Operations and processing report, Bonney Well airborne geophysical survey, NTGS 1999 (flown by AGS, covering parts of Bonney Well, Lander River and Frew River 1:250 000 map sheets).

Australian Geophysical Surveys
Australian Geophysical Surveys

Operations and processing report, Bonney Well airborne geophysical survey, NTGS 1999 (flown by AGS, covering parts of Bonney Well, Lander River and Frew River 1:250 000 map sheets).

ISSN 1443-1149; Geological Survey Record 2000-0005

ISBN 0 7245 3433 4

© Northern Territory Government 2000

Published by the Northern Territory Geological Survey
Radiometric Calibration Report

Australian Geophysical Surveys

Aircraft VH-AGS

33 litre sensor

Date: March - 1999

Compiled By

Baigent Geosciences Pty. Ltd.
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1 System configuration</td>
<td>3</td>
</tr>
<tr>
<td>1.2 System deadtime and energy calibration</td>
<td>3</td>
</tr>
<tr>
<td>1.3 Aircraft and cosmic background calculation</td>
<td>3</td>
</tr>
<tr>
<td>1.4 Spectral stripping coefficient calculation</td>
<td>4</td>
</tr>
<tr>
<td>1.5 Window height attenuation coefficient calculation</td>
<td>5</td>
</tr>
<tr>
<td>1.6 Window sensitivity calculation</td>
<td>6</td>
</tr>
<tr>
<td>References</td>
<td>7</td>
</tr>
<tr>
<td>Appendix 1</td>
<td>8</td>
</tr>
<tr>
<td>Appendix 2</td>
<td>15</td>
</tr>
<tr>
<td>Appendix 3</td>
<td>16</td>
</tr>
<tr>
<td>Appendix 4</td>
<td>21</td>
</tr>
</tbody>
</table>
1.1 System configuration

The system configuration of the aircraft VH-AGS at the time of radiometric calibration was as follows:

<table>
<thead>
<tr>
<th>Aircraft Type</th>
<th>Cessna Grand Caravan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spectrometer Type</td>
<td>Exploranium GR820</td>
</tr>
<tr>
<td>Crystal Volume</td>
<td>33.6L</td>
</tr>
</tbody>
</table>

1.2 System deadtime and energy calibration

Radiometric data is firstly corrected for system deadtime in the manner described below.

\[
N = \frac{n}{1 - t} \tag{A1}
\]

where

\[
N = \text{ corrected counts in each second;}
\]
\[
n = \text{ all counts processed in each second by the ADC; and}
\]
\[
t = \text{ the recorded dead-time, the time taken to process all pulses reaching the detector in one second.}
\]

Following correction for system deadtime, the 256 channel spectrometer data may be energy calibrated using the following procedure:

For each line, the individual 256 channel data from each sample point were stacked to produce a single spectrum. The peak positions of the standard potassium and thorium windows were found by performing a gaussian fit of the spectral data for the energy range of each window after first removing the Compton continuum slope. If the measured peak positions were shifted by more than a specified number of channels for the thorium or potassium peaks, an energy recalibration was performed to obtain the correct spectral channel positions for the lower and upper bounds of each of the required windows. Using these corrected channel limits, new window counts were extracted from the 256 channel data for each 1 second data sample on the line.

Note that energy recalibration was not performed for overwater stack data or for data obtained over calibration pads due to the lack of suitable window peaks for determining the recalibration coefficients. However verification of peak positions was made using suitable data acquired before and after these calibrations.

1.3 Aircraft and cosmic background calculation

The cosmic and aircraft backgrounds for each channel are of the form:

\[
N = a + bC \tag{A2}
\]
where:
\( N \) = the combined cosmic and aircraft background in each spectral window;
\( a \) = the aircraft background in the window (plus a possible small radon component);
\( C \) = the cosmic channel count; and
\( b \) = the cosmic stripping factor for the window.

The values of \( a \) and \( b \) for each window were calculated from a series of calibration flights over the sea. Flown at heights between 1000 and 10000 feet.
The full 256 channel spectrum for the aircraft background and the normalised cosmic spectrum are shown in Appendix 1.

A table of the standard 3 window coefficients for aircraft and cosmic correction coefficients are also shown in Appendix 1, along with the linear regression plots from which the coefficients were derived.

