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U N C L A S S I F I E D

DEPARTMENT OF MINES

SOUTH AUSTRALIA

AIRBORNE SCINTILLOMETER SURVEY OF EASTERN EYRE PENINSULA

by

K.R. Seedsman, Geophysicist
J.L. Harris, Geophysicist.

GEOPHYSICAL REPORT GS4/54

D.M. 610/52

SUMMARY:

An airborne scintillometer survey covering 3,370 square miles of Eastern Eyre Peninsula was carried out between December 1953 and July 1954 Avro Anson Mk XIX aircraft carrying two scintillometers were used.

Those of the 42 major anomalies and 1,300 minor anomalies revealed which have been investigated on the ground have been found to be caused by the mass effect of widespread, low-grade sources of radioactivity.

A discussion of some of the difficulties and limitations of the technique has been included in the report.

INTRODUCTION:

An airborne scintillometer survey of Eastern Eyre Peninsula was commenced on 2nd December, 1953 and completed on 21st July 1954, flying taking place on 58 days for a total of 182½ hours. The aircraft used in the survey were two Avro Ansons, MK XIX, hired from the British Ministry of Supply. Crews and maintenance were provided by 34 Squadron R.A.A.F, Mallala.

The area covered (Plan US 386) was approximately 3,370 square miles, surveyed by flying E - W traverse lines spaced a quarter of a mile apart. Five hundred and eight flight lines were flown covering a distance of almost 13,500 miles.

METHOD:

Aerial photographs were used as a base control for most of the area. One section south of Cowell in the hundreds of Roberts, Boothby, Butler and Dixson, between flight lines 142-208 however was flown from hundred maps since no photographs of the area were available at the time. Adastra photographs (approximately 40 chains/inch) were used for the Lincoln, Coulta, Cummins, and Tumby military sheets; Lands Department photographs (approximately 30 chains/inch) for the Yeelanna, Neill, Verran, Arno, Darke, and Glynn sheets; and R.A.A.F. photographs (approximately 40 chains/inch) for the Roopena, McGregor, Middleback, and Wilton sheets. These photographs were also used to place in position ground reference pegs marking the ends of traverses. During the survey air to ground control was maintained by placing Land Rovers fitted with Aldis lamps at the pegs.

Flight lines were drawn on the photographs and the aircraft navigator endeavoured to follow these lines, marking his position as often as possible. These "fixes" were later joined to give the actual track flown.

The aircraft was for the first nine days flown at a height of 200 feet above the terrain with an airspeed of 90 knots. Following an accident with this aircraft near Port Lincoln in December 1953, the R.A.A.F. insisted upon a minimum airspeed of 110 knots.

Two instruments for detecting radioactivity were installed in the aircraft. The Electronic Associates Canada, Scintillometer, Type SM115, was used throughout the survey and a Nuclear Enterprises Ltd., Brownell Scintillometer MK 6, on loan from the Bureau of Mineral Resources, was used when not required elsewhere. As only one chart recorder was available the indicating meter on the Brownell was watched continuously to correlate with peaks on the E.A.C. instrument. Both these instruments were operated from the 24 volt aircraft supply. The heads were mounted so as to project beneath the floor just aft of the main spar and were shielded by lead to allow an acceptance angle of approximately 90 degrees.

GEOLOGY:

A generalised geological plan of the area surveyed is shown in plan US 386. Information for this has been drawn from the published maps of the 1 mile military sheets of Roopena, Middleback, and McGregor; the geological plan of County Flinders compiled by R.K. Johns (L51-22/1 and L51-23/1); and a sketch map of County Jervois from a geological reconnaisance by R.L. Jack (G.S.S.A. Bulletin No. 3).

In the north, siliceous sands, sand dunes, and mallee soil plains predominate, whilst in the south, aeolean sands, aeoleanites, and laterites cover the flatter areas. The hills consist mainly of Archaean gneisses, quartzites, and schists, together with a range of other metasediments andigneous rocks. Apart from the iron ore of the Middleback Ranges, metallic mineral deposits are scattered and in very small quantities, copper, lead, silver, being the chief minerals found.

Scattered occurrences of secondary uranium minerals have been found in the area prior to the commencement of the survey, but no knowledge of the genesis of such minerals was available to indicate which particular rocks were most likely to contain concentration of uranium. Hence the area was chosen to include all Archaean outcrops.

TOPOGRAPHY:

Most of the area flown consisted of flat and undulating country, the more rugged ranges being associated with outcrops of Pre-Cambrian rocks.

