ARTPIE PROC

TESLA-10

A.C.N. 009 039 918

PROCESSING REPORT

AIRBORNE GEOPHYSICAL SURVEY

NORTHWEST TASMANIA

for

Tasmania Development and Resources

by

Tesla-10 Pty Ltd
3 Fox Close
Kariong NSW 2250

Perth Office: 41 Kishorn Road, Applecross, Western Australia 6153
Telephone (09) 364 8444 Fax (09) 364 6575

Eastern Office: 3 Fox Close, Kariong, New South Wales 2250
Telephone: (043) 400 122 Fax (043) 400 155

CONTENTS

List of Figures

INTRODUCTION

Tesla Airborne Geoscience Pty Ltd (TAG) acquired airborne geophysical data for Tasmania Development and Resources over the Northwest Tasmania survey area. All final processing, as discussed in this report, was carried out by Tesla-10 Pty Ltd in their Kariong, NSW office.

EQUIPMENT AND SOFTWARE

Processing was carried out with the use of the following equipment and software.

DEC Alpha workstation
DEC Ultrix workstation
DEC Pentium PC
HP Designjet 650C
Exabyte 8mm Tape Subsystem

ERMapper 4.2 & 5.1
Tesla-10 Pty Ltd in-house software

SUMMARY: NORTHWEST TASMANIA

The following is a summary of the methods, parameters, coefficients, etc, used during the processing of the data from the Northwest Tasmania survey.

GENERAL

Date of Survey	April 1996
Contractor	Tesla Airborne Geoscience Pty Ltd
Tesla Job No.	TA2294
Aircraft	VH - BNZ
Terrain Clearance	90 m

NW Tasmania area lines

	Spacing	Direction	Number Range
Flight Lines	200m	090-270	100000-169999
Tie Lines	2000m	000-180	170000-199999

Norfolk Range sub-area lines

	Spacing	Direction	Number Range
Flight Lines	100m	162-342	200000-200669
Tie Lines	As practical	072-252	200670-200690

Navigation — Novatel GPS
Differentially post-processed

Acquisition System — Tesla TAG3

Coordinates

Projection	UTM
Coordinates	AMG Zone 55
Coordinate Datum	AGD 1984

MAGNETICS

Magnetometer	Scintrex Cesium vapour, Model CS2
Resolution	0.001 nT
Recording Interval	0.1 seconds (approximately 7 metres)
System Parallax	3.8 fids (fid = 0.1 seconds)
Diurnal Corrections	Base level: 62030 nT

IGRF Removal

1995 model upgraded for secular variation to April, 1996.

Base level: 62030 nT

Inclination: -71.98

Levelling — Tie-line and micro-levelling

RADIOMETRICS

Spectrometer	Exploranium GR820 Crystal volume 33.5 litres
Recording Interval	1.0 seconds (approximately 70 metres)
Region of Interest Windows	
Total Count	34 - 225
Potassium	110 - 126
Uranium	134 - 150
Thorium	194 - 225
Spectral Ratio Windows	
Potassium	102 - 133
Uranium	41 - 63 , 82 - 103 , 128 - 161
Thorium	65 - 90 , 189 - 232
Spectral Method Ratios	
Rr (Radon only)	1.089
Rg (Ground only)	0.220
Stripping Coefficients	
α (Th to U)	0.2658
β (Th to K)	0.3955
γ (U to K)	0.7800
a (U to Th)	0.0505
b (K to Th)	0.0000
c (K to U)	0.0060

Other Coefficients

	Cosmic	Aircraft Background	Radon Background	Height Correction
TC	0.8670	98.50	13.13	0.00737
K	0.0534	17.70	0.88	0.01150
U	0.0421	0.63	-	0.00950
Th	0.0428	1.51	0.05	0.00786

Levelling
- Tie-line
- Micro-levelling

DIGITAL TERRAIN

Digital Terrain Model (DTM)	=	GPS Altitude - Radar Altimeter
Levelling		Tie-line and micro-levelling

MAGNETIC DATA PROCESSING

PRINCIPAL STAGES

Magnetic data processing by Tesla-10 Pty Ltd proceeds in the following principal stages.

1. Raw data read into database

2. Latitude/longitude positions converted to easting/northing for survey zone and required geodetic datum.

3. Quality control plots and data produced

4. System parallax removed.

5. Diurnal corrections applied

6. IGRF removed.

7. Levelling : tie-line and micro-levelling as required.

8. Geophysical processes, as required (derivatives, etc).

Images, contours and profiles are produced during processing to monitor data integrity through all stages.

RAW DATA INPUT

Field data is loaded onto Tesla-10's DEC system and progressively added to the database. Flight logs and acquisition reports from TAG provide information on each flight. There is also regular contact between Tesla-10 processing personnel and TAG acquisition crews to discuss job progress, data quality and any reflights required.

QUALITY CONTROL

All aspects of magnetic data processing are subject to quality control. In addition to general statistics for each channel (maximum, minimum, s.d., etc), the following plots are produced.

I. Flight Path	Displays lines flown and their geographic positions.
II. System Noise	4th difference or high-pass cosine roll-off filters.
III. Ground Speed	Displays profiles of aircraft ground speed and highlights line sections with speeds outside pre-determined limits.
IV. Plan Deviation	Displays actual flight path but also highlights line sections deviated from the flight plan by a pre-determined distance.
V. Radar Altimeter	Displays profiles of radar altimeter and highlights line sections deviated from the planned survey height by a pre-determined distance.
VI. Profiles	Produced for data channels such as magnetics, diurnal, radalt, gpsalt, temperature, etc.
VII.Contours/Images	Used to monitor the effects of processes such as parallax correction, IGRF removal, levelling,etc.

SYSTEM PARALLAX

System parallax adjustments are performed by interpolating the position data to fit the magnetic data.

DESPIKING AND FILTERING

Despiking and/or filtering may be applied to the data channels as required or deemed necessary. Median and cosine roll-off filters are most commonly used, with a new, filtered channel produced and the raw data maintained.

Data may be interpolated through spikes using linear or polynomial fits.

DIURNAL CORRECTIONS

Raw diurnal data is subjected to a five-point median filter followed by a cosine roll-off low-pass filter. Profiles from each day are produced, displaying both raw and filtered data. Diurnal corrections are then applied to the compensated magnetic data using the filtered diurnal data, with the average diurnal value over the early stages of the survey used as the base level.

