ASEG-PESA 2015
Geophysics and Geology together for Discovery
24th International Geophysical Conference and Exhibition
15–18 February 2015 Perth, Western Australia

Monitoring airborne gamma ray spectrometer sensitivities using the natural background.

R.L. Grasty
GammaBob Inc.
3924 Shirley Avenue
Ottawa, Ontario,
K1V1H4 Canada
grasty@rogers.com

M. P. Bates
Sander Geophysics Ltd.
260 Hunt Club Road
Ottawa, Ontario,
K1V1C1 Canada
mbates@sgl.com

A. Smetny-Sowa
Sander Geophysics Ltd.
260 Hunt Club Road
Ottawa, Ontario
K1V1C1 Canada
asmetny@sgl.com

SUMMARY

In many airborne gamma-ray surveys, uranium and thorium sources are required to verify that the airborne system maintains the same sensitivity for each survey flight. Recently, due to radioactive material regulations, it has become increasingly difficult to transport these radioactive sources around the world. Measurements of the natural radioactivity of the ground, recorded as part of source tests carried out in Tanzania were analysed. These data involved three different aircraft at two bases of operation. The results have shown that in all cases the potassium and thorium background measurements were more consistent than the measurements from the uranium and thorium sources. In addition, the variations in the potassium and thorium measurements could be reduced even further by removing the effect of airborne radon daughter fluctuations using stripping ratios derived from measurements on concrete calibration pads.

Key words: Gamma-Ray, Surveys, Airborne, Sources.

INTRODUCTION

In airborne gamma ray surveys it is important to verify that the potassium, uranium and thorium system sensitivities have remained constant throughout the survey. The International Atomic Energy Agency (IAEA) has recommended the use of thorium and uranium source tests to achieve this and has described the procedure (IAEA, 1991). They have recommended that if a source check gives results that differ by more than 5% from the average value of previous measurements, the cause of the change should be investigated.
Uranium and thorium source tests are included in the contract for most large airborne gamma-ray surveys carried out around the world. However, in recent years, due to the strict regulations in transporting radioactive material, it has become increasingly difficult to move these sources across country boundaries. In order to overcome this problem, we have investigated using the natural radioactivity of the ground to verify that the sensitivities of the airborne system have remained constant during the course of the survey.

In 2013, Sander Geophysics (SGL) carried out an airborne gamma ray survey that covered a large area in Tanzania. The survey used 3 aircraft, each of which carried two airborne detector packs with four 10.2 x 10.2 x 40.6 cm (4 x 4 x 16 inch) downward looking sodium iodide detectors. Each pack also had a single upward looking detector for monitoring radon variations. The airborne contract specified the use of uranium and thorium sources before and after each survey flight to check that the system sensitivities remained constant.

In order to measure the response of the spectrometers to the uranium and thorium sources, a background measurement of the ground beneath the aircraft is required. As recommended by the IAEA, these background measurements were recorded for at least 60 seconds. This was then followed by measurements of at least 60 seconds for the uranium and thorium sources. For each source test, sources were mounted in cradles beneath the centres of each of the two aircraft packs approximately 30 cm from the underside of each pack. The results of the uranium and thorium source tests were then compared with the background measurements of the count rates in the potassium, uranium and thorium windows.

Due to the large area of the survey, there were two different bases of operation. Consequently, source test and background measurements were available for analysis at two different locations. The results of the background measurements and source tests were compared for the 3 aircraft at the two bases. At the first base of operations, Dodoma airport, each of the 3 aircraft flew approximately 300 survey flights. Consequently there were approximately 900 source and background measurements available for analysis. At the second base, Kilimanjaro airport, each aircraft flew approximately 70 survey flights resulting in approximately 210 source and background measurements. In this paper, all figures use data recorded for aircraft C-GSGJ at Kilimanjaro airport.

RESULTS

Due to variations in radon daughter concentrations in the air, the uranium background cannot be used to monitor sensitivity variations. This is illustrated in Figure 1 where the peak values in the measurements can be explained by increases in airborne radon daughter concentrations. Several of these increases exceed 5

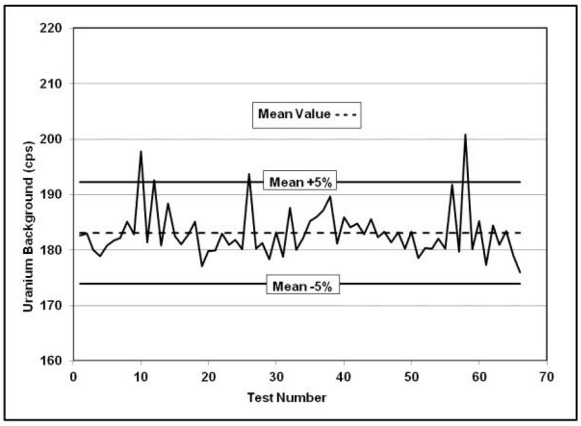

Figure 1. Variation in the uranium background.