These are:-

1. Middleback Ranges in Co. York.
2. SW - NE trending ranges to the west and north-west of Cowell.
3. A range running north from Port Lincoln parallel to the coast.
4. Marble Range and Mount Dutton trending north and south between Lake Wangary and Coulta.
5. Carappee Hill of limited extent near Darke's Peak.

The flatter parts of the counties of Jervois and York are occupied for the main part by a series of NW - SE trending sand dunes, which also occur on the plateau of central northern County Jervois, and the massif of the Charleston granite. Sediments in Tertiary Recent Basins in County Flinders form flat plains with poor drainage and much swampy country. North of Tumby Bay the main drainage channels to reach the sea are the Rivers Driver and Dutton, both slowly flowing saline streams which exist because of the shallowness of the superficial deposits overlying the bedrock. Generally the rainfall is dissipated by evaporation and the temporary streams which commence in the hills are quickly lost in alluvial fans as the gradient falls on the plains.

The approximate extent of the larger ranges is :-

Middleback Ranges	20 m x 2.5m	height up to	1500 feet
W and N.W. of Cowell	30 m x 12	" "	1450 "
North of Pt. Lincoln	30 m x 2.5m	" "	1050 "
Marble Range	20 m x 4m	" "	1250 "
Carappee Hill	6 m x 3m	" "	1650 "

RESULTS

Two orders of anomalous radioactivity were plotted:-

1. Readings greater than 4 times "background" (greater than 0.8 milliamps). using Range 1.
2. Readings between 2 and 4 times "background" (0.4 - 0.8 milliamps) using Range 1.

(Full scale deflection is 1.0 milliamp).

The positions of these anomalies are shown in detail on military sheets, (Plans, US381-385, US387-390, US393-398), and generally on plan US 399.

The term "background" as applied to radioactivity means the general reading obtained in a certain locality due to radioactive material dispersed through the rocks, soils, vegetation of the area, plus a cosmic ray effect. In a long aerial traverse a number of different types of country may be flown over, e.g. outcropping rock, residual soil, wind blown sands, each with a particular general radioactivity. Over Eastern Eyre Peninsula it was found using the E.A.C. instrument that the general readings with certain instrument settings varied from .15 MA over sand to .35 MA over granitic rocks. Over the covered parts of the area a reading of .20 MA was common and instrument settings were checked each day to maintain this value.

Results have been interpreted by calling this reading of .2 MA "background" for the whole of the area surveyed. It is necessary to adopt a standard value for the whole area for the following reasons. Over sand (.15 MA general reading)

a peak of .35 MA might be significant, Over outcropping granitic rocks the general reading could be .35 MA and a similar concentration of radioactive material would give a reading of .55 MA. It is impossible to determine continually the rock or soil type over which the aircraft is flying, hence a background for the whole survey must be adopted. It is apparent then that values determined relative to background over an area on the ground may bear little relationship to the intensity relative to background as determined from results of the aerial survey.

No radioaltimeter was installed in the aircraft and therefore it was not possible when plotting results to make corrections for height. Many of the lower order anomalies can be attributed to variation in height but they are far too numerous for more than a small percentage of them to be accounted for in this way.

Using the previously mentioned system of classification there were 42 major anomalies and 1300 minor anomalies. Quite a few of these were checked on the ground either by prospector T. Antamis, (see appended report) or by members of the geophysical party.

The major anomalies which were ground checked and which gave no indication of mineralisation can be explained in terms of slightly increased radioactivity and a mass effect (solid angel effect). These include such areas as parts of Marble Range, the Charleston massif, and the ranges to the west and north-west of Cowell, all granitic or gneissic outcrops.

During the early part of the survey "peaks" were recorded over salty mud flats at the mouth of the River Dutton and at several points along the River Driver. Later the River Driver was flown from the source, approximately five miles south of Rudall, to the sea. Numerous peaks were recorded along the

length of the river. A sample of dark grey mud taken from the mouth of the nearby River Dutton was radiometrically and chemically assayed showing one of the decomposition products to be the cause of radioactivity.

The minor anomalies (2-4 times background) are generally concentrated in a number of areas shown in plan US399. While flying over the Charleston Granite (McGregor US398), a minor peak was recorded almost every time the granite appeared through the covering sand. Other areas where minor anomalies are concentrated occur in the north of County Jervois and the north of County Flinders. By comparison with the generalised geological plan (US 386) it seems likely that these anomalies are caused by ou crops of granites or gneisses containing a small amount of radioactive material.

