GM 64511

HIGH RESOLUTION STINGER MOUNTED MAGNETOMETER AND RADIOMETRIC SURVEY

Report #07059a

HIGH RESOLUTION STINGER MOUNTED MAGNETOMETER AND RADIOMETRIC SURVEY FOR AREVA QUEBEC INC.

NORTHERN QUEBEC

NTS: 24I/5,6,10-15 and 24P/2,3,5,6,7

Fugro Airborne Surveys Corp.
Mississauga, Ontario

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SUMMARY

This report describes the logistics, data acquisition and processing of results from the first phase of flying on a high resolution magnetometer and radiometric airborne geophysical survey carried out for Areva Quebec Inc., over one complete and one partial block located in northern Quebec. Total coverage of the 2007 season flying amounted to 4153.3 km. Survey flying was undertaken from August 8th to September 9th, 2007.

The purpose of the survey was to record detailed magnetic and radiometric data over the properties to provide information that could be used to map the geology and structure of the survey area and highlight potential targets for follow-up. This was accomplished by using a high sensitivity cesium magnetometer and a 256-channel spectrometer. The information from these sensors was processed to produce maps that display the magnetic and radiometric properties of the survey area. A GPS electronic navigation system ensured accurate positioning of the geophysical data with respect to the base maps.

The survey data were processed and compiled in the Fugro Airborne Surveys Toronto office.

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1. INTRODUCTION

A high resolution magnetic and radiometric survey was started for Areva Quebec Inc., with flying from August 8th to September 9th, 2007, covering one complete and one partial survey block of the planned Cage Zones and Extensions survey area located in Nunavik, Northern Quebec. The survey areas can be located on NTS map sheets 24I/5,6,10,11,12,13,14,15 and 24P/2,3,5,6,7.

Survey coverage in 2007 consisted of approximately 4153.3 line-km, including 1214.2 line-km of tie lines. Flight lines were flown in an azimuthal direction of 45° for all blocks with a line separation of 150 m. Tie lines were flown orthogonal to the traverse lines for each block with a line separation of 1500 m.

The survey employed the HM1 magnetic system. Ancillary equipment consisted of radar, laser and barometric altimeter, video camera, digital recorders, a 256-channel spectrometer and an electronic navigation system. A single system was employed for the duration of the survey with the instrumentation installed in an AS350B type turbine helicopters (C-FDYS) provided by Questral Helicopters Ltd.. The helicopter flew at an average airspeed of 145 km/h with a magnetometer sensor height of approximately 50 m. The spectrometer crystal package was housed within the helicopter, with a nominal terrain clearance of 50 m.

Figure 1: Fugro Airborne Surveys HM1 with AS350B

2. SURVEY OPERATIONS

Survey operations were based in Kangiqsualujjuaq (George River), Nunavik, Northern Quebec for the duration of flying from August 8th to September 9th, 2007.

The planned survey areas can be located on NTS map sheets 24I/5,6,10-15 and 24P/2,3,5,6,7. All survey blocks are found in UTM Zone 20N coordinate system (Figure 2). Survey flying in 2007 consisted of complete coverage of the Cage_A block and partial coverage of the Cage_B block.

Table 2-1 lists the corner coordinates of the flight planning for CAGE_A and CAGE_B survey blocks in NAD83, UTM Zone 20N, central meridian 63°.

TABLE 2-1

Vertex #	Block	X_UTM	Y_UTM
1	**CAGE_A**	354422	6588899
2		358854	6592464
3		383973	6584665
4		375047	6575850
5		371840	6578017
6		371358	6579094
7		366133	6573845

Vertex #	Block	X_UTM	Y_UTM
1	**CAGE_B**	387307	6571501
2		390557	6530225
3		396557	6522725
4		394557	6520475
5		395735	6512137
6		383557	6502476
7		371430	6517968
8		368250	6515309
9		354245	6530103
10		352330	6536543

The survey specifications were as follows:

ALL SURVEY BLOCKS

Parameter	Specifications
Traverse line direction	N45°E
Traverse line spacing	150 m
Tie line direction	N135°E
Tie line spacing	1500 m
Sample interval	10 Hz, 4.0 m @ 145 km/h for mag; 1Hz, 40m @ 145 km/h for spectrometry
Aircraft mean terrain clearance	50 m
Mag sensor mean terrain clearance	50 m
Average speed	145 km/h
Navigation (guidance)	±5 m, Real-time GPS
Post-survey flight path	±2 m, Differential GPS

Survey block locations are as follows:

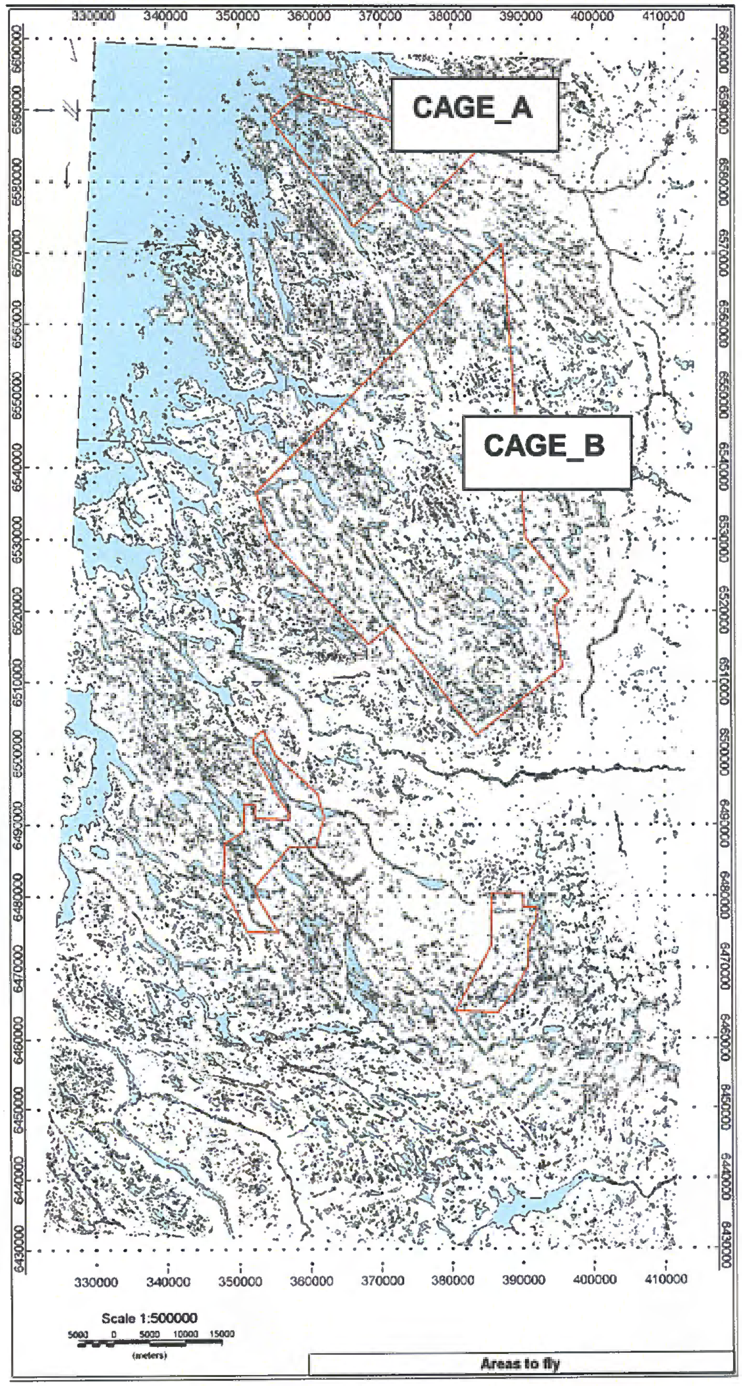

Figure 2
Location Map
Cage Zones and Extensions, Northern Quebec
Job # 07059

3. SURVEY EQUIPMENT

This section provides a brief description of the geophysical instruments used to acquire the survey data and the calibration procedures employed. The geophysical equipment was installed in an AS350B type helicopter. This aircraft provides a safe and efficient platform for surveys of this type.

Airborne Magnetometer

Model:	Fugro D1344 processor with Scintrex CS3 sensor
Type:	Optically pumped cesium vapour
Sensitivity:	0.01 nT
Sample rate:	10 per second

The magnetometer sensor is housed in a stinger mounted on the helicopter.

Magnetic Base Station

There were two magnetic base station setups used for this survey. One was located close to the survey blocks and was known as the CAGE_AREVA location. The second was located at the operational base in George River. The base station known as CAGE_AREVA was moved to George River on August 23 to act as the backup base station for the duration of the survey.

Primary – CAGE AREVA

Model:	GEM Systems GSM-19T
Type:	Digital recording proton precession
Sensitivity:	0.10 nT
Sample rate:	3 second intervals

Primary – George River

Model:	Fugro CF1 base station with timing provided by integrated GPS	
Sensor type:	Scintrex CS-2	
Counter specifications:	Accuracy:	±0.1 nT
	Resolution:	0.01 nT
	Sample rate	1 Hz
GPS specifications:	Model:	Marconi Allstar with CMT-1200 antenna
	Type:	Code and carrier tracking of L1 band, 12-channel, C/A code at 1575.42 MHz
	Sensitivity:	-90 dBm, 1.0 second update
	Accuracy:	Manufacturer's stated accuracy for differential corrected GPS is 2 metres
Environmental Monitor specifications:	Temperature:	

- Accuracy: ±1.5°C max
- Resolution: 0.0305°C
- Sample rate: 1 Hz
- Range: -40°C to +75°C

Barometric pressure:

- Model: Motorola MPXA4115A
- Accuracy: ±3.0° kPa max (-20°C to 105°C temp. ranges)
- Resolution: 0.013 kPa
- Sample rate: 1 Hz
- Range: 55 kPa to 108 kPa

Backup – George River

Model:	GEM Systems GSM-19T
Type:	Digital recording proton precession
Sensitivity:	0.10 nT
Sample rate:	3 second intervals

A digital recorder is operated in conjunction with the base station magnetometer to record the diurnal variations of the earth's magnetic field. The clock of the base station is synchronized with that of the airborne system, using GPS time, to permit subsequent removal of diurnal drift. There were two magnetic base stations at the start of the survey operations, at George River and near the survey area at CAGE_AREVA. The magnetic base station location for each of these base station set-ups, in WGS84 LAT/LONG coordinates, was as follows:

Location	Date (2007)	Latitude	Longitude	Height
CAGE_AREVA	Aug 15 – Aug 23	59º 10' 16"N	65º 35' 04"W	50 m
George River	Aug 10 – Sep 9	58º 42' 31"N	66º 59' 25"W	52 m

George River Primary Magnetic Base station setup
Job 07059, 2007

Navigation (Global Positioning System)

Airborne Receiver for Flight Path Recovery and Navigational Guidance

Model:	Novatel OEM4
Type:	Code and carrier tracking of L1-C/A code at 1575.42 MHz and L2-P code at 1227.0 MHz. Dual frequency, 24-channel.
Sample rate:	10 Hz update. 2Hz recording
Accuracy:	Manufacturer's stated accuracy for differential corrected GPS is better than 1 metre.
Antenna:	Mounted on tail of aircraft.

