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COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS.

RECORDS

1956, No.99

AIRBORNE SCINTILLOGRAPH SURVEY, TASMANIA, 1955.

by

L.E. HOWARD

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ILLUSTRATIONS

Plate 1	Map showing areas surveyed

NOTE The radioactive anomaly maps listed below are referred to in the report, and copies can be obtained on application from:-

(a) The Director of Mines,
Department of Mines,
Box 177E, G.P.O.,
Hobart, Tasmania.

(b) The Director,
Bureau of Mineral Resources,
485, Bourke Street,
Melbourne, Victoria.

G 202	Smithton - Table Cape
G 203	Trowutta - Burnie
G 204	Beaconsfield District
G 205	Balfour
G 206	Magnet - Välentine's Peak (Waratah District)
G 207	Moina District
G 208	St. Helens
G 209	Ben Lomond - Snow Hill (Avoca District)
G 210	Zeehan - Murchison
G 211	Queenstown District
G 212	Royal George District
G 213	Commonwealth Creek District

ABSTRACT

An airborne scintillograph survey was conducted in Tasmania during March and April 1955 by officers of the Commonwealth Bureau of Mineral Resources. An Auster aircraft was used to carry equipment and personnel. Eleven separate districts totalling about 1,500 square miles of country were surveyed.

Several areas showing radioactive anomalies were found, but most of these anomalies were recorded over granite outcrops. Some of the anomalies detected from the air were later investigated on the ground, and most were found to be due to large areas of outcrop, mostly of granite.

Although further ground investigation of these anomalies may be warranted, it is considered that in general the chance of finding any economic deposits of uranium-bearing minerals in the areas surveyed is not encouraging. The large anomalies recorded near the Royal George Mine appear to be the most promising and further ground surveys should be carried out in the region of the mine.

1. INTRODUCTION.

An airborne scintillograph survey for radioactive minerals was conducted over eleven separate districts in the west, north-west, north and north-east of Tasmania by officers of the Bureau of Mineral Resources during March and April, 1955. The eleven districts, shown on Plate 1, total approximately 1,500 square miles and comprise the whole or part of seven areas selected for survey by officers of the Tasmanian Department of Mines and the Bureau of Mineral Resources.

The areas were selected to cover country considered to be geologically favourable to the occurrence of uranium-bearing minerals. No previous airborne scintillograph surveys had been conducted in Tasmania, although the uranium mineral torbernite was known to occur in small quantities near the Royal George Mine in the Ben Lomond - Snow Hill district.

An Auster "Autocar" aircraft, VH-GVC, was chartered from Goulburn Valley Air Services and fitted with a scintillation counter and a pen-writing recorder. The aircraft was piloted by Mr. T. Dearden.

Mr. L. E. Howard (geophysicist) was in charge of operations and he was assisted by A. Crowder (assistant draftsman) and R. Underwood (university vacation student) in the early part of the survey, and later by J. E. Gardener (geophysicist).

2. EQUIPMENT USED.

A Mk VI Brownell Scintillometer, serial No. C601, was installed in the aircraft and was coupled to an Esterline-Angus pen-writing recorder. The combined instrument is called a scintillograph.

The scintillometer detects gamma radiation at the position in which it is installed in the aircraft and gives an output current which is proportional to the average rate at which gamma rays are being detected. The detector consists of a cylindrical sodium iodide crystal, 3 inches in diameter and 2 inches deep, which is optically coupled to an R.C.A. photo-multiplier tube, type 5819. Gamma rays impinging on the sodium iodide crystal produce scintillations which are converted in the photomultiplier to electrical impulses. These impulses are fed into a ratemeter which gives an output current proportional to the number of gamma rays detected in the crystal during the preceding period of about one second.

The output of the ratemeter is connected to an Esterline-Angus recording milliammeter which gives a full-scale deflection for a current of one milliampere, this being equivalent to a count rate of 800 gamma rays per second. The output recorded at any time has three components, namely:-

(a) Gamma rays due to cosmic radiation.

This component is small and cannot be readily eliminated.

(b) Gamma rays due to radioactivity within the aircraft.