IGRF REMOVAL

The International Geomagnetic Reference Field is removed from the magnetic data using the most recently available model upgraded for secular variation to the date of acquisition. The height of the survey data is input from the GPS altitude data channel.

LEVELLING

Tie-line and micro-levelling is carried out after the above processes to produce final line data. Tie-line levelling uses a least squares process to calculate adjustments to be made at the intersection points to both the tie lines and the traverse lines, with constraints built in to prevent short wavelength variations in the adjustments.

Micro-levelling is used to remove minor residual errors.

RADIOMETRIC DATA PROCESSING

PRINCIPAL STAGES

Radiometric data processing proceeds in the following principal stages:

1. Each flight is checked for spectral stability.

2. 256 channel data is pre-processed to obtain data needed for Radon gas background removal.

3. Main processing carried out, following closely the prescription layed out in IAEA publication, “Technical Reports Series No. 323” (1991). Stages are:

    a) Filtering
    b) Background Removal
    c) Channel Stripping
    d) Height Corrections
    e) Tie-line and Micro-levelling

Coefficients for background removal and height corrections are obtained from test flights, as discussed in the following sections.

Stripping coefficients are obtained from pad tests.

BACKGROUND CORRECTION COEFFICIENTS

Cosmic and Aircraft Background Coefficients

This series of coefficients is obtained from multi-level flights, typically every 300 metres from 300 metres to 3,000 metres over the ocean, where the ambient count rate is negligible.

As with all other flights, the channel windows are selected symmetric about the peak, with the windows equal to the IAEA channel width specifications.

The channels, other than cosmic count, are corrected for dead-time. With the Exploranium GR820, the cosmic count is not subject to a variable dead-time. The live time with this instrument is automatically recorded, and dividing a channel count by this time provides the dead-time correction.

Plots of total count, potassium, uranium and thorium counts are plotted against cosmic count. The cosmic count increases exponentially with height, while the Compton scattering from cosmic rays into the channels is proportional to the cosmic count itself. Consequently, the points should fall on a straight line for each plot, with the slope providing the cosmic background corrections and the y-axis intercept the aircraft background count, for that channel.

Deviations from a straight line are invariably due to variations in Radon gas concentrations at different levels. If the deviations are excessive, re-flight is necessary.

Example plots of each channel versus cosmic count are shown in Figures 1 to 4.

Radon Gas Background Coefficients

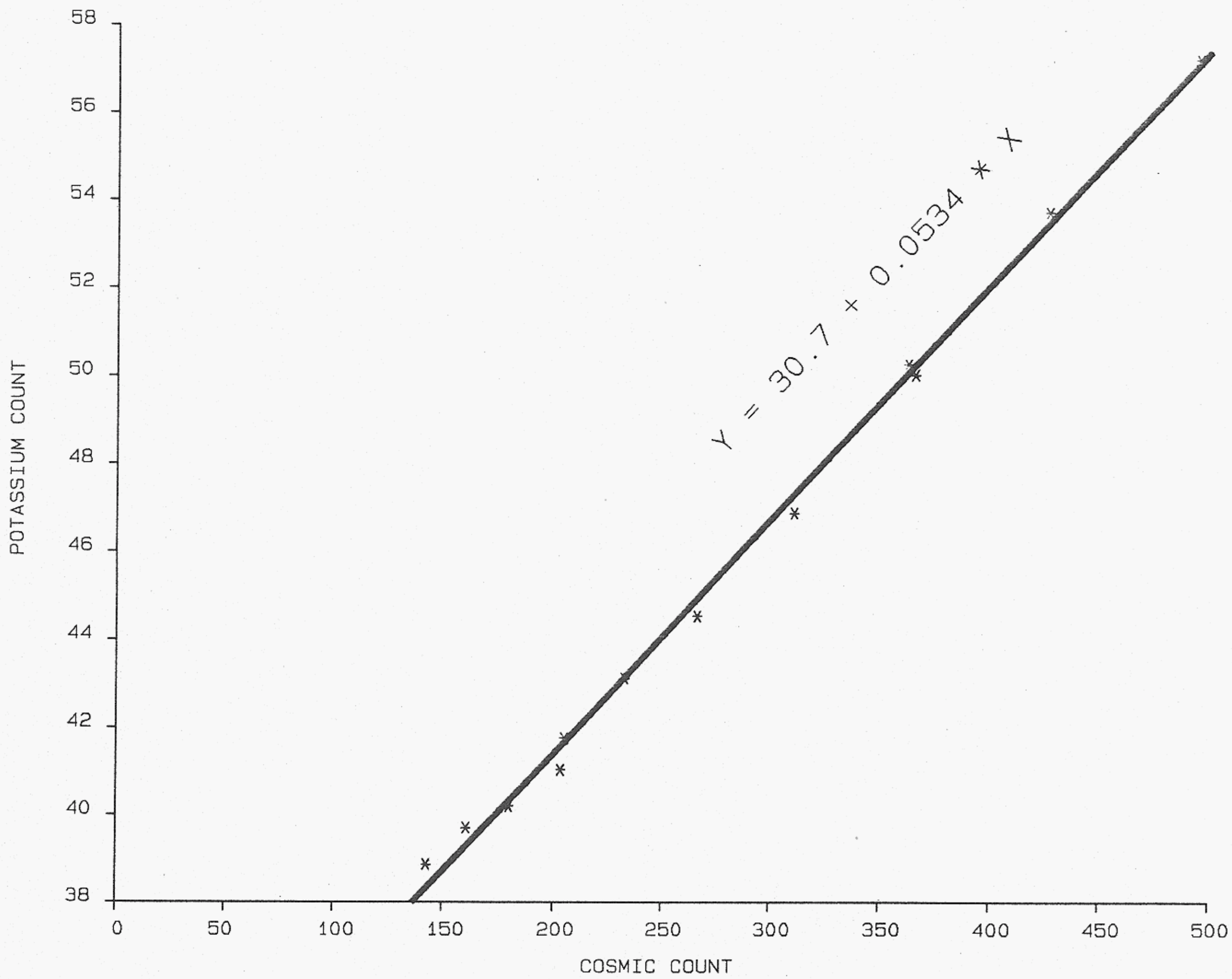
Radon gas background is calculated using the differential absorption spectral ratio technique. This separates the uranium count into a component due to the normal ground contribution and a component due to Radon gas in the atmosphere, by calculation of the ratio of the count rate of the Bismuth peak at 0.609 MeV to the count rate of the Bismuth peak at 1.76 MeV (the normal uranium channel). The measured ratio should lie between the ratio relevant to a pure ground source and the ratio due to a pure Radon gas source. The 0.609 MeV gamma rays are much more easily absorbed (or Compton scattered) than the 1.76 MeV gamma rays. Consequently, the ratio due to airborne Radon gas is considerably higher than that due to a pure ground source.