Primary GPS Base Station

Model:	Novatel OEM4
Type:	Code and carrier tracking of L1-C/A code at 1575.42 MHz and L2-P code at 1227.0 MHz. Dual frequency, 24-channel.
Sample rate:	10 Hz update. 2Hz recording
Accuracy:	Manufacturer's stated accuracy for differential corrected GPS is better than 1 metre.

The Novatel OEM4 captured the airborne positional data which were post processed using the base station GPS to provide differentially corrected positional data. The Novatel OEM4 is operated as the primary base station and utilizes time-coded signals from at least four of the twenty-four NAVSTAR satellites. The base station raw XYZ data are recorded, thereby permitting post-survey processing for theoretical accuracy of better than 5 m.

The Novatel OEM4 receiver was coupled with a PNAV navigation system for real-time guidance.

Although the base station receiver is able to calculate its own latitude and longitude, a higher degree of accuracy can be obtained if the reference unit is established on a known benchmark or triangulation point. For this survey there was one operational base in George River with both a primary and secondary GPS base station setup. The GPS location for each of these base station set-ups, in WGS84 LAT/LONG coordinates, was as follows:

Location	Date (2007)	Latitude	Longitude	Height
George River primary	Aug 10 – Sep 9	58° 42' 31"N	65° 59' 22"W	53.5 m
George River secondary	Aug 10 – Sep 9	58° 42' 31"N	65° 59' 25"W	53 m

The GPS records data relative to the WGS84 ellipsoid, which is the basis of the revised North American Datum (NAD83). Conversion software is used to transform the WGS84 coordinates to the NAD83 UTM system displayed on the maps.

George River Primary GPS base station setup
Job 07059, 2007

Radar Altimeter

Manufacturer:	Honeywell/Sperry
Model:	RT300/AT220
Type:	Short pulse modulation, 4.3 GHz
Sensitivity:	0.3 m
Sample rate:	2 per second

The radar altimeter measures the vertical distance between the helicopter and the ground, except in areas of dense trees.

Barometric Pressure and Temperature Sensors

Model:	DIGHEM D 1300
Type:	Motorola MPX4115AP analog pressure sensor AD592AN high-impedance remote temperature sensors
Sensitivity:	Pressure: 150 mV/kPa Temperature: 100 mV/°C or 10 mV/°C (selectable)
Sample rate:	10 per second

The D1300 circuit is used in conjunction with one barometric sensor and up to three temperature sensors. Three sensors (baro, temp_int and temp_ext) are installed in the data acquisition system in the aircraft, to monitor pressure and internal and external operating temperatures.

Laser Altimeter

Manufacturer:	Optech
Model:	G150
Type:	Fixed pulse repetition rate of 2 kHz
Sensitivity:	±5 cm from 10°C to 30°C ±10 cm from -20°C to +50°C

Sample rate: 2 per second

The laser altimeter is mounted to the helicopter belly, and measures the distance from the ground.

Digital Data Acquisition System

Manufacturer: Fugro

Model: HeliDAS

Recorder: Compact Flash Card

The stored data are downloaded to the field workstation PC at the survey base, for verification, backup and preparation of in-field products.

Compensation System

Manufacturer: Fugro

Model: HeliDAS, with fluxgate magnetometer

The presence of the helicopter in close proximity to the sensors causes considerable deviations on the readings. The orientation of the aircraft with respect to the sensors and the motion of the aircraft through the earth's magnetic field are contributing factors.

A special calibration flight is flown to record the information necessary to remove these effects.

The manoeuvre consists of flying a series of calibration lines at high altitude to gain information in each of the required line directions. During this procedure, the pitch, roll and yaw of the aircraft are varied. Each variation is conducted in succession (first vary pitch, then roll, then yaw). This provides a complete picture of the effects of the aircraft at designated headings in all orientations.

The HeliDAS compensation system derives a set of coefficients for each line direction and for each magnetometer sensor. The coefficients can be applied real-time or in a post-processing environment.

Video Flight Path Recording System

Type:	Panasonic WVCD/32 Colour
Recorder:	Panasonic AG720
Format:	Blocked binary digital format with index to allow for extraction of individual JPEG images (.BDX, .BIN files)

Fiducial numbers are recorded continuously and are displayed on the margin of each digital image. This procedure ensures accurate correlation of data with respect to visible features on the ground.

Spectrometer

Manufacturer:	Exploranium
Model:	GR-820
Type:	256 Multichannel, Thorium stabilized
Accuracy:	1 count/sec.
Update:	1 integrated sample/sec.

The GR-820 Airborne Spectrometer was coupled with four downward looking crystals (1024 cu.in.- 16.8 L) and one upward looking crystal (256 cu.in.- 4.2 L). The downward crystals record the radiometric spectrum from 410 KeV to 3 MeV over 256 discrete energy windows, as well as a cosmic ray channel which detects photons with energy levels above 3.0 MeV. From these 256 channels, the standard Total Count, Potassium, Uranium and Thorium channels are extracted. The upward crystal is used to measure and correct for Radon.

The shock-protected Sodium Iodide (Thallium) crystal package is unheated, and is automatically stabilized with respect to the Thorium peak. The GR-820 provides raw or Compton stripped data that has been automatically corrected for gain, base level, ADC offset and dead time.

The system is calibrated before and after each flight using three accurately positioned hand-held sources. Additionally, fixed-site hover tests or repeat test lines are flown to determine if there are any differences in background. This procedure allows corrections to be applied to each survey flight, to eliminate any differences that might result from changes in temperature or humidity.

4. QUALITY CONTROL AND IN-FIELD PROCESSING

Digital data for each flight were transferred to the field workstation, in order to verify data quality and completeness. A database was created and updated using Geosoft Oasis Montaj and proprietary Fugro Atlas software. This allowed the field personnel to calculate, display and verify both the positional (flight path) and geophysical data on a screen or printer. Records were examined as a preliminary assessment of the data acquired for each flight.

In-field processing of Fugro survey data consists of differential corrections to the airborne GPS data, spike rejection and filtering of all geophysical and ancillary data, verification of flight videos, diurnal correction, preliminary leveling of magnetic data, and verification of spectrometer source checks and the repeat test line.

All data, including base station records, were checked on a daily basis, to ensure compliance with the survey contract specifications. Reflights were required if any of the following specifications were not met.

Navigation - Digital positioning must be available; PDOP of less than 10 and 4 or more satellites to be available for GPS solution.

Flight Path - No lines to exceed ±30 m departure from planned flight path over a continuous distance of more than 2000 m, except for reasons of safety.

Clearance - Mean terrain sensor clearance of 50 m with altitude deviation from planned clearance not to exceed +/- 15 m over a continuous distance of 2000 m, except where precluded by safety considerations, e.g., restricted or populated areas, severe topography, obstructions, tree canopy, aerodynamic limitations, etc., as decided by the pilot.

Airborne Mag - The typical Figure of Merit for the magnetometer will be no greater than 2.0 nT The non-normalized 4^{th} difference not to exceed 1.6 nT over a continuous distance of 1000 m excluding areas where this specification is exceeded due to natural anomalies. Noise envelope for the magnetometer data not to exceed +/- 0.1 nT over a continuous distance of 2000 m

Base Mag - Diurnal variations not to exceed 10 nT peak to peak over a straight line time chord of 1 minute.

Spectrometer - Resolution of the spectrometer and crystal pack as calculated by FWHM of the Th peak must be better than 7%.

5. DATA PROCESSING

Flight Path Recovery

The raw range data from at least four satellites are simultaneously recorded by both the base and mobile GPS units. The geographic positions of both units, relative to the model ellipsoid, are calculated from this information. Differential corrections, which are obtained from the base station, are applied to the mobile unit data to provide a post-flight track of the aircraft, accurate to within 2 m. Speed checks of the flight path are also carried out to determine if there are any spikes or gaps in the data.

The corrected WGS84 latitude/longitude coordinates are transformed to the coordinate system used on the final maps. Images or plots are then created to provide a visual check of the flight path.

Total Magnetic Field

The magnetic data were corrected to produce a final leveled total field product by the application of the following sequence of procedures:

- Data quality check on the raw and compensated magnetic data.
- Lag correction.

- Loading, checking and application of the measured diurnal data.
- Removal of the IGRF
- Leveling of total magnetic field data.

The data quality check was accomplished in the field by applying a fourth difference filter to all raw compensated magnetic data after it had been loaded into the Oasis montaj™ database. Plotting the raw and compensated data together permitted tracking the performance of the magnetometer sensor as well as monitoring the noise levels that were superimposed on the data during survey activities. Magnetometer noise levels were maintained within stated specifications.

The aeromagnetic data from the magnetic sensor was inspected in both grid and profile format. Spikes were removed manually with the aid of a fourth difference calculation and small gaps were interpolated using an Akima spline.

A lag correction was applied to remove the effects of temporal delay inherent in the data acquisition system. A correction 1.4 seconds was applied to data collected from both systems.

The diurnal variations recorded by the base station were edited for any cultural contamination and filtered to remove high-frequency noise. This diurnal magnetic data was then subtracted from the despiked, lagged TMI to provide a first order diurnal correction. Average base values were added back to the diurnal corrected airborne total magnetic field. For processing of CAGE_A, CAGE_AREVA magnetic base station was used as the primary base station and the average base value is as follows:

Location	Date (2007)	Average Magnetic Base Value (nT)
CAGE_AREVA	Aug 10 – Sep 9	56436.0

For CAGE_B, George River CF1 magnetic base station was used as the primary base station.

The diurnal removed magnetic field data were then gridded and compared to a grid of the despiked, lagged magnetic data to ensure that the data quality was improved by diurnal removal.

Once the lag had been removed grids were created and examined, and additional leveling was performed. Tie line leveling was only used on lines which had a minimum of two intersections with tie lines. A Geosoft MAP (Block_A_MAGIGRF_DIFF.MAP) showing the difference between the IGRF removed magnetic field values at the tieline/traverse-line intersection point accompanies this report. The levelling procedure allows for rejection of intersection information in the levelling process, based on criteria of 1) localized magnetic gradients, 2) altitude differences between the tie line data and traverse line data, and 3) amplitude of magnetic differences at the intersection point. There are significant differences in altitude at intersection points in this dataset, particularly in the southern part of the block. This can be clearly seen in the accompanying Geosoft MAP (BLOCK_A_ALT_DIFF.MAP) which shows the altimeter difference at the intersection points. Intersections were therefore not rejected based on the second criteria as it removed too many intersections to allow for valid statistics on the remaining crossovers. In particular, the two additional tie lines flown in topographic valleys in the southern part of the survey block have been flown at significantly lower altitude than the traverse lines they are intersecting. Intersections were rejected based only on localized magnetic gradients and intersection error was distributed between the traverse lines and tie lines. Manual adjustments were made to the resulting levelling network, including editing of intersection values, removal of some intersections and addition of other intersections where more control is required, as indicated by shadowed images of the gridded vertical gradient. After the application of tie-line leveling, a procedure known as microleveling was applied. This technique is designed to remove any persistent, low-amplitude component of flight line noise remaining after tie-line leveling. A series of directional filters were applied to the magnetic grid to produce a decorrugation "noise" grid. This grid is then re-sampled back into the database where the resultant "noise" channel was filtered to remove any remaining short wavelength responses that could be due to geologic sources. The amplitude of the "noise" channel was also limited to restrict the effect that the microleveling might have on strong geologic response. Finally, the "noise" channel is subtracted from the leveled channel created earlier in the processing sequence, resulting in the final leveled IGRF removed magnetic field channel.