The luminous dials on the aircraft instruments are radioactive. Their effect could be reduced by shielding the detector with lead, with a consequent undesirable reduction of the "pay load" of the aircraft. This component is large and constant but not large enough to obscure significant anomalies in the radiation from the ground.

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(c) Gamma rays due to radiation from the ground.

This component is variable and dependent upon the nature of the ground surface over which the aircraft passes.

Over average country rock containing no significant concentration of radioactive minerals, the third component is small, and the combined output due to all three components is then called the "background count". Any appreciable increase in recorded output, above the background value, is called an anomaly.

A C.A.E. portable scintillation counter, type 963, was used in the few places where brief checks were made on the ground, of anomalies recorded from the air. This instrument has a much smaller detecting crystal (1" x 1" x ½") than has the Brownell scintillometer used in the aircraft, and is therefore less sensitive.

3. METHOD OF SURVEYING

The efficiency of an airborne scintillation counter in detecting anomalies in the intensity of gamma radiation from the ground, depends upon the sensitivity of the scintillation counter and the altitude and speed of the aircraft. These factors are considered below.

(a) Sensitivity of the scintillation counter.

The sensitivity may be defined as the count recorded when the crystal detector is placed in gamma radiation of known intensity. For a given gamma-ray intensity, a high sensitivity and a high count rate will be obtained by using a large, optically clear, sodium iodide crystal and an efficient photomultiplier tube.

The use of a high-sensitivity instrument will result in a higher background count and also a greater response from a radioactive source. The Brownell scintillation counter used in this survey had a normal background count of 70 per second. The sensitivity was more than adequate.

(b) Speed and altitude of the aircraft.

The gamma rays from a radioactive source are not emitted at a steady rate but in a random manner. To obtain a steady output on the recorder, the pulses produced by the gamma rays must be intergrated in the ratemeter over a certain time interval, and the time taken by the instrument to reach half the final steady value is called the "time constant". If pulses are received at a fast rate, that is if the instrument has a high sensitivity, the "time constant" can be made small and the steady output will be reached quickly. The "time constant" used with the Brownell scintillation counter was one second. This was considered to be adequate, although the optimum "time constant" for an instrument being flown at 80 miles per hour at 100 feet above the ground would be about half a second. However, such a short "time constant" could be achieved only by having an instrument of greater sensitivity.

The maximum range, in air, at which the Brownell scintillometer will detect gamma radiation from a naturally-occurring radioactive deposit, is estimated to be about 300 feet. Thus, for an Auster aircraft flying over a radioactive source at 80 miles per hour and a height of 100 feet the scintillometer willdetect gamma rays emitted from the source for a period of five seconds. This assumes that the source is not at any time during the flight shielded from the detector by intervening ground, heavy timber or scrub.

The main advantage of flying at a low altitude is that the response from a source of limited area increases much more rapidly with decreasing altitude than does the response from a broad source. It is of some importance to differentiate between these two types or source because the broad sources are usually large areas of outcropping rock such as granite, with a low radioactive content, whereas the sources of limited area are more likely to be those associated with deposits of some economic value.

During the survey the speed of the Auster aircraft was maintained as nearly as possible at 80 miles per hour and the altitude at 50-100 feet, which was as low as could be maintained consistent with safe flying.

Apart from considerations of safety, there are two other factors which make it undesirable to fly at a height of much less than 100 feet. The lower the aircraft is flown the greater are the fluctuations in the recorded gamma-ray intensity caused by different surface conditions, such as the varying rock types and soil and water cover, over which the aircraft passes. This produces a greatly varying background count against which it is sometimes difficult to identify an anomaly even though the response from a radioactive deposit may also be expected, within limits, to be greater when the aircraft is flown at a lower height.

The second factor has already been referred to, namely the possibility of the radioactive source, or deposit, being screened from the field of view of the detector crystal by intervening uneven ground or heavy timber or scrub. If the aircraft were flown at a height of less than 50 feet, especially over broken or heavily timbered country, the effect of this shielding would greatly reduce the effective width of the strip of ground surveyed along each traverse, and would also reduce the response produced in the scintillometer by a radioactive source within that strip.

(c) <u>Navigation and positioning of the aircraft</u>.

