendale CCT
Eight Mile Plains
QLD 4113

Acquisition for this survey commenced on the 28th of March and was completed on the 12th of April 2015.

2 SURVEY SPECIFICATIONS

The areas surveyed were centered approximately 55km North West and 46km North-North East of the Town of Tenant Creek in Northern Territory. The survey was flown using the WGS84 coordinate system (a Universal Transverse Mercator projection) derived from the World Geodetic System and was contained within zone 53 with a central meridian of 135 degrees. Details of the datum and projection system are provided in Appendix B of this report. Survey boundary coordinates are listed in Appendix C.

The survey data acquisition specifications for each area flown are specified in the following table:

PROJECT NAME	LINE SPACING	LINE DIRECTION	TIE LINE SPACING	TIE LINE DIRECTION	SENSOR HEIGHT	TOTAL LINE KM
Tennant Creek A1	100m	090-270	1000m	000-180	30m	6,089
Tennant Creek A2	100m	090-270	1000m	000-180	30m	473
TOTAL						**6,562**

The specified sensor height for the magnetic samples is as stated in the above table. This sensor height may be varied where topographic relief or laws pertaining to built up areas do not allow this altitude to be maintained, or where the safety of the aircraft and equipment is endangered.

3 AIRCRAFT AND SURVEY EQUIPMENT

A specialised geophysical survey aircraft fitted with a flight control computer, data acquisition system, and geophysical sensors was used, the list of geophysical and navigation equipment used for the survey is as follows:

General Survey Equipment

- PAC-750XL fixed wing survey aircraft.
- AG-NAV line navigation system.
- RMS DAARC500 data acquisition system
- Novatel 12 Channel differentially corrected GPS.
- Bendix King KRA-405B radar altimeter.

Magnetic Data Acquisition Equipment

- UTS/Geotech tail stinger magnetometer installation.
- Geometrics G822 Cesium Vapour total field magnetometer.
- Billingsley Fluxgate three component vector magnetometer.
- RMS DAARC500 magnetic compensator.
- Diurnal monitoring magnetometer (Scintrex Envimag - Geometrics GR-856).

Radiometric Data Acquisition Equipment

- RSI RSX500 gamma ray detector packs.
- Barometric altimeter (pressure measurements).
- UTS Geophysics temperature and humidity sensor.

3.1 Survey Aircraft

The aircraft used was a PAC-750XL fixed wing survey aircraft, operated by UTS Aviation Pty Ltd, registration VH-UTW. The specifications for this aircraft are as follows:

Power Plant

- Engine Type — Pratt and Whitney PT6A-34
- Shaft Horse Power — 750 SHP
- Fuel Type — JET-A1

Performance

- Cruise speed — 155 Kn
- Survey Speed — 140 Kn
- Stall speed — 50 Kn
- Range — 1628 Km
- Fuel tank capacity — 1436 litres

3.2 Data Positioning and Flight Navigation

Survey data positioning and flight line navigation was derived using real-time differential GPS (Global Positioning System).

Navigation was provided through a AG-NAV electronic pilot navigation system providing computer controlled navigation information displayed on a LCD screen as well as cross-track guidance on an LED light-bar.

The same GPS derived positions used to provide real-time aircraft navigation information were also recorded by the acquisition system to locate the survey data.

The GPS system used for the survey was:

- Aircraft GPS Model — Novatel 39xx series
- Sample rate — 0.1Seconds(10Hz)
- GPS satellite tracking channels — 12 parallel
- Typical differentially corrected accuracy — 1-2metres(horizontal)
3-5 metres (vertical)

3.3 RMS Instruments Data Acquisition System and Digital Recording

All geophysical sensor data and positional information measured during the survey was recorded using an RMS Instruments DAARC500 acquisition system. Survey data was downloaded on completion of each survey flight.

3.4 Altitude Readings

Survey height above the terrain was measured using a Bendix King radar altimeter installed in the aircraft. The height of each survey data point was measured by the radar altimeter and stored by the RMS data acquisition system.

- Radar altimeter models — Bendix King KRA-405B
- Accuracy — +/- 5%
- Resolution — 0.1 metres
- Range — 0 - 762 metres
- Sample rate — 0.1 Seconds (10Hz)

The digital terrain model is calculated by subtracting the terrain clearance (radar altimeter) from the differentially corrected GPS height,

The GPS height data had the ellipsoid to geoid separation “N” values applied to it real time and is relative to the geoid and as such the resulting calculated digital terrain height is relative to the Australian Height Datum or AHD.

3.5 UTS Geophysics Stinger Mounted Magnetometer System

The installation platform used for the acquisition of magnetic data was a tail mounted stinger. This stinger system was constructed of carbon fibre and designed for maximum rigidity and stability.

Both the total field magnetometer and three component vector magnetometer are located within the tail stinger.