More or less isolated minor anomalies are scattered over the area surveyed. It is not possible to say whether they are due to widespread low grade sources, or localised higher grade occurrences.

CONCLUSIONS AND RECOMMENDATIONS:

Of the major anomalies revealed by the survey, all those checked on the ground have been found to be due to large, low-grade sources of no economic significance. The remaining fourteen, in the hundreds of Mangalo, Mann, Miltalie, Hawker, James, Glynn and Stokes, should be visited next time a geologist or prospector is in the area.

A very large percentage of the minor anomalies are probably due to outcrops of granites or gneisses slightly more radioactive than the other rocks and soils. Should a programme of geological mapping be undertaken in the Counties of Flinders and Jervois, those areas where these anomalies occur should be examined carefully.

The writers suggest that the following points should be considered in the event of another survey being planned using the present Avro Anson technique.

Length of runs should be limited to 20-25 miles otherwise difficulties experienced in navigation are further increased. Particularly are these difficulties evident when flying over hilly country where the range of vision at 200 feet is strictly limited; and over flat sandy featureless country, characteristic of many parts of Eyre Peninsula. The navigator must be directly over or very close to a landmark to be able to fix with any degree of accuracy. Estimation of distances from the air requires considerable experience and flying at 200 feet does not normally fall within the duties of a navigator.

In the event of a high being recorded there are two time lags which cause error in fixing. Firstly there is the time lag between flying over the radioactive spot and the recording of a peak on the chart and secondly the time taken for the navigator to fix himself accurately. At 120 m.p.h. a time delay of 8 seconds means a ground displacement of at lease $\frac{1}{4}$ mile. Since the Anson is non- aerobatic a considerable distance is required to complete a turn should it be decided to re-fly the anomaly immediately. Unless a high is associated with a prominent land mark, this is very difficult, particularly if the anomaly has limited areal extent. Theoretical adjustments can be made for this lag provided the navigator obtains fixes at short intervals, and also provided the pilot flies a set course, height and airspeed. A fixed height and airspeed over hilly and undulating country is practically impossible.

A set course is difficult to fly over hilly ground

due to variations in valley winds. The possibility of using a gyroscopically controlled strip camera for such work is not considered practicable when operating from a height of 200 feet due to the high cost (at least £5 for one hours flying) and because photographs of featureless country would be almost impossible to fix on base control photographs.

When using an airborne scintillometer the solid angle subtended by a source is unknown, and the solid angle of mass effect may give misleading results. A large outcrop of weakly radioactive granite may give a pronounced radioactive peak but an exposed narrow vein of highly radioactive material may go unrecorded because the solid angle it subtends is very small. The accompanying graph (S944) has been drawn from the results of a mathematical analysis of the solid angle effect of the radiation from a dispersed circular source received by a scintillometer vertically above the centre. Assuming the radioactivity to be evenly distributed over the area of the source, the graph shows the relative intensity of radioactivity required for a source smaller in area than the total area "seen" by the crystal to give the same reading as a source occupying the total area. Calculations have been based on an aircraft height of 200 feet above terrain with the acceptance angle of the instrument 90°. The graph emphasises the great intensity required from sources less than 75 feet radius for them to give readings comparable with sources of larger area.

Areas of very high readings obtained over part of Marble Range (Hundred of Warrow), when checked on the ground were found to be gneissic rocks of (2-3) times background with no evidence of mineralisation. These may be explained in terms of this solid angle effect. Similarly the failure to record the limited Gibson Project at Port Lincoln may be accounted for by the small angle subtended by the source.

Ground control is essential for an Anson survey. Since roads or tracks are necessary for this, much soil-covered and unfavourable country must be flown whereas a smaller aircraft with greater manoeuvrability could cover rock outcrop only. With such an aircraft at a height of 75 feet and traverse interval 50 yards, a complete coverage of an area could be obtained and a "high" quickly and conveniently reflown, thereby fixing accurately and saving much unnecessary ground searching. It is impracticable to fly Anson traverses less than a quarter of a mile apart because of the relatively high speed necessary for this aircraft. Assuming an acceptance angle of 90^{o}, and flight straight and level at 200 feet, a strip of ground 133 yards wide is covered by the instrument - approximately one third of the total area to be surveyed.

Difficulties in interpretation arise as a result of the inverse square fall-off of radioactivity with distance.