Further details of a non-confidential nature may be obtained from Tesla-10 Pty Ltd.

STRIPPING COEFFICIENTS

These are calculated from pad tests using standard sets of pads. The stripping coefficients are calculated by the solution to simultaneous equations describing the count rates as a function of the background, potassium, uranium and thorium pads.

The stripping coefficients used for the Northwest Tasmania survey processing were derived from pad tests carried out on August 15, 1995, at Jandakot Airport, Western Australia. Kevron pads were used.



TESLA-10 PTY. LTD.

ACQUISITION :

Aircraft: VH-BNZ
Flown: Aug17, 1995
Height stack over ocean

PROCESSING :

Mean ROI potassium count and mean ROI cosmic count at each height

PRESENTATION :

Cosmic count vs potassium count

Linear regression as blue line with algebraic relationship

Gradient is cosmic stripping ratio

Y-intercept is aircraft background

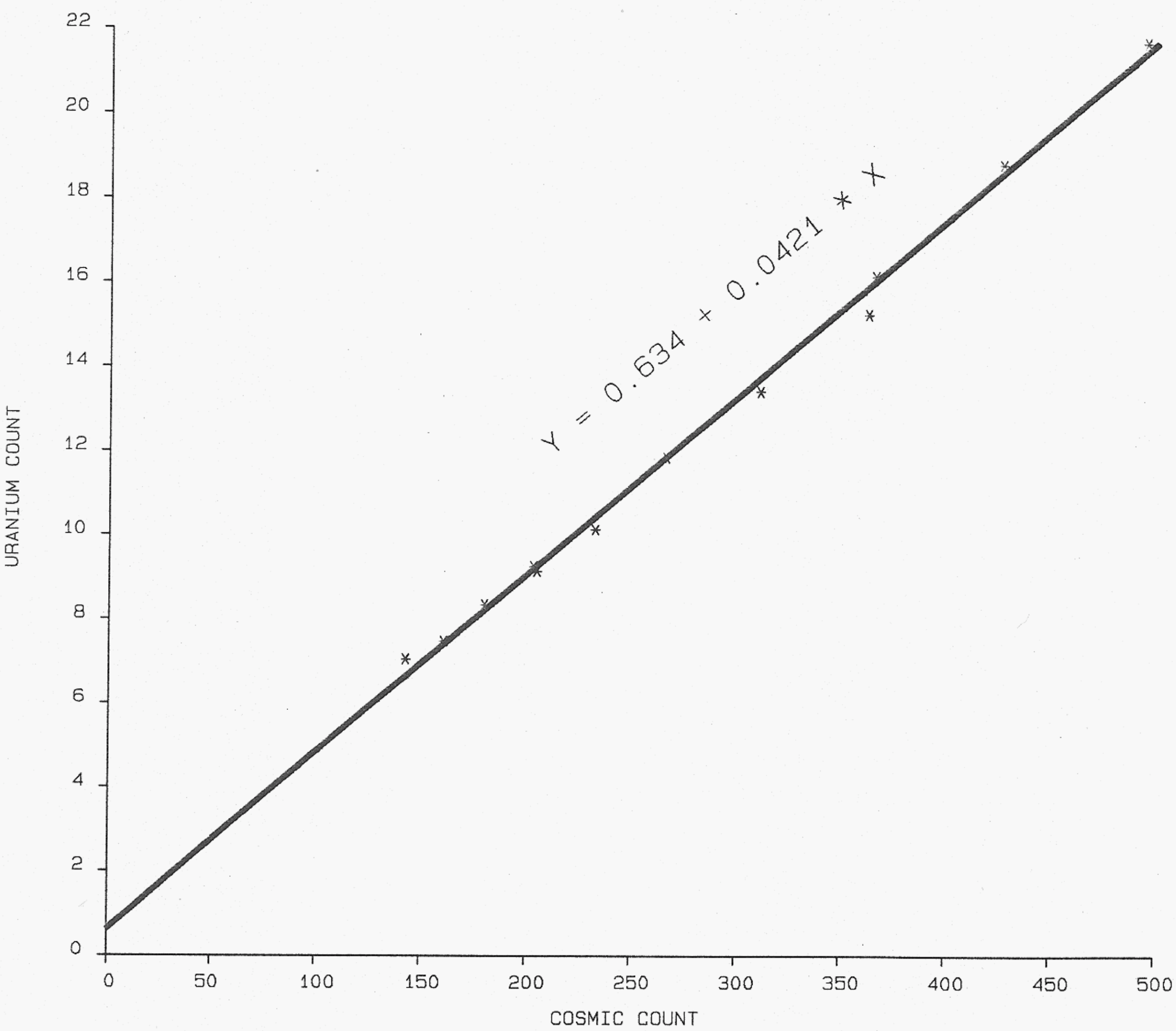
TESLA AIRBORNE GEOSCIENCE

OVER-OCEAN TESTS

MEAN POTASIUM COUNT VS MEAN COSMIC COUNT

VH-BNZ

FIGURE 1



TESLA-10 PTY. LTD.

