GM 63660

HIGH RESOLUTION AEROMAGNETIC AND GAMMA-FAY SPECTROMETRIC SURVEY, FINAL TECHNICAL REPORT, LAC DANIEL PROJECT

High Resolution Aeromagnetic and Gamma-ray Spectrometric Survey

Lac Daniel Project
Kangusulujuak, Northern Quebec

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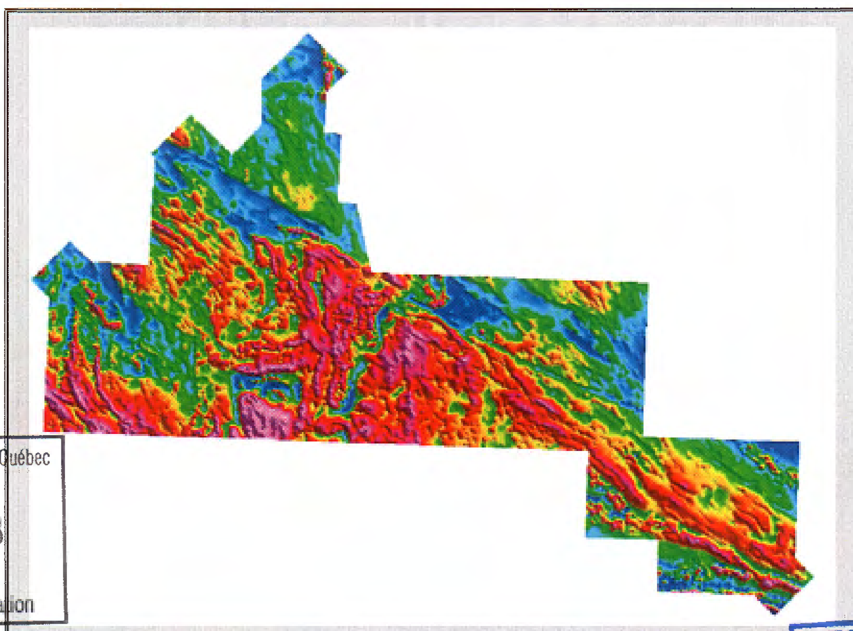
Project Ref.: P07-024 **Final Technical Report**

November 2007



NORTHWESTERN MINERAL VENTURES INC.

High Resolution Aeromagnetic and Gamma-ray Spectrometric Survey

LAC DANIEL PROJECT
Kangusulujuak, Northern Quebec

Project Ref.: P07-024

FINAL TECHNICAL REPORT

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1.0 INTRODUCTION

On August 22nd, 2007, **GEO DATA SOLUTIONS INC. (GDS)** was awarded contract P07-024 by **NORTHWESTERN MINERAL VENTURES INC. (NorthWestern)**. The contract required **GDS** to carry out a high-resolution Aeromagnetic and Airborne Gamma-ray Spectrometric (AGS) survey on 4 blocks (ABE, C, F and G) located near Kangusulujuak, Northern Quebec.

All traverse lines were oriented N45°E with a spacing of 200 metres while control-lines were oriented N135°E with a spacing of 1000 metres (table 2). The survey was flown with a helicopter nominal ground clearance of 50 metres. The blocks flown are shown on figures 1 and table 1 define their co-ordinates.

The field base of operation was located at the camp Barnoin, which is located approximately 20 km from the survey areas (figure 1). Excluding calibration and test flights, 16 flights were needed to cover the survey areas. The first production flight began on September 9th and the last flight ended on September 15th, 2007.

This report describes the survey procedures and data verification, which were carried out in the field, and the data processing, which followed at the office.

Table 1: Block Co-ordinates (WGS84, UTM zone 20N)

Block ABE

Vertex	X(m)	Y(m)
1	332996	6467481
2	333317	6474607
3	332308	6475698
4	334490	6477892
5	335682	6476706
6	338210	6476624
7	338582	6477022
8	338885	6481833
9	338444	6482274
10	340884	6484708
11	343015	6482590
12	344516	6484046
13	344497	6486077
14	344251	6486329
15	347152	6489274
16	349327	6487042
17	348098	6485743
18	347984	6484122
19	348476	6483630
20	348861	6483618
21	348735	6480540
22	349435	6479847
23	349674	6479853
24	350418	6476158
25	363818	6475647
26	364367	6476252
27	365451	6475162
28	365086	6474821
29	364846	6467267
30	373113	6466983
31	372924	6460690
32	373964	6459605
33	371726	6457430
34	370477	6458666
35	365495	6458760
36	365502	6461566
37	361611	6461674
38	361800	6465974
39	361371	6466390
40	332989	6467412
41	333002	6467481

BLOCK C

Vertex	X(m)	Y(m)
1	384848	6470089
2	383675	6471218
3	383241	6470794
4	382167	6471825
5	382503	6472140
6	382720	6481149
7	381711	6482126
8	383968	6484394
9	385043	6483320
10	388527	6483222
11	388874	6483602
12	389558	6482983
13	389189	6482581
14	390253	6481442
15	388060	6479228
16	386834	6480432
17	386215	6480226
18	386096	6473269
19	387007	6472260
20	384848	6470089

Block G

Vertex	X(m)	Y(m)
1	323665	6491083
2	323304	6490732
3	322214	6491832
4	322741	6492359
5	322842	6495696
6	326605	6499459
7	327724	6499394
8	328352	6500005
9	329203	6499256
10	329360	6499376
11	329693	6499099
12	329517	6498877
13	330137	6498248
14	329536	6497536
15	329480	6496094
16	327946	6494494
17	327844	6491943
18	327104	6491277
19	325264	6491249
20	325255	6491000
21	323647	6491074

Block F

Vertex	X(m)	Y(m)
1	327271	6475577
2	326517	6476324
3	327054	6476834
4	327074	6480012
5	326925	6480161
6	327536	6480732
7	327387	6481126
8	328005	6481785
9	327183	6484114
10	326952	6484427
11	329214	6486675
12	330484	6485425
13	330280	6481139
14	331129	6480291
15	330667	6479829
16	330613	6477975
17	331747	6476868
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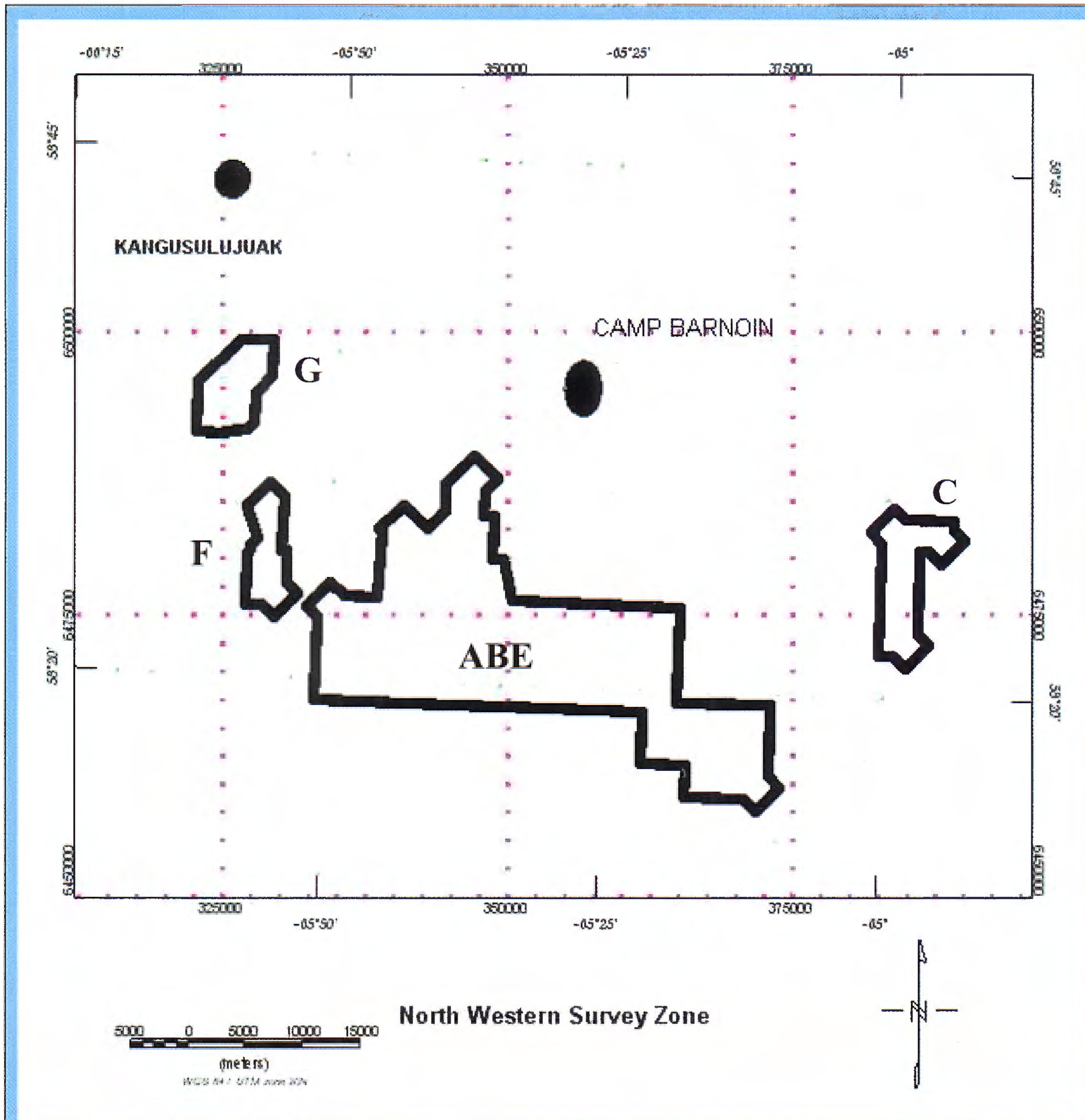

