COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS.

RECORDS

1958, No. 70

AIRBORNE RADIOMETRIC SURVEY OF THE SOUTH ALLIGATOR RIVER REGION NORTHERN TERRITORY.

by

D.F. LIVINGSTONE

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ABSTRACT

During the months of September and October, 1957, an Auster aircraft of the Bureau of Mineral Resources carried out a low-level airborne radiometric survey of several areas in the South Alligator River region, in the Northern Territory.

A total area of the order of 210 square miles was surveyed, and 53 anomalies of gamma-ray intensity were located. Traverses were also flown across the Upper Proterozoic plateau of Arnhem Land. Some anomalies were followed up by Bureau geologists. The positions of anomalies are plotted on the map which accompanies this report.

1. INTRODUCTION

During the months of September and October, 1957, the Geophysical Section of the Bureau of Mineral Resources carried out a low-level airborne radiometric survey of several areas in the region of the South Alligator River in the Northern Territory. The areas covered are irregular in shape and distribution, and total about 210 square miles. Traverses were also flown across sections of the Arnhem Land plateau (Plate 1).

Several uranium prospects exist in the South Alligator River valley. From north to south the more important are Rockhole, El Sharana, Palette, Saddle Ridge, and Coronation Hill. Of these, the first three are producing in quantity; others of minor importance are Koolpin Creek, Cliff Face, the various Scinto leases, and B.M.R. No.1. Uranium occurs in shears in rocks of the South Alligator Group (Lower Proterozoic) and the Katherine River Group (Upper Proterozoic).

The succession may be summarised briefly as follows, following information from Walpole (1957) :

	(Kombolgie Formation	
Katherine River Group (Upper Proterozoic)	(Edith River Volcanics <u>including</u>	Pul Pul Rhyolite Scinto Breccia Coronation Hill Member.
	<u>Unconformity</u>	
South Alligator Group (Lower Proterozoic)	(Fisher Creek Siltstone (Koolpin Formation <u>including</u>	Banded Iron Formation Reef dolomite Reef breccia
	<u>Disconformity</u>	
Goodparla Group (Lower Proterozoic)	(Masson Formation <u>including</u>	Coirwong Greywacke
	<u>Unconformity</u>	
(? Archaean)	(Stag Creek Volcanics	

The striking feature of uranium mineralisation in the South Alligator River field is its localisation in shears near the unconformity between the Upper and Lower Proterozoic. The majority of occurrences are in the reef limestones and Banded Iron Formation of the Koolpin Formation and carbonaceous siltstones immediately below the unconformity, but mineralisation also occurs in the "valley fill" deposits at the base of the Katherine River Group. In some cases mineralisation transgresses the unconformity. The unconformity is therefore of prime interest in the search for further uranium mineralisation in the area.

The primary object of the airborne survey was a detailed coverage of the South Alligator River uranium field, which may be taken as the strip of country lying along the South Alligator River Valley between the eastern bounding escarpment (Kombolgie Formation) and the South Alligator Fault, which runs roughly down the centre of the valley. Coverage was designed to extend from the Coirwong Greywacke to the Edith River Volcanics. The southern limit of coverage was fixed at a point just south of Big Sunday Hill, where an unexplained anomaly was already known to occur. To the north, the survey was continued eastwards out of the South Alligator River valley, following the unconformity along the base of the Upper Proterozoic escarpment south of the Mt. Partridge range and the basin of Jim Jim Creek. The area covered in the South Alligator River amounts to about 80 square miles.

Some airborne radiometric survey had already been carried out in this area by United Uranium N.L. in 1954 and 1956. The results of this work were made available to the Bureau's airborne survey party, and a good degree of correlation between the company's results and the Bureau's results was evident. Much of the area surveyed in 1957 is held under Authorities to Prospect by United Uranium N.L. and South Alligator Uranium N.L., and liaison was maintained with these companies, and with United Uranium N.L. on behalf of North Australian Uranium Corporation N.L.

Secondary objects of the airborne survey were four in number. A positive test for uranium had been obtained by Debnam (1954) from the water of Jim Jim Creek near the Goodparla-Oenpelli track, and it was decided to follow this up by an exploration of the drainage basin of Jim Jim Creek and the headwaters of Nourlangie Creek as far south as the Upper Proterozoic escarpment. Radioactive arkose and conglomerate were known in the vicinity of Spring Peak, in the Mt. Partridge Formation, and it was felt that an investigation of this formation would be worth while, although the known radioactivity was due to thorium. On a creek draining into the Katherine River east of Sleisbeck there was an occurrence of radioactive mud (uraniferous), and it was desired to track down the source of this mineralisation. Finally, three traverses were laid out across the Upper Proterozoic plateau of Arnhem Land to obtain a general picture of the radioactivity there.

The survey was directed by D.F. Livingstone (Geophysicist), assisted by F.P. Fraser (Geophysical Assistant), A. Crowder (Draftsman), and N.A. Ashmore (Driver). The Bureau's Auster aircraft, VH-RES, was piloted by F/O A.H. Worley (Trans-Australia Airlines). Geological follow-up of some anomalies was carried out by C.E. Prichard, P.R. Dunn, and R. Bryan, of the Geological Section of the Bureau.

The survey was materially assisted by the co-operation and hospitality of Mr. W.J. Fisher, Mr. J. Martin, Mr. D. Wing, and the staff of United Uranium N.L., El Sharana. The writer is greatly indebted to B.P. Walpole of the Geological Section for a most instructive introduction to the geology of the South Alligator River region, and much stimulating discussion in the field.