Flight lines were selected and marked on aerial photographs for most of the areas surveyed. Photographs were not available for four small areas and for these the flight lines were marked on a map with a scale of four miles to the inch. The position of the aircraft was marked on either the aerial photograph or the 4-mile map as flights were made along selected flight lines.

The accuracy of plotting the position of the aircraft by this method depends upon the following factors:-

(i) The amount of detail of the photographs.

> Lack of detail on the photographs may result from poor photography or from lack of outstanding and easily recognisable features on the ground. The latter is very largely true of the Magnet and Trowutta districts, where there are large areas of thick forest. In the northern part of the Trowutta district it was possible to position the flight lines only by commencing each one at some identifiable point on a river and flying a course of known bearing until another river was crossed at a point which could be identified. In this way the start and finish of each line were determined even though it was not possible to identify points between.

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(ii) The accuracy of the map.

For surveys in some parts of the St. Helen's district and the small area around Commonwealth Creek, it was found that the 4-mile map was not sufficiently accurate or detailed for the purpose of positioning the flight lines.

(iii) The observer.

The experience of the operator and his ability to navigate by aerial photographs both affect the accuracy of plotting. The extent to which the operator is distracted by having to attend to the equipment is also a factor of some importance. An experienced operator using good photographs containing sufficient topographic detail should be able to fix the position of the aircraft to within 250 feet.

Two different types of traversing were employed. The more usual method was to fly approximately straight flight-lines at 50-100 feet above the ground and at a fairly uniform spacing. In this way a reasonably systematic reconnaissance was made of the selected areas.

This method could not be used on steep mountain slopes because of the difficulty of maintaining a suitable speed, especially when descending. In mountainous areas therefore, such as characterize much of the Queenstown district, flights were made around the mountains at a constant altitude, keeping the aircraft about 50-100 feet away from the side of the mountain. The first flight line was selected near the top of the mountain and the second was traversed at an altitude 500 feet below the first. Successive flight lines were flown below these at intervals of 500 feet in altitude until the base of the mountain was reached. During these flights, radiation was received by the scintillometer from one side of the aircraft only but, as the scintillometer was not shielded in any way, it was equally sensitive to radiation from all directions. It therefore recorded radiation from the mountain-side above, as well as below, the level of the aircraft.

4. SIGNIFICANCE OF ANOMALIES

In determining a scale for the measurement of anomalies and in deciding which anomalies may be donsidered significant, it is necessary to review several relevant factors.

(a) Area scanned by scintillometer.

The area scanned by the scintillometer depends very largely on the topography. It is also necessary to specify the minimum size and grade of a radioactive deposit that is considered to be significant, before the effective scanning area can be determined. For instance, if the aircraft were flown at a height of 50-100 feet and at a distance of 200 feet to one side of a circular outcrop 10 feet in diameter and containing 0.25 per cent of equivalent uranium oxide, the scintillometer would record an increase in radiation equal to the background count. An equal increase in recorded radiation would result if the aircraft were flown at the same height directly above an outcrop of the same size but containing only 0.02 per cent equivalent uranium oxide.

Over relatively flat ground, the Brownell scintillometer flown at a height of 50-100 feet can be expected to record a measureable anomaly from any outcrop of radioactive mineral of significant size and grade within a strip about 300-450 feet wide.

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When the aircraft is flying in a narrow river gorge the area being scanned is limited laterally by the two sides of the gorge but the scintillometer will record radiation from sources above and below the aircraft within 300 feet of it.

When flying around a mountain side, radiation will be recorded from all parts of the mountain, or the slopes below, that are within 300 feet of the aircraft.

Under such different conditions it is not possible to specify the effective width of the strip of ground scanned by the scintillometer at all times.

(b) Variations in background count.

Most rocks show a slight amount of radioactivity due to the inclusion of dissemiminated radioactive minerals containing uranium, thorium and potassium, and there is a fairly wide range of radioactivity between such rock types even though they may not contain useful concentrations of uranium or thorium minerals.

Therefore the scintillometer output shows some fluctuations as the aircraft passes over country rock of different types. Also, areas covered with soil usually show a lower radioactivity than do rock outcrops. A cover of only a few inches of non-radioactive soil is sufficient to absorb the greater part of any gamma radiation originating below. The background radiation recorded by the scintillometer, as the aircraft is flown along any one flight line, can vary by as much as one third of the total background count.