1.4 Spectral Stripping

The stripping ratios \( \alpha, \beta, \gamma, a, b \) and \( g \) were determined over calibration pads owned by World Geoscience Corporation. These stripping ratios are measured at ground level. The concentrations of the calibration pads were as follows:

<table>
<thead>
<tr>
<th></th>
<th>Potassium Percent</th>
<th>Uranium Ppm</th>
<th>Thorium Ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Background Pad</td>
<td>1.43±0.01</td>
<td>0.94±0.02</td>
<td>2.32±0.08</td>
</tr>
<tr>
<td>Potassium Pad</td>
<td>7.57±0.05</td>
<td>1.22±0.09</td>
<td>1.40±0.12</td>
</tr>
<tr>
<td>Uranium Pad</td>
<td>1.07±0.01</td>
<td>46.93±0.32</td>
<td>2.95±1.92</td>
</tr>
<tr>
<td>Thorium Pad</td>
<td>1.43±0.02</td>
<td>1.74±0.15</td>
<td>121.0±1.06</td>
</tr>
</tbody>
</table>

The deadtime corrected window count rates were obtained by counting for approximately 10 minutes for each of the calibration pads.

\( \alpha \) is the thorium into uranium stripping ratio, equal to the ratio of counts detected in the uranium window to those detected in the thorium window from a pure thorium source;

\( a \) is the reversed stripping ratio, uranium into thorium, equal to the ratio of counts detected in the thorium window to those detected in the uranium window from a pure source of uranium.

Similarly, \( \beta \) is the thorium into potassium stripping ratio for a pure thorium source;

\( b \) is the reversed stripping ratio, potassium into thorium from a pure potassium source;

\( \gamma \) is the uranium into potassium stripping ratio for a pure uranium source; and,

\( g \) is the reverse stripping ratio, potassium into uranium for a pure potassium source.

The stripping ratios obtained are given in Appendix 2.

If 5 stripping ratios are used, then the stripped count rates in the potassium, uranium and thorium channels \((N_k, N_u, N_t)\) are given by:

\[
N_k = \frac{n_{th}(\alpha \gamma - \beta) + n_u(a \beta - \gamma) + n_k(1-a \alpha)}{A},
\]  
(A3)
\[ N_u = \frac{\left[ n_u (g \beta - \alpha) + n_u - n_k g \right]}{A}, \]  
(A4)

\[ N_{th} = \frac{\left[ n_{th} (1 - g \gamma) - n_u a + n_k a g \right]}{A}, \]  
(A5)

where

\[ A = 1 - g \gamma - a (\alpha - g \beta). \]  
(A6)

1.5 Window height attenuation coefficient calibration

The attenuation factors were determined from test flights carried out over the test range at Carnamah, W.A. on 6 March 1998. A series of traverses were flown at heights from 50m to 600m over a specified ground line for which measured ground concentrations were taken. The radar altimeter data was lightly filtered. The data were then converted to effective height \( h_e \) at standard temperature and pressure using the expression:

\[ h_e = \frac{h \times P \times 273}{1013 \times (T + 273)} \]  
(A7)

where
\[ h \quad = \quad \text{the observed radar altitude in metres;} \]
\[ T \quad = \quad \text{the measured air temperature in degrees C;} \]
\[ P \quad = \quad \text{the barometric pressure in millibars.} \]

The stripping coefficients used for the test range data were adjusted for height according to the following table.

<table>
<thead>
<tr>
<th>Stripping Ratio</th>
<th>Increase per metre</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \alpha )</td>
<td>0.00049</td>
</tr>
<tr>
<td>( \beta )</td>
<td>0.00065</td>
</tr>
<tr>
<td>( \gamma )</td>
<td>0.00069</td>
</tr>
</tbody>
</table>

The background corrected and stripped count rates were corrected for variations in the altitude of the detector using the equation:
\[ N_{\text{corr}} = N_{\text{obs}} e^{-\mu(h_c-h)} \]  \hspace{1cm} \text{(A8)}

where

- \( N_{\text{corr}} \) = the count rate normalised to the nominal survey altitude, \( h_c \);
- \( N_{\text{obs}} \) = the background corrected, stripped count rate at STP height \( h \);
- \( \mu \) = the attenuation coefficient for that window.

The height attenuation coefficients were obtained by fitting a linear regression to the graph of the resulting STP corrected radar altimeter against the log of the corrected counts. The linear regression plots, and the tabulated results are contained in Appendix 3.