Figure 1: Survey Location

2.0 SURVEY SPECIFICATIONS

Blocks flown are located to the South and South-East of Kangusulujuak, northern Quebec.

The airborne survey and noise specifications for the Lac Daniel survey are as follows:

a) traverse line spacing and direction
- flight line spacing is 200 m
- flight line direction is: N45°E

b) control line spacing and direction
- control line spacing is 1,000 m
- control line direction is N135°E

c) Number of line-km flown (table 2)
- Block ABE: 2,855 km
- Block C: 336 km
- Block F: 208 km
- Block G: 248 km

d) terrain clearance

• helicopter mean terrain clearances are:	Block ABE:	48.0 m.
	Block C:	66.3 m.
	Block F:	48.3 m.
	Block G:	49.4 m.
• magnetometer mean terrain clearances are:	Block ABE:	32.5 m.
	Block C:	50.8 m.
	Block F:	32.8 m.
	Block G:	33.9 m.
• spectrometer mean terrain clearance are:	Block ABE:	48.0 m.
	Block C:	66.3 m.
	Block F:	48.3 m.
	Block G:	49.4 m.

e) magnetic diurnal variation
- A maximum tolerance of 5.0 nT (peak to peak) deviation from a long chord equivalent to a period of one minute for the magnetometer base station

f) magnetometer noise envelope
- in-flight noise envelope could not exceed 0.5 nT, for straight and level flight
- base station noise envelope could not exceed 0.1 nT

g) Re-flights and turns
- all reflights of flight line segments intersected at least two control lines

h) Soil moisture
- no gamma-ray spectrometric survey was flown during or for 3 hours after measurable precipitation
- in the event of heavy precipitation yielding more than 2 cm of ground soaking rain, flying should be suspended for at least 12 hours after end of precipitation or until soil returns to its "normal" moisture level

Table 2: Required Survey Specifications

Block	Traverse Direction	Control Line Direction	Traverse Spacing (m)	Control Line Spacing (m)	Line-Km
ABE	N45°E	N135°E	200	1000	2,855
C	N45°E	N135°E	200	1000	336
F	N45°E	N135°E	200	1000	208
G	N45°E	N135°E	200	1000	248
				Total line-km	**3,647**

3.0 AIRCRAFT, EQUIPMENT AND PERSONNEL

3.1 Aircraft and Geophysical On-Board Equipment

Aircraft: Bell 206B helicopter (figure 2)
Mean Survey Speed: 40 m/sec
Nominal Ground Clearance: 50 metres

Magnetometer: Geometrics cesium vapour sensor, bird installation, sensitivity of 0.001 nT, sampling rate of 0.1 sec., ambient range 20,000 to 100,000 nT. The general noise level was kept below 0.01 nT. Nominal sensor height of 35 metres above ground.

Gamma-ray Spectrometric System: Radiation Solutions RSX-5
Downward-looking crystal: 16 litres
Upward-looking crystal: 4 litres
Self-calibrating and automatic gain control which eliminates the use of radioactive sources in the field
Recording at a rate of 1 Hz, the:
- total, potassium, uranium and thorium counts
- entire 256 channel spectra

Digital Acquisition System: RMS Data Acquisition System

Radar Altimeter: TRA-3000, accuracy 5%, sensitivity one foot, range 0 to 2,500 feet, 1 sec. recording interval

Electronic Navigation: Real-Time Differentially Corrected Omnistar System, 0.2 sec. recording interval, accuracy of ±5 metres.

Figure 2: The Bell 206B

3.2 Ground Equipment

Magnetometer: One GEM GSM-19 Overhauser magnetometer base station was mounted in a magnetically quiet area. The base station measured the total intensity of the earth's magnetic field in units of 0.01 nT at intervals of 1 second, within a noise envelope of 0.10 nT. The base station was located near the base of operation at the following coordinates:

Latitude: -65° 27' 27.93"
Longitude: 58° 33' 21.02"

Ancillary Equipment: Computer workstation, complement of spare parts and test equipment

3.3 Personnel

The general management of the project was monitored offsite by Mr. Mouhamed Moussaoui, **GDS**'s President. Mr. Saleh Elmoussaoui was responsible for the field data processing to ensure that the work was carried out according to contractual specifications. The final data evaluation and processing was carried out at the Laval **GDS** office by Mr. Elmoussaoui and Mr. François Caty.

Survey crew and office personnel are listed in table 3.

Table 3: Field and Office Crew	
Position	**Name**
Project Manager	Mr. Mouhamed Moussaoui, P.Eng.
Field Geophysicist & data quality control	Mr. Saleh Elmoussaoui
Field Operator	Mr. Pierre Filion
Pilot	Mr. Christophe Zaragoza
Office Data Verification & Final Processing	Mr. Saleh el Moussaoui Mr. François Caty
Survey Report	Mr. Camille St-Hilaire, P.Geo

4.0 SURVEY SCHEDULE

The survey was made of four blocks with flight line bearing selected to run perpendicular to the average trend of the local geological structures. The base of operation was set up at the camp Barnoin, which is located approximately 20 km North of the survey blocks.

Mobilization to the camp started on September 7th, 2007. The survey was carried out from September 9th to September 15th, 2007. Areas are covered by a total of 3,647 line-kilometres. Preliminary results were sent to **NorthWestern** on September 17th, 2007. After acceptation by the client of the preliminaries, demobilization occurred on September 17th, 2007. Final maps and data were sent to **NorthWestern** in mid November 2007.

5.0 DATA ACQUISITION

The following tests and calibrations were performed prior to the commencement and during the survey flying:

- Magnetometer lag test
- Altimeter calibration
- AGS calibrations for:
    - Compton stripping coefficients;
    - aircraft and cosmic backgrounds;
    - height attenuation coefficient;
    - radioelement sensitivities;
    - radon removal parameters.

These calibrations and tests were flown either near the Breckenridge test site or over the survey site, as part of the start-up and monitoring procedures. Details of each test and their results are given in Appendix A.

Periodic AGS tests were performed as follow:

- test line (daily pre- and post flight)
- background-over-water

After each day, profiles were examined as a preliminary assessment of the noise level of the recorded data. Altimeter deviations from the prescribed flying altitudes were also closely examined as well as the magnetic diurnal activity, as recorded on the base station.

All digital data were verified for validity and continuity. The data from the helicopter and base station were transferred to the PC's hard disk. Basic statistics were generated for each parameter recorded. These included the minimum, maximum and mean values, the standard deviation and any null values located. Editing of all recorded parameters for spikes or datum shifts was done, followed by final data verification via an interactive graphic screen with on-screen editing and interpolation routines.