2. EQUIPMENT

The scintillograph used consisted of a detector head and ratemeter, Austronic Engineering Laboratories type A.S. 1, coupled to a Texas Instrument Company dual-recording milliammeter, on one channel of which the ratemeter output was recorded. Operation of the scintillograph was controlled and monitored in flight by a remote control unit.

The detecting element in the scintillograph consists of a thallium-activated sodium iodide crystal, cylindrical in shape, 4½ inches in diameter and 2 inches thick, mounted with its axis vertical. This is optically coupled to a photomultiplier tube, Dumont type 6364. Gamma radiation impinging on the crystal produces scintillations which are converted to electrical impulses in the photomultiplier. These electrical impulses are integrated in the ratemeter, whose output current, registered on a counting-rate meter, is proportional to the gamma radiation detected over the preceding short interval of time. One channel of the recording milliammeter is in series with the country rate meter, and provides a continuous record of gamma radiation detected, on which record the interpretation of results is based.

Since the efficiency of airborne radiometric survey depends to a great extent on the maintaining of a near-constant height above ground level, a radioaltimeter type AN-APN1 was fitted. Divergence from a pre-selected altitude above ground level was indicated to the pilot by a system of limit lights on the aircraft dashboard, and a record of altitude above ground level was made on the second channel of the recording milliammeter.

3. OPERATIONS

The survey was flown at a height of 200 ft. above ground level. At this height the lane scanned is of the order of 500 ft. in width. In extremely rugged terrain, however, this lane width may be expected to be less in places, and flying in certain areas covered by this survey had to be designed accordingly.

A further complication was introduced by the fact that, while it is preferable to direct flight lines at right angles to the strike of the geological formations, it was not possible to do this in the South Alligator River valley; the strike of the formations runs along the valley, which is bounded by formidable escarpments and is of the order of only two miles in width in the area of particular interest between Coronation Hill and Rockhole Creek; in addition, a range of high, steep hills runs along beneath the eastern escarpment. It was necessary, therefore, to fly along the valley parallel to the strike with cross-lines down the steep gorges which dissect the hills; a minimum flight-line spacing of 10 per mile was adopted, giving a coverage of at least 80%, allowing for screening of the detector by minor ridges and shelves.

The Mt. Partridge area, east of Barramundie Creek, was flown at a flight-line spacing of 4 to 5 per mile, giving a reconnaissance coverage of 40 to 50%. The basin of Jim Jim Creek was at first covered by traverses along Jim Jim Creek and its tributaries and along the enclosing Upper Proterozoic escarpment; the Mt. Basedow range was then flown at a flight-line spacing of 8 to 10 per mile, giving a coverage of at least 80%. The investigation of the anomaly on the Katherine River, upstream from Sleisbeck, was a tracking-down operation, for which no precise flight-line spacing can be given. Traverses across the Arnhem Land plateau were spaced approximately one half-mile apart.

Whenever possible, the aircraft speed was maintained in the region of 80 to 90 m.p.h. However, speed showed considerable variations when flying over the hills along the South Alligator River valley. Without a synchronised chart drive on the recorder, the only method of making allowance for these variations of speed was to take a considerable number of check points; this, combined with re-location of anomalies by flights in the reverse direction and/or at right angles to the original line of flight served to minimise the errors introduced.

Flight lines and check points were plotted by the observer on aerial photographs during flight. As far as possible these lines were kept straight. Anomalies which were deemed significant were re-located whenever possible. The accuracy of positioning is considered to be of the order of ± 300 ft.

The response of the scintillograph to a standard flux of gamma radiation was checked before and after each survey flight by placing a standard radioactive source in a fixed position relative to the detecting element. This enabled the instrumental performance to be checked accurately over the period of a survey flight. This check was carried out at an altitude of 2,000 ft. above ground level, at which height the background due to cosmic rays and contamination effects was also determined, ground radiation being effectively reduced to zero. It was found that when the standard source was carried in the aircraft as remote as possible from the detecting element the increased flux detected was negligible. A confidence check on the radioaltimeter was carried out at take-off and landing, the aircraft being flown at 200 ft. along the airstrip, and the radioaltimeter checked against the barometric altimeter.

Operations were conducted from Fisher airstrip. Severe thermal turbulence and strong winds which developed at about 10 a.m. each day limited survey flying to the early morning. It was occasionally possible to carry out test flights in the calm period of half an hour or so before sunset. The coverage totalled something of the order of 210 square miles, plus traverses.

The terrain, with the exception of the basin of Jim Jim Creek, was severe. The hills and escarpments in the South Alligator River valley called for aircraft handling of the highest order, and the Mt. Partridge area fell little behind in difficulty. Nevertheless, even with increasingly unfavourable weather conditions, it was usually possible to keep up to the tight schedule of operations which the limited time available necessitated.

The day-to-day direction of the survey was based on survey results to date, available geological evidence, and weather conditions. The party withdrew from the area just before the first heavy storms of the summer, late in October.

4. INTERPRETATION PROCEDURE

The results have been interpreted in terms of anomalies of gamma-ray intensity. This interpretation was carried out by initial inspection of the records of gamma-ray intensity and altitude above ground level, in conjunction with examination of aerial photographs and geological maps (Livingstone, 1957).

The radioaltimeter record was utilised with discretion. For one thing, the varying types of country rock and extent of overburden rendered accurate signal/height relationships difficult to determine and apply; indeed, it was not considered worth while to attempt this, even though some traverses ran along one formation fairly continuously. For another, the cone of acceptance of the scintillograph detector head does not coincide with the more restricted acceptance figure of the radioaltimeter receiving antenna. In terrain as rugged as much of the South Alligator River country, therefore, it cannot be assumed that the scintillograph is recording gamma radiation from the point, approximately beneath the line of flight, from which the radioaltimeter transmission is reflected.