1.6 Calculation of window sensitivities

The window sensitivities were calculated for multiple flying heights. The airborne radiometric data were fully corrected by removing backgrounds, spectral stripping, and applying the height attenuation corrections. The average count rate for each of the windows, at each of the selected heights was then calculated. The ground concentration data were obtained by measuring the ground counts using a calibrated portable hand-held spectrometer. The ground count rates were then converted to concentrations. The sensitivities were calculated by use of the formula

\[ S = \frac{N}{C} \]  \hspace{1cm} \text{(A9)}

where

- \( S \) = sensitivity coefficient for the window;
- \( N \) = fully corrected average count rate; and
- \( C \) = average ground concentration.

The air-absorbed dose rate at ground level from natural sources of radiation was calculated from the corrected total count rate following the procedure as described in Grasty and Minty (1995) using the equation

\[ D = \frac{N_{\text{TC}}}{F} \]  \hspace{1cm} \text{(A10) (equation 4.18, page 42)}

where

- \( D \) = air absorbed dose rate in nanograys per hour;
- \( N_{\text{TC}} \) = fully corrected total count rate; and
- \( F \) = experimentally determined conversion factor.

The average air-absorbed dose rate in nGy h\(^{-1}\) for these lines is given by

\[ A = 13.1 \times K + 5.43 \times U + 2.69 \times \text{Th} \]  \hspace{1cm} \text{(A11) (equation 4.19, page 42)}

where

- \( A \) = average air-absorbed dose rate; and
- \( K \) = %K, \( U \) = ppm eU and \( \text{Th} \) = ppm eTh.

The results of the window sensitivities are given in Appendix 4.
REFERENCES


B.R.S Minty: The Analysis of Multichannel Airborne Gamma-Ray Spectra

Doctor of Philosophy Thesis 1996
Appendix 1  Aircraft and cosmic background calibration results

The overwater calibration data for calculation of the aircraft and cosmic backgrounds was acquired in January 1999.

Normalised cosmic spectrum and aircraft background spectrum are shown on the following two pages.

The corresponding standard window aircraft and cosmic correction coefficients are as follows:

<table>
<thead>
<tr>
<th>Window</th>
<th>Cosmic factor</th>
<th>Aircraft background</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potassium</td>
<td>0.050893</td>
<td>8.6652</td>
</tr>
<tr>
<td>Uranium</td>
<td>0.043913</td>
<td>0.3253</td>
</tr>
<tr>
<td>Thorium</td>
<td>0.052943</td>
<td>0.0000</td>
</tr>
<tr>
<td>Total Count</td>
<td>0.926200</td>
<td>29.5111</td>
</tr>
</tbody>
</table>

The four linear regression plots from which the above coefficients were obtained follow the two spectral plots.
Aircraft background spectrum for VH-AGS
Normalised cosmic spectrum for VH-AGS
Aircraft and Cosmic Background coefficients
Date: 14/1/99  Aircraft: VH-AGS

Slope = 0.050893, Intercept = 6.665239
Aircraft and Cosmic Background coefficients
Date: 14/1/99  Aircraft: VH-AGS

Slope = 0.043913, Intercept = 0.325339
Aircraft and Cosmic Background coefficients
Date: 14/1/99   Aircraft: VH-AGS

Slope = 0.062942, Intercept = -0.121403
Aircraft and Cosmic Background coefficients
Date: 14/1/99  Aircraft: VH-AGS

Slope = 0.926200, Intercept = 29.511091
Appendix 2  Spectral stripping results

The average deadtime corrected count rates for each of the calibration pads are shown below.

<table>
<thead>
<tr>
<th></th>
<th>Potassium</th>
<th>Uranium</th>
<th>Thorium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Background Pad</td>
<td>268.93</td>
<td>35.73</td>
<td>37.20</td>
</tr>
<tr>
<td>Potassium Pad</td>
<td>1006.4</td>
<td>39.12</td>
<td>32.39</td>
</tr>
<tr>
<td>Uranium Pad</td>
<td>564.89</td>
<td>495.2</td>
<td>65.71</td>
</tr>
<tr>
<td>Thorium Pad</td>
<td>540.14</td>
<td>210.4</td>
<td>648.6</td>
</tr>
<tr>
<td>Background Pad</td>
<td>266.49</td>
<td>35.33</td>
<td>36.77</td>
</tr>
</tbody>
</table>