(c) Random statistical variations.

As mentioned earlier (section 3(b)), gamma rays from a radioactive source are emitted in a random manner. This is true whether the source is cosmic rays, the dials of the aircraft instruments, the country rock, or a deposit of radioactive minerals. Therefore, the radiation measured at any fixed point above the ground will show small, rapid fluctuations with time. The period of these fluctuations is usually much shorter (e.g. 1 or 2 seconds) than the period of the variations recorded in background count as the aircraft passes over different types of country rock. The two types of variation can therefore usually be separately identified.

In deciding what constitutes an anomaly, due allowance must be made for the three factors described above. It is clear that variations caused by these factors can have an amplitude of as much as half the average background count. Therefore, it was decided that an increase in recorded radiation would not be considered significant unless it attained an amplitude at least equal to the background count i.e., unless the total count reached at least twice background. A second order anomaly has been marked on the aerial photographs and maps, where the recorded output was between two and three times the average background count, and a first order anomaly has been marked where the recorded count exceeded three times the background.

The choice of these levels for the measurement of anomalies, although somewhat arbitrary, has had the desirable effect of excluding a very large number of smaller anomalies arising from topographic features without rejecting any that might have arisen from useful deposits of radioactive minerals. It should be mentioned that, with the single crystal detector and ratemeter used in the Brownell scintillometer, it is not possible to discriminate between uranium, thorium and potassium as sources of gamma radiation.

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5. AREAS SURVEYED AND RESULTS OBTAINED.

The several areas included in the survey are shown on Plate 1. The positions of the flight lines and the anomalies recorded are shown on twelve maps (G 202 to G 213) copies of which can be obtained on application from the Bureau or from the Department of Mines, Tasmania.

(a) Zeehan - Murchison.

This area includes the zinc-lead field at Rosebery, the tin field at Renison Bell and the abandoned silver-lead and tin mines around Zeehan. The area covered by the survey is shown on Map G 210.

Flights were made totalling about 27 hours and the area specified by the Department of Mines was completed with the exception of a small part on the Corinna 1-mile sheet and another on the Mackintosh 1-mile sheet.

Large anomalies were found on the granite outcrops in the Heemskirk Range area. Anomalies were associated with large orange-coloured outcrops at Red Hill, south of Mt. Murchison, and also over similar outcrops south of Williamsford. Part of the Heemskirk Range was investigated on the ground and readings of about three times the background count at Zeehan were obtained with the portable scintillometer. The anomalies were found to be associated with large granite outcrops.

(b) Queenstown District.

This district, shown on Map G 211, includes the large copper-mining area of Queenstown. Approximately 26 hrs. flying was done in this area but there were still small parts of it uncompleted when the survey ended. The areas not yet surveyed amount to about one-fifth of the total area and are mostly comparatively low, flat country. A few traverses were flown in the Eldon Range just north of the area. The Queenstown district is about 100 miles from the base at Wynyard, and this resulted in more than half the flying time being used in travelling to and from the area. Only a few small anomalies were located and these were almost always associated with large areas of exposed rock. Some of the anomalies on the mountain sides were recorded at places where the soil cover has been eroded after the vegetation was destroyed by fumes from the smelters.

(c) Moina District and Commonwealth Creek.

This area was surveyed in more detail than areas done earlier in the survey. About 31 hours flying was completed and, as the area was quite close to the Wynyard base, most of this was useful survey flying. The results are shown on Map G 207. Some large anomalies on the Forth river, just north of Lorinna, are due to granite outcrops. These anomalies were checked on the ground and gave readings of less than three times background. Other smaller anomalies a few miles south-east of Lake Lea were not checked on the ground.

A small area near Commonwealth Creek was surveyed at the request of the Regional Geologist of the Tasmanian Department of Mines, but no anomalies were obtained. The area surveyed is shown on Map G 213.

(d) Beaconsfield.