Considerable caution had therefore to be exercised in applying any form of correction based on the radioaltimeter record. In the South Alligator River uranium field, the majority of known deposits occur on saddles or spurs high up in the hills, and it is extremely difficult to correlate scintillograph and radioaltimeter records when the aircraft is flying along the side of these hills. In addition, heavy rubble cover on the lower slopes has a masking effect, so that even a small anomaly might prove very important.

Taking these factors into consideration, however, it was possible to establish in many cases that fluctuations of the record of gamma-ray intensity were due solely to decrease in altitude above ground level, resulting from topographical elevation or erratic flying; inspection of aerial photographs provided confirmatory evidence. Those anomalies which could not be explained as resulting from the effects of topography, erratic flying, or exposure of country rock in an environment of low general radioactivity, were selected for final plotting. It was expected that some of these anomalies would prove of no interest, and this expectation was strengthened in some cases by photogeological interpretation but sufficient evidence did not exist to justify discarding any without inspection of the locality on the ground. Some of course, coincide with existing uranium prospects.

5. DISCUSSION OF RESULTS

During the course of the survey 53 anomalies of gamma-ray intensity were located. It is convenient to discuss these in groups, according to the areas in which they fall. The anomalies located in the South Alligator River valley and in the Mt. Basedow range are discussed in more detail below. A total of 45 anomalies were located in these two areas, 36 in the South Alligator River valley and 9 in the Mt. Basedow Range. The latter were examined on the ground by Bureau geologists.

In the Mt. Partridge area, which is taken to include the long chain of hills making up Mt. Partridge, and the isolated mass of Spring Peak to the north, 4 anomalies were located, all in the vicinity of Spring Peak (Nos. 1-4). One of these (No. 1) falls on a position where thorium-bearing arkose had previously been observed. Though these have not been examined on the ground, it seems most probably that they all represent thorium-bearing arkose or conglomerate.

It was hoped that the Mt. Partridge formation in this area might afford interesting results, since it presents to an extent lithological conditions similar to those at Blind River (Walpole, 1957). However, results of the airborne survey amounted to these 4 anomalies near Spring Peak, and nothing more.

East of the South Alligator River, one anomaly (No.14) occurs on a creek draining into Barramundie Creek. Its position near to the unconformity was suggestive, but on inspection from the air it appeared to lie in a mud, in a similar environment to the anomalies near the Katherine River.

A strong radiometric anomaly had been observed, during airborne survey by North Australian Uranium Corporation N.L., on a stream draining into the Katherine River upstream from Sleisbeck. This anomaly (No. 52) was re-located, and it was found that, while radioactivity was highest in one spot, anomalous radioactivity could be traced upstream to where the stream debouched from a deep gorge trenched in the Upper Proterozoic plateau. By a process of flying along and across the gorge, it was found that strong radioactivity occurred some way up the gorge (No. 51). The airborne survey could detect no anomalous radioactivity higher up the gorge or on the plateau and in the branching gorges on either side. It was already known that the anomaly recorded earlier lay in a radioactive mud which was uraniferous, and follow-up work by P.R. Dunn showed that the anomaly upstream also lay in a radioactive mud. Geological opinion (Walpole, 1957) was that it would not be worth while to pursue the search further, and the airborne survey was not able to provide any evidence for further work.

Three traverses, each consisting of three flight lines spaced approximately half a mile apart, were flown across the plateau of Arnhem Land (Plate 1). One small sharp anomaly was located just beneath the escarpment near a tributary of the Katherine River (No. 53). No follow-up of this anomaly was possible. The remainder of the traverses provided no results of any interest, the radiometric pattern being uniformly featureless.

6. LOCALITIES OF PARTICULAR INTEREST

By far the majority of the anomalies located lay in the South Alligator River valley, and the only area of particular interest outside this proved to be the Mt. Basedow range. It was always to be expected, of course, that radiometric results in the South Alligator River valley would be more interesting than anywhere else. The Mt. Basedow range was covered in a process of elimination, in an endeavour to trace the source of uranium which had been identified by Debnam (1954) in the water of Jim Jim Creek. Jim Jim Creek and all its tributaries, and Nourlangie Creek, were flown systematically as far south as the Upper Proterozoic escarpment without result; it was then decided, in discussion with B.P. Walpole, to fly the Mt. Basedow range as a last reøort; this resulted in 9 anomalies being located.

SOUTH ALLIGATOR RIVER VALLEY

In all, 36 anomalies were located in the South Alligator River valley. Of these, 10 fall on existing uranium prospects (Nos. 15,19,26,27,28,29,32,37,38 and 43), one on the El Sharana stockpile (No. 21), one on the site of a former stockpile near Palette (No. 31), and one on the camp at El Sharana (No. 20). The elongation of the anomalous areas at El Sharana (No. 19) and the stockpile is due to spill of ore in the vicinity. The anomaly on the camp at El Sharana represents specimens stored there, including a boulder of massive pitchblende.

None of the remaining 23 anomalies had been examined on the ground by the time the airborne survey party withdrew from the area. However, a few general comments can be made about these, some of which were already known to companies operating in the area.