ACQUISITION :

Aircraft: VH-BNZ
Flown: Aug 17, 1995
Height stack over ocean

PROCESSING :

Mean ROI uranium count and mean ROI cosmic count at each height

PRESENTATION :

Cosmic count vs uranium count

Linear regression as blue line with algebraic relationship

Gradient is cosmic stripping ratio

Y-intercept is aircraft background

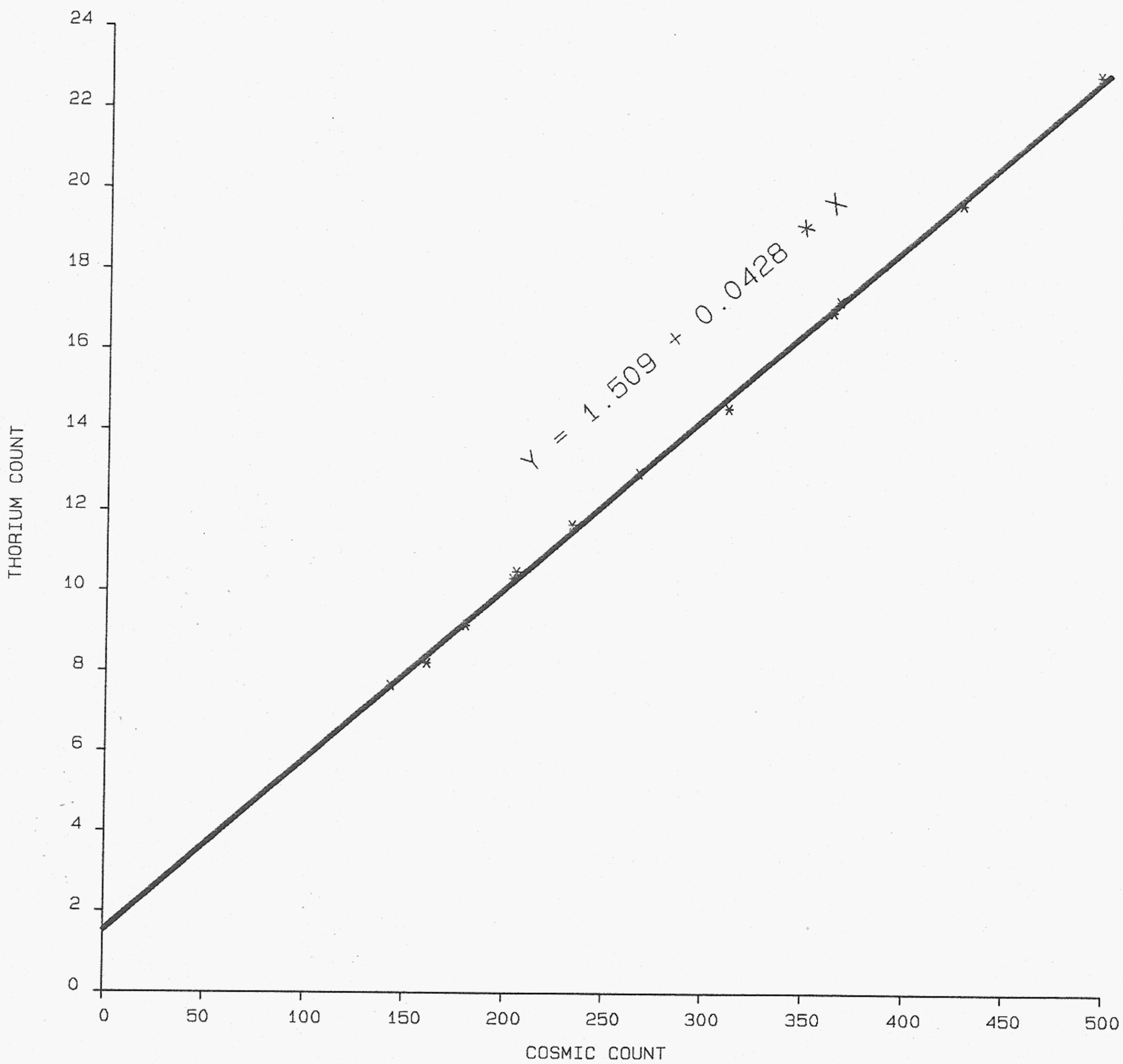
TESLA AIRBORNE GEOSCIENCE

OVER-OCEAN TESTS

MEAN URANIUM COUNT VS MEAN COSMIC COUNT

VH-BNZ

FIGURE 2



TESLA-10 PTY. LTD.

ACQUISITION :

Aircraft: VH-BNZ
Flown: Aug 17, 1995

PROCESSING :

Mean ROI thorium count and mean ROI cosmic count at each height

PRESENTATION :

