AIRBORNE GAMMA - RAY SPECTROMETRY SURVEY

URANIUM CITY - ELDORADO
SASKATCHEWAN

Flown August 10, 1976

Geological Survey of Canada

Resource Geophysics and Geochemistry Division

Department of Energy, Mines and Resources
INTRODUCTION

On August 10, 1976, the Geological Survey of Canada, at the request of the Atomic Energy Control Board, flew airborne gamma-ray spectrometry surveys over Uranium City and the Eldorado townsite in Northern Saskatchewan.

The surveys were made with the high sensitivity spectrometer system installed in the GSC Skyvan aircraft. The spectrometer, with twelve 22.86 cm diameter x 10.16 cm thick sodium iodide detectors (50,040 cc. detector volume), was flown at 500 feet above ground level, at 120 knots. Counts were measured over 0.5 second intervals in four windows over the following energy ranges:

<table>
<thead>
<tr>
<th>Window</th>
<th>Energy Range</th>
<th>Photon Energy</th>
<th>Nuclide Measured</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Count</td>
<td>0.41 - 2.81 Mev</td>
<td>1.46 Mev</td>
<td>K⁴⁰</td>
</tr>
<tr>
<td>Potassium</td>
<td>1.36 - 1.56 Mev</td>
<td>1.46 Mev</td>
<td>Bi²¹⁴</td>
</tr>
<tr>
<td>Uranium</td>
<td>1.66 - 1.86 Mev</td>
<td>1.76 Mev</td>
<td></td>
</tr>
<tr>
<td>Thorium</td>
<td>2.41 - 2.81 Mev</td>
<td>2.62 Mev</td>
<td>Tl²⁰⁸</td>
</tr>
</tbody>
</table>

The data were corrected for background (due to atmospheric radon, radioactivity of the aircraft and instrumentation, and cosmic radiation), for deviations from planned survey altitude, and for spectral scattering. The results are presented as gamma ray counts which are proportional to
the concentration of the measured nuclide. However, with the survey parameters (500 foot terrain clearance and 0.5 second counting time, during which period the aircraft travels approximately 30 metres) each half-second count gives an indication of the radionuclide concentration over an oval-shaped area on the order of 300 metres wide and 330 metres long, lying along the flight path. An effect of this integration of the gamma radiation over a large area, is that small or point sources of contamination produce relatively lower airborne count rates than would be measured at ground level. Also, small sources of high radioelement concentration can be detected by the airborne system when the aircraft is on the order of 150 metres distant from the source. Consequently, point sources on the ground may appear to be 300 metres or so in diameter on the airborne results.

The surveys included in this report comprise a total of approximately 80 line kilometres. This is made up of i) 31 flight lines over Uranium City, which were used to compile a contour map and a profile map of the Bi$^{214}$ count rate; ii) one flight line directly over the hospital on the north side of Uranium City; and iii) three flight lines over Eldorado.

Uncontrolled photomosaics used as base maps for these surveys were not sufficiently accurate to warrant spacing the survey lines at closer than 120 metres (400 feet).
GEOLOGY

A geological map of the Uranium City area (from L. P. Tremblay, 1972, Geology of the Beaverlodge Mining Area, Saskatchewan. GSC Memoir 367) is shown in Figure 1. The survey area is cut by the northeast trending Black Bay Fault, rocks southeast of the fault are arkose and conglomerate, those northwest of the fault are granite, impure quartzite and amphibolite.

Tremblay gives the uranium content of some of these rock types.

<table>
<thead>
<tr>
<th>Rock Type</th>
<th>Uranium Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Granite</td>
<td>5.4 ppm (15 specimens, range 1.0 - 13.0 ppm)</td>
</tr>
<tr>
<td>Impure Quartzite</td>
<td>4.3 ppm (5 specimens, range 3.4 - 6.8 ppm)</td>
</tr>
<tr>
<td>Amphibolite</td>
<td>0.8 ppm (15 specimens, range 0.3 - 2.7 ppm)</td>
</tr>
</tbody>
</table>

GSC experience gained from ground follow-up of previous Skyvan spectrometer surveys indicates that airborne count rates in the uranium channel, over the above three rock types should average approximately 40 counts per second for the granite, 30 counts per second for the quartzite and 10 counts per second for the amphibolite.