A little over 2 miles south-east of Rockhole is the Airstrip anomaly (No. 16); this is reported to be uranium mineralisation of low grade in a siltstone below the unconformity. Just under 2 miles east-north-east of El Sharana two anomalies (Nos. 17 and 18) occur in a position close to the unconformity; it is possible that these may fall on a shear in which uranium mineralisation occurs in a saddle a little to the eastwards. One anomaly (No. 25) opposite the Koolpin Creek prospect is reported to represent a small occurrence of high-grade uranium mineralisation. Immediately west of Saddle Ridge is a strong anomaly (No. 36), which may lie on a shear in which uranium mineralisation occurs at the Saddle Ridge prospect. About 700 yards north-west of this anomaly, another (No. 35) falls in an area on the lower slopes of the hill where anomalous radioactivity has been reported by ground parties. An anomaly on the river itself (No. 41) is due to monazite washed down from the Middle Creek Granite. Little can be said at the moment about the remainder of the anomalies in the valley. Inspection of aerial photographs and geological maps suggests that most of them lie near the unconformity. However, it is not possible to say whether they occur above or below the unconformity. Some, indeed, could be on the Pul Pul Ryholite; this is reported as being moderately radioactive, but the airborne survey results do not confirm this to any marked extent; radioactivity in this formation could, of course, be patchy. It must be pointed out also that uranium mineralisation has been reported from one locality in the Pul Pul Ryholite near El Sharana. Two anomalies (Nos. 39 and 50) are so situated that no suggestions can be made about them.

MT. BASEDOW RANGE

The Mt. Basedow range is a steep ridge lying within the angle formed by Jim Jim Creek and the Goodparla-Oenpelli track. A total of 9 anomalies (Nos. 5-13) were located in the range, one of these, lying on Lavender Hill (No.11), being extensive. These localities were examined by R. Bryan and later by C.E. Prichard and C.D. Cooper (Prichard, 1957).

It was found that the anomalies occurred in quartz-schists and quartz-mica schists in an area of moderately severe contortion. With the exception of the Lavender Hill anomaly, all were small and sharply-defined, the areas of anomalous radioactivity varying from 20 x 10 ft. to 100 x 60 yds. (It is interesting to note in passing the very small area of the smallest anomaly located). The Lavender Hill anomaly was mapped as nearly a mile long, with a maximum width of half a mile, which compares favourably with the extent delineated by the airborne survey, namely 4/5ths of a mile by half a mile.

No visible mineralisation was reported, and there appeared to be no evidence of structural control. Radiometric assays of specimens from several anomalies ranged from 0.01 to 0.03%eU_3O_8; the equilibrium factors lay mainly in the range 0.76 to 1.6, but one was as low as 0.61: this low equilibrium factor suggests the presence of thorium, which, however, would not be suggested by the other values. The rocks of the Mt. Basedow range are mapped as Mt. Partridge Formation (Lower Proterozoic) which, as has been mentioned above, contains thorium-bearing arkose near Spring Peak; it is possible that the Mt. Basedow beds are a metamorphosed facies of this arkose. However, taking into account also the presence of uranium in the water of Jim Jim Creek nearby and the range of equilibrium factors, it is a reasonable postulation that both uranium and thorium may be present. Further work is required to arrive at a true conclusion.

7. CONCLUSIONS AND RECOMMENDATIONS

The results of the airborne survey are in part a reflection of the amount of exploratory work already carried out in the South Alligator River valley. All the anomalies in the valley (other than Nos. 39 and 50) occur in geological environments in which anomalous radioactivity has already been observed, though some of the actual localities are new. Some anomalies may fall on the Pul Pul Rhyolite, but it cannot be said whether they are due to ore deposits or to general high radioactivity in the rhyolite as a whole. Of the new anomalies five (Nos. 17,18,30,34 and 36) excite the most interest, but presumably all the anomalies lying within Authorities to Prospect will be followed up by the companies concerned. It is recommended that those lying outside these Authorities (Nos.47-50) be examined by Bureau geologists.

Outside the South Alligator River valley, the most interesting area is the Mt. Basedow range. A programme of pitting and trenching is recommended, and it is understood that this may be carried out by the Bureau during the 1958 dry season. The writer is not in a position to advise whether further work on the radioactive muds (Nos. 51 and 52, and possibly No. 14) should be undertaken. The small anomaly under the Upper Proterozoic plateau of Arnhem Land (No.53) seems worth examination on the ground. It is considered that the Mt. Basedow range should have highest priority in further investigations.

8. REFERENCES

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Livingstone, D.F., 1957 - Notes on the technique and interpretation of airborne radiometric surveys, Bur.Min. Res.Aust., Records, 1957, No. 102.

Prichard, C.E., 1957 - Report on activities of the Darwin Uranium Group for October, 1957, Bur.Min. Res.Aust., Records, 1957 (un-numbered).