If the aircraft passes 200 feet to one side of a source the strength of the signal received would be one half the value obtained directly over the source. When this factor is considered in conjunction with the solid angle effect it is apparent that the size of an anomaly registered need not necessarily be indicative of the strength of the source.

Whilst the Anson technique has served a useful purpose in the past in covering large areas, broadly and reasonably quickly, the Archaean areas in which it can be suitably used in future must be somewhat limited.

The Olary region and Eastern Eyre Peninsula are two of the larger areas of Archaean outcrop flown. Topography at Mt. Painter and the Musgrave Ranges would present considerable difficulty if using an aircraft of this type.

Plans accompanying report -

US 381	Rudall
US 382	Cowell
US 383	Arno
US 384	Verran
US 385	Glynn
US 386	Generalised Geological Plan
US 387	Cummins
US 388	Lincoln
US 389	Darke
US 390	Coulta
US 393	Neill
US 394	Tumby
US 395	Yeelanna
US 397	Middleback
US 398	McGregor
US 399	Military Sheets and Anomalies
S 944	Graph Illustrating Solid Angle Effect.

J.L. Harris,
GEOPHYSICIST

K.R. Seedsman
GEOPHYSICIST

JLH:KRS:BK
1/9/54

A P P E N D I X. D.M. 610/52

REPORT ON PROSPECTING IN PORT LINCOLN - COWELL DISTRICT FOR PERIOD - 12/7/54 to 6/8/64.

Prospecting has been continued in the Marble Range area, and in the Glynn and McGregor Military Sheet areas. The work has been carried out in close collaboration with the Geophysical team operating air-borne scintillometer surveys in the district.

No important uraniferous deposits have been found, and in most cases no explanation for air borne anomalies were detected on the ground. Some weakly radioactive samples have been submitted for petrological and mineralogical determinations.

LOCALITY PLAN - See Plan US386 accompanying Geophysical Report.

Details are:-

McGregor Military Sheet (Hundreds of McGregor and Charleston)

Radioactive anomalies greater than 4 x background were located by air radiation survey, chiefly in the two areas described hereunder:-

(a) A long zone of Archean rocks exposed along the Murninnie Fault, consisting of gneisses, granite etc. Locally very weak radio-activity was found but nothing significant or of size comparable to air borne anomalies. Copper-graphite mines in this area also showed negative results on radioactivity testing.

(b) Granite outcrops in Sheoak Hill - Pine Hill area, Hd. Charleston, in the western portion of the McGregor Military Sheet. No abnormal radioactivity.

Hundred of Mangalo:

Old copper mines on Section 2B, hundred of Mangalo, known as at the W.G. Mines, were examined and the dump found to contain a highly radioactive brown glassy mineral resembling samarskite. A sample has been submitted to the Departmental Petrologist (T.A. 40).

It should be noted that this mine was previously examined by L.W. Parkin (U.P. 98) and a radioactive sample taken determined as a rare thorium mineral Auerlite.

Hundred of Glynn:

In areas of air borne anomalies only weakly radioactive gneiss was found. At Locality TA 35 (Section 18) there is a N-S line of gneissic granite which is in places slightly radioactive. A sample has been sent to the Petrologist for examination. Similar rock was also found on Section 6 (TA 33) where there is no air borne anomaly.

Hundred of James:

Area of abnormal radioactivity shown by aerial survey is high sand dune country.

Marble Range: hundred of Warrow.

The Marble Range area was found to be abnormally radioactive over large areas by airborne work. The ground survey also revealed weak radioactivity in many places in the gneissic rocks, but nothing higher than 2-3 times background. A sample was taken from the area of highest counts in Section J, hundred of Warrow (TA 39), where a hole was dug to 3 feet on weakly radioactive schist and gneiss detritus.

Hundred of Stokes:

Numerous air-borne anomalies are recorded here but on the ground found only laterite with counts up to 3 x background (e.g. sections 58 and 59), and sporadic granite outcrops with local readings of 2 x background.

(T. ANTMANIS)
PROSPECTOR.