The stripping ratios obtained were as follows:

<table>
<thead>
<tr>
<th>Stripping Coefficient</th>
<th>Coefficient Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>alpha (α)</td>
<td>0.2686</td>
</tr>
<tr>
<td>beta (β)</td>
<td>0.4097</td>
</tr>
<tr>
<td>gamma (γ)</td>
<td>0.7449</td>
</tr>
<tr>
<td>a</td>
<td>0.0569</td>
</tr>
<tr>
<td>b</td>
<td>-0.0006</td>
</tr>
<tr>
<td>g</td>
<td>0.0030</td>
</tr>
</tbody>
</table>
Height Attenuation coefficients
Date: 14/1/99  Test Range: Carnamah
Aircraft: VH-AGS.

Slope = -0.008149, Intercept = 6.644881

STP corrected height (metres)
Height Attenuation coefficients
Date: 14/1/99  Test Range: Carnamah
Aircraft: VH-AGS.

Slope = -0.006755, Intercept = 4.543815
Height Attenuation coefficients
Date: 14/1/99 Test Range: Carnamah
Aircraft: VH-AGS.

Slope = -0.006853, Intercept = 6.051091

Ln Thorium

STP corrected height (metres)
Height Attenuation coefficients
Date: 14/1/99 Test Range: Carnamah
Aircraft: VH-AGS.

Slope = -0.006344, Intercept = 9.030573
COMMERCIAL IN CONFIDENCE

Appendix 4  Window sensitivity coefficient calibration results

The average ground concentrations for the test range on the 3-March 1998 were

<table>
<thead>
<tr>
<th>Radioelement</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potassium (%K)</td>
<td>3.13</td>
</tr>
<tr>
<td>Uranium (ppm)</td>
<td>4.70</td>
</tr>
<tr>
<td>Thorium (ppm)</td>
<td>38.33</td>
</tr>
</tbody>
</table>

The dose rate conversion factor is determined by the following formula

\[ nG/Hr = A = 13.1 \times K + 5.43 \times U + 2.69 \times Th \]

Thus the conversion factor is

\[ A = 13.1 \times 3.34 + 5.43 \times 6.22 + 2.69 \times 36.17 = 169.63 \text{ nG/Hr} \]

<table>
<thead>
<tr>
<th>STP Height (metres)</th>
<th>Potassium (cps)</th>
<th>Potassium Sensitivity</th>
<th>Uranium (cps)</th>
<th>Uranium Sensitivity</th>
<th>Thorium (cps)</th>
<th>Thorium Sensitivity</th>
<th>Total Count (cps)</th>
<th>Total Count Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>46</td>
<td>547.65</td>
<td>174.9681</td>
<td>73.63</td>
<td>15.66596</td>
<td>332.20</td>
<td>8.666841</td>
<td>6925.82</td>
<td>40.83447</td>
</tr>
<tr>
<td>88.53</td>
<td>372</td>
<td>118.8498</td>
<td>50.92</td>
<td>10.83404</td>
<td>235.80</td>
<td>6.151839</td>
<td>4938.76</td>
<td>29.11541</td>
</tr>
<tr>
<td>130.8</td>
<td>262.7</td>
<td>83.92971</td>
<td>36.11</td>
<td>7.682979</td>
<td>169.96</td>
<td>4.434125</td>
<td>3623.81</td>
<td>21.36281</td>
</tr>
<tr>
<td>159.6</td>
<td>195.85</td>
<td>62.57188</td>
<td>30.83</td>
<td>6.559574</td>
<td>142.50</td>
<td>3.717715</td>
<td>2936.55</td>
<td>17.31133</td>
</tr>
<tr>
<td>232.41</td>
<td>114.69</td>
<td>36.64217</td>
<td>20.76</td>
<td>4.417021</td>
<td>82.69</td>
<td>2.157318</td>
<td>1685.77</td>
<td>9.937824</td>
</tr>
<tr>
<td>325.91</td>
<td>54.3</td>
<td>17.314821</td>
<td>11.12</td>
<td>3.004255</td>
<td>13.08</td>
<td>1.123921</td>
<td>965.98</td>
<td>5.694572</td>
</tr>
<tr>
<td>429.1</td>
<td>24.89</td>
<td>7.952077</td>
<td>11.1</td>
<td>2.381702</td>
<td>22.01</td>
<td>0.574224</td>
<td>517.48</td>
<td>3.050609</td>
</tr>
<tr>
<td>500.86</td>
<td>13.85</td>
<td>4.42492</td>
<td>9.42</td>
<td>2.004255</td>
<td>12.69</td>
<td>0.331072</td>
<td>345.4</td>
<td>2.036176</td>
</tr>
<tr>
<td>588.86</td>
<td>5.81</td>
<td>1.85623</td>
<td>7.96</td>
<td>1.693617</td>
<td>8.48</td>
<td>0.221237</td>
<td>225.42</td>
<td>1.328879</td>
</tr>
</tbody>
</table>