Cosmic count vs thorium count

Linear regression as blue line with algebraic relationship

Gradient is cosmic stripping ratio

Y-intercept is aircraft background

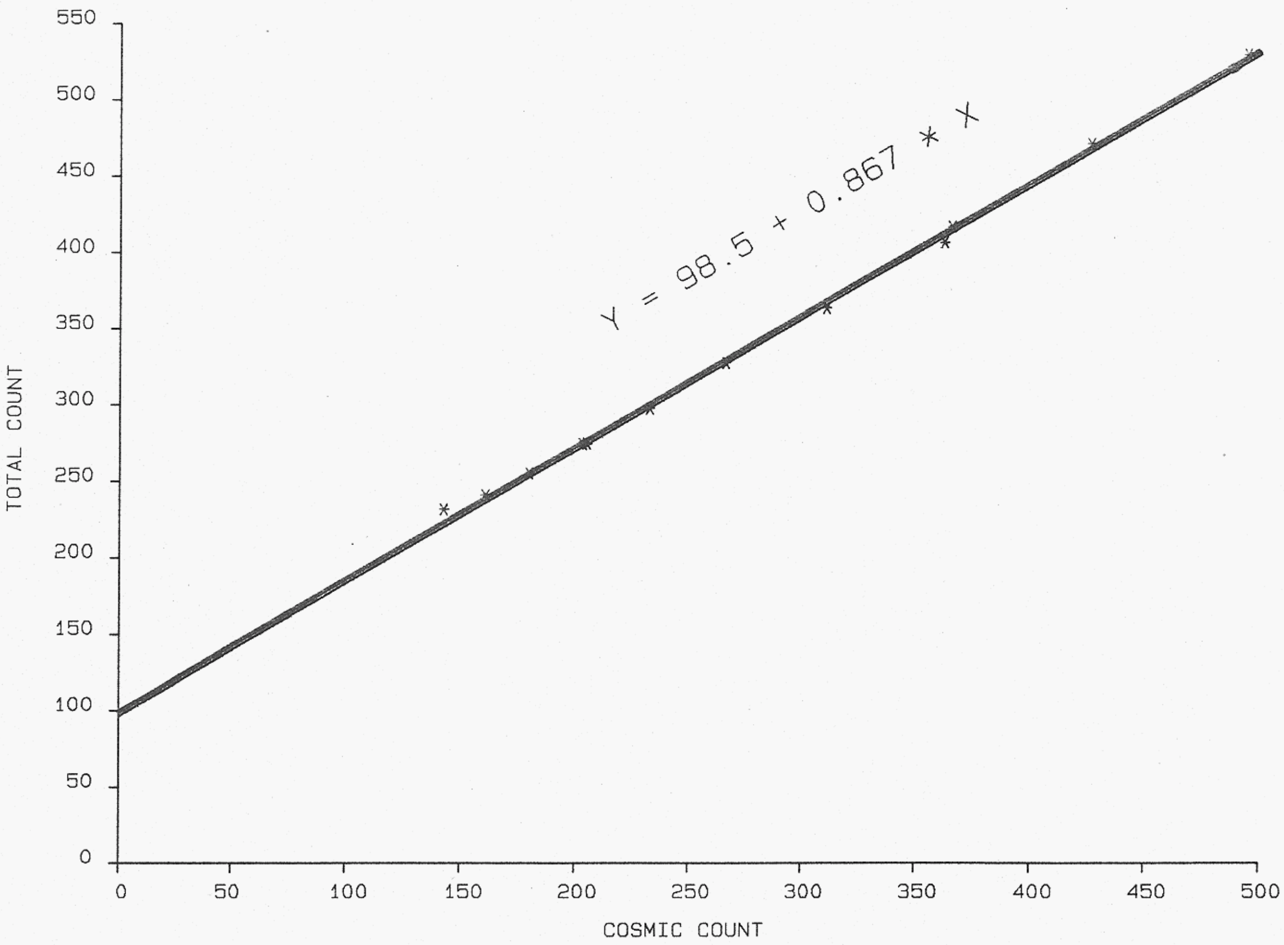
TESLA AIRBORNE GEOSCIENCE

OVER-OCEAN TESTS

MEAN THORIUM COUNT VS MEAN COSMIC COUNT

VH-BNZ

FIGURE 3



TESLA-10 PTY. LTD.

ACQUISITION :

Aircraft: VH-BNZ
Flown: Aug 17, 1995
Height stack over ocean

PROCESSING :

Mean ROI total count and mean ROI cosmic count at each height

PRESENTATION :

Cosmic count vs total count

Linear regression as blue line with algebraic relationship

Gradient is cosmic stripping ratio

Y-intercept is aircraft background

TESLA AIRBORNE GEOSCIENCE

OVER-OCEAN TESTS

MEAN TOTAL COUNT VS MEAN COSMIC COUNT

VH-BNZ

FIGURE 4

HEIGHT CORRECTION COEFFICIENTS

The count rates decrease exponentially with terrain clearance due to Compton scattering. The correlation coefficients to a nominal terrain clearance are derived from low-level flights on a test line, typically every 20 metres from 40 metres to, say 200 metres. The measured heights are corrected to STP, and the usual dead-time, background and stripping corrections are applied to get corrected counts. The natural logarithm of the count rates plotted versus corrected height should lie on straight lines, whose slopes give the required height correction coefficients. It is necessary that the test line should be in an area of fairly uniform count rates for all channels, and be flown on a day fairly free of airborne Radon gas.

The height correction coefficients used for the Northwest Tasmania processing were determined from height stacks flown over the Albury Test Range on December 15, 1995. The subsequent regression plots are given as Figures 5 to 8.