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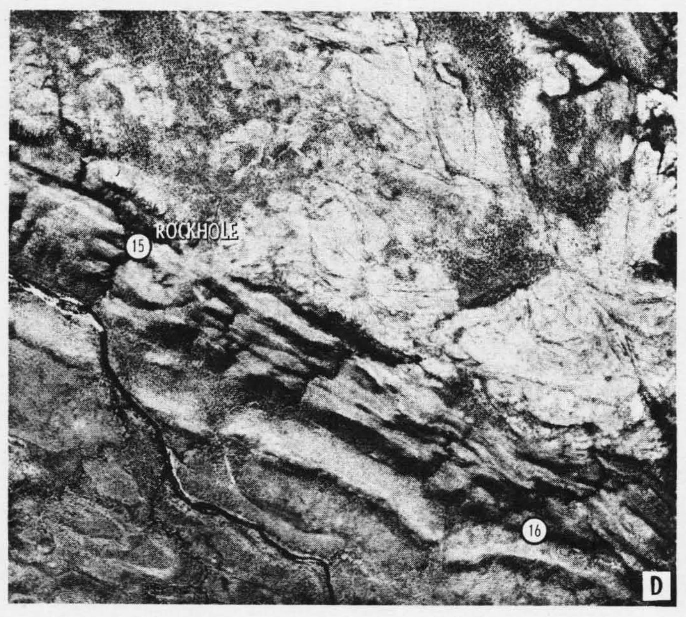
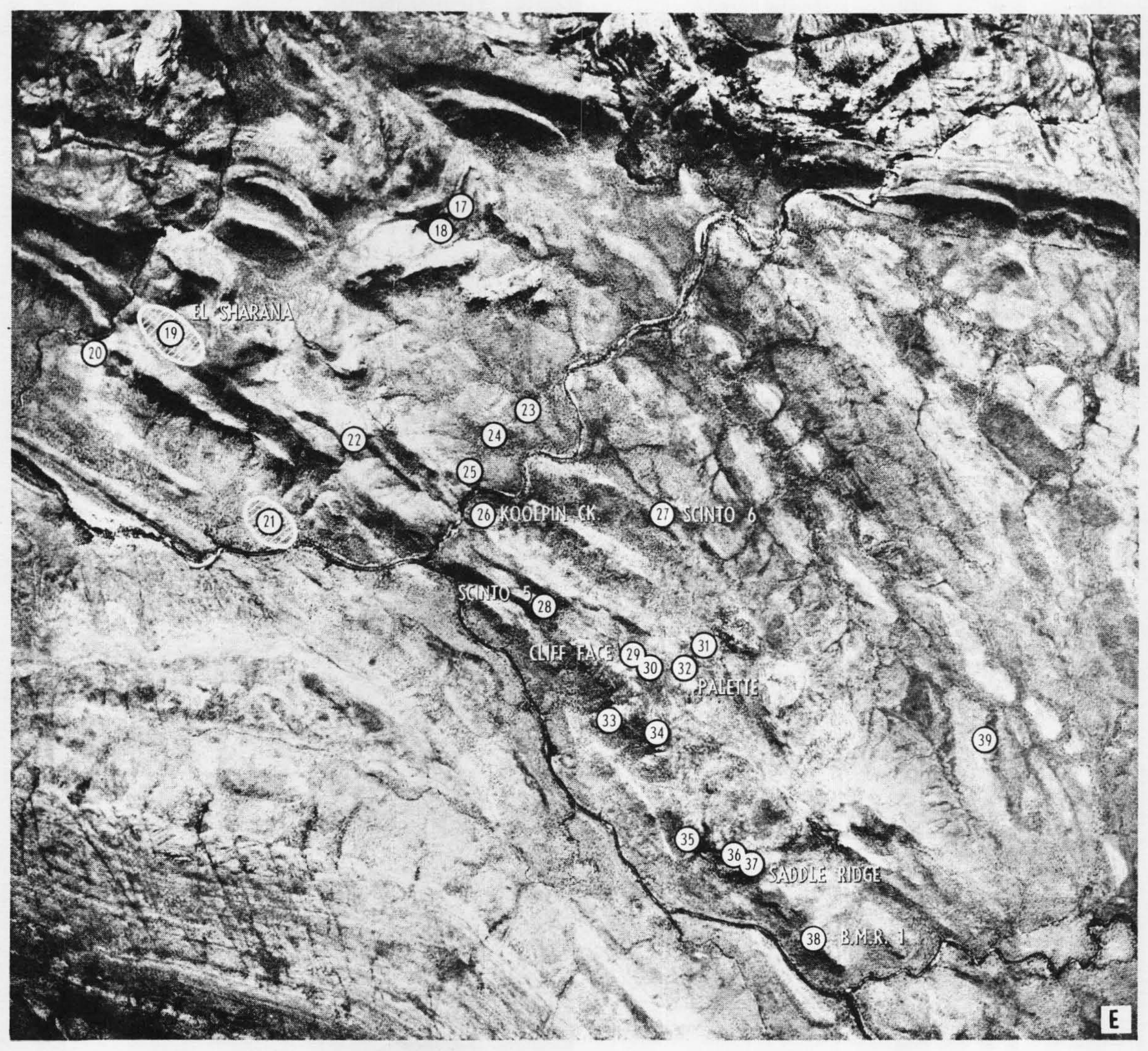