Plots of the sensitivity factors for each of Potassium, Uranium and Thorium and Total Count as a function of STP corrected height are on the following four pages.
Radiometric Calibration Report

Australian Geophysical Surveys

Aircraft VH-FDN

33 litre sensor

Date: April - 1999

Compiled By

Baigent Geosciences Pty. Ltd.
# Table of Contents

1.1 System configuration ........................................... 3  
1.2 System deadtime and energy calibration ................... 3  
1.3 Aircraft and cosmic background calculation .............. 3  
1.4 Spectral stripping coefficient calculation ............... 4  
1.5 Window height attenuation coefficient calculation ...... 5  
1.6 Window sensitivity calculation ............................. 6  

References .................................................................. 7  
Appendix 1 .................................................................. 8  
Appendix 2 .................................................................. 15  
Appendix 3 .................................................................. 16  
Appendix 4 .................................................................. 21
1.1 System configuration

The system configuration of the aircraft VH-FDN at the time of radiometric calibration was as follows:

Aircraft Type: Beechcraft Baron
Spectrometer Type: Exploranium GR820
Crystal Volume: 33.6L

1.2 System deadtime and energy calibration

Radiometric data is firstly corrected for system deadtime in the manner described below.

\[ N = \frac{n}{1-t} \]  \hspace{1cm} (A1)

where

\( N \) = corrected counts in each second;
\( n \) = all counts processed in each second by the ADC; and
\( t \) = the recorded dead-time, the time taken to process all pulses reaching the detector in one second.

Following correction for system deadtime, the 256 channel spectrometer data may be energy calibrated using the following procedure:

For each line, the individual 256 channel data from each sample point were stacked to produce a single spectrum. The peak positions of the standard potassium and thorium windows were found by performing a gaussian fit of the spectral data for the energy range of each window after first removing the Compton continuum slope. If the measured peak positions were shifted by more than a specified number of channels for the thorium or potassium peaks, an energy recalibration was performed to obtain the correct spectral channel positions for the lower and upper bounds of each of the required windows. Using these corrected channel limits, new window counts were extracted from the 256 channel data for each 1 second data sample on the line.

Note that energy recalibration was not performed for overwater stack data or for data obtained over calibration pads due to the lack of suitable window peaks for determining the recalibration coefficients. However verification of peak positions was made using suitable data acquired before and after these calibrations.

1.3 Aircraft and cosmic background calculation

The cosmic and aircraft backgrounds for each channel are of the form:

\[ N = a + bC \]  \hspace{1cm} (A2),
where:
\[ N = \text{the combined cosmic and aircraft background in each spectral window}; \]
\[ a = \text{the aircraft background in the window (plus a possible small radon component)}; \]
\[ C = \text{the cosmic channel count; and} \]
\[ b = \text{the cosmic stripping factor for the window}. \]

The values of \( a \) and \( b \) for each window were calculated from a series of calibration flights over the sea. Flown at heights between 1000 and 10000 feet. The full 256 channel spectrum for the aircraft background and the normalised cosmic spectrum are shown in Appendix 1.

A table of the standard 3 window coefficients for aircraft and cosmic correction coefficients are also shown in Appendix 1, along with the linear regression plots from which the coefficients were derived.