The process of tie-line levelling and micro-levelling does a good job of creating a dataset that is consistent at the intersection network nodes but cannot compensate for line to line altitude variation which can have a significant effect on amplitude/spectral content of the measured magnetic field. There are several regions within this dataset which suffer from the effects of significant line to line altitude variation on magnetic anomaly shape and amplitude.

IGRF Removal

The International Geomagnetic Reference Field (IGRF) was calculated at a 1 Hz interval for all survey data based on the flight date, the latitude and longitude of each survey point and the value of the GPS height above the spheroid. The IGRF field was calculated using the 2005 IGRF model and interpolated to 10 Hz before being subtracted from the final lagged, diurnally corrected total magnetic field. The IGRF corrected channel was used in the magnetic levelling procedure. The final levelled magnetics with IGRF removed are archived as MAG_LEV.

Calculated Vertical Magnetic Gradient

The leveled total magnetic field data were subjected to a processing algorithm that enhances the response of magnetic bodies in the upper 500 m and attenuates the response of deeper bodies. The resulting vertical gradient map provides better definition and resolution of near-surface magnetic units. It also identifies weak magnetic features that may not be evident on the total field map. However, regional magnetic variations and changes in lithology may be better defined on the total magnetic field map.

Digital Elevation

The radar altimeter values (ALTR – aircraft to ground clearance) are subtracted from the differentially corrected and de-spiked GPS-Z values to produce profiles of the height above the ellipsoid along the survey lines. These values are gridded to produce contour maps showing approximate elevations within the survey area. Any remaining subtle line-to-line discrepancies are manually removed. After the manual corrections are applied, the digital terrain data can be filtered with a microleveling algorithm if necessary.

The accuracy of the elevation calculation is directly dependent on the accuracy of the two input parameters, ALTR and GPS-Z. The ALTR value may be erroneous in areas of heavy tree cover, where the altimeter reflects the distance to the tree canopy rather than the ground. The GPS-Z value is primarily dependent on the number of available satellites. Although post-processing of GPS data will yield X and Y accuracies in the order of 1-2 metres, the accuracy of the Z value is usually much less, sometimes in the ±5 metre range. Further inaccuracies may be introduced during the interpolation and gridding process.

Because of the inherent inaccuracies of this method, no guarantee is made or implied that the information displayed is a true representation of the height above sea level. Although this product may be of some use as a general reference, <u>THIS PRODUCT MUST NOT BE USED FOR NAVIGATION PURPOSES.</u>

Radiometrics

All radiometric data reductions performed by Fugro rigorously follow the procedures described in the IAEA Technical Report[1].

All processing of radiometric data was undertaken at the natural sampling rate of the spectrometer, i.e., one second. The data were not interpolated to match the fundamental 0.1-second interval of the magnetic data.

The following sections describe each step in the process.

Spectrum Stability

In order to monitor spectral drift, the average spectrum for each flight line was examined and peak position analysis was performed on the K, U and Th peaks. The centroid position for each peak is reported to one tenth of a channel and is reviewed according to the radiometric QC requirement of less than one channel change in peak position for the Th peak. The results of this analysis for data from CAGE_A are shown in Appendix D.

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1 Exploranium, I.A.E.A. Report, Airborne Gamma-Ray Spectrometer Surveying, Technical Report No. 323, 1991. Revised and improved in 2003 : Technical Report no 1363, IAEA, Vienna

Pre-filtering

Four parameters were filtered, but not returned to the database:

- Radar altimeter, pressure and temperature data was processed with a 7-point median filter to remove spikes and then smoothed with a 7-point Hanning filter
- The Cosmic window was smoothed with a 13-point Hanning filter (Cos_f).

Reduction to Standard Temperature and Pressure

The radar altimeter data were converted to effective height (h_e) in metres using the acquired temperature and pressure data, according to the following formula:

$$h_e = h * \frac{273.15}{T + 273.15} * \frac{P}{1013.25}$$

where: *h* is the observed crystal to ground distance in metres

T is the measured air temperature in degrees Celsius

P is the barometric pressure in kilopascals

Statistical Noise Reduction (spectrum smoothing)

Noise reduction of the 256 channel spectrum was carried out using the noise adjusted singular value decomposition (NASVD) method as described by Hovgaard and Grasty, 1997. The resulting spectrum is archived in the final database and windowed data was resampled from the NASVD spectrum for further processing of the downward looking total count, potassium, thorium and uranium regions of interest (ROI).

Live Time Correction

The spectrometer, an Exploranium GR-820, uses the notion of "live time" to express the relative period of time the instrument was able to register new pulses per sample interval. This is the opposite of the traditional "dead time", which is an expression of the relative period of time the system was unable to register new pulses per sample interval.

The GR-820 measures the live time electronically, and outputs the value in milliseconds. The live time correction is applied to the total count, potassium, uranium, thorium, upward uranium and cosmic channels. The formula used to apply the correction is as follows:

$$C_{lt} = C_{raw} * \frac{1000.0}{L}$$

where: C_{lt} is the live time corrected channel in counts per second

C_{raw} is the raw channel data in counts per second

L is the live time in milliseconds

Aircraft and Cosmic Background

Aircraft background and cosmic stripping corrections were applied to the total count, potassium, uranium, thorium and upward uranium channels using the following formula:

$$C_{ac} = C_{lt} - (a_c + b_c * \text{Cos}_f)$$

where: C_{ac} is the background and cosmic corrected channel

C_{lt} is the live time corrected channel

a_c is the aircraft background for this channel

b_c is the cosmic stripping coefficient for this channel

Cos_f is the filtered Cosmic channel

Radon Background

The determination of calibration constants that enable the stripping of the effects of atmospheric radon from the downward-looking detectors through the use of an upward-looking detector is divided into two parts:

1) Determine the relationship between the upward- and downward-looking detector count rates for radiation originating from the ground.

2) Determine the relationship between the upward- and downward-looking detector count rates for radiation due to atmospheric radon.

The procedures to determine these calibration factors are documented in IAEA Report #323 on airborne gamma-ray surveying. The calibrations for the first part were determined as outlined in the report.
The latter case normally requires many over-water measurements where there is no contribution from the ground. Where this is not possible, it is standard procedure to establish a test line over which a series of repeat measurements are acquired. From these repeat flights, any change in the downward uranium window due to variations in radon background would be directly related to variations in the upward window and the other downward windows.

The validity of this technique rests on the assumption that the radiation from the ground is essentially constant from flight to flight. Inhomogeneities in the ground, coupled with deviations in the flight path between test runs, add to the inaccuracy of the accumulated results. Variations in flying heights and other environmental factors also contribute to the uncertainty.

The use of test lines is a common solution for a fixed-wing acquisition platform. The ability of rotary wing platforms to hover at a constant height over a fixed position eliminates a number of the variations which degrade the accuracy of the results required for this calibration.

A test site was established in or near the survey area. The tests were carried out at the start and end of each day, and at the end of each flight. Data were acquired over the test line at the nominal survey altitude (50 m). The data were then corrected for live time, aircraft background and cosmic activity.

Once the survey was completed, the relationships between the counts in the downward uranium window and in the other four windows due to atmospheric radon were determined using linear regression for each of the hover sites. The following equations were used:

$$u_r = a_u Ur + b_u$$

$$K_r = a_K U_r + b_K$$

$$T_r = a_T U_r + b_T$$

$$I_r = a_I U_r + b_I$$

where: u_r is the radon component in the upward uranium window

K_r, U_r, T_r and I_r are the radon components in the various windows of the downward detectors

the various "a" and "b" coefficients are the required calibration constants

In practice, only the "a" constants were used in the final processing. The "b" constants, which are normally near zero for over-water calibrations, were of no value as they reflected the local distribution of the ground concentrations measured in the five windows.

The thorium, uranium and upward uranium data for each line were copied into temporary arrays, then smoothed with 21, 21 and 51 point Hanning filters to product Th_f, U_f, and u_f

respectively. The radon component in the downward uranium window was then determined using the following formula:

$$U_r = \frac{u_f - a_1 * U_f - a_2 * Th_f + a_2 * b_{Th} - b_u}{a_u - a_1 - a_2 * a_{Th}}$$

where: U_r is the radon component in the downward uranium window

u_f is the filtered upward uranium

U_f is the filtered uranium

Th_f is the filtered thorium

a_1, a_2, a_u and a_{Th} are proportionality factors and

b_u and b_{Th} are constants determined experimentally

The effects of radon in the downward uranium are removed by simply subtracting U_r from U_{ac}. The effects of radon in the total count, potassium, thorium and upward uranium are then removed based upon previously established relationships with U_r. The corrections are applied using the following formula:

$$C_{rc} = C_{ac} - (a_c * U_r + b_c)$$

where: C_{rc} is the radon corrected channel

C_{ac} is the background and cosmic corrected channel

U_r is the radon component in the downward uranium window

a_c is the proportionality factor and

b_c is the constant determined experimentally for this channel

Compton Stripping

Following the radon correction, the potassium, uranium and thorium are corrected for spectral overlap. First, α,β and γ the stripping ratios, are modified according to altitude. Then an adjustment factor based on a, the reversed stripping ratio, uranium into thorium, is calculated. (Note: the stripping ratio altitude correction constants are expressed in change per metre. A constant of 0.3048 is required to conform to the internal usage of height in feet):

$$\alpha_h = \alpha + h_{ef} * 0.00049$$

$$\alpha_r = \frac{1.0}{1.0 - a * \alpha_h}$$

$$\beta_h = \beta + h_{ef} * 0.00065$$

$$\gamma_h = \gamma + h_{ef} * 0.00069$$

where: α, β, γ are the Compton stripping coefficients

α_h, β_h, γ_h are the height corrected Compton stripping coefficients

h_{ef} is the height above ground in metres

α_r is the scaling factor correcting for back scatter

a is the reverse stripping ratio

The stripping corrections are then carried out using the following formulas:

$$Th_c = (Th_{rc} - a * U_{rc}) * \alpha_r$$

$$U_c = (U_{rc} - \alpha_h * Th_{rc}) * \alpha_r$$

$$K_c = K_{rc} - \gamma_h * U_c - \beta_h * Th_c$$

where: U_c, Th_c and K_c are corrected uranium, thorium and potassium

α_h,β_h,γ_h are the height corrected Compton stripping coefficients

U_{rc}, Th_{rc} and K_{rc} are radon-corrected uranium, thorium and potassium

α_r is the backscatter correction

Attenuation Corrections

The total count, potassium, uranium and thorium data are then corrected to a nominal survey altitude, in this case 50 m. This is done according to the equation:

$$C_a = C * e^{\mu(h_0 - h_{ef})}$$

where: C_a is the output altitude corrected channel

C is the input channel

e^{μ} is the attenuation correction for that channel

h_{ef} is the effective altitude

h_0 is the nominal survey altitude to correct to

Conversion to Apparent Radioelement Concentrations

The fully corrected count rate data is used to estimate the concentrations in the ground of each of the three radioelements, potassium, uranium and thorium. The procedure determines the concentrations that would give the observed count rates, if uniformly distributed in an infinite horizontal slab source. Because the U and Th windows actually measure ^{214}Bi and ^{208}Tl respectively, the calculation implicitly assumes radioactive equilibrium in the U and Th decay series. The U and Th concentrations are therefore expressed as equivalent concentrations, eU and eTh. The calculated potassium, uranium and thorium concentrations are determined using the expression:

$$C = N / S \qquad (4.7)$$

where: C is the concentration of element (K%, eU ppm or eTh ppm)

S is he broad source sensitivity for the window, and

N is the count rate for each window, after dead-time, background, stripping and attenuation correction.