No anomalies were located in the Beaconsfield area, which is shown on Map G 204. About 8 hours flying was done and a day was spent walking down the main mountain ridge in the area. There are many rock outcrops but they all gave low scintillometer readings., The gold mines at Beaconsfield were examined but no anomalies were recorded there.

(e) St. Helens.

This district was surveyed using 4-mile maps, but the flight lines and results have been plotted on the 1-mile area shown on Map G 208. About 7 hours of flying was done in the area and no anomalies were obtained. The country is comparatively featureless and positioning from the 4-mile map was difficult. Nevertheless the coverage obtained is considered adequate.

(f) Ben Lomond - Snow Hill (Avoca District and Royal George District.)

This district was surveyed using the 4-mile map for the Ben Lomond area and aerial photographs for the Snow Hill area. The results are shown on Map G 209. The presence of many prominent features made positioning quite easy. The principal inaccuracy in plotting the flight lines is due to the large scale of the map. About 8 hours flying was done and many large anomalies were obtained. These were mainly due to large granite outcrops but small amounts of uranium minerals have been obtained in the part of this area where the anomalies were recorded.

The part of the Snow Hill area surveyed lies mainly in the St. Paul's River valley. About 14 hours of flying was done and large anomalies were obtained, particularly near the Royal George Mine. Two areas of high readings near the mine were surveyed in detail and the results are shown separately on Map G 212. Parallel traverses, about 60 ft. apart, were flown over the open cut which is about 1000 ft. long by 100 ft. wide. The positions of these lines were controlled by flying the aircraft on a fixed bearing so that it passed directly over one of the members of the party who took up successive positions at 60 feet intervals along the open cut. The activity appears to be distributed fairly evenly along the mine and not concentrated in a few small area.

Other parallel lines 100 ft. apart were flown over patches of tailings which have apparently been washed downhill towards the river from a former treatment plant. The intensity of radiation is quite high over the tailings but it decreases rapidly away from them. In a subsequent ground survey, readings up to eight times the normal background a short distance away were obtained over the tailings with the portable scintillometer. Other smaller anomalies were located on hills to the west of the Royal George Mine and on the hills to the north of the valley. Some of these anomalies are due to outcrops of granite, but others have not been checked on the ground.

(g) Magnet - Valentine's Peak (Waratah District).

This is part of a large district in the north-west which was still uncompleted when the survey ended. The area surveyed is shown on Map G 206. Much of the eastern part of this area is basalt-covered. About 10 hours flying was done but no anomalies were found. The small increase in intensity recorded over the Mt. Bischoff Mine is probably due to the removal of the soil dover and vegetation. The area was not surveyed completely but particular attention was directed to the surroundings of the old mines and to the few areas in which there are outcrops. Aerial photographs were used for positioning.

(h) Balfour.

In the Balfour District, shown on Map G 205, particular attention was paid to the old Mt. Balfour Mine and its environs.

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Twelve closely spaced parallel flight lines were traversed over the mine and small anomalies were recorded. Aerial photographs were used for navigation and a total of about 10 hours of flying was done.

(i) Trowutta - Burnie.

About 12 hours of flying was done in this district which is shown on Map G.203. Positioning by aerial photograph was difficult except near the Arthur River and other rivers and creeks. No anomalies were recorded. Much of the area is thickly covered with tall trees and it is probable that the soil has low radioactivity and is sufficiently thick to prevent radiation reaching the surface from any radioactive source that might lie below. There are few outcrops.

(j) Smithton-Table Cape.

Only 5 hours of flying was done in this district and no anomalies were recorded. The area surveyed is shown on Map G 202.