### 1.4 Spectral Stripping

The stripping ratios \( \alpha, \beta, \gamma, a, b \) and \( g \) were determined over calibration pads owned by World Geoscience Corporation. These stripping ratios are measured at ground level. The concentrations of the calibration pads were as follows:

<table>
<thead>
<tr>
<th></th>
<th>Potassium Percent</th>
<th>Uranium Ppm</th>
<th>Thorium Ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Background Pad</td>
<td>1.43±0.01</td>
<td>0.94±0.02</td>
<td>2.32±0.08</td>
</tr>
<tr>
<td>Potassium Pad</td>
<td>7.57±0.05</td>
<td>1.22±0.09</td>
<td>1.40±0.12</td>
</tr>
<tr>
<td>Uranium Pad</td>
<td>1.07±0.01</td>
<td>46.93±0.32</td>
<td>2.95±1.92</td>
</tr>
<tr>
<td>Thorium Pad</td>
<td>1.43±0.02</td>
<td>1.74±0.15</td>
<td>121.0±1.06</td>
</tr>
</tbody>
</table>

The deadtime corrected window count rates were obtained by counting for approximately 10 minutes for each of the calibration pads.

\( \alpha \) is the thorium into uranium stripping ratio, equal to the ratio of counts detected in the uranium window to those detected in the thorium window from a pure thorium source;

\( a \) is the reversed stripping ratio, uranium into thorium, equal to the ratio of counts detected in the thorium window to those detected in the uranium window from a pure source of uranium.

Similarly, \( \beta \) is the thorium into potassium stripping ratio for a pure thorium source;

\( b \) is the reversed stripping ratio, potassium into thorium from a pure potassium source;

\( \gamma \) is the uranium into potassium stripping ratio for a pure uranium source; and,

\( g \) is the reverse stripping ratio, potassium into uranium for a pure potassium source.

The stripping ratios obtained are given in Appendix 2.

If 5 stripping ratios are used, then the stripped count rates in the potassium, uranium and thorium channels \((N_k, N_u, N_t)\) are given by:

\[
N_k = \left[ n_{th}(\alpha \gamma - \beta) + n_u(a\beta - \gamma) + n_k(1-a\alpha) \right],
\]  
(A3)
\[
N_U = \frac{\left[ n_\theta (g\beta - \alpha) + n_u - n_\kappa g \right]}{A}, \quad (A4)
\]

\[
N_{\tau_3} = \frac{\left[ n_\tau (1 - g\gamma) - n_u a + n_\kappa ag \right]}{A}, \quad (A5)
\]

where

\[
A = 1 - g\gamma - a(\alpha - g\beta). \quad (A6)
\]

1.5 Window height attenuation coefficient calibration

The attenuation factors were determined from test flights carried out over the test range at Carnamah, W.A. on 6 March 1998.

A series of traverses were flown at heights from 50m to 600m over a specified ground line for which measured ground concentrations were taken.

The radar altimeter data was lightly filtered. The data were then converted to effective height \((h_e)\) at standard temperature and pressure using the expression:

\[
h_e = \frac{h \times P \times 273}{1013 \times (T + 273)} \quad (A7)
\]

where

\[
\begin{align*}
h &= \text{the observed radar altitude in metres;} \\
T &= \text{the measured air temperature in degrees C;} \\
P &= \text{the barometric pressure in millibars.}
\end{align*}
\]

The stripping coefficients used for the test range data were adjusted for height according to the following table.

<table>
<thead>
<tr>
<th>Stripping Ratio</th>
<th>Increase per metre</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\alpha)</td>
<td>0.00049</td>
</tr>
<tr>
<td>(\beta)</td>
<td>0.00065</td>
</tr>
<tr>
<td>(\gamma)</td>
<td>0.00069</td>
</tr>
</tbody>
</table>

The background corrected and stripped count rates were corrected for variations in the altitude of the detector using the equation:
\( N_{\text{corr}} = N_{\text{obs}} e^{-\mu (h_0 - h)} \) \hspace{1cm} (A8)

where

\( N_{\text{corr}} \) = the count rate normalised to the nominal survey altitude, \( h_0 \);
\( N_{\text{obs}} \) = the background corrected, stripped count rate at STP height \( h \);
\( \mu \) = the attenuation coefficient for that window.

The height attenuation coefficients were obtained by fitting a linear regression to the graph of the resulting STP corrected radar altimeter against the log of the corrected counts. The linear regression plots, and the tabulated results are contained in Appendix 3.

1.6 Calculation of window sensitivities

The window sensitivities were calculated for multiple flying heights. The airborne radiometric data were fully corrected by removing backgrounds, spectral stripping, and applying the height attenuation corrections. The average count rate for each of the windows, at each of the selected heights was then calculated. The ground concentration data were obtained by measuring the ground counts using a calibrated portable hand-held spectrometer. The ground count rates were then converted to concentrations. The sensitivities were calculated by use of the formula

\[ S = \frac{N}{C} \] \hspace{1cm} (A9)

where \( S \) = sensitivity coefficient for the window;
\( N \) = fully corrected average count rate; and
\( C \) = average ground concentration.