Figures 2 and 3 show the results of the uranium and thorium source tests together with the mean value and the 5 percent control levels. The standard deviation of all the measurements as a percentage of the mean value is also indicated on both figures. The uranium and thorium source tests both show one measurement exceeding 5 percent of the mean value. The reason for this would have required investigation.

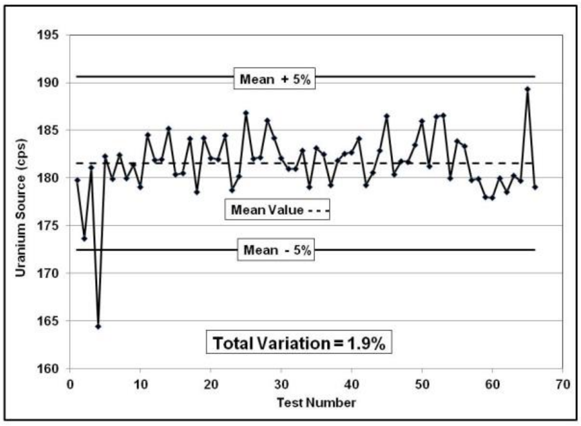

Figure 2. Results of the uranium source tests.

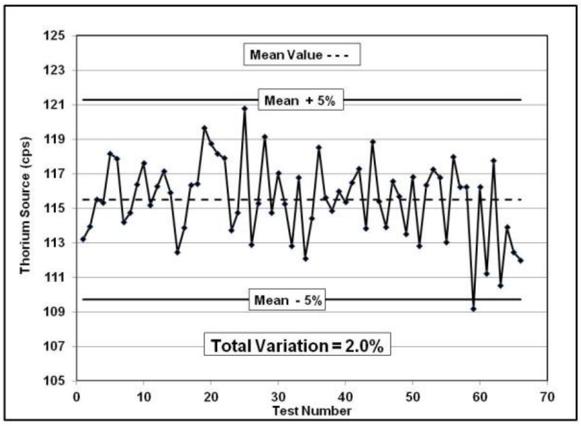

Figure 3. Results of the thorium source tests.

percent above the mean value of all 65 measurements. Figures 4 and 5 show the thorium and potassium background measurements that were recorded prior to the measurements of the uranium and thorium sources.

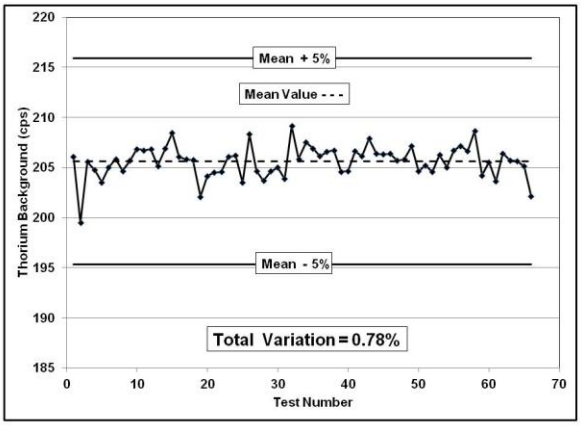

Figure 4. Thorium background measurements.

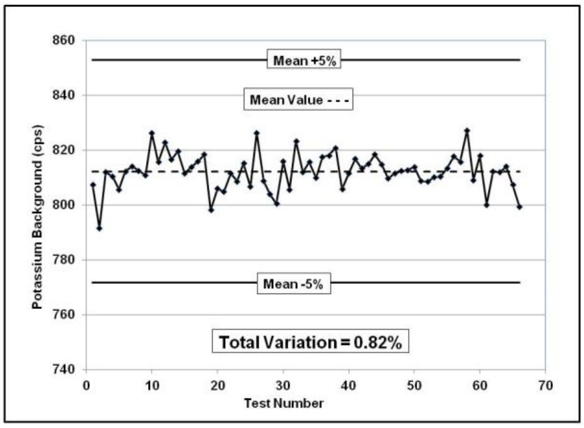

Figure 5. Potassium background measurements

Some of the variation in the potassium background can be attributed to daily variations in radon daughter concentrations in the air. A gamma ray spectrum of airborne radon is almost identical to a uranium spectrum from the ground since almost all gamma rays from uranium and radon daughters originate from bismuth-214 and lead-214. Consequently, it is possible to remove variations in the potassium window due to radon using the uranium/potassium stripping ratio obtained from measurements on calibration pads (Grasty et al. 1991).