The quality of the GPS navigation was controlled on a daily basis by recovering the flight path of the helicopter.

Checking all data for adherence to specifications was carried out in the field by **GDS**'s field geophysicist.

6.0 DATA COMPILATION AND PROCESSING

6.1 Base maps

Base maps of the survey area were plotted from topographic maps of the Department of Natural Resources Canada at a scale of 1:50 000.

Projection description

Datum:	WGS84
Projection:	Universal Transverse Mercador (UTM Zone 20N)
Central Meridian:	63° West
False Easting:	500 000
False Northing:	0
Scale Factor:	0.9996

6.2 Processing of Base Station data

The recorded magnetic diurnal data from the magnetometer base station were reformatted and loaded into the OASIS database. After initial verification of the integrity of the data from statistical analysis, the appropriate portion of the data was selected to correspond to the exact start and end time of the flight. The data were then checked and corrected for spikes using a fourth difference editing routine. Following this, interactive editing of the data was done, via a graphic editing tool, to remove events caused by man-made disturbances. A small low pass noise filter (9 seconds) was then applied. The final processing step consisted of subtracting result from the airborne magnetic data as a pre-levelling step. The average of the Total Field Magnetic Intensity measured at the Base Station was 56,641.7 nT for blocks C, F and G, and 56 646.3 for the block ABE.

6.3 Processing of the Positioning Data (GPS)

The raw GPS data were recovered and corrected from spikes. The resulting corrected latitudes and longitudes were then converted to the local map projection and datum (WGS84). A point-to-point speed calculation was then done from the final X, Y coordinates and reviewed as part of the quality control. The flight data were then cut back to the proper survey line limits and a preliminary plot of the flight path was done and compared to the planned flight path to verify the navigation. The positioning data were then exported to the other processing files.

6.4 Processing of the Altimeter data

The altimeter data, which includes the radar altimeter and the GPS elevation values were checked and corrected for spikes using a fourth difference editing routine. A small low pass filter of 2 seconds was then applied to the data. Following this, a digital terrain trace was computed by subtracting the radar altimeter values from the corrected GPS elevation values. All resulting parameters were then checked, in profile form, for integrity and consistency, using a graphic viewing editor.

6.5 Processing of Magnetic data

The airborne magnetic data were reformatted and loaded into the OASIS database. After initial verification of the data by statistical analysis, the values were adjusted for system lag. The data were then checked and corrected for any spikes using a fourth difference editing routine and inspected on the screen using a graphic profile display. Interactive editing, if necessary, was done at this stage. Following this, the long wavelength component of the diurnal was subtracted from the data as a pre-levelling step. A preliminary grid of the values was then created and verified for obvious problems, such as errors in positioning or bad diurnal. Appropriate corrections were then applied to the data, as required.

Following this, the final levelling process was undertaken. This consisted of calculating the positions of the control points (intersections of lines and tie lines), calculating the magnetic differences at the control points and applying a series of levelling corrections to reduce the misclosures to zero. A new grid of the values was then created and checked for residual errors. Any gross errors detected were corrected in the profile database and the levelling process repeated. Finally, a micro levelling routine was applied to the magnetic data.

6.6 Total Magnetic field and First Vertical Derivative Grids

The reprocessed total field magnetic grid was calculated from the final reprocessed profiles by a minimum curvature algorithm (Briggs, 1974). The accuracy standard for gridding was that the grid values fit the profile data to within 0.01 nT for 99.99% of the profile data points.

Minimum curvature gridding provides the smoothest possible grid surface that also honours the profile line data. However, sometimes this can cause narrow linear anomalies cutting across flight lines to appear as a series of isolated spots.

The first vertical derivative of the residual total magnetic field was computed to enhance small and weak near-surface anomalies and as an aid to delineate the geologic contacts having contrasting susceptibilities. The calculation was done in the frequency domain, using Geosoft FFT algorithms.

7.0 AGS DATA PROCESSING

The Airborne Gamma-ray Spectrometric data was subjected to primary quality control, complete data reduction, gridding and imaging in the field during the data acquisition phase. The final processing procedure starts by analysing the raw, 256-channel spectra to reduce statistical noise using a spectral component analysis technique (NASVD).

Subsequent processing consists of:

- refining the various parameters used for ROI (region-of-interest) data reduction;
- reducing the whole dataset with increased attention to detail;
- statistical and image evaluation of the reduced data;
- adjustment to the data reduction as necessary;
- applying micro-levelling to the gridded data and transferring adjustments to profile data;
- preparing the required products.

7.1 Data Processing Overview

GDS utilizes an ***improved*** methodology for AGS data reduction based on the standard techniques outlined in the following references:

- IAEA-Tecdoc-1363, *Guidelines for radioelement mapping using gamma ray spectrometric data*;
- AGSO Record 1995/60, *A Guide to the Technical Specifications for Airborne Gamma-Ray Surveys.*
- IAEA-TECDOC-1363, "Guidelines for radioelement mapping using gamma ray spectrometry data" (July 2003).

The parameters used for this processing were based on those determined during the calibration and testing phase of the survey (see Appendix A) and on subsequent analysis of the whole AGS data set including background-over-water measurements. The primary AGS data consists of the 256 channel spectra collected at 1 Hz for both the downward-looking (16 litres) and upward-looking (4 litres) crystal packs. The major data reduction stages are:

- NASVD analysis of the 256 channel AGS spectra
- Appropriate filtering of auxiliary data (ground clearance, temperature, pressure and cosmic)
- Calculation of effective height (at STP = "Hstp")
- Background removal (aircraft, cosmic and atmospheric radon)
- Compton stripping (spectral unfolding)
- Adjustment for height attenuation
- Conversion to radioelement ground concentrations (TC, K U, TH)
- Gridding and evaluation
- Calculation of derivative products

Each of the radioelement results: total count (TC); potassium (K); uranium (U); and thorium (TH) were evaluated using statistical and image analysis techniques.

7.2 NASVD Statistical Noise Reduction

GDS's personnel have extensive experience with the application of Noise Adjusted Singular Value Decomposition (NASVD), which was initially developed by Hovgaard and Grasty (1997), and evaluated in depth by Minty (2003). NASVD was applied to both the downward and upward 256-channel spectra in order to reduce statistical noise. A formulation of the method modelled on that of Minty was used.

The noise–reduced spectra were used to extract new TC, K, U and TH and UPU (upward-looking uranium) ROI count rates, which then have less noise than the original raw ROI. For the uranium measurement, in particular, it is possible to achieve a significant reduction in statistical noise.

NASVD analysis results in a more precise measure of the radioelement ground concentrations, which improves the discrimination between different geologic units with similar concentration values. However, no significant improvement occurs for the total count measurement since it already incorporates a major part of the gamma-ray spectrum. The improved maps or images can reveal patterns and shapes previously hidden or barely discernible in the noise.

7.3 Filtering

All primary data was edited in the field to eliminate rare instances of spikes, noise or corrupted data points. During data reduction, appropriate filtering was applied to selected AGS fields in order to match measurement parameters to the primary gamma-ray data and/or improve accuracy.

7.4 Ground Clearance

Aircraft ground clearance was well maintained during this survey. AGS data is quite sensitive to height of the spectrometer above ground. The effective height at STP (Hstp) is used in data reduction. Note that the mean ground clearance (52.9 m.) is quite close to the planned survey height of 50 m. (figure 3). The ground clearance values were well within the accepted limits for statistically meaningful AGS data (detector volume 16 litres). Accordingly, it was not necessary to reject any AGS data points due to extreme height.