256 CHANNEL PRE-PROCESSING

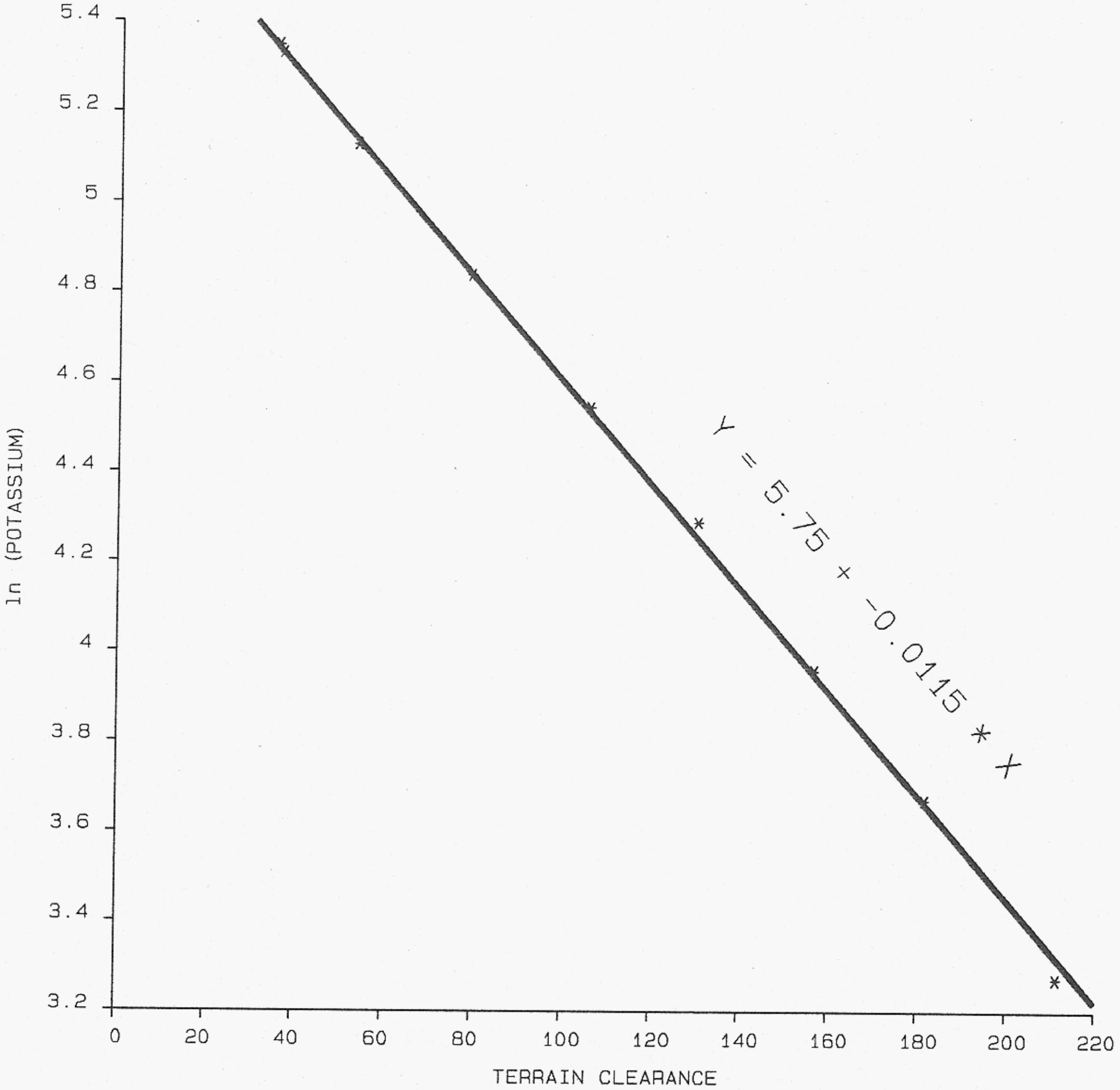
Spectral Verification

256 channel plots are produced of each flight carried out, with each line of the flight plotted separately and the channel windows for the usual potassium, uranium and thorium peaks shown as boxes. Each of the three main peak channel locations are calculated and displayed on the plot as a dashed line. The test flight has a separate display of the minimum, mean and maximum counts, for comparison from flight to flight. The thorium count on the test line should be stable to within 5% or so, as it is almost unaffected by airborne Radon gas variations.Similar plots are produced for the daily button source tests.

Raw Count Rate Extraction

The count rates actually used for final processing are obtained by summing the 256-channel data over the IAEA windows, defined by the central peak locations, to the nearest channel, and with the IAEA width, with the energy to channel conversion rate, about 12 keV per channel.

On the rare instances where significant deviations of the peak positions occurred, these were accounted for line by line.



TESLA-10 PTY. LTD.

ACQUISITION :

- Aircraft: VH-BNZ
- Flown: Dec 15, 1995
- Job: TA2243
- Flight: 076
- Height stack over line of DTR
- Flying heights: 60, 90, 120, 150 ...240 metres

PROCESSING :

Height corrected to STP

Count rate corrected for aircraft and cosmic background

Terrain clearance from radar altimeter

PRESENTATION :

Linear regression as blue line with algebraic relationship

Gradient is POTASSIUM attenuation coefficient

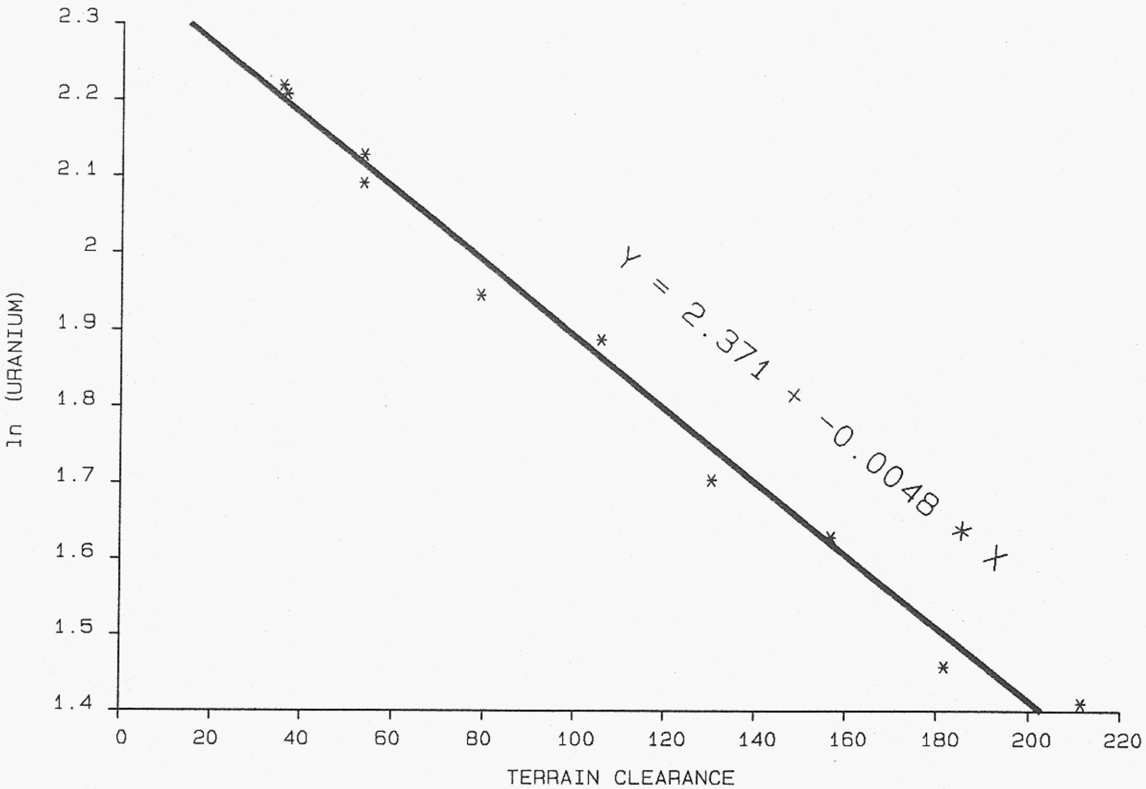
TESLA AIRBORNE GEOSCIENCE

HEIGHT ATTENUATION TEST

LN (POTASSIUM) VS TERRAIN CLEARANCE

ALBURY TEST LINE

FIGURE 5



TESLA-10 PTY. LTD.