Contour, Colour and Shadow Map Displays

The magnetic geophysical data and the digital terrain data are interpolated onto a regular grid using a modified Akima spline technique. The resulting grid is suitable for image processing and generation of contour maps. The grid cell size is 20% of the line interval.

The radiometric geophysical data are interpolated onto a regular grid using a minimum curvature technique. The grid cell size is 25% of the line interval. Resulting grids are resampled to 20% of the line interval to match the final cell size of the magnetic and dem grids.

Colour maps are produced by interpolating the grid down to the pixel size. The parameter is then incremented with respect to specific amplitude ranges to provide colour "contour" maps.

6. PRODUCTS

This section lists the final maps and products that have been provided under the terms of the survey agreement. Other products can be prepared from the existing dataset, if requested.

Base Maps

Base maps of the survey area were produced by scanning published topographic maps to a bitmap (.bmp) format. This process provides a relatively accurate, distortion-free base that facilitates correlation of the navigation data to the map coordinate system. The topographic files will be combined with geophysical data for plotting the final maps. Maps will be created using the following parameters:

Projection Description:

Datum:	NAD83 Canada		
Ellipsoid:	GRS80		
Projection:	UTM (Zone: 20N)		
Central Meridian:	63°		
False Northing:	0		
False Easting:	500000		
Scale Factor:	0.9996		
WGS84 to Local Conversion:	Molodensky		
Datum Shifts:	DX: 0	DY: 0	DZ: 0

All maps include flight lines, contours and topography, unless otherwise indicated. No map products have been produced. Final map products will be prepared at 1:100000 scale and delivered in HP2500 compatible print file format as well as PDF format.

Final Products

	No. of Map Sets		
	Mylar	Blackline	Colour
Flight Lines		5	
DEM			5
Total Magnetic Field – IGRF removed			5
Radiometrics - Doserate			5
- Potassium (%)			5
- Uranium (eq. ppm)			5
- Thorium (eq. ppm)			5

7. CONCLUSIONS AND RECOMMENDATIONS

This report provides a very brief description of the survey results and describes the equipment, data processing procedures and logistics of the survey.

Respectfully submitted,

FUGRO AIRBORNE SURVEYS CORP.

APPENDIX A

LIST OF PERSONNEL

The following personnel were involved in the acquisition, processing, interpretation and presentation of data, relating to a high resolution magnetometer and radiometric airborne geophysical survey carried out for Areva Quebec Inc..

David Miles	Manager, Helicopter Operations
Emily Farquhar	Manager, Data Processing and Interpretation
Rildo Araujo	Geophysical Operator
Brett Robinson	Field Geophysicist/ Supervisor
Marcio de Souza	Field Geophysicist
Matt Ritchie	Pilot
Wayne Keizer	Pilot
Stephane Fortin	AME
Barry Orme	AME
Lyn Vanderstarren	Drafting Supervisor
Susan Pothiah	Word Processing Operator
Albina Tonello	Secretary/Expeditor

The survey consisted of 4153.3 km of coverage, flown from August 8th to September 9th, 2007.

All personnel are employees of Fugro Airborne Surveys, except for the pilots and AMEs who are employees of Questral Helicopters.

APPENDIX B

BACKGROUND INFORMATION

BACKGROUND INFORMATION

Magnetic Responses

The measured total magnetic field provides information on the magnetic properties of the earth materials in the survey area. The information can be used to locate magnetic bodies of direct interest for exploration, and for structural and lithological mapping.

The total magnetic field response reflects the abundance of magnetic material in the source. Magnetite is the most common magnetic mineral. Other minerals such as ilmenite, pyrrhotite, franklinite, chromite, hematite, arsenopyrite, limonite and pyrite are also magnetic, but to a lesser extent than magnetite on average.

In some geological environments, an EM anomaly with magnetic correlation has a greater likelihood of being produced by sulphides than one which is non-magnetic. However, sulphide ore bodies may be non-magnetic (e.g., the Kidd Creek deposit near Timmins, Canada) as well as magnetic (e.g., the Mattabi deposit near Sturgeon Lake, Canada).

Iron ore deposits will be anomalously magnetic in comparison to surrounding rock due to the concentration of iron minerals such as magnetite, ilmenite and hematite.

Changes in magnetic susceptibility often allow rock units to be differentiated based on the total field magnetic response. Geophysical classifications may differ from geological classifications if various magnetite levels exist within one general geological classification. Geometric considerations of the source such as shape, dip and depth, inclination of the earth's field and remanent magnetization will complicate such an analysis.

In general, mafic lithologies contain more magnetite and are therefore more magnetic than many sediments which tend to be weakly magnetic. Metamorphism and alteration can also increase or decrease the magnetization of a rock unit.

Textural differences on a total field magnetic contour, colour or shadow map due to the frequency of activity of the magnetic parameter resulting from inhomogeneities in the distribution of magnetite within the rock, may define certain lithologies. For example, near surface volcanics may display highly complex contour patterns with little line-to-line correlation.

Rock units may be differentiated based on the plan shapes of their total field magnetic responses. Mafic intrusive plugs can appear as isolated "bulls-eye" anomalies. Granitic intrusives appear as sub-circular zones, and may have contrasting rings due to contact metamorphism. Generally, granitic terrain will lack a pronounced strike direction, although granite gneiss may display strike.

Linear north-south units are theoretically not well-defined on total field magnetic maps in equatorial regions due to the low inclination of the earth's magnetic field. However, most stratigraphic units will have variations in composition along strike that will cause the units to appear as a series of alternating magnetic highs and lows.

Faults and shear zones may be characterized by alteration that causes destruction of magnetite (e.g., weathering) that produces a contrast with surrounding rock. Structural breaks may be filled by magnetite-rich, fracture filling material as is the case with diabase dikes, or by non-magnetic felsic material.

Faulting can also be identified by patterns in the magnetic total field contours or colours. Faults and dikes tend to appear as lineaments and often have strike lengths of several kilometres. Offsets in narrow, magnetic, stratigraphic trends also delineate structure. Sharp contrasts in magnetic lithologies may arise due to large displacements along strike-slip or dip-slip faults.

Gamma Ray Spectrometry

Radioelement concentrations are measures of the abundance of radioactive elements in the rock. The original abundance of the radioelements in any rock can be altered by the subsequent processes of metamorphism and weathering.

Gamma radiation in the range that is measured in the thorium, potassium, uranium and total count windows is strongly attenuated by rock, overburden and water. Almost all of the total radiation measured from rock and overburden originates in the upper 0.5 metres. Moisture in soil and bodies of water will mask the radioactivity from underlying rock. Weathered rock materials that have been displaced by glacial, water or wind action will not reflect the general composition of the underlying bedrock. Where residual soils exist, they may reflect the composition of underlying rock except where equilibrium does not exist between the original radioelement and the products in its decay series.

Radioelement counts (expressed as counts per second) are the rates of detection of the gamma radiation from specific decaying particles corresponding to products in each radioelements decay series. The radiation source for uranium is bismuth (Bi-214), for thorium it is thallium (Tl-208) and for potassium it is potassium (K-40).

The uranium and thorium radioelement concentrations are dependent on a state of equilibrium between the parent and daughter products in the decay series. Some daughter products in the uranium decay are long lived and could be removed by processes such as leaching. One product in the series, radon (Rn-222), is a gas which can easily escape. Both of these factors can affect the degree to which the calculated uranium concentrations reflect the actual composition of the source rock. Because the daughter products of thorium are relatively short lived, there is more likelihood that the thorium decay series is in equilibrium.

Lithological discrimination can be based on the measured relative concentrations and total, combined, radioactivity of the radioelements. Feldspar and mica contain potassium. Zircon, sphene and apatite are accessory minerals in igneous rocks that are sources of uranium and thorium. Monazite, thorianite, thorite, uraninite and uranothorite are also sources of uranium and thorium which are found in granites and pegmatites.

In general, the abundance of uranium, thorium and potassium in igneous rock increases with acidity. Pegmatites commonly have elevated concentrations of uranium relative to thorium. Sedimentary rocks derived from igneous rocks may have characteristic signatures that are influenced by their parent rocks, but these will have been altered by subsequent weathering and alteration.

Metamorphism and alteration will cause variations in the abundance of certain radioelements relative to each other. For example, alterative processes may cause uranium enrichment to the extent that a rock will be of economic interest. Uranium anomalies are more likely to be economically significant if they consist of an increase in the uranium relative to thorium and potassium, rather than a sympathetic increase in all three radioelements.

Faults can exhibit radioactive highs due to increased permeability which allows radon migration, or as lows due to structural control of drainage and fluvial sediments which attenuate gamma radiation from the underlying rocks. Faults can also be recognized by sharp contrasts in radiometric lithologies due to large strike-slip or dip-slip displacements. Changes in relative radioelement concentrations due to alteration will also define faults.

Similar to magnetics, certain rock types can be identified by their plan shapes if they also produce a radiometric contrast with surrounding rock. For example, granite intrusions will appear as sub-circular bodies, and may display concentric zonations. They will tend to lack a prominent strike direction. Offsets of narrow, continuous, stratigraphic units with contrasting radiometric signatures can identify faulting, and folding of stratigraphic trends will also be apparent.

APPENDIX C

DATA ARCHIVE DESCRIPTION

APPENDIX C

ARCHIVE DESCRIPTION

FUGRO JOB NUMBER.....	07059
SURVEY COMPANY.......	Fugro Airborne Surveys Pty Ltd
CLIENT...............	Areva Quebec Inc.
SURVEY TYPE..........	MAG/RADIOMETRICS
AREA NAME............	CAGE_A, CAGE_B areas, Nunavik, Northern Quebec
DATE FLOWN...........	Aug 8th to September 9th, 2007 from George River

AIRBORNE SURVEY PARAMETERS

LINE SPACING.........	150 m
TIE LINE SPACING.....	1500 m
LINE DIRECTION.......	045 / 225 degrees
TIE LINE DIRECTION...	135 / 315 degrees
TERRAIN CLEARANCE....	50 m nominal
AIRCRAFT.............	AS-350B
AIRCRAFT SPEED.......	40 m/s
POSITIONAL CONTROL...	Post-processed differential GPS used in processing,
DIGITAL RECORDING....	HeliDAS acquisition system

EQUIPMENT SPECIFICATIONS

SAMPLING............. 10 Hz (approximately 4.8 m)

CORRECTIONS.......... The radar altimeter data has been filtered and lagged where necessary for this dataset.
The Mag data have been compensated, lagged, diurnally corrected and IGRF removed before tie line levelling was applied.
Radiometric data has had statistical noise reduce through NASVD, then rewindowed and processed with coefficients determined from test flights. Conversion to concentrations was made with historic calibration coefficients appropriate to platform type and survey altitude.