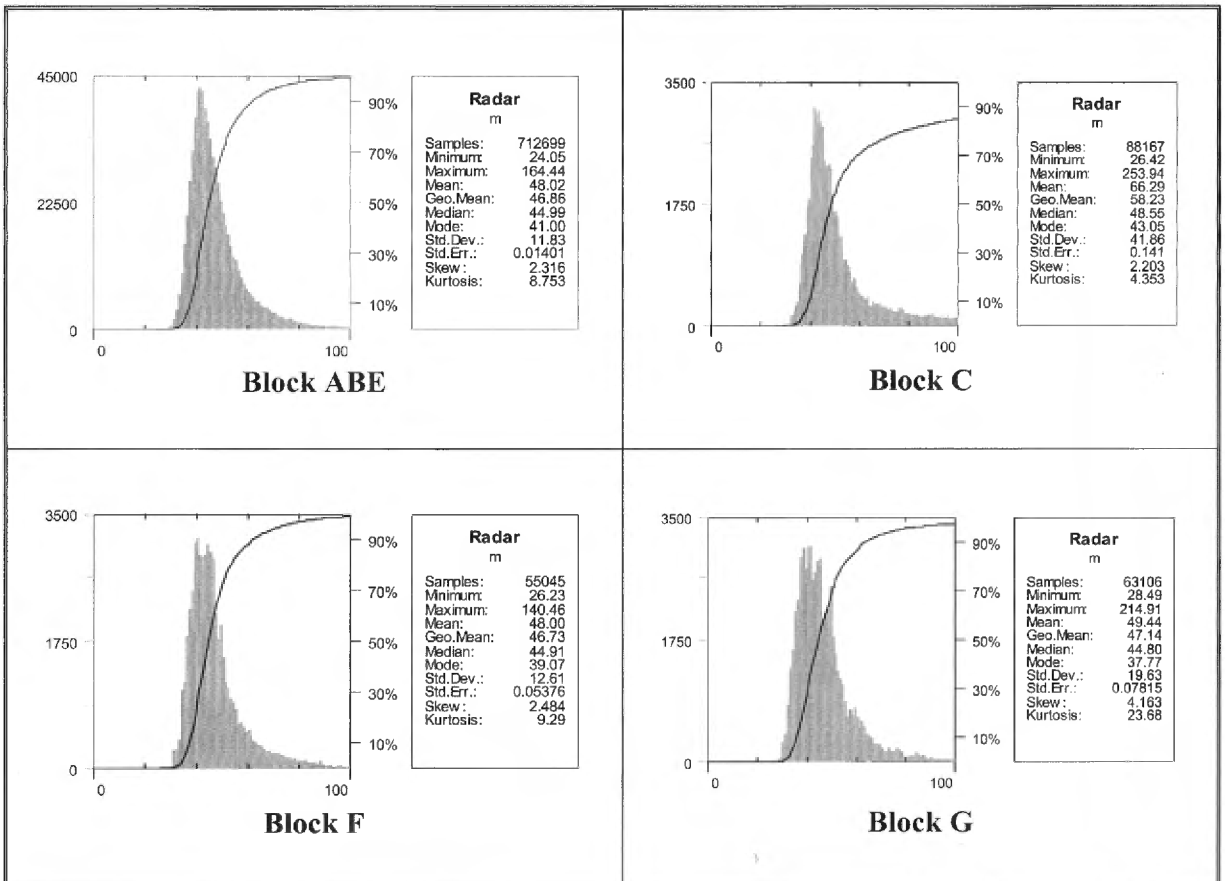

Figure 3: Helicopter and Spectrometer Ground Clearances

7.5 Atmospheric Radon Background Removal

The upward-looking detector method was used to remove the effects of atmospheric radon from the downward spectrometer count rates. The determination of the coefficients to be applied in this process, are described in Appendix A. The upward-looking spectrometer measures count rates in a "uranium" ROI. The statistics of these counts are improved by NASVD analysis.

The atmospheric radon levels during this survey, fell within the expected range of concentrations.

In order to determine the AGS system response to atmospheric radon, a series of data were collected at survey height over the larger lakes in the survey area. All measurement points were at least 500m from shore, which results in negligible gamma contribution from the land. The background-over-water measurements (BOW) were made under a range of times-of-day and weather conditions in order to encounter a range of atmospheric radon concentrations. The resulting data are analyzed to obtain:

(a) Radon response coefficients for use with the upward-looking radon-removal technique;
(b) An improved estimate of the aircraft background.

7.6 Gridding

Total Count, uranium, thorium and potassium contributions were gridded using a minimum curvature algorithm (*Oasis Montaj*) with controls optimized for AGS data. A grid cell size of 50 metres was used. Tie lines were not included in the gridding process. The grids were evaluated at all stages using image analysis techniques.

7.7 Micro-Levelling

Complex airborne datasets acquired on parallel lines often exhibit subtle artefacts in the line direction. In the case of AGS data these are mostly due to limitations in the radon removal technique. The upward-looking detector method is generally quite effective but the necessity to use long filters results in loss of sensitivity to shorter wavelength variations. Non-uniform atmospheric radon distribution will also produce errors. These can result in small line-to-line lineations in the gridded data.

Micro levelling is used to filter the primary gridded data in order to reduce or remove long-wavelength noise along survey lines, caused by non-geological effects. For this survey, GDS used a proprietary micro levelling technique. It uses modified median filters that are designed to match the statistical nature of AGS data. Along-line and cross-line directional filters plus clean-up filters are used to isolate and remove this sort of noise from the gridded images. Naudy-type thresholds are used to limit the amplitude of change at any data point.

Once the micro levelling process was applied, colour-shaded images were studied to verify that the residual line noise has been minimised, and that new line noise has not been introduced. The micro level correction grid was reviewed to confirm that no significant geological signal had been removed.

The final stage was to sample the correction grid and apply these corrections to the radioelement profile data.

8.0 FINAL PRODUCTS

8.1 Maps:

One paper copy of the following final maps were delivered to **NorthWestern**:

(a) Potassium Percent (colour interval)
(b) equivalent Uranium parts per million (colour interval)
(c) equivalent Thorium parts per million (colour interval)
(e) Total Count (colour interval)
(f) Shaded Magnetic Total Field (colour interval)
(g) Shaded Magnetic First Vertical Derivative (colour interval)

All final map products were delivered at a scale of 1:20 000. **GDS** provided also the PDF formats of the maps.

8.2 Final digital archive of line data:

Three copies of geophysical, positional and environmental data were delivered in Geosoft compatible format on DVD with gamma-ray spectrometric data reproduced at 1 second intervals. Magnetometer and positional data were reproduced at 0.1-second intervals. Appendix B describes the archive content.

8.3 Miscellaneous

Three paper copies of this technical report, with the corresponding digital PDF file, have been produced and delivered to **NorthWestern**.

9.0 CONCLUSION

Flown between September 9th and September 15th, 2007, the Lac Daniel survey was completed inside the estimated time frame.

All airborne and ground-based records were of excellent quality.

Data acquisition was done in good diurnal conditions. It was found that even though diurnal was within specifications, diurnal subtraction was not good enough to level the data and, in fact, good intersections were required to produce a reliable final data set.

The noise level for the measured Total Magnetic Field was well within the accepted limits, determined from the fourth difference of the lagged, edited airborne magnetic data.

GPS results proved to be of high quality. The flight path was surveyed accurately and the speed checks showed no abnormal jumps in the data. The helicopter was able to remain within the ±20 metre elevation differences at the traverse/control line intersections.

It is hoped that the information presented in this report, and on the accompanying products, will be useful both in planning subsequent exploration efforts and in the interpretation of related exploration data.