ACQUISITION :

Aircraft: VH-BNZ
Flown: Dec 15, 1995
Job: 2243
Flight: 076
Height stack over line of DTR
Flying heights: 60, 90, 120, 150 ...240 metres

PROCESSING :

Height corrected to STP

Count rate corrected for aircraft and cosmic background

Terrain clearance from radar altimeter

PRESENTATION :

Linear regression as blue line with algebraic relationship

Gradient is URANIUM attenuation coefficient

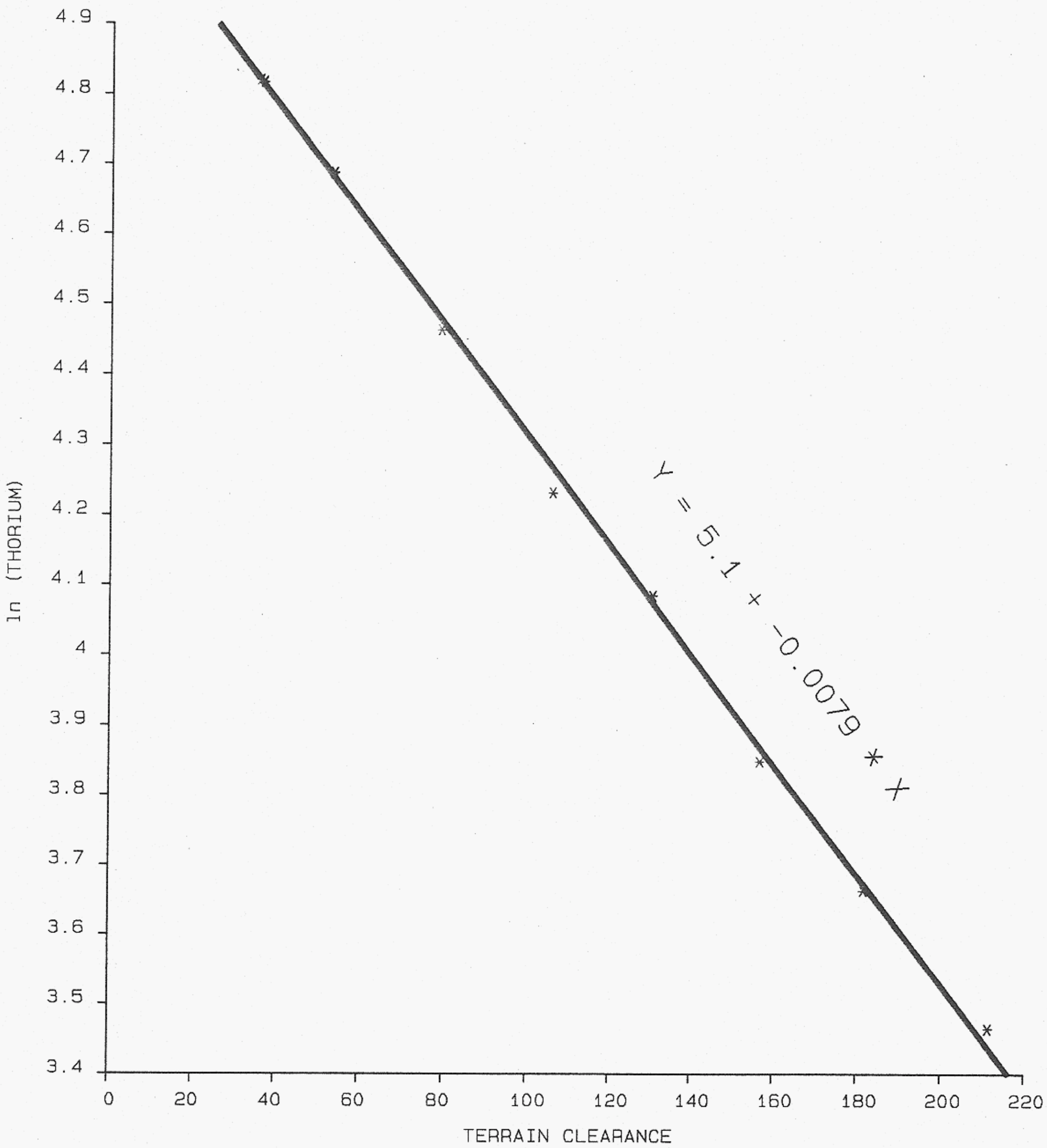
TESLA AIRBORNE GEOSCIENCE

HEIGHT ATTENUATION TEST

LN (URANIUM)
VS TERRAIN CLEARANCE

ALBURY TEST LINE

FIGURE 6



TESLA-10 PTY. LTD.

ACQUISITION :

Aircraft: VH-BNZ
Flown: Dec 15, 1995
Job: 2243
Flight: 076
Height stack over line of DTR
Flying heights: 60, 90, 120, 150 ...240 metres

PROCESSING :

Height corrected to STP

Count rate corrected for aircraft and cosmic background

Terrain clearance from radar altimeter

PRESENTATION :

