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RADIOACTIVE SURVEYS KATHERINE-DARWIN REGION

ANNUAL REPORT FOR 1953

by

R.S. Matheson

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SUMMARY

As a result of the field activities of the Bureau during 1953 regional geological maps have been prepared for the Rum Jungle district, the Katherine-Edith River district and the Coronation Hill-Goodparla district, which cover the Katherine, Lewin Springs and Mt. Todd 1 mile military sheets and portions of the Marrakai, Mt. Tolmer, Batchelor, Tumbling Waters, Goodparla North, Goodparla South and Mt. Evelyn sheets. Detailed geological and geophysical reports and plans have also been prepared for all known radioactive mineral prospects, costeaning and diamond drilling has been undertaken to test some of the prospects and inspectional reports have been made on practically all airborne scintillometer anomalies located during surveys in 1952, and on some of those found during 1953. Prospecting operations have also been undertaken.

A total of 3071 feet of diamond drilling was completed during the season, 1587 feet 4 inches at the Brodribb prospect, 1006 feet 7 inches at the Coronation Hill prospect, and 477 feet at the Ella Creek prospect.

The Bureau was directly responsible during the year for the discovery of four new uranium prospects, namely:-

ABC Prospect, Katherine area
Coronation Hill Prospect, South Alligator River
Mt. Shoobridge Prospect, near Mt. Shoobridge
Waterhouse No. 2 Prospect, 5 miles south of Batchelor

Some testing of these prospects has already been undertaken but is not yet completed.

Other new radioactive mineral discoveries were made by private enterprise during the year in the Edith River area, at Yenberrie, in the Brock's Creek area and near Bynoe Harbour. The latter discovery proved to be due to the presence of thorium however.

As a result of the airborne investigations regional scintillometer and magnetometer surveys were completed over about 1700 square miles in the northern part of the region, giving coverage of the Burnside sheet and portions of the Reynolds River, Ban Ban and Tipperary sheets; and about 1200 square miles were flown in the Katherine area giving part coverage of the Lewin Springs, Mt. Todd, Florina and Katherine sheets. The anomalies located will be inspected on the ground during the 1954 field season.

The work done during the year has provided valuable regional information, and also detailed information concerning the radioactive prospects and anomalies, to help in a proper understanding of uranium mineralization in the region. There has been a strong demand for this information by mining companies and prospectors, whose interest in the search for uranium deposits in the region is now greatly stimulated.

Prior to 1953 the search for uranium minerals in the region was practically confined to belts of rocks of Lower Proterozoic age, but during 1953 uranium mineralization was discovered by the Bureau in association with rocks of Upper Proterozoic age. This discovery has greatly advanced our knowledge of uranium mineralization in the region and increased the scope for prospecting at least three fold.

A considerable amount of the Katherine-Darwin region is yet to be investigated, and it is expected that activities by the Bureau during 1954 will be on at least an equal scale to those carried out during 1953.

INTRODUCTION.

At the end of 1952 the Commonwealth Government arranged for Territory Enterprises Pty. Ltd (a subsidiary of Consolidated Zinc Pty. Ltd) to take over from the Bureau of Mineral Resources the further testing and development of the uranium deposits in the Rum Jungle area, and the general search for other uranium deposits in the Hundred of Goyder. To facilitate the changeover some geologists and geophysicists of the Bureau were seconded to Territory Enterprises Pty. Ltd. for a period of six months, and a few months were spent by the headquarters staff of the radioactive minerals group of the Bureau in finalising the results of their activities at Rum Jungle during the period 1950 to 1952, for the benefit of the company.

As a result of the new arrangements concerning further work at Rum Jungle, the activities of the Bureau during 1953 were conducted outside the Hundred of Goyder, and were generally of an exploratory character and on a much larger scale than in previous years. The work carried out was in accordance with a programme laid down at the beginning of 1953, which called for the establishment of a Darwin office, equipment store and laboratory; ground geological, geophysical and geochemical investigations in the Brodribb, Waterhouse, Edith River and Arnhem Land areas; airborne scintillometer and magnetometer surveys; and, where warranted diamond drilling and prospect mining operations. The mining public were also to receive general advice and assistance from the Bureau staff, and arrangements were to be made to house the Bureau staff resident in Darwin.

A summary of the activities of the Bureau during 1953 and the results achieved is given in the following pages, and further details can be obtained from the reports mentioned in the list of references.