MAP COORDINATES

MAP PROJECTION.....	UTM Z20N
SPHEROID...........	WGS84
CENTRAL MERIDIAN...	63 degrees west

Output field format : Geosoft database channels
Number of fields : 40

Field	Channel	Sample Rate	Units	Description
1	LINE	0.10		Line No

2	FLT	0.10		Flight No
3	Date	0.10		Flight Date
4	FID	0.10		Fiducial
5	UTC_SSM	0.10		UTC TIME seconds
6	X_UTM	0.10	m	UTME-Z20N
7	Y_UTM	0.10	m	UTMN-Z20N
8	GPS_Z	0.10	m	Height above Spheroid
9	LON_WGS84	0.10	Degrees	LONGITUDE- WGS84
10	LAT_WGS84	0.10	Degrees	LATITUDE - WGS84
11	ALTRAD_MT	0.10	m	Radar Altimeter
12	DTM	0.10	m	Digital Terrain relative to GPS spheroid
13	DIURNAL	0.10	nT	Diurnal Magnetics
14	DIURNAL_COR	0.10	nT	Diurnal Correction
15	DIURNAL_FILT	0.10	nT	Filtered Diurnal Magnetics
16	MAG_RAW	0.10	nT	Raw Total Field Magnetics
17	MAG_COMP	0.10	nT	Compensated Total Field Magnetics
18	MAG_LD	0.10	nT	Lagged, diurnal cor, total field magnetics
19	IGRF	0.10		IGRF
20	RES_MAG	0.10		Leveled total field mag, IGRF removed
21	PRESSURE	0.10	kpa	Air pressure
22	TEMP_EXT	0.10	degrees C	External air temperature
23	Effective Height	0.10	m	Effective hgt for radiometric correction
24	COSMIC	1.00	counts	Cosmic counts
25	LIVE_TIME	1.00	mS	Spectrometer livetime
26	TC_NASVD	1.00	counts	Total count raw NASVD
27	K_NASVD	1.00	counts	Potassium window counts raw NASVD
28	U_NASVD	1.00	counts	Uranium window counts raw NASVD
29	TH_NASVD	1.00	counts	Thorium window counts raw NASVD
30	U_UP	1.00	counts	Upward looking Uranium window raw
31	TC_COR_CPS	1.00	cps	Total count corrected
32	K_COR_CPS	1.00	cps	Potassium window counts corrected
33	U_COR_CPS	1.00	cps	Uranium window counts corrected
34	TH_COR_CPS	1.00	cps	Thorium window counts corrected
35	Doserate	1.00	nGy/h	Doserate from Total Count
36	K_percent	1.00	%	Potassium concentration
37	U_PPM	1.00	ppm	Equivalent Uranium concentration
38	TH_PPM	1.00	ppm	Equivalent Thorium concentration
39	GR820_DOWN			256 channel spectrum, array channel
40	GR820_DOWN_NASVD			NASVD 256 channel spectrum, array

APPENDIX D

TESTS AND CALIBRATIONS

APPENDIX D

TESTS AND CALIBRATIONS

LAG TEST

A magnetic lag test is flown to calculate the positional lag that develops between the time a reading is made and the time it is recorded in the data. A large metallic body such as railway tracks, a bridge, buildings or a distinct magnetic anomaly is flown over along a single line, at survey altitude, in opposite directions. This allows the time constant value that will line-up the magnetic anomaly peaks or troughs that are produced to be determined. This time shift constant is then applied to the data collected during the survey.
Lag test was flown on Aug 20, 2007. Lag determined for job 07059 is 1.5 seconds. In processing the survey data that was later refined to 1.4 seconds.

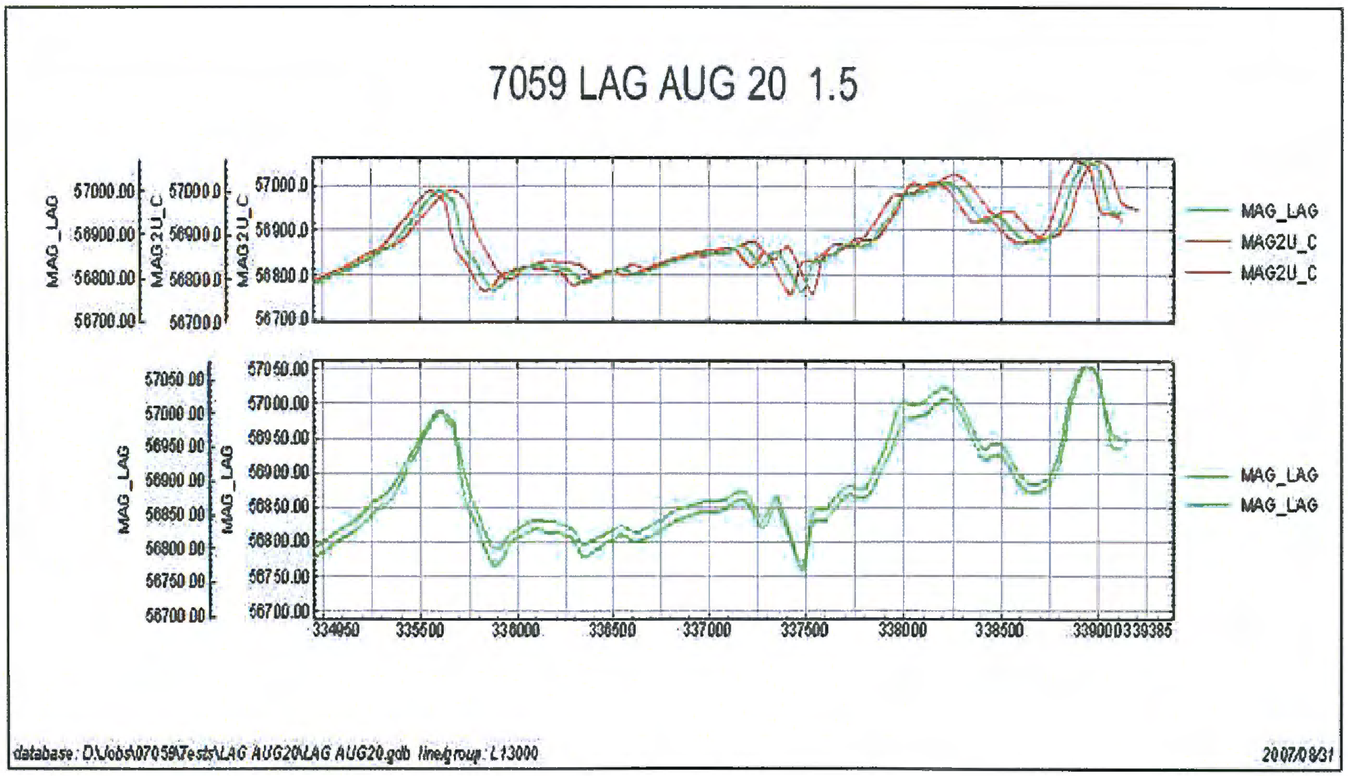


FIGURE OF MERIT

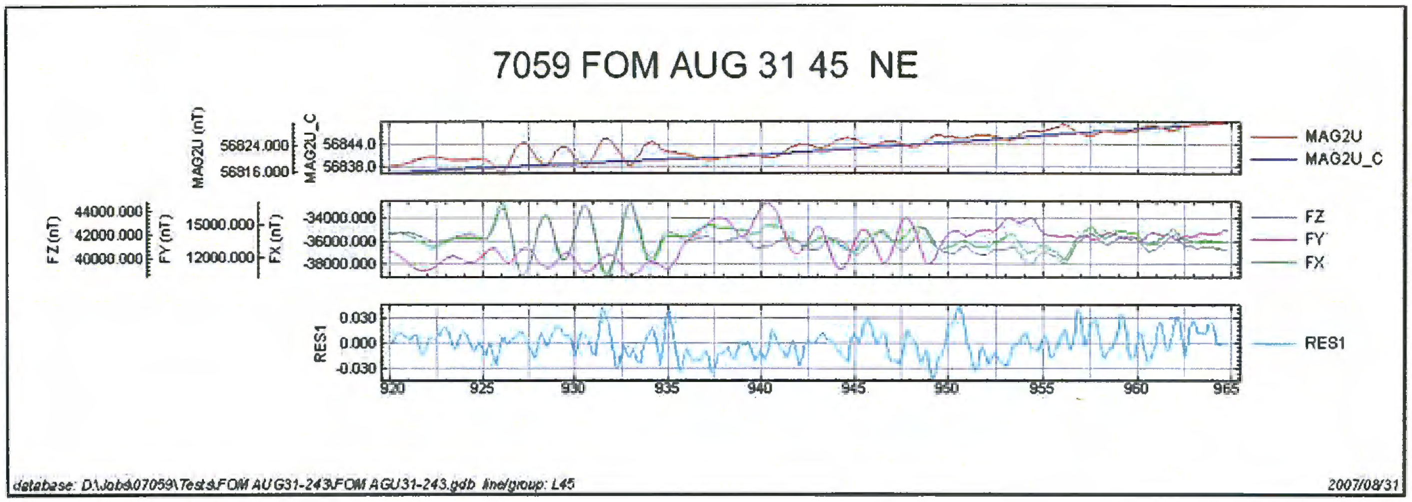
Compensation of magnetic readings is required when the magnetometers are mounted on, or in close proximity to, the aircraft. The aircraft with its metallic parts and surfaces creates secondary magnetic fields while the aircraft moves through the earth's magnetic field. Therefore the compensation calibration test is flown to calculate the effects of the aircraft and its control surfaces on the magnetic field. The test is flown at high altitude, outside the effect of geology on the magnetic readings. The aircraft flies in each of the survey directions performing a series of manoeuvres that moves the aircraft along each of its three axis of rotation. The aircrafts affect on the magnetic data is calculated and then subtracted from the magnetic data collected during the survey.