Respectfully Submitted,

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APPENDIX A

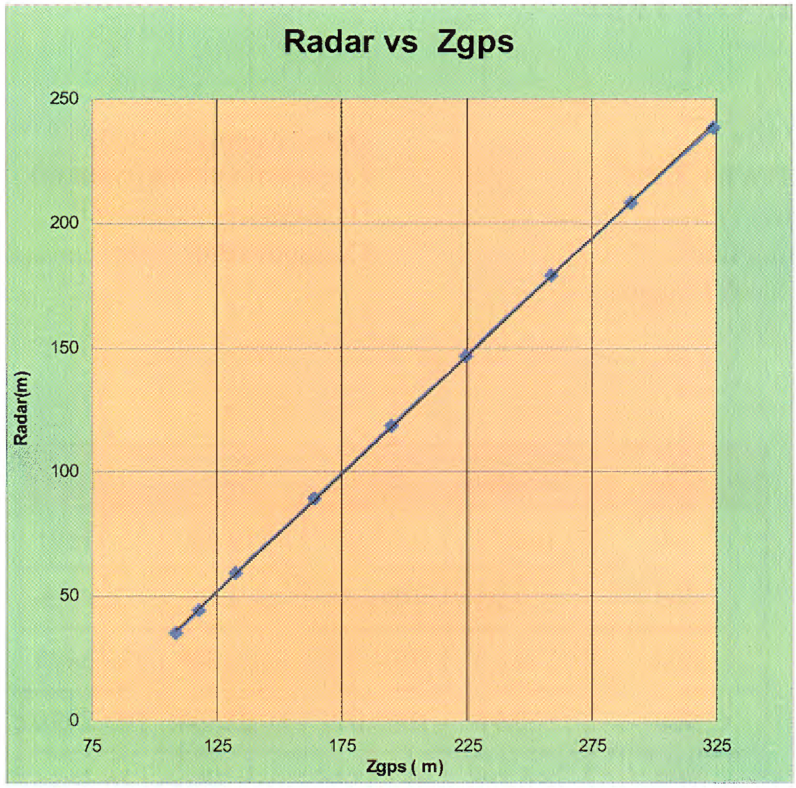
TESTING AND CALIBRATION

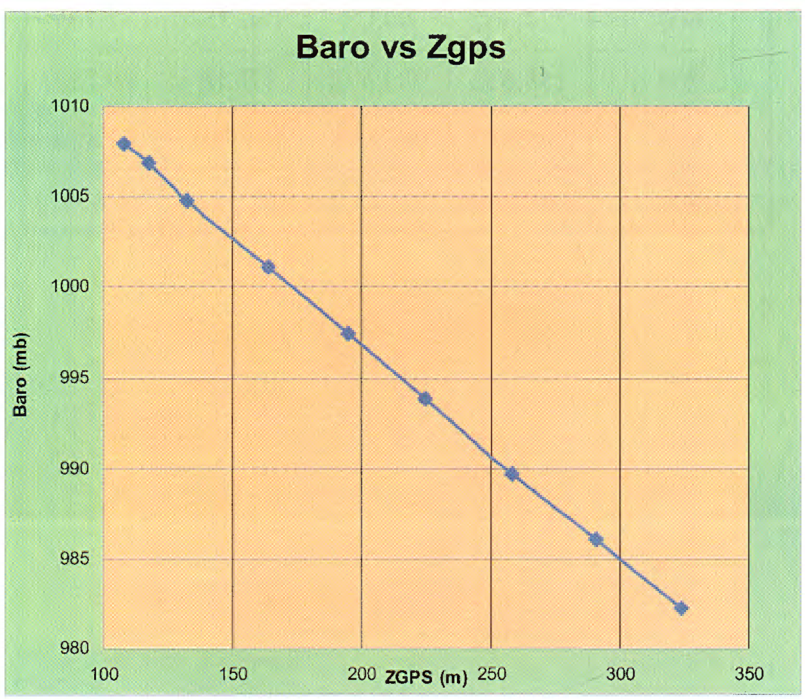
1.0 ALTIMETER TEST

Project #: P07-024
Client: NORTHWESTERN
Pilot: Christophe
Operator: Pierre Filion
Compiled By: Saleh Elmoussaoui

Date: August 21, 2007
Location: Ottawa (Ontario)
Helicopter: BELL206B
Configuration: mag. and spectro.

Line	zgps	baro	radar	Diff
100	108.38	1007.952	35.06409	73.31591
200	117.95	1006.86	43.9975	73.9525
300	132.69	1004.796	59.05505	73.63495
400	163.95	1001.071	89.32004	74.62996
500	194.898	997.4345	118.787	76.111
600	224.462	993.8	146.757	77.705
700	258.612	989.676	178.86	79.752
800	290.857	986.098	207.991	82.866
900	324.1558	982.2376	238.3221	85.8337


Radar vs Zgps
250
200
150
100
50
0
Radar(m)
75
125
175
225
275
325
Zgps (m)


Baro vs Zgps
1010
1005
1000
995
990
985
980
Baro (mb)
100
150
200
250
300
350
ZGPS (m)

2.0 BRECKENRIDGE CALIBRATION

BRECKENRIDGE RESULTS Bell 206B

Project #: P07-024
Client: NORTHWESTERN
Pilot: Christophe
Operator: Pierre Fillion
Compiled By: Saleh Elmoussaoui

Date: August 21, 2007
Location: Ottawa (Ontario)
Helicopter: BELL206B
Configuration: mag. and spectro.

LINE	HSTP	TC	K	TH	U	NO OF POINTS
120	**31.72489**	**1242.067427**	**169.9854**	**33.43566**	**19.7498174**	**160**
150	**39.46254**	**1157.181004**	**154.61**	**30.74898**	**18.816446**	**160**
200	**52.58636**	**1044.882892**	**135.0795**	**27.57034**	**16.4944395**	**160**
300	**79.67799**	**830.9929969**	**101.8893**	**22.58755**	**13.608**	**160**
400	**106.1187**	**677.4289663**	**79.51078**	**18.38615**	**11.1659091**	**160**
500	**131.5065**	**563.9818263**	**63.47365**	**15.04831**	**9.66987599**	**160**
600	**158.8839**	**453.273899**	**50.18947**	**12.14167**	**8.24**	**160**
700	**185.4275**	**368.2913907**	**39.76821**	**10.10143**	**6.86176143**	**160**
800	211.1406	299.6848251	29.77495	8.115942	5.5245098	**160**

LINE	**HSTP**	**ln TC**	**ln K**	**ln TH**	**ln U**	**NO OF POINTS**
120	**31.72489**	**7.12**	**5.14**	**3.51**	**2.98**	**160**
150	**39.46254**	**7.05**	**5.04**	**3.43**	**2.93**	**160**
200	**52.58636**	**6.95**	**4.91**	**3.32**	**2.80**	**160**
300	**79.67799**	**6.72**	**4.62**	**3.12**	**2.61**	**160**
400	**106.1187**	**6.52**	**4.38**	**2.91**	**2.41**	**160**
500	**131.5065**	**6.34**	**4.15**	**2.71**	**2.27**	**160**
600	**158.8839**	**6.12**	**3.92**	**2.50**	**2.11**	**160**
700	**185.4275**	**5.91**	**3.68**	**2.31**	**1.93**	**160**
800	211.1406	**5.70**	**3.39**	**2.09**	**1.71**	**160**

3.0 AIRBORNE GAMMA-RAY SPECTROMETRY

Airborne Gamma-Ray Spectrometry (**AGS**) requires careful calibration on proper facilities and/or under particular environmental conditions. Three major radiometric calibrations are reported here, namely:

- **Dynamic Calibration Range** (dcr) measurements, which evaluate the altitude attenuation coefficients and the radioelement sensitivity of the airborne spectrometer system.
- **Cosmic Flight,** which is used to determine the aircraft background values and cosmic coefficients.
- **Background-0ver-Water** (bow) measurements, used to determine the spectrometer response to airborne radon.

Measurements were made in accordance with **GDS** procedures for AGS data acquisition, which were designed in accordance with: IAEA technical report series No. 323, "Airborne Gamma Ray Spectrometer Surveying"; AGSO Record 1995/60, "A Guide to the Technical Specifications for Airborne Gamma-Ray Surveys"; and IAEA-TECDOC-1363, "Guidelines for radioelement mapping using gamma ray spectrometry data" (July 2003).

4.0 AGS STANDARDS

This section provides information on a range of standard values and terminology used by **GDS** for AGS data acquisition.

4.1 Gamma Peak Positions

GDS maintains the gamma-ray spectrometer so that:

- the spectrometer (channel number) versus (gamma energy) relationship is linear and fixed (stable) in the energy range of interest (400 – 3,000 keV).
- the channel versus energy intercept equals zero.

The gamma peak positions thus remain constant and for the most important peaks are:

SOURCE NAME	PEAK ENERGY (keV)	POSITION (channel no.)
Rn (radon / Bi-214)	609	51.1
Cs-137	662	55.5
K (potassium / K-40)	1460	121.5
U (uranium / Bi-214)	1764	147.5
TH (thorium / Tl-208)	2615	218.5

Note that the peak positions are provided to 0.1 channel accuracy.