KIMBA

BARNA

MIDDLEBACK

KOPI

DARKE

DARKES PEAK

GLYNN

MC GREGOR

LOCK

LOCK

RUDALL

RUDALL

CLEVE

COWELL

COWELL

WILTON

TOOLIGIE

VERRAN

ARNO

ARNO BAY

KIANA

YEELANNA

NEILL

PORT NEIL

UNGARRA

CUMMINS

LAKE GREENLY

COULTA

CUMMINS

EDILILIE

TUMBY BAY

TUMBY

WANILLA

WANGARY

LINCOLN

SPILSBY

BOSTON ISLAND

PORT LINCOLN

SLEAFORD

LEGEND

MAJOR ANOMALY (MORE THAN 4 TIMES BACKGROUND)

COLLECTION OF MINOR ANOMALIES (2 TO 4 TIMES BACKGROUND)

AREA COVERED BY AIRBORNE SCINTILLOMETER SURVEY

BOUNDARIES OF I.M. MILITARY SHEETS

SCALE

MILES 4 3 2 1 0 4 8 12 16 20 MILES

S.A. DEPARTMENT OF MINES

Prog. No
D.M.
Compiled from

EASTERN EYRE PENINSULA
LOCALITY PLAN
SHOWING MILITARY SHEETS AND AIRBORNE SCINTILLOMETER ANOMALIES

Approved

Director of Mines

Passed

C.D.

Drn.
Tcd.
Ckd. A.R.
Exd.

Scale : 4 miles to 1 inch

LUS 399/1

Dkstms.

Date : 30 · 8 · 54 (5)

WHYALLA
ASH
RANDELL
YORK
MOONABIE
BATCHELOR
POYNTON
PASCOE
JAMIESON
HEGGATON
JAMES
GLYNN
CHARLESTON
Mc GREGOR
DARKE'S PEAK
LOCK
SMEATON
CAMPOONA
MANGALO
MILTALIE
MINBRIE
WARREN
RUDALL
YADNARIE
MANN
CLEVE
PLAYFORD
WILTON
COWELL
HAWKER
JERVOIS
BOOTHBY
VERRAN
ROBERTS
ARNO BAY
BUTLER
DIXSON
PORT NEIL
YEELANNA
UNGARRA
ULIPA
CUMMINS
STOKES
YARANYACKA
LAKE GREENLY
TUMBY BAY
WARROW
MORTLOCK
KOPPIO
HUTCHISON
EDILLILIE
FLINDERS
WANILLA
LOUTH
LAKE WANGARY
ULEY
LINCOLN
BOSTON Id
PORT LINCOLN
SLEAFORD
FLINDERS
THISTLE Id

Geological Survey by K. A. Miles
" " " R. L. Jack
" " " R. K. Johns

Scale : 16 miles to 1 inch

K. A. MILES	R. L. JACK	R. K. JOHNS
Samphire swamp ; Mallee soil plains, colonized siliceous sand and sand dunes, gypsum dune deposits. Lateritic gravel, siliceous cement, grit, sandstone, fossiliferous marine limestone.	Unconsolidated blown sand clay, loam, gypsum, travertine, ferruginous gravel. Consolidated shale, sandstone, limestone.	Lagoons, swamps, resorted aeolian sands, aeolianite. Laterites
Porphyritic granite Charleston granite	Coarsely crystalline uncrushed granite of Midgee type.	
Middleback Group (Upper Middleback quartzite, Cook Gap schists. Lower Middleback quartzite, Middleback North dolomite)	Micaceous and hornblende schists, quartzitic conglomerate, jaspilite, slate, crystalline limestone and dolomite.	Warrow Series Quartzites and thin schists
Gneissic Complex - (Sedimentary schists quartzite, phyllite, migmatite, lit-par-lit gneiss, granitic gneiss and gneissic granite)	Larger development of granite and gneiss.	Dutton gneisses and granites. Flinders gneisses migmatites, banded augen and parphyritic gneisses Hutchison Series (schists and gneisses, marbles, quartzites, para-amphibolites, gneisses)

GENERAL LEGEND

TERTIARY RECENT

PRE-CAMBRIAN (ARCHAEAN)

GRANITES (CHARLESTON)

METASEDIMENTS

GNEISSIC COMPLEX

SCALE

MILES 4 3 2 1 0 4 8 12 16 20 MILES

AREA COVERED BY AIRBORNE SCINTILLOMETER SURVEY

S.A. DEPARTMENT OF MINES

Req. No.
D.M.
Compiled from

EASTERN EYRE PENINSULA
GENERALIZED GEOLOGICAL PLAN
SHOWING AREA COVERED BY AIRBORNE SCINTILLOMETER SURVEY

Approved
Director of Mines

Passed
C.D.

Drn.
Tcd.
Ckd. R.A.
Exd.

Scale : 4 miles to 1 inch
LUS 386/1
Dk+mn.
Date : 13 · 8 · 54
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