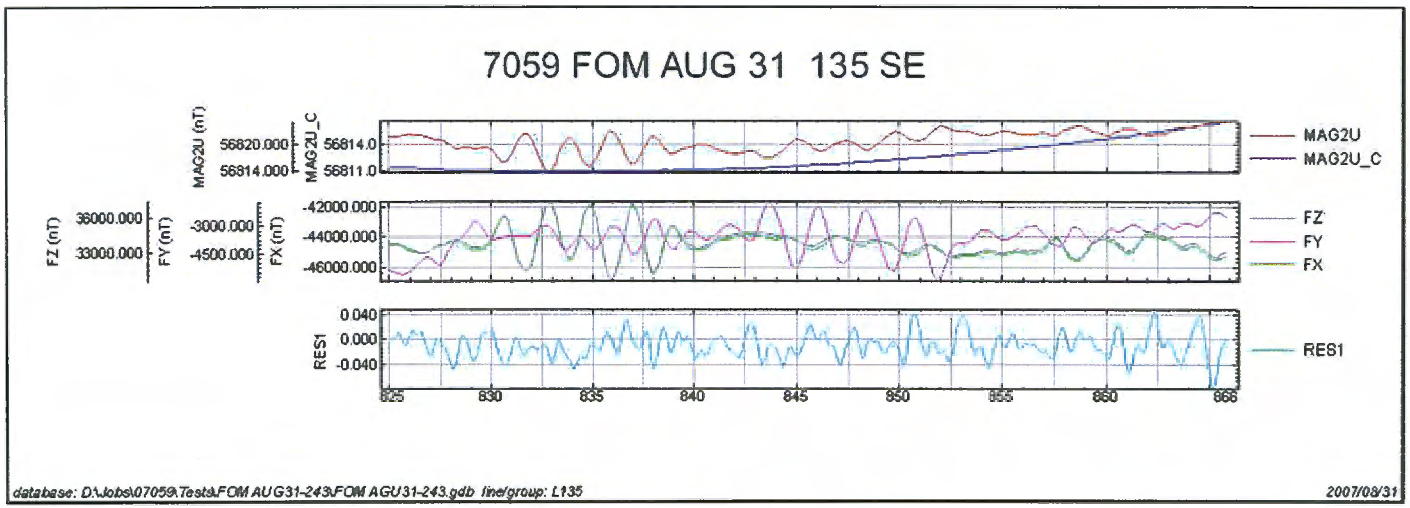
MAGNETIC COMPENSATION CALIBRATION

Job Number:	07059	**Geosoft Database:**	FOM AUG31-243.gdb
Date Flown:	31-Aug-07	**Helicopter Registration:**	C-FDYS
Flight Number:	70/71	**System Type:**	

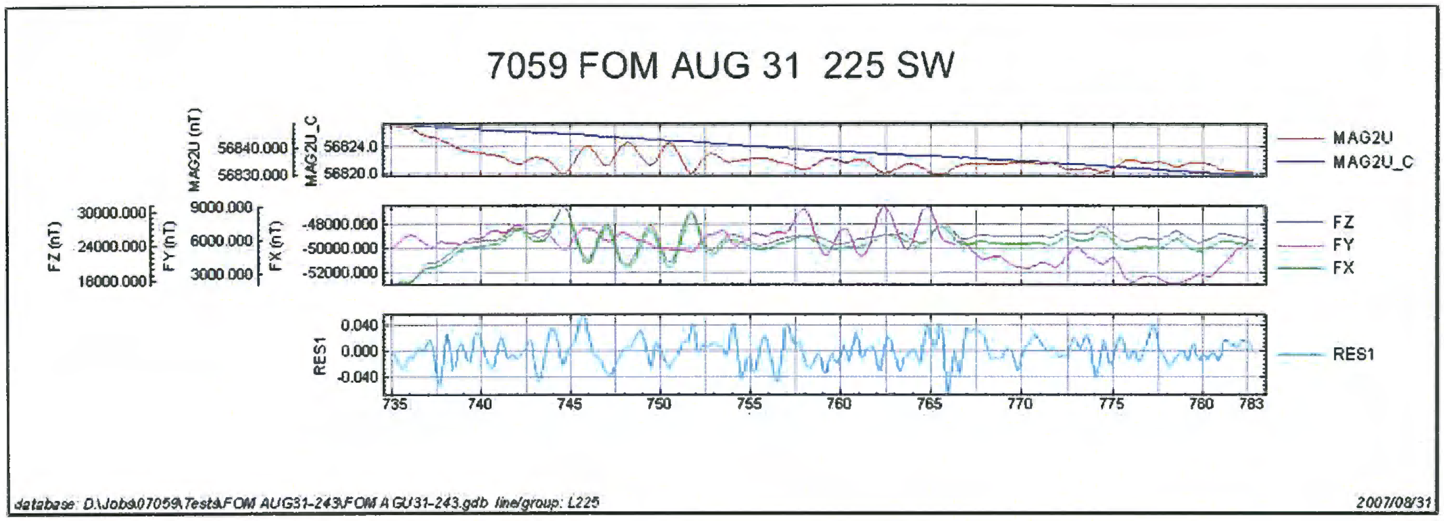
BOX 1	Sensor Position:		-	Pitch			Roll			Yaw			Figure of Merit
	Raw Mag Channel:		MAG2_U	Residual Peak to Peak			Residual Peak to Peak			Residual Peak to Peak			
	Line Number	Bearing	Ave GPS Height	min	MAX	Total	min	MAX	Total	min	MAX	Total	
Direction 1:	S1	045		-0.03	0.042	0.072	-0.039	0.027	0.066	-0.021	0.032	0.053	0.909
Direction 2:	S1	135		-0.046	0.029	0.075	-0.04	0.04	0.08	-0.053	0.045	0.098	
Direction 3:	S1	225		-0.037	0.055	0.092	-0.034	0.027	0.061	-0.041	0.041	0.082	
Direction 4:	S1	315		-0.038	0.037	0.075	-0.035	0.043	0.078	-0.034	0.043	0.077	

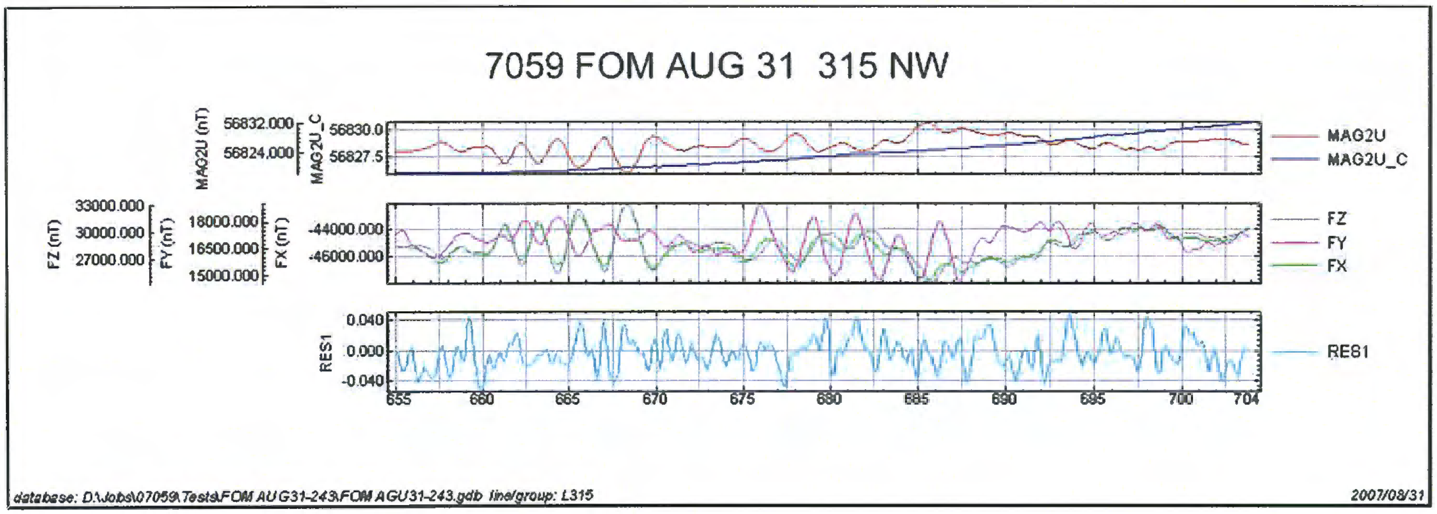
- Appendix D.10





- Appendix D.11





COSMIC / AIRCRAFT BACKGROUND TEST

A cosmic test is conducted to determine both the effects of cosmic radiation and aircraft background radiation on the spectrometer readings. This test is conducted at high altitude, outside the geological effect on the spectrometer data and well above the maximum altitude that will be achieved during survey. The aircraft is flown at a series of altitudes for a set amount of time to minimize statistical error. The effects of altitude on the level of cosmic radiation are calculated and this data is extrapolated to and corrected for in the data collected during the survey.

COSMIC CORRECTION COEFFICENTS

Job Number:	07059	Heli Registration:	C-FDYS	Spec Pack(s) Serial Number:	2516
Date Flown:	21-AUG-2007	GDB Name:	Cosmic-aug21-233.gdb	Spec Console Type:	-GR820
Flight Number:	1034	Crystal Pack Volume:	- One Crystal Pack 16.8 L Down, 4.2 L Up	Spec Console Serial Number:	8329

LINE	AVERAGE TC_DOWN_COS	Use Data Point	AVERAGE K_DOWN_COS	Use Data Point	AVERAGE U_DOWN_COS	Use Data Point	AVERAGE TH_DOWN_COS	Use Data Point	AVERAGE U_UP_COS	Use Data Point	AVERAGE COSMIC_COS
8000	170.3		11.9		7.2		8.1		2.0		199.4
8500	185.9		12.9		7.9		9.1		2.3		218.7
9000	199.8		13.7		8.5		9.9		2.4		238.3
9500	215.3		15.2		9.1		10.7		2.6		255.9
10000	231.9		15.7		10.2		11.6		2.8		279.0

Summary of Cosmic Correction Coefficents

	Cosmic Stripping (Slope)	Aircraft Background (Intercept)
TC	0.776	15.729
K	0.050	1.843
U	0.037	0.0
Th	0.044	0.0
U Up	0.009	0.0

ALTITUDE ATTENUATION TEST

An altitude attenuation test is conducted to determine the drop off rate of the spectrometer signal with altitude. A test line is flown at several different altitudes and the attenuation, with increased ground clearance, of the various spectral elements is determined. These attenuation factors are applied to the data collected throughout the survey.

ALTITUDE ATTENUATION COEFFICENTS

Job Number:	07059	Heli Registration:	C-FDYS	Spec Pack(s) Serial Number:	2516
Date Flown:	15-AUG-2007	GDB Name:	7059-ATTENUATION AUG15.GDB	Spec Console Type:	GR820
Flight Number:	1013	Crystal Pack Volume:	One Crystal Pack 16.8 L Down, 4.2 L Up	Spec Console Serial Number:	8329

LINE	AVERAGE TC_DOWN_ ATTENCOR	Use Data Point	AVERAGE K_DOWN_ ATTENCOR	Use Data Point	AVERAGE U_DOWN_ ATTENCOR	Use Data Point	AVERAGE TH_DOWN_ ATTENCOR	Use Data Point	AVERAGE EFFECTIVE HEIGHT
100	1028.8		137.6		11.1		25.9		29.5
200	863.9		104.1		11.3		21.6		56.2
300	695.3		74.1		9.7		17.8		83.9
400	572.7		58.6		8.3		14.1		109.5
500	509.1		47.6		8.1		13.4		137.7

Summary of Altitude Attenuation Coefficents (Must Be Negative)	
TC	-0.00670
K	-0.00998
U	-0.00571
Th	-0.00740