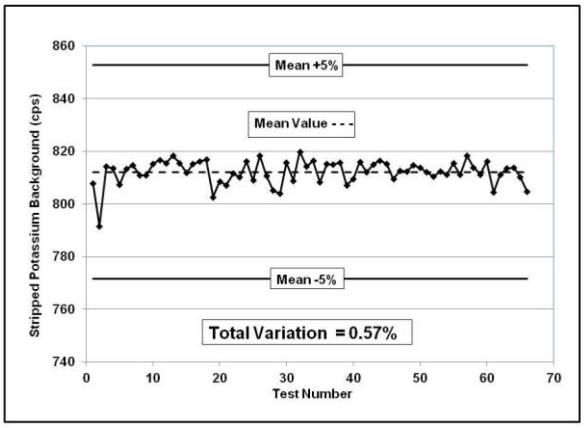

Figure 6. The stripped potassium background

Figure 6 shows the stripped potassium backgrounds where any changes in the uranium window count rate (Figure 1) from the mean value were stripped from the potassium values. The variation in the stripped potassium value of 0.57 percent is significantly reduced from the unstripped value of 0.82 percent. An analysis of the thorium backgrounds showed a smaller but significant decrease in the variation of the stripped thorium compared to the unstripped value.

Table 1 gives a summary of the variations in the measurements of the uranium and thorium sources for all three aircraft at the two survey bases. The variations in the stripped and unstripped potassium and thorium backgrounds are also shown. In the case of aircraft C-GSGY, the values shown in the table are for the first 250 measurements since the aircraft was moved closer to the edge of the parking area after the earlier measurements. Similarly, the results for aircraft C-GSGL only include the first 116 measurements.

CONCLUSIONS

1) For three airborne gamma ray spectrometer systems operating at two different bases in Tanzania, the potassium and thorium ground measurements have a significantly smaller variation than those for the uranium and thorium sources. Therefore, for the surveys in Tanzania, the use of uranium and thorium sources for monitoring system sensitivities was not necessary.
2) Variations in the potassium and thorium ground measurements due to radon daughter fluctuations were reduced even further using uranium/potassium and uranium/thorium stripping ratios derived from measurements on concrete calibration pads.
3) The use of ground measurements of potassium and thorium for monitoring system sensitivities depends on maintaining a consistent location for the aircraft.
4) The background measurements were taken when the aircraft were parked on asphalt parking ramps. The results could have been quite different if the aircrafts were parked on grass or gravel where changes in the moisture content of the ground could increase the variation of the potassium and thorium backgrounds.

REFERENCES

IAEA, 1991, Airborne Gamma Ray Spectrometer Surveying: Technical Report Series 323, International Atomic Energy Agency, Vienna, Austria.

Grasty, R.L., Holman, P.B., and Blanchard, Y.B., 1991, Transportable calibration pads for ground and airborne gamma-ray spectrometers: Geological Survey of Canada Paper 90-23.

Table 1. The uranium and thorium source test measurements and the stripped and unstripped potassium and thorium backgrounds for surveys carried out in Tanzania.

		The standard deviation as a percentage of the mean value					
Aircraft	Airport	U-Source	T-Source	K- Background	Stripped K- Background	T-Background	Stripped T-Background
C-GSGJ	Kilimanjaro	1.9	2.0	0.82	0.57	0.78	0.73
C-GSGL	Kilimanjaro	2.5	2.8	0.67	0.45	0.77	0.73
C-GSGY	Kilimanjaro	2.7	2.4	0.52	0.34	0.52	0.48
C-GSGJ	Dodoma	1.4	1.9	1.2	1.2	1.3	1.3
C-GSGL	Dodoma	1.7	4.0	1.0	1.0	1.2	1.1
C-GSGY	Dodoma	2.8	2.4	1.1	1.2	1.4	1.4