4.2 Energy ROI (Regions of Interest)

The airborne radiometric technique requires measurement of count rates for specific energy regions (ROI or windows) in the natural gamma-ray spectrum. The standard energy regions (in accordance with IAEA 323) and the corresponding channel limits are:

DOWNWARD SPECTROMETER ENERGY ROI				
DESIGNATION	ENERGY LIMIT (keV)		CHANNEL LIMIT (inclusive)	
	Lower	Upper	Lower	Upper
Total Count = **TC**	410	2810	34	233
Potassium = **K**	1370	1570	115	130
Uranium = **U**	1660	1860	139	155
Thorium = **TH**	2410	2810	202	233
Upward Uran. = **UPU**	1660	1860	139	155
Cosmic = **COS**	3200	infinity		

4.3 DYNAMIC CALIBRATION RANGE

Dynamic calibration range (dcr) measurements were performed with the helicopter in AGS survey configuration, over the Breckenridge range near Ottawa, on August 21st, 2007.

The range was flown by acquiring data on a series of 9 passes over its 9 km length, at constant ground clearances ranging from 120 to 800 feet. These passes alternated between the land and adjacent fresh water sections of the range. The measurements where used to determine altitude attenuation coefficients and radioelement sensitivities.

4.4 Altitude Attenuation

The airborne data from Breckenridge were checked for quality, edited and divided into lines for each pass. Mean values were calculated for each pass over the water. The AGS ROI was then corrected for background (aircraft, cosmic and radon) by subtracting the mean over-water values from the corresponding (same height) over-land data values.

The ground clearance was then converted to an equivalent height at standard temperature and pressure – "$\mathbf{H_{STP}}$". The K, U and TH ROI were corrected for spectral overlap using the stripping coefficients measured. Finally the mean processed values for the over-land portions of the range were calculated. The results of this processing are:

4.5 COSMIC CALIBRATION FLIGHT

It is important for the cosmic flight to be conducted in a location that will minimize the presence of airborne radon. This is difficult anywhere over a landmass, since radon is constantly being released from soil and rocks. The cosmic flight was performed over a huge fresh water body.

The purpose of the cosmic flight is to:

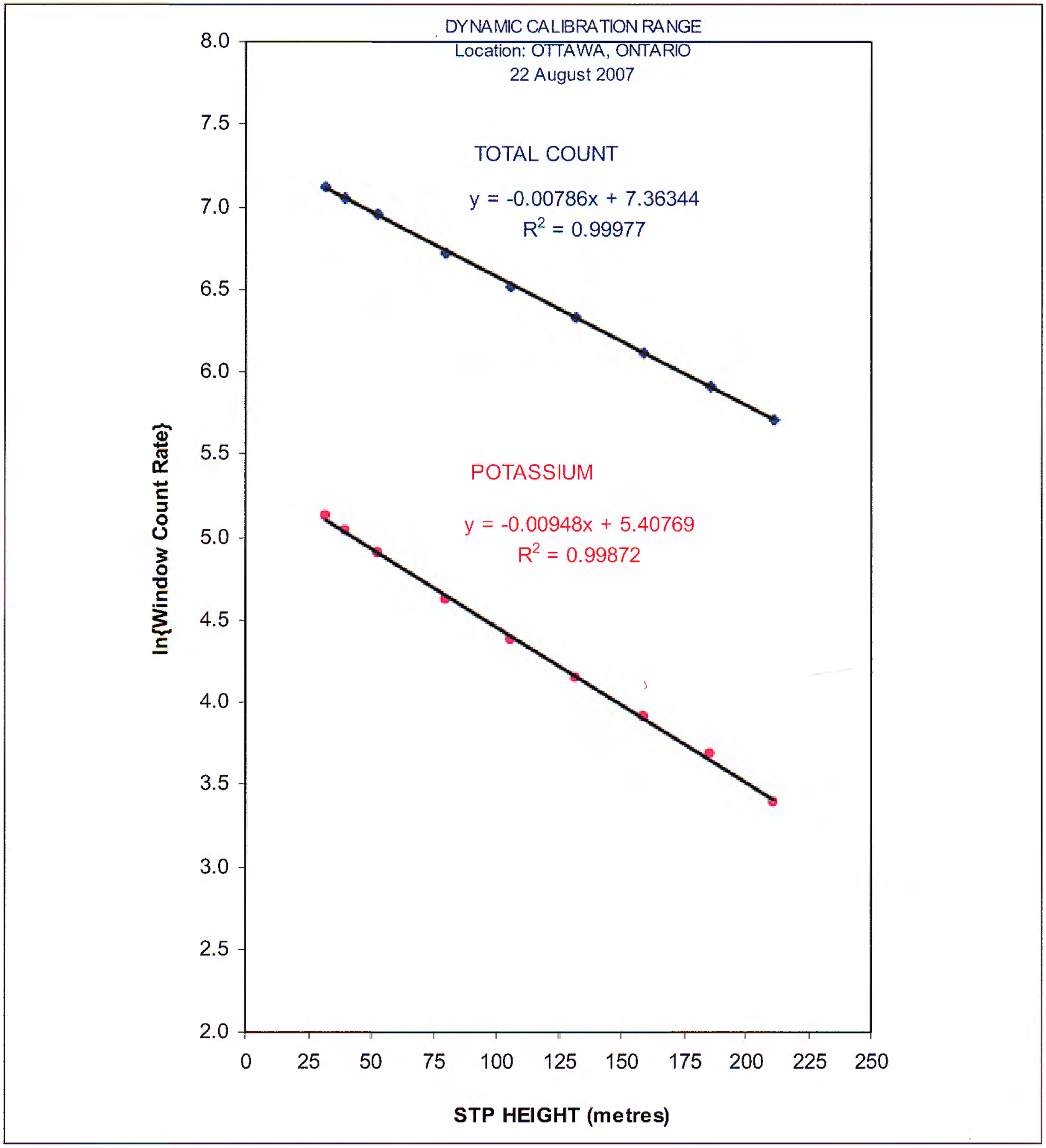
1. perform an accurate measurement of the relationship between the cosmic ROI (all gamma-rays of energy greater than 3.2 MeV) and the lower energy radiometric ROI TC, K, U, TH and upward uranium (UPU)

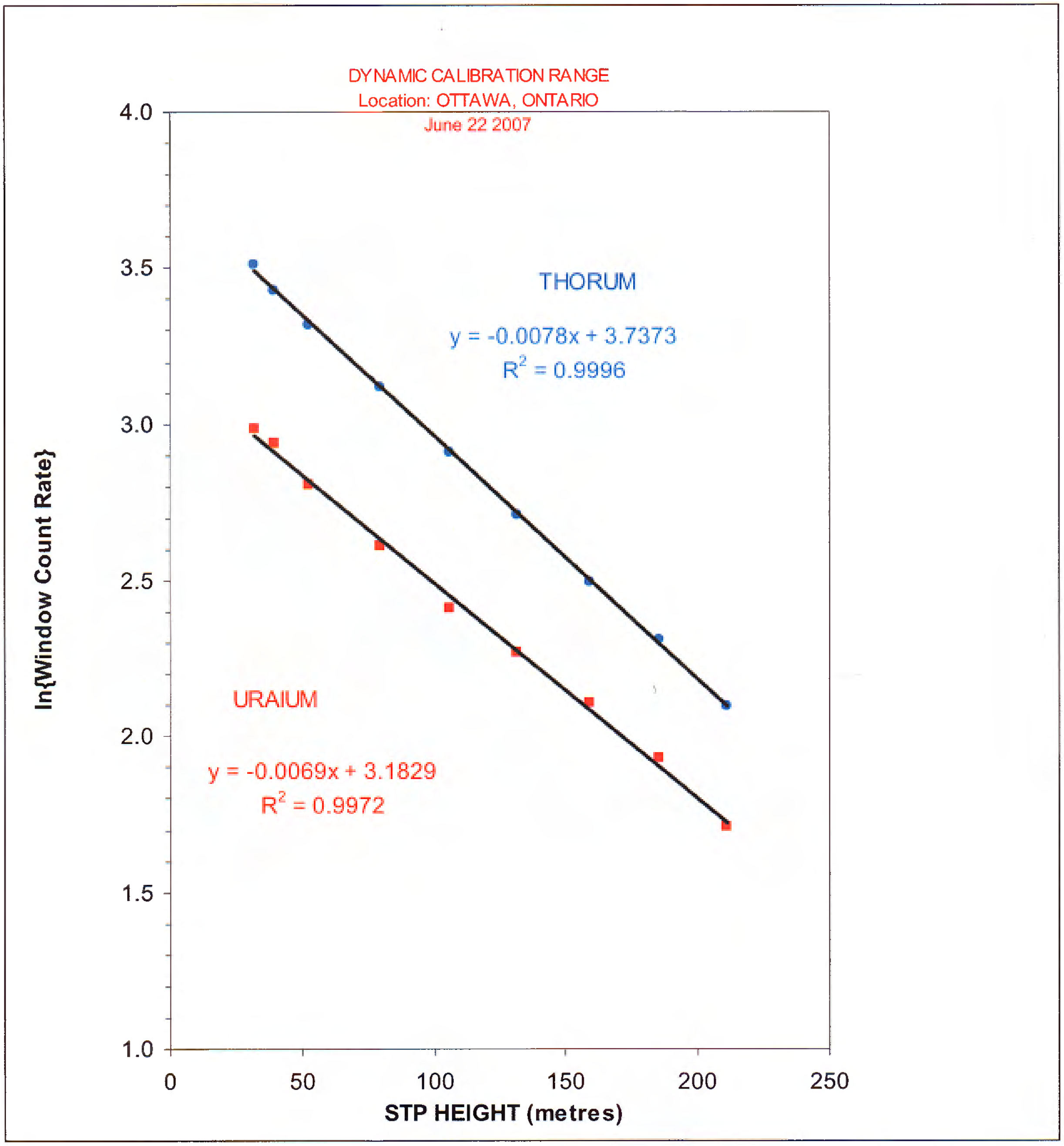
2. provide an ***initial*** measure of the aircraft background.