TEST LINE STATISTICS

DATE	LINE NUMBER	AVERAGE ALTITUDE			VALUE OF CHANNEL AVERAGED ALONG THE TEST LINE						
		ALTRADM	ALTLASM	EFFECTIVE HEIGHT	TC_COR	K_COR	U_COR	Th_COR	U_UP_COR	MAG_LD	Th % dev
14-Aug-07	12007	51.31	71.67	48.027	771.98	75.69	9.67	23.67	1.75	56335.22	-1.78
14-Aug-07	12010	60.46	77.04	56.33	752.49	74.51	9.57	22.76	1.73	56393.17	-5.56
15-Aug-07	12014	52.44	0	47.87	775.84	75.7	9.83	23.11	1.9	56339.76	-4.11
15-Aug-07	12017	63.14	57.49	52.56	782.26	77.91	10.22	23.48	2.08	56335.22	-2.57
19-Aug-07	12023	57.84	53.48	51	766.77	76.84	9.56	23.42	1.79	56338.24	-2.82
19-Aug-07											
20-Aug-07	12029	66.19	74.05	63.35	741.71	73.88	9.01	22.54	1.54	56339.48	-6.47
20-Aug-07	12030	59.28	71.51	56.65	733.13	71.45	9.53	22.04	1.89	56339.65	-8.55
22-Aug-07	12037	56.92	62.99	53.69	774.67	75.85	10.67	22.85	2.27	56333.31	-5.19
22-Aug-07	12040	51.96	72.68	48.29	769.46	77.35	9.89	22.81	1.78	56300.55	-5.35
23-Aug-07	12043	54.54	60.62	50.27	781.92	76.49	10.7	23.50	2.18	56333.89	-2.49
23-Aug-07	12046	47.35	36.27	43.2	790.83	78.66	10.53	23.30	1.9	56334.25	-3.32
24-Aug-07	12049	48.28	49.53	44.33	810.21	79.74	10.85	23.87	2.14	56335.36	-0.95
24-Aug-07	12051	48.71	50.86	44.78	855.05	80.94	14.13	24.10	2.84	56329.91	0.00
27-Aug-07	12054	53.09	55.43	50.58	757.36	75.48	10.1	22.90	1.83	56330.98	-4.98
27-Aug-07	12060	50	57.83	46.24	793.46	79.2	10.91	23.53	2.02	56325.32	-2.37
29-Aug-07	1065	49.86	59.71	46.77	751.39	75.3	9.81	22.71	1.76	56338.05	-5.77
29-Aug-07	1067	48.93	65.46	45.8	794.4	79.53	10.27	24.19	2	56333.96	0.37
03-Sep-07	1076	48.22	50.65	45.39	806.06	80.34	10.82	24.14	2.18	56327.41	0.17
03-Sep-07	1080	48.02	49.59	44.9	802.44	80.17	10.59	24.01	1.91	56337.11	-0.37
04-Sep-07	1083	48.88	49.24	46.9	760.41	76.95	9.57	23.15	1.73	56333.62	-3.94
04-Sep-07											
07-Sep-07	1090	49.99	58.48	48.3	754.16	76.12	9.63	23.07	1.84	56336.51	-4.27
07-Sep-07	1092	48.53	71.91	46.86	772.64	77.37	10.37	22.67	1.92	56331.9	-5.93

SOURCE CHECK STATISTICS C-FDYS

Check #	Date	AM / PM	U Cnts	U Ave	U % Dev	Th Cnts	Th Ave	Th % Dev	Cs Peak	Cs Res
1	14-Aug-07	AM	2374	-	#VALUE!	4291	-	-	0.0	0.0%
2	14-Aug-07	PM	2038	2206	-7.62	4044	4168	-2.96	0.0	0.0%
3	15-Aug-07	AM	2189	2200	-0.52	4317	4217	2.36	0.0	0.0%
4	15-Aug-07	PM	1931	2133	-9.47	3949	4150	-4.85	0.0	0.0%
5	19-Aug-07	AM	1982	2103	-5.74	4077	4136	-1.42	54.7	8.6%
6	19-Aug-07	PM	1989	2084	-4.55	4100	4130	-0.72	0.0	0.0%
7	20-Aug-07	AM	2051	2079	-1.35	4006	4112	-2.58	54.7	8.6%
8	20-Aug-07	PM	2018	2072	-2.58	3994	4097	-2.52	0.0	0.0%
9	23-Aug-07	AM	1973	2061	-4.25	3864	4071	-5.09	54.8	8.9%
10	23-Aug-07	PM	2037	2058	-1.03	3777	4042	-6.55	0.0	0.0%
11	24-Aug-07	AM	1959	2049	-4.40	4032	4041	-0.22	54.9	8.7%
12	24-Aug-07	PM	2092	2053	1.91	3988	4037	-1.20	0.0	0.0%
13	27-Aug-07	AM	2096	2056	1.94	4125	4043	2.02	54.6	8.6%
14	27-Aug-07	PM	2024	2054	-1.45	4244	4058	4.59	54.9	8.7%
15	29-Aug-07	AM	2165	2061	5.04	4215	4068	3.61	54.7	8.6%
16	29-Aug-07	PM	2047	2060	-0.65	4121	4072	1.22	54.7	8.6%
17	3-Sep-07	AM	2002	2057	-2.67	4044	4070	-0.64	54.6	8.9%
18	3-Sep-07	PM	1970	2052	-4.00	3944	4063	-2.93	54.9	8.8%
19	4-Sep-07	AM	2045	2052	-0.33	4080	4064	0.40	54.8	8.6%
20	4-Sep-07	PM	2037	2051	-0.68	4199	4071	3.16	54.8	8.7%

RESULTS OF PEAK ANALYSIS FOR CAGE_A DATASET

InputSpectrum = GR820_DOWN
PEAK CENTROID POSITION AND RESOLUTION

Line/Flt	CentroidK	ResK	CentroidU	ResU	CentroidTh	ResTh
L10010:1008	121.942	6.270	149.528	4.968	217.916	5.260
L10020:1008	121.933	6.299	148.395	5.236	217.872	5.232
L10030:1008	121.859	6.445	148.231	5.454	217.815	5.128
L10040:1008	122.099	6.433	148.461	5.479	217.925	5.120
L10050:1008	122.190	6.429	148.216	5.615	218.473	4.997
L10060:1008	122.295	6.285	148.358	5.215	218.834	4.616
L10070:1008	122.145	6.498	148.769	4.748	218.192	5.084
L10080:1008	122.148	6.510	148.468	5.140	218.341	5.008
L10090:1008	122.178	6.456	148.232	5.329	218.168	5.208
L10100:1008	122.247	6.370	148.621	5.018	218.425	5.147
L10110:1008	122.391	6.458	148.535	5.069	218.371	5.011
L10120:1008	122.354	6.308	148.337	5.315	218.694	5.357
L10130:1008	122.420	6.379	148.165	5.525	218.704	5.161
L10140:1008	122.366	6.623	148.325	5.348	218.710	5.183
L10150:1008	122.227	6.217	148.133	5.594	218.318	5.073
L10160:1008	122.423	6.305	148.359	5.369	218.706	4.975
L10170:1008	122.268	6.405	148.600	5.182	218.392	5.177
L10180:1008	122.329	6.247	149.252	4.779	218.380	5.039
L10190:1008	122.281	6.328	148.384	5.279	218.434	5.088
L10200:1008	122.207	6.297	148.297	5.380	218.416	4.972
L10210:1008	122.256	6.334	148.358	5.374	218.319	5.219
L10220:1008	122.304	6.316	148.266	5.401	218.404	5.094
L10230:1008	122.188	6.445	148.115	5.501	218.255	4.990
L10240:1008	122.148	6.434	149.489	4.977	218.422	5.265
L10250:1008	121.966	6.449	148.206	5.532	218.064	5.201
L10260:1008	122.179	6.462	148.134	5.481	218.093	4.840
L10270:1008	122.186	6.356	148.632	4.977	218.228	5.188
L10280:1008	122.233	6.476	148.175	5.439	218.032	5.120
L10290:1008	122.042	6.454	148.299	5.491	217.941	5.337
L10300:1008	122.243	6.355	148.536	5.046	218.490	5.110

L10310:1008	122.356	6.374	148.899	4.759	218.654	5.324
L10320:1008	122.430	6.242	148.308	5.507	218.580	4.986
L10330:1008	122.343	6.363	148.146	5.465	218.501	4.949
L10340:1008	122.448	6.289	148.207	5.477	218.420	5.333
L10350:1008	122.213	6.471	148.334	5.383	218.492	5.110
L10360:1008	122.393	6.348	148.573	4.709	218.113	5.212
L10370:1008	122.194	6.318	148.281	5.329	218.374	5.141
L10380:1008	122.424	6.193	148.247	5.394	218.268	5.132
L10390:1009	121.536	6.410	148.143	5.398	217.560	5.071
L10400:1009	121.781	6.381	148.304	5.329	217.810	5.032
L10410:1009	122.102	6.389	148.794	5.421	218.194	5.252
L10420:1009	122.196	6.392	148.344	5.525	218.444	5.070
L10430:1009	122.175	6.401	148.231	5.422	218.318	5.117
L10440:1009	122.337	6.277	148.325	5.402	218.437	5.226
L10450:1009	122.300	6.577	148.173	5.557	218.338	5.091
L10460:1009	122.293	6.455	148.215	5.367	218.459	5.045
L10470:1009	122.371	6.362	148.367	5.313	218.541	5.261
L10480:1009	122.427	6.571	148.342	5.344	218.617	5.154
L10490:1009	122.303	6.328	148.357	5.330	218.463	5.083
L10500:1009	122.344	6.494	148.159	5.377	218.690	5.318
L10510:1009	122.273	6.381	147.967	5.634	218.605	5.096
L10520:1009	122.313	6.454	148.885	4.881	218.608	5.072
L10530:1009	122.234	6.437	148.382	5.263	218.306	5.030
L10540:1009	122.279	6.348	148.764	5.144	218.425	5.270
L10550:1009	122.151	6.580	148.607	5.106	218.250	5.229
L10560:1009	122.226	6.492	148.457	5.247	218.327	5.090
L10570:1009	122.252	6.479	148.249	5.381	218.307	4.924
L10580:1009	122.296	6.498	148.563	5.003	218.443	5.325
L10590:1009	122.303	6.478	148.739	4.942	218.343	5.125
L10600:1009	122.385	6.354	148.423	5.171	218.411	5.097
L10610:1009	122.433	6.306	148.710	5.132	218.594	5.104
L10620:1009	122.424	6.312	148.941	4.773	218.580	4.839
L10630:1009	122.212	6.392	148.115	5.534	218.055	5.296
L10640:1009	122.250	6.530	148.979	4.853	218.446	5.241
L10650:1009	122.443	6.272	148.875	4.764	218.650	5.122
L10660:1009	122.444	6.348	148.690	4.838	218.692	5.170