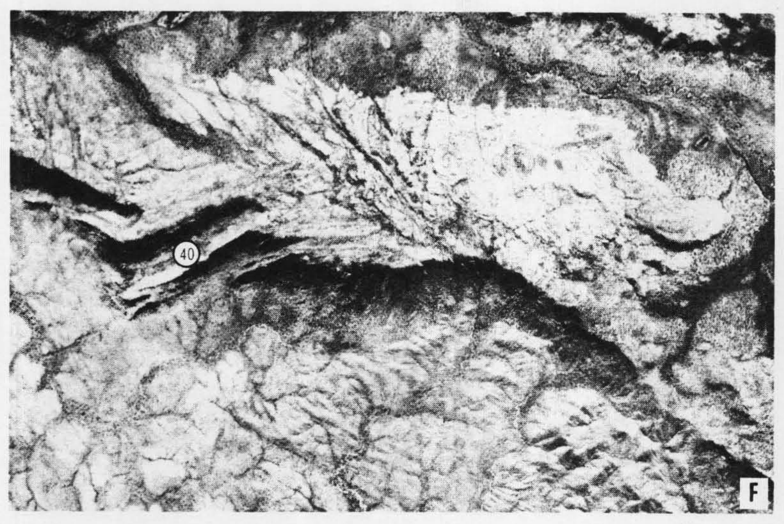
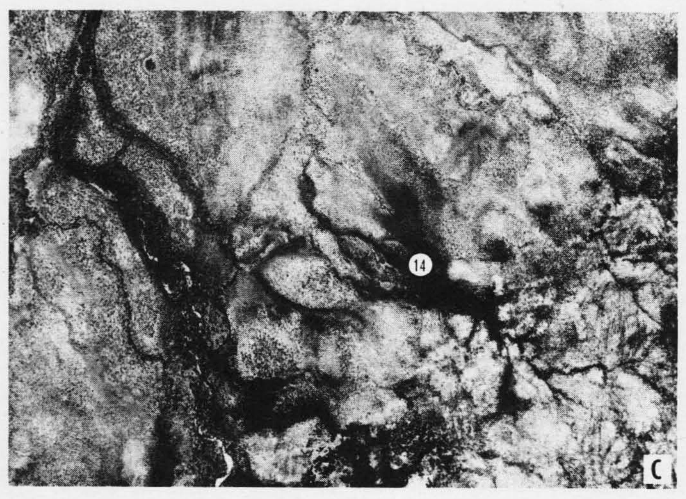
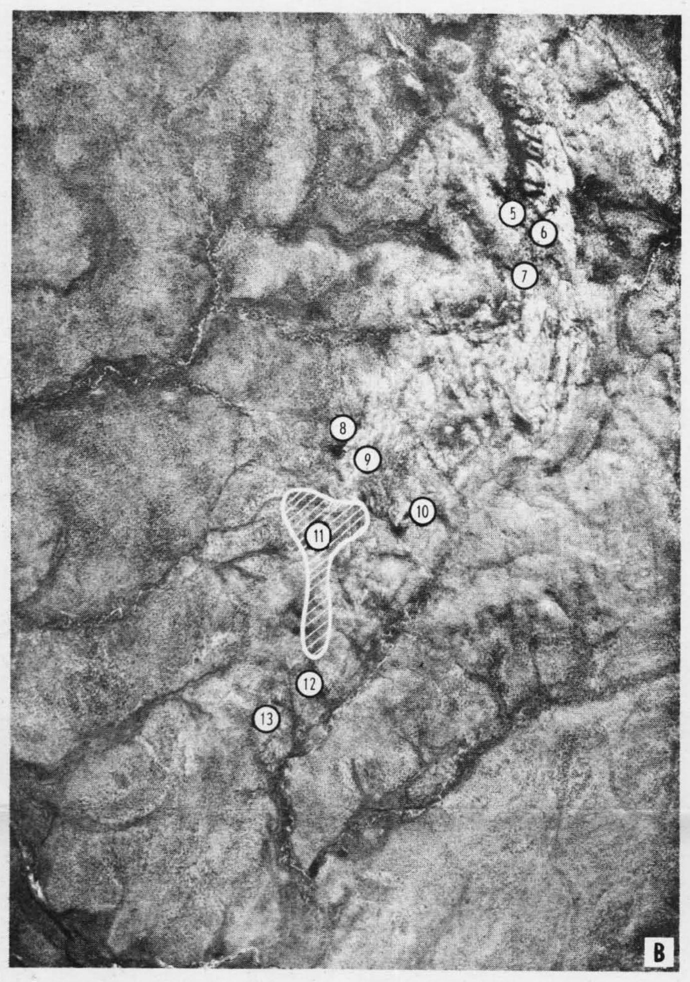
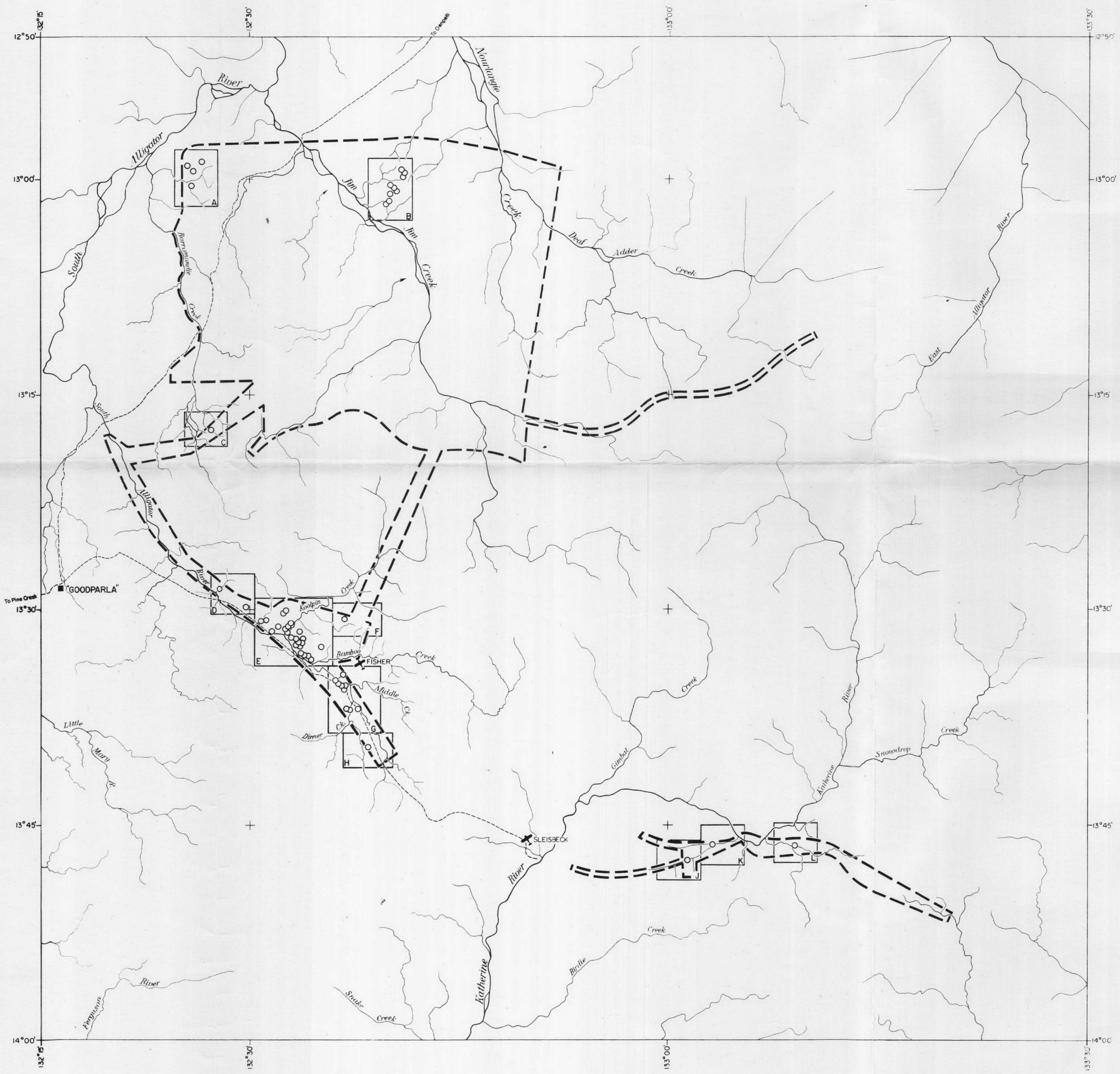