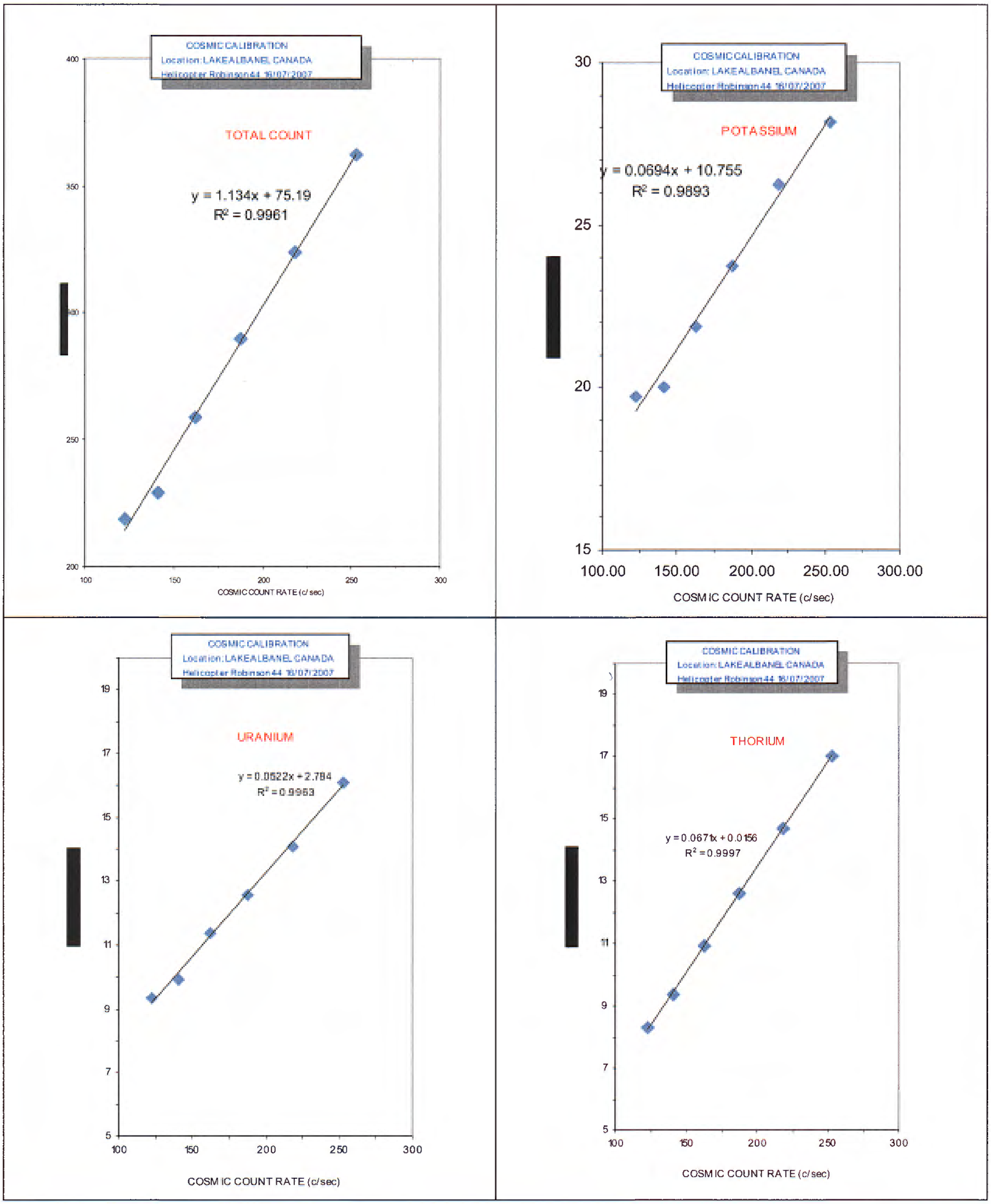
Primary ROI data is re-extracted, when necessary, in order to improve the energy definition. The data for each altitude was evaluated for quality. Mean values were then extracted. They are listed in the table below.

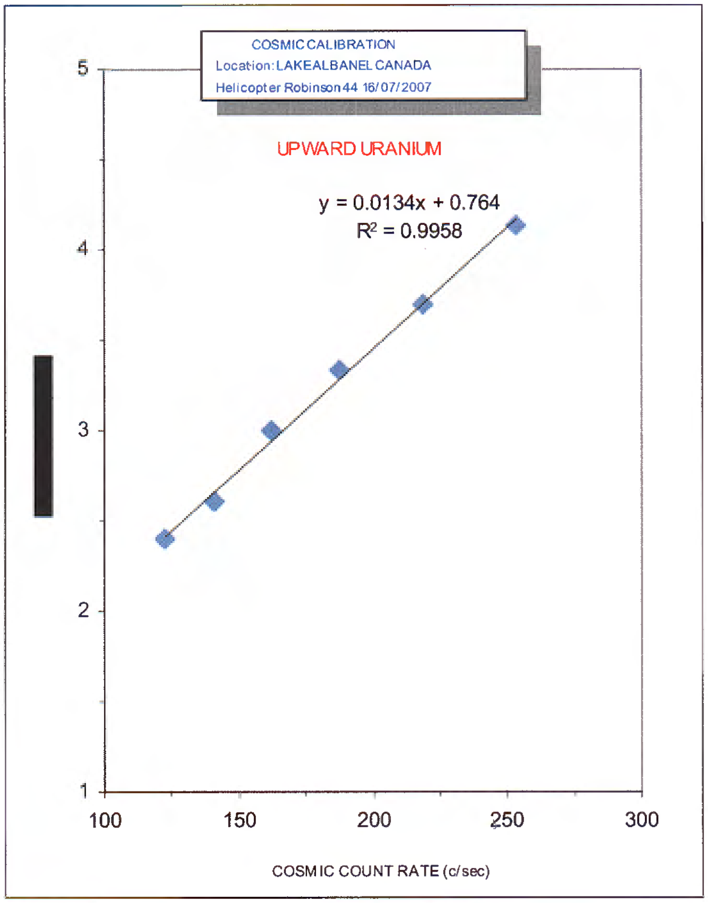
ROI	AIRCRAFT BACKGROUND (cps)	COSMIC COEFFICIENT
TC	75.19	1.134
K	10.75	0.069
U	2.784	0.052
TH	0.015	0.067
Uup	0. 764	0.013

ROI	AIR ATTENUATION (per metre at STP)	SENSITIVITY
TC	-0.00786	20.1
K	-0.00948	71.82
U	-0.0069	11.67
TH	-0.00777	3.68