The air-absorbed dose rate at ground level from natural sources of radiation was calculated from the corrected total count rate following the procedure as described in Grasty and Minty (1995) using the equation

\[ D = \frac{N_{\text{TC}}}{F} \] \hspace{1cm} (A10) \hspace{1cm} (equation 4.18, page 42)

where \( D \) = air absorbed dose rate in nanograys per hour;
\( N_{\text{TC}} \) = fully corrected total count rate; and
\( F \) = experimentally determined conversion factor.

The average air-absorbed dose rate in nGy\(^{-1}\) for these lines is given by

\[ A = 13.1 \times K + 5.43 \times U + 2.69 \times \text{Th} \] \hspace{1cm} (A11) \hspace{1cm} (equation 4.19, page 42)

where \( A \) = average air - absorbed dose rate; and
\( K = \%K \), \( U = \text{ppm eU} \) and \( \text{Th} = \text{ppm eTh} \). The results of the window sensitivities are given in Appendix 4.
REFERENCES

B.R.S Minty: The Analysis of Multichannel Airborne Gamma-Ray Spectra
Doctor of Philosophy Thesis 1996
Appendix I  Aircraft and cosmic background calibration results

The overwater calibration data for calculation of the aircraft and cosmic backgrounds was acquired in January 1999.
Normalised cosmic spectrum and aircraft background spectrum are shown on the following two pages.
The corresponding standard window aircraft and cosmic correction coefficients are as follows:

<table>
<thead>
<tr>
<th>Window</th>
<th>Cosmic factor</th>
<th>Aircraft background</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potassium</td>
<td>0.050135</td>
<td>8.4088</td>
</tr>
<tr>
<td>Uranium</td>
<td>0.04143148</td>
<td>0.8685</td>
</tr>
<tr>
<td>Thorium</td>
<td>0.049253</td>
<td>0.6213</td>
</tr>
<tr>
<td>Total Count</td>
<td>0.877651</td>
<td>41.5517</td>
</tr>
</tbody>
</table>

The four linear regression plots from which the above coefficients were obtained follow the two spectral plots.
Aircraft background spectrum for VH-FDN
Normalised cosmic spectrum for VH-FDN
Aircraft and Cosmic Background coefficients
Date: 22/1/99  Aircraft: VH-FDN

Slope = 0.050135, Intercept = 8.408830
Aircraft and Cosmic Background coefficients
Date: 22/1/99  Aircraft: VH-FDN

Slope = 0.041431, Intercept = 0.868507
Aircraft and Cosmic Background coefficients
Date: 22/1/99  Aircraft: VH-FDN

Slope = 0.045233, Intercept = 0.621294
Aircraft and Cosmic Background coefficients
Date: 22/1/99  Aircraft: VH-FDN

Slope = 0.877651, Intercept = 41.551666
Appendix 2  Spectral stripping results

The average deadtime corrected count rates for each of the calibration pads are shown below.

<table>
<thead>
<tr>
<th></th>
<th>Potassium</th>
<th>Uranium</th>
<th>Thorium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Background Pad</td>
<td>304.96</td>
<td>54.50</td>
<td>50.72</td>
</tr>
<tr>
<td>Potassium Pad</td>
<td>1059.46</td>
<td>57.87</td>
<td>44.28</td>
</tr>
<tr>
<td>Uranium Pad</td>
<td>660.64</td>
<td>572.8</td>
<td>84.12</td>
</tr>
<tr>
<td>Thorium Pad</td>
<td>665.64</td>
<td>281.53</td>
<td>692.60</td>
</tr>
<tr>
<td>Background Pad</td>
<td>307.43</td>
<td>54.58</td>
<td>49.03</td>
</tr>
</tbody>
</table>

The stripping ratios obtained were as follows:

<table>
<thead>
<tr>
<th>Stripping Coefficient</th>
<th>Coefficient Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>alpha ($\alpha$)</td>
<td>0.2811</td>
</tr>
<tr>
<td>beta ($\beta$)</td>
<td>0.4218</td>
</tr>
<tr>
<td>gamma ($\gamma$)</td>
<td>0.7445</td>
</tr>
<tr>
<td>a</td>
<td>0.06579</td>
</tr>
<tr>
<td>b</td>
<td>0.00107</td>
</tr>
<tr>
<td>g</td>
<td>0.00267</td>
</tr>
</tbody>
</table>
Appendix 3  