3.6 Total Field Magnetometer

Total field magnetic data readings for the survey were made using a Geometrics G822 Cesium Vapour Magnetometer. This precision sensor has the following specifications:

- Model G822
- Sample Rate 0.05 seconds (20Hz)
- Resolution 0.001nT
- Operating Range 15,000nT to 100,000nT
- Temperature Range -40^{o}C to +50^{o}C

3.7 Three Component Vector Magnetometer

Three component vector magnetic data readings for the survey were made using a Fluxgate Magnetometer. This precision sensor has the following specifications:

- Model Billingsley
- Sample Rate 0.05 seconds (20Hz)
- Resolution 0.1nT
- Operating Range 20,000nT to 100,000nT
- Temperature Range -20^{o}C to +50^{o}C

3.8 Aircraft Magnetic Compensation

At the start of the survey the systems were calibrated for reduction of magnetic heading error. The heading and manoeuvre effects of the aircraft on the magnetic data were removed using an Data Acquisition & Adaptive Aeromagnetic Real-Time Compensator (DAARC500).

Calibration of the aircraft heading effects were measured by flying a series of pitch, roll and yaw manoeuvres at high altitude while monitoring changes in the three axis magnetometer and the effect on total field readings. A 26 term polynomial model of the aircraft magnetic noise covering permanent, induced and eddy current fields was determined. These coefficients were then applied to the data collected during the survey in real-time. The coefficients are listed in Appendix F.

The compensation flight data was recorded and then checked to ensure the acquisition of the compensation solution was without artifacts. A testbox flight was then recorded repeating the series of pitch, roll and yaw manoeuvre on all cardinal headings as with the compensation flight but now using the approved solution stored in the DAARC500. This testbox flight data was then processed to test the validity of the compensation for all cardinal headings, north, south, east and west.

3.9 Diurnal Monitoring Magnetometer

A base station magnetometer was located in a low gradient area beyond the region of influence of any man made interference to monitor diurnal variations during the survey.

The specifications for the magnetometers used are as follows:

- Model Scintrex Envimag
- Resolution 0.1 nT
- Sample interval 2 seconds (0.5 Hz)
- Operating range 20,000nT to 90,000nT
- Temperature -20^{o}C to +50^{o}C

3.10 Barometric Pressure

An Air DB barometric altimeter was installed in the aircraft so as to record and monitor barometric pressure. The data was recorded at 0.10 second intervals and is used for the reduction of the radiometric data.

- Model — PTB200 barometric altimeter
- Accuracy — 2 metres
- Height resolution — 0.1 metres
- Height range — 0 - 3500 metres
- Maximum operating pressure — 5000 mb
- Pressure resolution: — 0.01 mb
- Sample rate — 0 Hz

3.11 Temperature and Humidity

Temperature and humidity measurements were made during the survey at a sample rate of 10Hz. Ambient temperature was measured with a resolution of 0.1 degree Celsius and ambient humidity to a resolution of 0.1 percent.

3.12 Radiometric Data Acquisition

The gamma ray detectors used for the survey were two Radiation Solutions Inc RSX500 crystal packs, each pack contains four thallium activated sodium iodide crystals each with its own micro-spectrometer which are self stabilising in order to minimise spectral drift, the radiometric data was recorded in 256 channels.

Thorium source measurements were made each survey day to monitor system resolution and sensitivity. A calibration line was also flown at the start and end of each survey day to monitor ground moisture levels and system performance.

- Spectrometer model RSX 500
- Detector volume 34 litres
- Sample rate 1 Hz

The following table lists the spectral windows used.

Window Name	Total Count	K	U	Th
Energy Range (MeV)	0.4-2.81	1.370-1.570	1.660-1.860	2.410-2.810

4 PROJECT MANAGEMENT

Aus-China Corporation of Coal Geology Yan Zhao

UTS Geophysics Field

Operator:	Trent Posetti
Pilots:	Matthew Borgas Johann Schutte Des McAtamney

UTS Geophysics Office

Project Manager:	Rod Fowler
Data Processing:	Adam Schubert
Final Data QA/QC:	Geoffrey Plastow

5 DATA PROCESSING PROCEDURES

5.1 Data Pre-processing

The raw binary survey data was downloaded from the aircraft after each flight and transferred to the field computer. Using UTS Geophysics developed software lines were then trimmed to the correct survey boundary extents and corrections were made to the data positions with respect to time to remove fixed system parallax or lag offsets, the magnetic and radar altimeter data was adjusted by -0.300 seconds, and the radiometric data by -1.400 seconds for each flight.

The trimmed and parallax corrected data was then exported as located ASCII data and loaded into field data bases for further quality control procedures which included visual scrutinisation of individual line profiles and grids.

5.2 Magnetic Data Processing

The diurnal base station data was checked for spikes and steps, and suitably filtered prior to the removal of diurnal variations from the aircraft magnetic data.