RESULTS

Figure 2 shows the stacked profiles (from bottom to top: total count, potassium, equivalent uranium, equivalent thorium, eU/eTh, eU/K, eTh/K, and altimeter) for the survey line over the hospital. The vertical scales are in counts per 0.5 seconds. The flight line location is shown on the photo strip below the profiles. Count rates over the hospital appear normal. Approximately 400 metres to the east of the hospital, a Bi$^{214}$ anomaly is apparent in the uranium trace, and also in
the total count, \( \text{eU/eTh} \) and \( \text{eU/K} \) traces. The \( \text{Bi}^{214} \) count rate over this anomaly reaches a maximum of about 140 counts per second.

Figure 3 is the photomosaic base with an overlay showing \( \text{Bi}^{214} \) profiles plotted along each of the survey flight lines. The scale of this illustration is the same as Figure 2. The map scale is approximately 1:15,750 (1 cm = 157.5 m.) and the vertical scale on the profiles is 400 cps/inch or 157 cps/cm. The anomaly shown in Figure 2, is seen northeast of the hospital, on flight lines 28 through 31. This anomaly lies along a mapped geological contact between arkose and conglomerate. Since the anomaly does not continue south along the mapped contact, and since the \( \text{Bi}^{214} \) anomaly is not accompanied by an anomaly in the thorium channel (on Figure 2) it seems probable that this anomaly is due to contamination.

The most prominent anomaly on Figure 3 is at the west end of lines 21, 22 and 23, with a maximum count rate of 640 counts per second. This is located over the Cayzor Mine shaft on the shore of Jean Lake.

The western ends of flight lines 1 to 6 also show increases in \( \text{Bi}^{214} \), in the area of the St. Michael shaft.

Each of the profiles from line 6 to 24 shows an anomaly over the main road running northeast through Uranium City. On most of these flight lines, fiducial number 1 is located at the road. This anomaly reaches a maximum amplitude of nearly 200 counts per second on line 22.

The distribution of the high \( \text{Bi}^{214} \) values is clearly shown in Figure 4, which is a contour map of corrected counts in the uranium window, contoured in counts per 0.5 seconds. The background levels to the east and west of
the town are generally below 40 cps, i.e. in the range expected over bedrock containing 4 or 5 parts per million of uranium. Almost the entire area of the town, the area northeast of the hospital, and the two mine shaft locations west of Uranium City are above 40 cps.

Figure 5 is a photomosaic of Eldorado, showing the location of 3 survey lines flown in a northeast direction over the townsite. The scale of the mosaic is approximately 1:4000 (1 cm = 40 m). Figures 6, 7 and 8 are profiles along the 3 flight lines, plotted at the same scale. The vertical scales on the profiles are in counts per 0.5 seconds. Each of the profiles shows high Bi\textsuperscript{214} count rates over the town; profile 3 shows the sharpest anomaly approaching 400 cps, and centered over the highway.
SUMMARY

The airborne gamma-ray spectrometer survey of Uranium City, carried out by the Geological Survey of Canada in August 1976, indicates a background radiation level, in the uranium window, ranging up to 40 counts per second. This level is consistent with published values of uranium concentration for rock types in the area.

Four areas of higher radioactivity are located by the survey:

1. An area including most of the buildings and roads in the town. Maximum count rate, at the northern end of the town, = 200 cps.

2. An area 400 metres east of the hospital. Maximum count rate = 140 cps.

3. The Cayzor Mine shaft area. Maximum count rate = 640 cps.


A fifth area, northwest of the hospital, has count rates approaching 70 cps; this may be the result of natural variations in uranium content of the rocks.

The Eldorado townsite is underlain by the same granitic rock type as the western part of the Uranium City survey area. Three flight lines over the town site give maximum count rates in the uranium window of 380 cps.