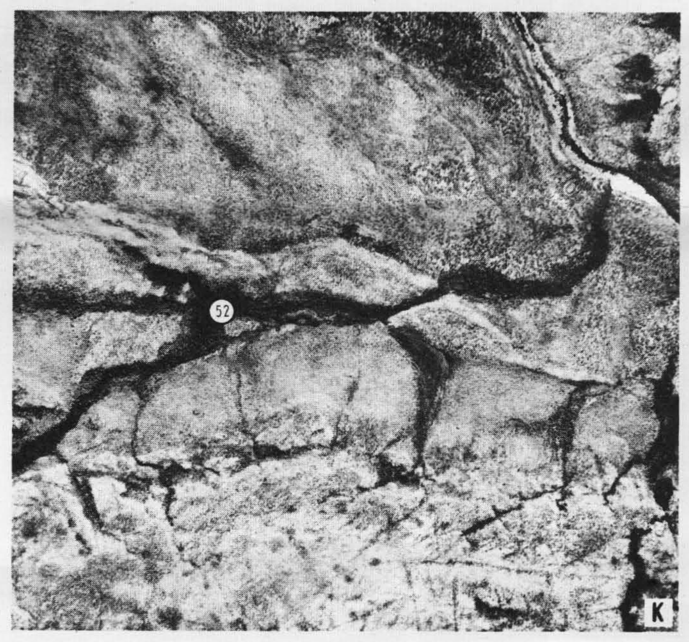


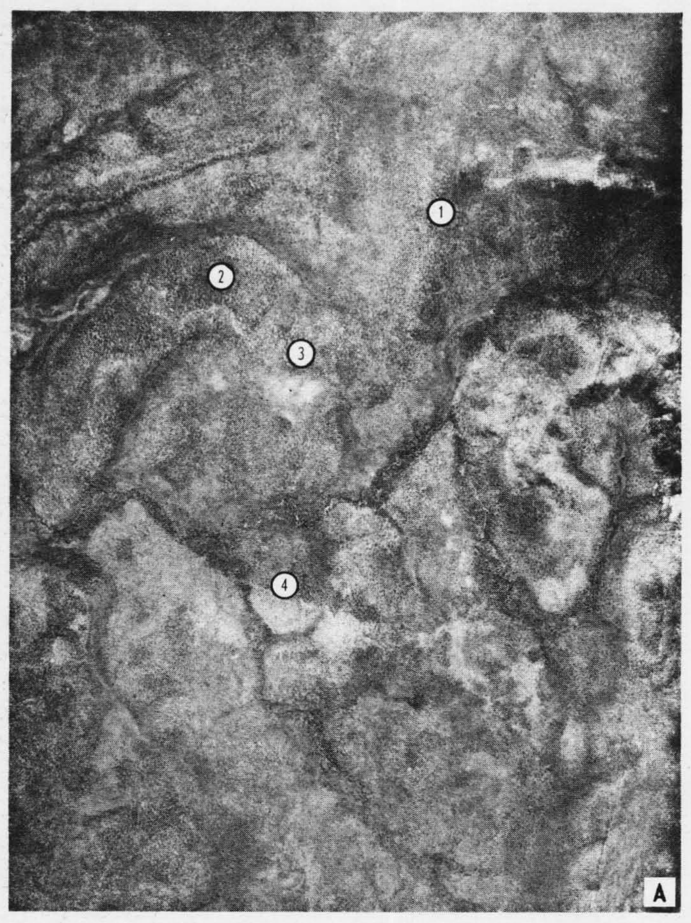


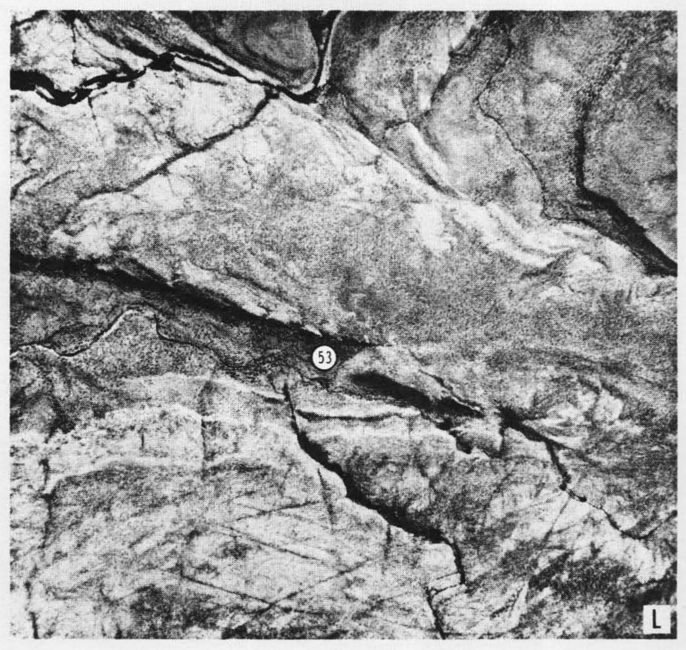




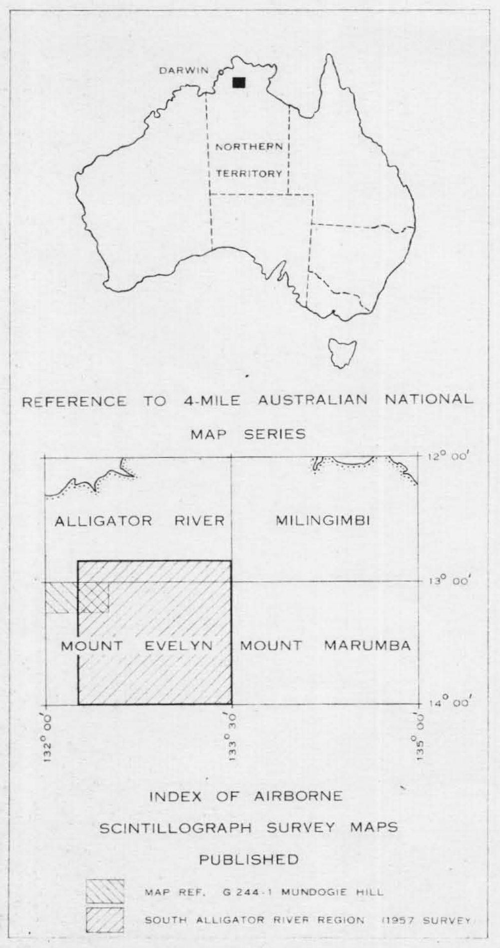








LOCATION DIAGRAM



LEGEND

TOPOGRAPHICAL DATA

- RIVER OR CREEK
- RAILWAY
- HIGHWAY
- ROAD
- TRACK
- TELEGRAPH LINE
- FENCE
- AERODROME OR LANDING GROUND
- TOWN
- HOMESTEAD
- SHED OR HUT
- TRIG. STATION
- MINE
- STATE BOUNDARY

SCINTILLOGRAPH DATA

- ANOMALY (ANOMALIES ARE NUMBERED FOR REFERENCE ONLY)
- LIMIT OF THE 1957 AIRBORNE SURVEY

NORTHERN TERRITORY

SOUTH ALLIGATOR RIVER REGION

MAP SHOWING

RADIOMETRIC ANOMALIES

DETECTED BY AIRBORNE SCINTILLOGRAPH

SEPT.-OCT., 1957

APPROXIMATE SCALE OF PHOTO MAPS

MILES 1 0 1 2 3 MILES

SCALE OF PLANIMETRIC MAP

MILES 8 4 0 8 16 24 32 MILES

MAP DATA

PROJECTION: TRANSVERSE MERCATOR, AUSTRALIAN SERIES

DETAIL: PLANIMETRIC DETAIL WAS COMPILED FROM AIR PHOTO MOSAICS SUPPLEMENTED BY SKETCH MAPS SUPPLIED BY DIVISION OF NATIONAL MAPPING. ADDITIONAL DATA WERE COMPILED FROM PHOTO INTERPRETATION BY GEOPHYSICAL SECTION, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RELIABILITY: SKETCH ONLY

NOTE: IMPERFECTIONS ON AIR PHOTO MAPS ARE DUE TO FAULTS ON ORIGINAL NEGATIVES.

EXPLANATORY NOTES

The airborne scintillograph records continuously the intensity of gamma radiation from the ground over which the aircraft flies. This radiation is due to the presence of the naturally occurring radioactive elements, radium and thorium and their decay products, and to a lesser extent potassium.

The scintillograph was carried in an Auster aircraft which was flown at an average altitude of 200 feet above the ground. The scintillograph effectively scanned a strip of ground approximately 500 feet wide.

The gamma-ray intensity over an area may show considerable variations, depending on the geology and topography of the area. Anomalies of gamma-ray intensity have been plotted on the map where the intensity showed a significant and localised increase.

The map shows the general position and grouping of the anomalies. To assist in making investigations on the ground, all the anomalies have been reproduced singly or in small groups on aerial photographs. The positioning of these anomalies is considered to be accurate to within 300 feet.

The higher intensities recorded by the scintillograph are not necessarily due to the presence of uranium deposits. Some of the higher intensities may be due to outcrops of igneous rocks, which contain a slightly higher concentration of the radioactive elements, uranium, thorium and potassium, than other rocks. No claim is made that all, or even any, of the higher intensities correspond to uranium deposits of economic significance, but it is possible that some do.

It should be noted that it is virtually only the radioactivity of the surface of the ground that has been recorded, because the radiation from any buried deposit is substantially reduced by a few inches of soil or rock cover.

COMPILED AND DRAWN BY GEOPHYSICAL SECTION, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS
DEPARTMENT OF NATIONAL DEVELOPMENT, MELBOURNE.

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