The filtered diurnal measurements were subtracted from the diurnal base field and the residual corrections applied to the survey data by synchronising the diurnal data time and the aircraft survey time. The average diurnal base station value was added to the survey data.

The X and Y positioning of the data was then checked for spikes before applying the IGRF correction. Any spikes in the positions were manually edited. The updated IGRF 2010 correction was calculated at each data point (taking into account the height above sea level).

This regional magnetic gradient was subtracted from the survey data points.

Tie line levelling was applied to the data by least squares minimization, using a polynomial fit of order 0, of the differences in magnetic values at the crossover points of the survey traverse and tie line data.

In order to remove any residual long wavelength variations in the tie line levelled data along the traverse lines, polynomial levelling was then applied.

Final micro-levelling techniques were then selectively applied to the tie line levelled data to remove minor residual variations in profile intensity

Located and gridded data were generated from the final processed magnetic data.

5.3 Radiometric Data Processing

Statistical noise reduction of the 256 channel data was performed using the Noise Adjusted Singular Variable Decomposition (NASVD) method described by Hovgaard and Grasty (1997).

Noise-adjusted singular value decomposition is performed, and the number of components to be used is determined by inspection of plots of the spectral components and by a statistical analysis of the contributions of the components. If the spectral shapes show any unusual characteristics, further analysis of the concentrations of the spectral components in the line data is performed in order to identify and eliminate any corrupt spectra. If such spectra were eliminated, the NASVD process is re-performed, in order to obtain spectral components free of any bias from corrupt spectra.

Only the dominant spectral shapes (identified as described above) were used in the spectral reconstruction process. The first 8 NASVD components were used for this process.

Channels 30-250 only are spectrally smoothed, as these contain the regions of interest and are not dominated by the lower end of the Compton continuum. The energy spectrum between the potassium and thorium peaks was recalibrated from the spectrally smoothed 256 channel measurements.

The aircraft background spectrum and the scaled unit cosmic spectrum were then subtracted from the 256 channel data. This 256 channel data was then windowed to the 5 primary channels of total count, potassium, uranium, thorium and low-energy uranium. Dead time corrections were then applied to the data. Radon background removal was performed using the Minty Spectral Ratio method (1992).

The radar altimeter data was corrected to standard temperature and pressure, and height corrected spectral stripping was then applied to the windowed data. Height attenuation corrections based on the STP radar altimeter were then performed to remove any altitude variation effects from the data.

The Uranium and Total Count channels were tie-levelled to remove the effects of residual radon background. The tie-levelling process employed was a least-squares/median filter procedure, which generated a single correction for each line of data. Mis-matches were calculated at each tie-traverse intersection and the median mismatch for each flight line was calculated as the residual levelling error for that line.

5.4 Digital Terrain Model Data Processing

The radar altimeter data was subtracted from the GPS altimeter data leaving digital terrain data.

The digital terrain data thus derived was tie line levelled and gridded. Tie line levelled data was then examined and selectively microlevelled to produce a grid without line dependent artifacts.

For further information concerning the survey flown, please contact the following office:

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Malaga, WA 6944

Quoting reference number: UT140416

APPENDIX A - LOCATED DATA FORMATS

MAGNETIC LOCATED DATA

FIELD	FORMAT	DESCRIPTION	UNITS
1	I8	LINE NUMBER	
2	I4	FLIGHT/AREA NUMBER	AAFF (Area/Flight)
3	I9	DATE	YYMMDD
4	F10.1	TIME	sec
5	I8	FIDUCIAL NUMBER	
6	I4	UTM ZONE	
7	F12.6	LATITUDE (WGS84)	degrees
8	F12.6	LONGITUDE (WGS84)	degrees
9	F12.2	EASTING (WGS84)	metres
10	F12.2	NORTHING (WGS84)	metres
11	F8.1	RADAR ALTIMETER HEIGHT	metres
12	F8.1	GPS HEIGHT (WGS84)	metres
13	F8.1	TERRAIN HEIGHT (WGS84)	metres
14	F10.3	RAW MAGNETIC INTENSITY	nT
15	F10.3	DIURNAL CORRECTED TMI	nT
16	F10.3	DIURNAL AND IGRF CORRECTED TMI	nT
17	F10.3	TIE LINE LEVELLED TMI	nT
18	F10.3	FINAL TOTAL MAGNETIC INTENSITY	nT