Linear regression as blue line with algebraic relationship

Gradient is THORIUM attenuation coefficient

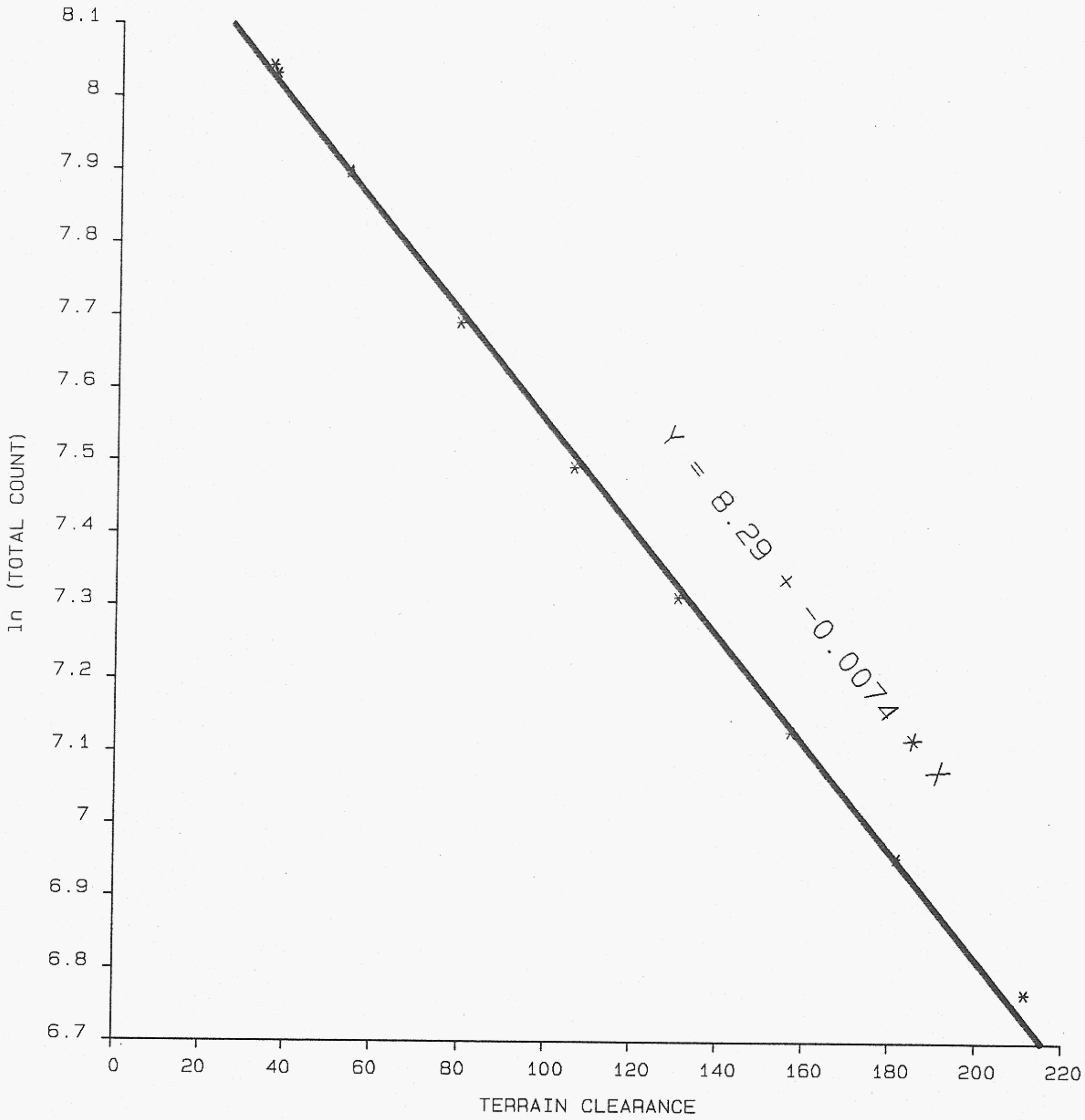
TESLA AIRBORNE GEOSCIENCE

HEIGHT ATTENUATION TEST

LN (THORIUM) VS TERRAIN CLEARANCE

ALBURY TEST LINE

FIGURE 7



TESLA-10 PTY. LTD.

ACQUISITION :

Aircraft: VH-BNZ
Flown: Dec 15, 1995
Job: 2243
Flight: 076
Height stack over line of DTR
Flying heights: 60, 90, 120, 150 ...240 metres

PROCESSING :

Height corrected to STP

Count rate corrected for aircraft and cosmic background

Terrain clearance from radar altimeter

PRESENTATION :

Linear regression as blue line with algebraic relationship

Gradient is TOTAL COUNT attenuation coefficient

TESLA AIRBORNE GEOSCIENCE

HEIGHT ATTENUATION TEST

LN(TOTAL COUNT) VS TERRAIN CLEARANCE

ALBURY TEST LINE

FIGURE 8

Radon Gas Correction Ratios

The 0.609 MeV peak correlation value, the 1.76 MeV peak correlation value, and the ratio of the first to the second, were obtained by the method described above, using exactly the same modified source spectral windows as used for the calibration of the ratios from the daily test flights. Very long filters are used to ensure that artificial anomalies are not introduced into the data, and to ensure stability of the ratios. Within a flight, the filters wrap around from one line to the next, to largely eliminate end effects. This methodology is consistent with a model of the distribution of airborne Radon gas as being slowly varying both spatially and temporally.

FINAL PROCESSING

Filtering

A very light filter is applied to the channel data to smooth out the worst of the 'saw-tooth' statistical variation.

Generally, longer filters are applied to such parameters as height, temperature, pressure etc.

Dead Time Correction

The live-time is automatically recorded by the GR820 spectrometer, so dead-time corrections involve the simple division of the channel count by the live-time, which is typically about 830 milliseconds. The cosmic count is not affected by dead-time and is not corrected.

Background Corrections

The cosmic stripping coefficients multiplied by the cosmic count are subtracted from the channel counts, as are the aircraft backgrounds.

The Radon background correction for the uranium channel is carried out as follows:

$$\text{Airborne Radon Uranium Count} = \left(\frac{R - Rg}{Rr - Rg}\right) \text{Uranium count}$$

R is the 0.609 MeV uranium correlation to 1.76 MeV uranium correlation ratio, while Rg is this ratio for a pure ground uranium source, and Rr the same ratio for a pure airborne Radon gas uranium source. R should be intermediate between Rr and Rg, depending upon the airborne concentration of Radon gas.

The airborne Radon gas uranium count component is removed from the uranium count, and the contribution to the other channels calculated by application of the Radon gas stripping coefficients. These in turn are removed from the respective channels, including the total count.

Stripping

The potassium, uranium and thorium count rates are corrected for Compton scattering from the other channels. The coefficients themselves are corrected to the STP corrected height using the theoretical linear corrections appropriate to the three primary stripping coefficients.

Height Corrections

Corrections to the nominal terrain clearance are made using STP corrected heights and the absorption factors appropriate to exponentially decreasing count rates with height.

LEVELLING

Minor levelling is still required after the above processing sequence, because of errors in the Radon gas background corrections and other factors such as soil moisture diurnal variations.

Tie-line levelling

Long Filters are used on both tie-lines and flight lines at the intersection points. The corrections actually applied are in the form of low order polynomials along both tie-lines and flight lines. A least squares process is used to calculate adjustments to be made at the intersection points to both the tie lines and the flight lines, with constraints built in to prevent short wavelength variations in the adjustments.

Micro-levelling

Very minor residual errors are removed by micro-levelling

DIGITAL TERRAIN MODEL

The digital terrain model (DTM) is produced by subtracting radar altimeter (radalt - height above ground) from GPS altitude (gpsalt - height above mean sea level). The gpsalt channel is corrected to the Australian Height Datum and interpolated from 1.0 second to 0.1 second data to match radalt. Both channels are despiked and/or filtered. Tie-line and micro-levelling are applied.

Tesla-10 Pty Ltd
June, 1996