*Height attenuation calibration results*

<table>
<thead>
<tr>
<th>Potassium</th>
<th>Uranium</th>
<th>Thorium</th>
<th>Total Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.008248</td>
<td>-0.006234</td>
<td>-0.006904</td>
<td>-0.006708</td>
</tr>
</tbody>
</table>

The linear regression plots from which the above coefficients were obtained are given on the following four pages.
Height Attenuation coefficients
Date: 11/4/99 Test Range: Carnamah
Aircraft: VH-FDN.

Slope = -0.007362, Intercept = 6.544427
Height Attenuation coefficients
Date: 11/4/99 Test Range: Carnamah
Aircraft: VH-FDN.

Slope = -0.003302, Intercept = 4.381363
Height Attenuation coefficients
Date: 11/4/99 Test Range: Carnamah
Aircraft: VH-FDN.

Slope = -0.006146, Intercept = 5.926446

Ln Thorium vs. STP corrected height (metres)
Height Attenuation coefficients
Date: 11/4/99  Test Range: Carnamah
Aircraft: VH-FDN.

Slope = -0.005788, Intercept = 9.015802
Appendix 4  
Window sensitivity coefficient calibration results

The average ground concentrations for the test range on the 3-March 1998 were

<table>
<thead>
<tr>
<th>Radioelement</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potassium (%K)</td>
<td>3.19</td>
</tr>
<tr>
<td>Uranium (ppm)</td>
<td>4.82</td>
</tr>
<tr>
<td>Thorium (ppm)</td>
<td>36.94</td>
</tr>
</tbody>
</table>

The dose rate conversion factor is determined by the following formula

\[ nG/Hr = A = 13.1 \times K + 5.43 \times U + 2.69 \times Th \]

Thus the conversion factor is

\[ A = 13.1 \times 3.34 + 5.43 \times 6.22 + 2.69 \times 36.17 \]

\[ = 167.33 \text{ nG/Hr} \]

<table>
<thead>
<tr>
<th>STP Height (metres)</th>
<th>Potassium (cps)</th>
<th>Potassium Sensitivity</th>
<th>Uranium (cps)</th>
<th>Uranium Sensitivity</th>
<th>Thorium (cps)</th>
<th>Thorium Sensitivity</th>
<th>Total Count (cps)</th>
<th>Total Count Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>44.75</td>
<td>535.27</td>
<td>167.7962</td>
<td>72.98</td>
<td>15.14108</td>
<td>304.08</td>
<td>8.231727</td>
<td>6520.2</td>
<td>38.96607</td>
</tr>
<tr>
<td>92.55</td>
<td>358.39</td>
<td>112.348</td>
<td>57.5</td>
<td>11.92946</td>
<td>219.34</td>
<td>5.937737</td>
<td>4778.47</td>
<td>28.55713</td>
</tr>
<tr>
<td>142.66</td>
<td>243.85</td>
<td>76.44201</td>
<td>48.31</td>
<td>10.02282</td>
<td>156.78</td>
<td>4.24418</td>
<td>3535.69</td>
<td>21.13002</td>
</tr>
<tr>
<td>165.89</td>
<td>205.23</td>
<td>64.33542</td>
<td>44.16</td>
<td>9.161826</td>
<td>135.09</td>
<td>3.657011</td>
<td>3088.56</td>
<td>18.45788</td>
</tr>
<tr>
<td>260.37</td>
<td>105.73</td>
<td>33.1442</td>
<td>35.43</td>
<td>7.350622</td>
<td>75.2</td>
<td>2.035734</td>
<td>1864.45</td>
<td>11.14234</td>
</tr>
</tbody>
</table>

Plots of the sensitivity factors for each of Potassium, Uranium and Thorium and Total Count as a function of STP corrected height are on the following four pages.
Appendix 3  

*Height attenuation calibration results*

<table>
<thead>
<tr>
<th>Potassium</th>
<th>Uranium</th>
<th>Thorium</th>
<th>Total Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.008149</td>
<td>-0.006755</td>
<td>-0.006853</td>
<td>-0.006344</td>
</tr>
</tbody>
</table>

The linear regression plots from which the above coefficients were obtained are given on the following four pages.