RADIOMETRIC LOCATED DATA

FIELD	FORMAT	DESCRIPTION	UNITS
1	I8	LINE NUMBER	
2	4	FLIGHT	FF
3	I9	DATE	YYYYMMDD
4	F10.1	TIME	sec
5	I8	FIDUCIAL NUMBER	
6	I4	UTM ZONE	
7	F12.6	LATITUDE (WGS84)	degrees
8	F12.6	LONGITUDE (WGS84)	degrees
9	F12.2	EASTING (WGS84)	metres
10	F12.2	NORTHING (WGS84)	metres
11	F8.1	RADAR ALTIMETER HEIGHT	metres
12	F8.1	GPS HEIGHT (WGS84)	metres
13	I5	LIVE TIME	milli sec
14	F8.1	PRESSURE	hPa
15	F6.1	TEMPERATURE	Degrees Celcius
16	I6	TOTAL COUNT (RAW)	Counts/sec
17	I6	POTASSIUM (RAW)	Counts/sec
18	I6	URANIUM (RAW)	Counts/sec
19	I6	THORIUM (RAW)	Counts/sec
20	I6	COSMIC (RAW)	Counts/sec
21	F8.1	TOTAL COUNT (CORRECTED)	Counts/sec
22	F8.1	POTASSIUM (CORRECTED)	Counts/sec
23	F8.1	URANIUM (CORRECTED)	Counts/sec
24	F8.1	THORIUM (CORRECTED)	Counts/sec
25	F9.4	DOSE RATE	nGy/hr
26	F9.4	POTASSIUM GRND CONCENTRATION	%
27	F9.4	URANIUM GRND CONCENTRATION	ppm
28	F9.4	THORIUM GRND CONCENTRATION	ppm

GRIDDED DATASET FORMATS

Gridding was performed using a bicubic spline algorithm.

The following grid formats have been provided:

- ER-Mapper format

LINE NUMBER FORMATS

Line numbers are identified with a six digit composite line number and have the following format - AALLLLB, where:

A or AA	Survey area number
LLLL	Survey line number 0001-8999 reserved for traverse lines 9001-9999 reserved for tie lines
B	Line attempt number, 0 is attempt 1, 1 is attempt 2 etc..

UTS FILE NAMING FORMATS

Located and gridded data provided by UTS Geophysics uses the following 8 character file naming convention to be compatible with PC DOS based systems.

File names have the following general format - JJJJAABB.EEE, where:

JJJJ UTS Geophysics Job number

AA Area number if the survey is broken into blocks

BB
- M Magnetic data
- R Radiometric data
- TC Total count data
- K Potassium counts
- U Uranium counts
- Th Thorium counts
- DT Digital terrain data

EEE File name extension
- DAT Located digital data file
- DFN Located data definition file
- ERS Ermapper gridded data header file
Ermapper data portion has no extension
- GRD Geosoft gridded data file

APPENDIX B - COORDINATE SYSTEM DETAILS

Locations for the survey data are provided in both geographical latitude and longitude and Universal Transverse Mercator metric projection coordinate systems.

WGS84	World Geodetic System 1984
Coordinate Type	Geographical
Semi Major Axis	6378137m
Flattening	1/298.257223563

APPENDIX C - SURVEY BOUNDARY DETAILS

Area Name: Tennant Creek A1
Coordinates in WGS84
Grid Zone: 53S

Easting	Northing
361022	7851851
361022	7876841
393285	7876841
393285	7879273.5
408990	7879273.5
408990	7874273.5
393285	7874273.5
393285	7865404
384440	7865404
384440	7863761
383590	7863761
383590	7865180
368542	7865180
368542	7868931
365264	7868931
365264	7865366
363527	7865366
363527	7863508
361832	7863508
361832	7856851
365092	7856851
365092	7861928
370558	7861928
370558	7860095
372322	7860095
372322	7858263
374115	7858263
374115	7851851

Area Name: Tennant Creek A2
Coordinates in WGS84
Grid Zone: 53S

Easting	Northing
426285	7875172
426285	7867572
431825	7867572
431825	7875172

APPENDIX E – PROCESSING PARAMETERS

Magnetic Processing Parameters

IGRF Date:	IGRF 2015.2
Average Declination:	4.564 degrees
Average Inclination:	-49.675 degrees
Average Field strength:	50249 nT
Average diurnal:	50445 nT

Radiometric Processing Parameters

Height Attenuation Coefficients

Total Count:	-0.0133
Potassium:	-0.0180
Uranium:	-0.0103
Thorium:	-0.0134

Cosmic Correction Coefficients

Total Count:	0.9389
Potassium:	0.0503
Uranium:	0.0413
Thorium:	0.0605

Aircraft Background Coefficients

Total Count:	187.583
Potassium:	30.3807
Uranium:	6.3689
Thorium:	0.000

Sensitivity Coefficients

Total Count:	40.53 cps/dose rate
Potassium:	118.22 cps/%k
Uranium:	14.91 cps/ppm
Thorium:	7.35 cps/ppm

Radiometric Stripping Coefficients

Alpha:	0.2858
Beta:	0.4715
Gamma:	0.7595
a:	0.0352

Final Reduction - All data reduced to STP height datum 30m