L10670:1015	121.293	6.810	148.305	5.449	216.472	5.721
L10680:1015	122.199	6.335	148.242	5.416	218.247	5.075
L10690:1015	121.996	6.495	148.128	5.498	217.962	5.064
L10700:1015	122.170	6.432	148.798	4.988	218.233	5.214
L10710:1015	122.270	6.374	148.360	5.386	218.251	5.181
L10720:1015	122.341	6.438	148.927	4.848	218.502	5.224
L10730:1015	122.381	6.452	148.972	4.921	218.615	5.286
L10740:1015	122.406	6.386	148.833	5.108	218.610	5.309
L10750:1015	122.336	6.414	148.994	5.055	218.403	5.222
L10760:1015	122.363	6.424	148.848	5.208	218.563	5.007
L10770:1015	122.329	6.319	148.260	5.470	218.268	5.262
L10780:1015	122.410	6.559	148.241	5.416	218.518	4.997
L10790:1015	122.421	6.491	149.139	4.542	218.754	5.189
L10800:1015	122.360	6.381	148.651	4.836	218.267	5.189
L10810:1015	122.268	6.459	148.333	5.345	218.226	5.029
L10820:1015	122.376	6.351	148.598	5.164	218.657	5.171
L10830:1015	122.304	6.381	148.393	4.962	218.247	5.203
L10840:1015	122.353	6.302	148.719	5.277	218.381	5.198
L10850:1015	122.126	6.467	148.194	5.407	218.303	5.295
L10860:1015	122.195	6.474	148.569	4.735	218.282	5.187
L10870:1015	122.266	6.450	148.343	5.439	218.260	5.251
L10880:1015	122.410	6.404	148.804	4.965	218.496	5.098
L10890:1015	122.374	6.365	148.210	5.475	218.455	5.304
L10900:1015	122.366	6.443	148.294	5.407	218.509	5.260
L10910:1015	122.216	6.528	148.251	5.419	218.230	5.248
L10920:1015	122.272	6.540	148.325	5.407	218.299	5.171
L10930:1016	121.903	6.557	148.242	5.494	217.694	5.231
L10940:1016	122.294	6.425	148.757	5.182	218.458	5.189
L10950:1016	122.146	6.477	148.338	5.365	218.206	5.093
L10960:1016	122.286	6.465	148.557	5.289	218.470	5.227
L10970:1016	122.331	6.367	148.437	5.300	218.445	5.239
L10980:1016	122.313	6.530	148.262	5.401	218.527	4.996
L10990:1016	122.211	6.494	148.574	5.197	218.326	5.227
L11000:1016	122.319	6.353	148.323	5.361	218.351	5.120
L11010:1024	122.349	6.380	148.854	5.254	218.963	5.160
L11020:1024	122.414	6.356	148.970	4.771	218.951	5.188

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L11030:1024	122.150	6.406	148.671	4.385	218.459	5.153
L11040:1024	122.273	6.487	148.317	5.361	218.625	5.064
L11050:1024	122.099	6.506	148.340	5.324	218.284	5.275
L11060:1024	122.161	6.498	148.099	5.327	218.295	5.192
L11070:1024	122.330	6.412	148.418	5.269	218.485	5.038
L11080:1024	122.331	6.511	148.507	4.951	218.919	5.190
L11090:1024	122.054	6.521	148.350	5.379	218.056	5.228
L11100:1024	122.183	6.422	148.310	5.330	218.260	5.002
L11110:1024	122.179	6.442	148.289	5.376	218.331	5.241
L11120:1024	122.023	6.381	148.353	5.390	218.262	5.188
L11130:1024	122.050	6.468	148.255	5.448	217.914	5.209
L11140:1024	122.221	6.434	148.887	4.702	218.590	5.189
L11150:1025	120.790	6.521	147.446	5.629	216.518	5.288
L11160:1025	121.521	6.515	148.141	5.528	217.770	5.321
L11170:1025	121.948	6.400	148.501	4.844	218.432	5.116
L11180:1025	122.096	6.451	148.506	4.962	218.561	5.112
L11190:1025	122.154	6.488	148.361	5.132	218.459	5.010
L11200:1025	121.954	6.453	148.307	5.445	218.544	5.464
L11210:1025	121.815	6.590	147.733	5.937	218.247	5.194
L11220:1025	122.009	6.451	148.359	5.497	218.163	5.208
L11230:1025	121.967	6.473	148.203	5.445	218.482	5.111
L11240:1025	122.051	6.526	148.120	5.463	218.383	5.033
L11250:1025	121.920	6.457	148.106	5.456	218.117	5.178
L11260:1025	121.894	6.419	148.252	5.323	218.315	5.386
L11270:1025	121.882	6.548	148.614	5.031	218.087	5.364
L11280:1025	121.853	6.416	148.645	5.142	218.109	4.939
L11290:1038	122.332	6.438	148.684	4.786	218.600	5.250
L11300:1038	122.440	6.382	149.180	4.521	218.566	5.290
L11310:1038	122.428	6.388	148.539	5.140	218.534	5.247
L11320:1038	122.270	6.450	148.685	5.144	218.299	5.217
L11330:1038	122.464	6.497	149.084	4.992	218.789	5.174
L11340:1038	122.331	6.437	149.017	4.879	218.341	5.213
L11350:1038	122.382	6.402	148.645	5.225	218.473	5.095
L11360:1038	122.282	6.428	148.288	5.363	218.424	5.093
L11370:1038	122.328	6.393	148.308	5.310	218.475	5.001
L11380:1039	122.431	6.467	148.659	5.329	218.543	5.068

L11390:1039	122.439	6.407	148.852	4.988	218.851	5.286
L11400:1039	122.323	6.386	149.141	4.457	218.321	5.079
L11410:1039	122.578	6.190	148.315	5.489	218.726	5.249
L11420:1039	122.486	6.311	148.377	5.399	218.755	5.200
L11430:1039	122.454	6.331	148.543	5.316	218.432	5.385
L11440:1039	122.314	6.344	148.542	5.136	218.574	5.294
L11450:1039	122.338	6.431	148.254	5.429	218.512	5.205
L11460:1039	122.296	6.485	148.963	5.265	218.517	5.194
L11470:1039	122.283	6.582	148.255	5.378	218.199	5.299
L11480:1039	122.230	6.454	148.303	5.390	218.206	5.194
L11490:1040	122.418	6.305	148.293	5.396	218.612	5.073
L11500:1040	122.511	6.364	148.747	4.927	218.770	5.264
L11510:1040	122.449	6.422	148.297	5.364	218.686	5.014
L11520:1040	122.482	6.440	148.847	5.061	218.773	4.897
L11530:1040	122.441	6.438	148.876	5.284	218.821	5.241
L11540:1040	122.357	6.413	148.469	5.411	218.573	5.179
L11550:1043	122.495	6.402	148.386	5.442	218.871	5.063
L11560:1043	122.337	6.501	148.500	5.094	218.374	5.131
L11570:1043	122.367	6.291	148.361	5.252	218.650	5.090
L11580:1043	122.310	6.543	148.294	5.423	218.353	5.237
L11590:1043	122.286	6.517	148.259	5.371	218.405	5.221
L19140:1079	122.293	6.464	148.354	5.085	218.434	4.980
L19150:1079	122.158	6.612	148.503	5.114	218.348	5.049
T19010:1029	122.216	6.270	148.319	5.404	218.693	4.812
T19020:1029	122.133	6.501	148.203	5.508	218.075	5.250
T19030:1029	122.224	6.355	148.244	5.461	218.553	5.096
T19040:1029	122.223	6.374	148.220	5.464	218.406	5.148
T19050:1029	122.284	6.236	148.338	5.398	218.500	5.091
T19060:1029	122.204	6.409	148.180	5.459	218.370	5.189
T19070:1029	122.280	6.373	148.453	5.264	218.504	5.082
T19080:1038	122.096	6.527	148.589	4.720	218.077	5.131
T19090:1038	122.463	6.212	148.704	4.877	218.804	5.153
T19100:1038	122.304	6.373	148.281	5.415	218.666	5.220
T19110:1038	122.269	6.304	148.528	5.197	218.265	5.084
T19120:1038	122.289	6.398	148.208	5.349	218.545	5.354
T19130:1038	122.376	6.485	148.520	5.514	218.640	5.137

APPENDIX E

RADIOMETRIC PROCESSING CONTROL FILE

APPENDIX E

RADIOMETRIC PROCESSING CONTROL FILE

FOR SURVEY PLATFORM : C-FDYS

```
/////////////////////////////////////////////
// Atlas Control/Workspace File
// # or // for commment
/////////////////////////////////////////////

CONTROL_BEGIN

 PROGRAM  = AGSCorrection
 VERSION  = 1.4.0

  ### Process or Calibration? ###
    WhatToDo = Process Survey Line

  ### Corrections to apply ###
    CorrectionType = Yes  Filtering
    CorrectionType = Yes  LiveTimeCorrection
    CorrectionType = Yes  CosmicAircraftBGRemove
    CorrectionType = Yes  CalcEffectiveHeight
    CorrectionType = Yes  RadonBGRemove
    CorrectionType = Yes  ComptonStripping
    CorrectionType = Yes  HeightCorrection
    CorrectionType = Yes  ConvertToConcentration


  ### Main I/O settings ###
    MainChannelIO|TC       = tc_nasvd   --> tc_rad_Cor
    MainChannelIO|K        = k_nasvd    --> k_rad_Cor
    MainChannelIO|U        = u_nasvd    --> u_rad_Cor
    MainChannelIO|Th       = th_nasvd   --> th_rad_Cor
    MainChannelIO|UpU      = U_UP       --> U_UP_Cor
    MainChannelIO|Cosmic   = COSMIC     --> COSMIC_Cor
    MainChannelIO|Spectrum =            -->

  ### Control Channel I/O settings ###
    ControlChannel|RadarAltimeter     = ALTRAD_MT_LAG  [metres]
    ControlChannel|Pressure/Barometer = KPA            [kPa]
    ControlChannel|Temperature        = TEMP_EXT


  ### Input for correction ###
```

```
   InputForCorrection    = ROIs


### Pre-filtering settings ###
   Filtering|TC     = 0
   Filtering|K      = 0
   Filtering|U      = 0
   Filtering|Th     = 0
   Filtering|UpU    = 0
   Filtering|Cosmic  = 13
   Filtering|RadarAltimeter    = 7
   Filtering|Pressure/Barometer = 7
   Filtering|Temperature       = 7

### Live-time correction settings ###
   LiveTimeChannel          = live_time
   LiveTimeUnits            = milli-seconds
   ApplyLiveTimeCorrToUpU     = Yes

### Cosmic correction settings ###
   CosmicCorrParam|TC    = 0.776,  15.729
   CosmicCorrParam|K     = 0.050,  1.8430
   CosmicCorrParam|U     = 0.037,  0.00
   CosmicCorrParam|Th    = 0.044,  0.00
   CosmicCorrParam|UpU   = 0.009,  0.00
   CosmicCorrParam|SpectrumBackgroundFile   =

### Effective-Height settings ###
   EffectiveHeightOutputChannel = EffectiveHeight
   EffectiveHeightOutputUnits   = metres

### Special Stripping (Compton Stripping) ###
   ComptonCorrParam_Stripping_Alpha     = 0.237000
   ComptonCorrParam_Stripping_Beta      = 0.384000
   ComptonCorrParam_Stripping_Gamma     = 0.713000
   ComptonCorrParam_AlphaPerMetre       = 0.000010
   ComptonCorrParam_BetaPerMetre        = 0.000010
   ComptonCorrParam_GammaPerMetre       = 0.000010
   ComptonCorrParam_GrastyBackscatter_a = 0.060000
   ComptonCorrParam_GrastyBackscatter_b = 0.003000
   ComptonCorrParam_GrastyBackscatter_g = 0.003000

### Height Correction settings ###
   SurveyHeightDatum     = 50.000000
   AttenuationCorrControl = 0
   HeightCorrParam|TC     = -0.0067, 300.000000
```

```
    HeightCorrParam|K      = -0.00998, 300.000000
    HeightCorrParam|U      = -0.00571, 300.000000
    HeightCorrParam|Th     = -0.00740, 300.000000

  ### Concentration settings ###
    ConcentrationParam|K      = Concentration_K,  49.329
    ConcentrationParam|U      = Concentration_U,  6.878
    ConcentrationParam|Th     = Concentration_Th,  2.890
    AirAbsorbedDoseRateParam  = DoseRate,  16.051
    NaturalAirAbsorbedDoseRateParam = NaturalDoseRate,  0.000000, 0.000000,
0.000000

CONTROL_END
```