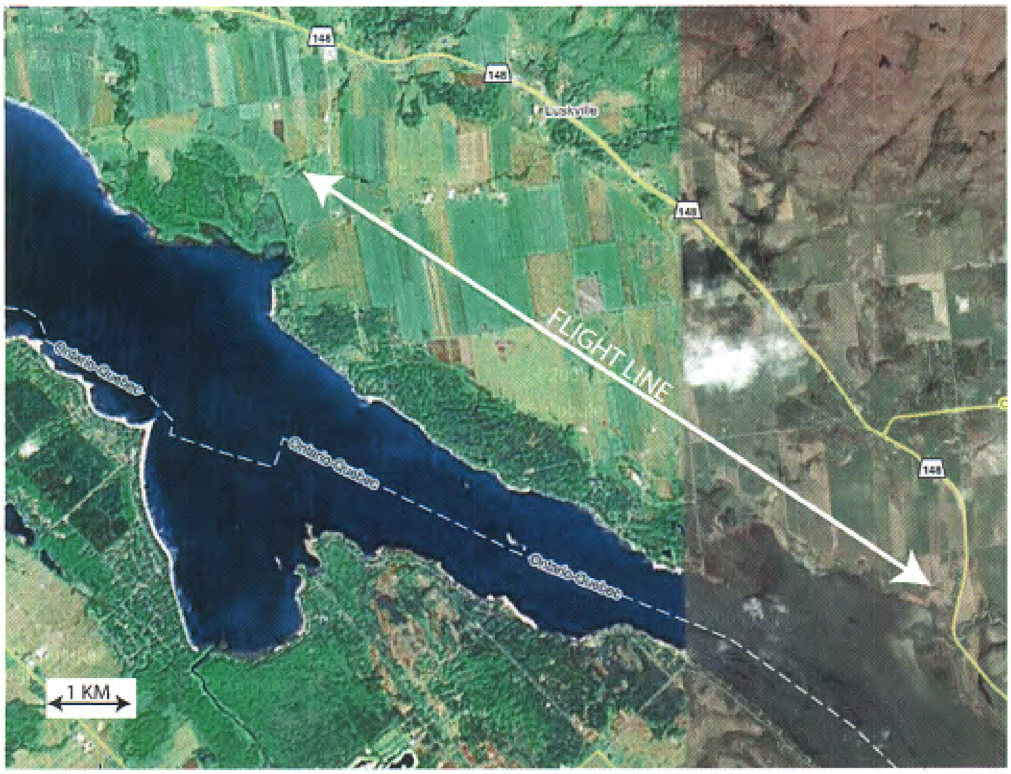

DYNAMIC CALIBRATION RANGE
Location: OTTAWA, ONTARIO
22 August 2007
TOTAL COUNT
y = -0.00786x + 7.36344
R2 = 0.99977
POTASSIUM
y = -0.00948x + 5.40769
R2 = 0.99872
ln{Window Count Rate}
STP HEIGHT (metres)
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
0
25
50
75
100
125
150
175
200
225
250


DYNAMIC CALIBRATION RANGE
Location: OTTAWA, ONTARIO
June 22 2007
THORUM
y = -0.0078x + 3.7373
R^2 = 0.9996
URAIUM
y = -0.0069x + 3.1829
R^2 = 0.9972
ln{Window Count Rate}
STP HEIGHT (metres)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0
50
100
150
200
250


COSMIC CALIBRATION
Location: LAKE ALBANEL CANADA
Helicopter Robinson44 16/07/2007
TOTAL COUNT
y = 1.134x + 75.19
R² = 0.9961
[redacted]
400
350
250
200
100
150
200
250
300
COSMIC COUNT RATE (c/sec)
COSMIC CALIBRATION
Location: LAKE ALBANEL CANADA
Helicopter Robinson44 16/07/2007
POTASSIUM
y = 0.0694x + 10.755
R² = 0.9893
[redacted]
30
25
20
15
100.00
150.00
200.00
250.00
300.00
COSMIC COUNT RATE (c/sec)
COSMIC CALIBRATION
Location: LAKE ALBANEL CANADA
Helicopter Robinson44 16/07/2007
URANIUM
y = 0.0522x + 2.784
R² = 0.9963
[redacted]
19
17
15
13
11
9
7
5
100
150
200
250
300
COSMIC COUNT RATE (c/sec)
COSMIC CALIBRATION
Location: LAKE ALBANEL CANADA
Helicopter Robinson44 16/07/2007
THORIUM
y = 0.0671x + 0.0156
R² = 0.9997
[redacted]
19
17
15
13
11
9
7
5
100
150
200
250
300
COSMIC COUNT RATE (c/sec)


COSMIC CALIBRATION
Location: LAKE ALBANEL CANADA
Helicopter Robinson 44 16/07/2007
UPWARD URANIUM
y = 0.0134x + 0.764
R^2 = 0.9958
[redacted]
5
4
3
2
1
100
150
200
250
300
COSMIC COUNT RATE (c/sec)

BRECKENRIDGE DYNAMIC CALIBRATION RANGE



LOCATION:

- Adjacent to Ottawa River, approximately 12 km northwest of the city of Ottawa.

LAND LINE:

- Geology: Non-marine clay developed from underlying marine clay during the last stages of the Champlain Sea and during subsequent estuarine and fluvial periods. It is probable that the gamma-ray signature of the clay is due to radioactive heavy minerals in the small amount of sandy matter enclosed within it.
- Homogeneity: highly uniform over its length and width.
- Length: 8.8 km.
- Altitude: 68 m ASL

WATER LINE:

- Background-over-water is measured over the adjacent Ottawa River. The water line extends to the west of the above map. Minimum width = 1.5 km. Length = 9 to 10 km.

APPENDIX B

PROFILE DATABASE ARCHIVE
CHANNEL DEFINITIONS
AND
GRID ARCHIVE DEFINITIONS

Mag: Channels included in the final database
(Oasis Montaj GDB format)

General line information:

Line	Unit	Line number

Clocks and system synchronization:

Fiducial	Sec	Fiducial
TimeGPS	Sec	Edited GPS time (second after midnight)
Flt		Flight number
Date		Flight date (yyyy/mm/dd)

Edited GPS channels

X	Metre	WGS-84 UTM Z20N Easting
Y	Metre	WGS-84 UTM Z20N Northing
Zgps	Metre	MSL GPS altitude
Longitude	Deg	Longitude, WGS-84
Latitude	Deg	Latitude, WGS-84

Radar altimeter

radarm	Metre	Radar Altimeter

Ground Mag base station data

Base	nT	Original, (in Block area) unedited primary mag base station
Basef	nT	Filtered Base_a

Mag TMF data

Magraw	nT	Mag despike, (bird sensor)
drift	nT	Diurnal correction removed
Magbc	nT	Diurnal corrected Mag (magbc=magraw-drift)
Corlvl	nT	Tie line levelling correction
Maglvl	nT	Tie line leveled Mag (maglvl=magbc+corlvl)
Cormicro	nT	Microleveling correction
Magmicro	nT	Micro leveled Mag (magmicro=maglvl-cormicro)

Spectro: Channels included in the final database
(Oasis Montaj GDB format)

General line information:

Line	Unit	Line number

Clocks:

Fiducial	Sec	Fiducial
TimeGPS	Sec	Edited GPS time (second after midnight)
Flt		Flight number
Date		Flight date (yyyy/mm/dd)

Edited GPS channels

X	Metre	WGS-84 UTM Z20N Easting
Y	Metre	WGS-84 UTM Z20N Northing
Zgps	Metre	MSL GPS altitude
Longitude	Deg	Longitude, WGS-84
Latitude	Deg	Latitude, WGS-84

Altimeter

Radar	Metre	Radar Altimeter
Baro	Mbar	Barometric Altimeter
Temp	C	Air temperature

Radiometric Data:

LTime	msec	Live Time
STime	msec	Sample Time
Cosmic	cps	Cosmic counts
upU	cps	Upward looking detector counts
Down	cps	Down detectors spectrum (256 channels)
Up	cps	Up detector spectrum (256 channels)
TC	cps	Total radiometric counts
K	cps	Potassium counts
TH	cps	Thorium counts
U	cps	Uranium counts
TCcorr	nGy/h	Total radiometric dose rate
Kcorr	%	Potassium concentration
THcorr	ppm	Equivalent Thorium concentration
Ucorr	ppm	Equivalent Uranium concentration