6. CONCLUSIONS AND RECOMMENDATIONS.

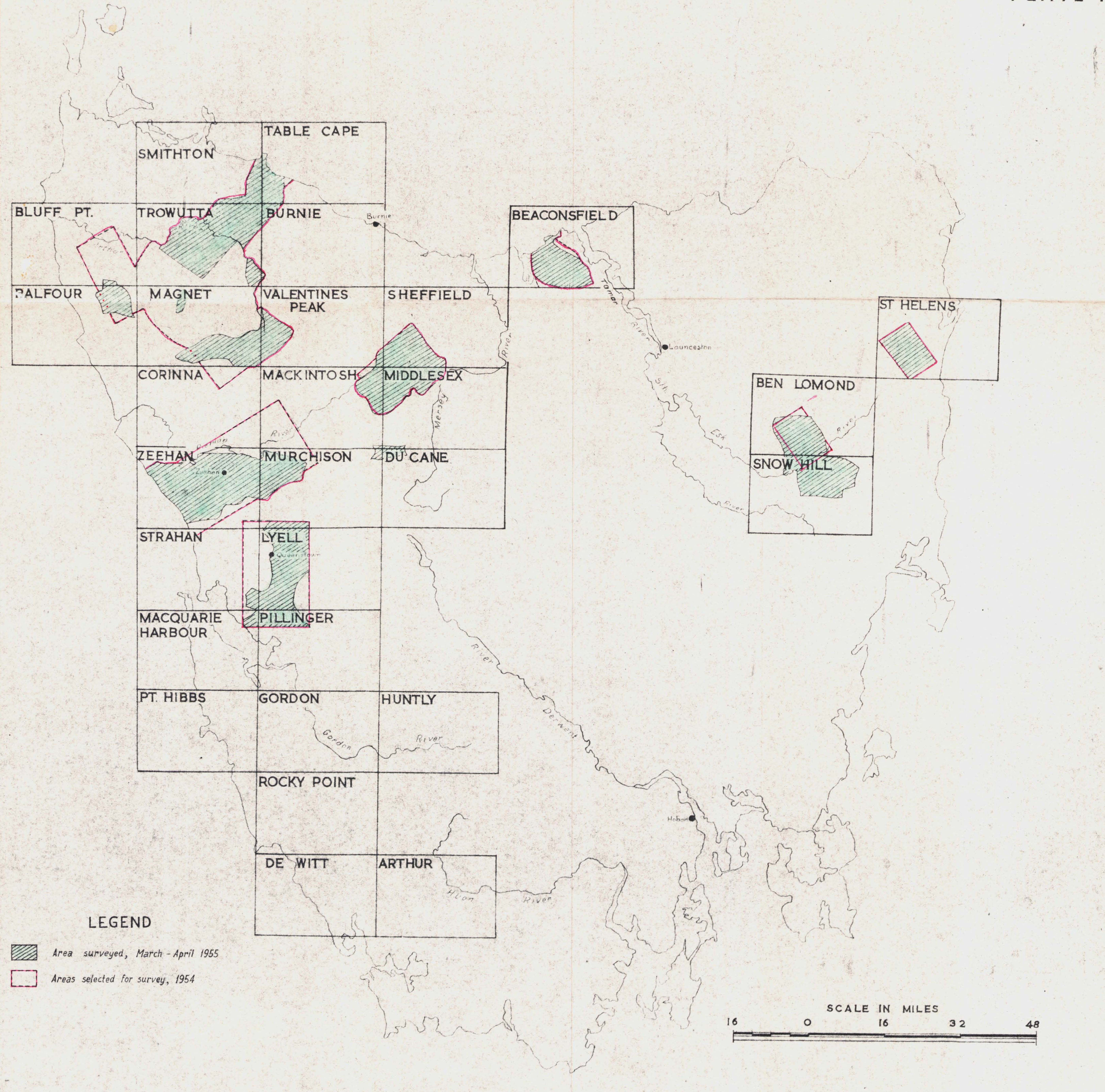
Further investigations on the ground are required to determine the significance of the anomalies recorded. It will probably be found that all or most of the second-order anomalies are due to large outcrops of rocks containing small amounts of disseminated radioactive minerals.

The anomalies near the Royal George Mine in the Avoca district are large and fairly sharp and should be investigated on the ground.

Further airborne surveying might with advantage be done in the Avoca district, which should be surveyed in greater detail. The Queenstown region also should be completed.

Any further airborne surveying in the Magnet and Trowutta districts would be of doubtful value because of the comparatively few outcrops and the basalt cover in some parts.

PLATE I



AIRBORNE SCINTILLOGRAPH SURVEYS, TASMANIA, 1955

MAP SHOWING

AREAS SURVEYED USING AN AUSTER AIRCRAFT

Geophysical Section, Bureau of Mineral Resources, Geology and Geophysics 469