HEADQUARTERS DARWIN

OFFICE.

The Darwin office was established for supervision of the Bureau's local activities in connection with radioactive mineral investigations and for general services to the regional parties operating in the northern part of the Territory.

A temporary office in the Larrakeyah Military area was occupied on the 25th May and remained the office of the Bureau of Mineral Resources throughout the year. This office is a very poor building, it is badly situated and conditions and space for staff are generally poor. Efforts are being made to obtain a house centrally situated in Darwin to improve conditions and facilities, and serve as a better temporary office until the permanent office is established.

Tenders are being called for the erection of a permanent Bureau office in Darwin, but it is not expected to be ready for occupation before the end of 1954.

WINNELLIE STORE AND LABORATORY.

Alterations were carried out during the year in a large shed situated at Winnellie, about 7 miles east of Darwin, to establish an equipment store and laboratory.

Delays have occurred in getting the equipment store and laboratory properly set up, as building alterations were not completed until December. The building should be properly set up and functioning by the beginning of the 1954 field season however.

During 1953 it was necessary for the Bureau to forward samples for instrumental uranium assay to T.E.P., Rum Jungle, as the Bureau's own laboratory was not operating.

Another building has been taken over on a temporary basis during the 1953-1954 "wet" season as an inter-field season vehicle store. Similar arrangements could probably be made during future "wet" seasons.

HOUSING

A contract was let early in the year for the erection of eight houses (four 3 bedroom and four 2 bedroom) for the Bureau staff resident in Darwin. At the 31st December 1953 only one house (a 3 bedroom) had been completed and occupied. The Department of Works, Darwin estimated at that time that an additional 2 bedroom house would be completed on the 8th January, 1954, and that the other houses would be completed at intervals of 2 and 3 weeks thereafter.

Tenders have been called for an additional twelve houses for the Bureau to be erected in Darwin during 1954.

STAFF

A total of 30 geologists and geophysicists of the Bureau staff, out of a total complement of 100 men, were connected with the radioactive mineral investigations during the year.

The Darwin office staff consisted initially of R.S. Matheson (Geologist in charge of investigations), a clerk and a shorthand typiste. Geophysicist, J.B. Misz joined the staff in August, and Geologist J.H. Lord replaced R.S. Matheson as officer in charge Darwin in November, the latter then returning to Canberra to take over the duties of Supervising Geologist Radioactive Mineral Investigations.

The Darwin office when finally set up allows for an establishment of seven persons, but experience during 1953 indicates that additional clerical and typing assistance will be needed for the office to function efficiently.

Senior Radio Technician W. Burns and two storemen were based at Winnellie during the year, and additions to this staff are to be made when the laboratory is ready for operation.

The staff of the Brodribb party consisted originally of Geologists D.E. Catley (party leader), D.N. Smith, K.G. Smith and K. Crank, and Geophysicist I.A. Mumme. Geologist B.P. Walpole replaced D.E. Catley as party leader towards the end of June, and was himself replaced, following on accident, by Geologist P.B. Rosenhain at the beginning of September. Geologist J. Wyatt was transferred to this party in December. Geologist K. Crank resigned in August.

The staff of the Waterhouse party consisted originally of Geologists P.B. Rosenhain (party leader), F. Joklik, J.B. Firman and J. Wyatt, and Geophysicist A. Alle. F. Joklik ceased work with the party at the end of June in order to take up a scholarship overseas, and was replaced by F.J. Frankovich, who had previously been seconded to Territory Enterprises Pty. Ltd. F.J. Frankovich became party leader in September when P.B. Rosenhain was transferred to the Brodribb party.

The staff of the Edith River Party consisted of Geologists D.E. Gardner (party leader), J.H. Rattigan, A.B. Clark and N.O. Jones and Geophysicist R. De Groote, and it remained unchanged throughout the field season.

The staff of the Arnhem Land party consisted originally of Geologists B.P. Walpole (party leader), B.J. Drew and R.A. Britten. Following the discovery of the Coronation Hill prospect the geophysical work was handled partly by R. de Groote and partly by J. Barlow and L. Hawkins. Following B.P. Walpole's transfer to the Brodribb party towards the end of June, B.J. Drew became party leader in this area. Geologist R.B. Allen, who is on loan to the Bureau as Consulting Geologist from the Eldorado Mining and Refining Company of Canada, took over the duties of party leader from September. From the time of his arrival in the area in June until September R.B. Allen assisted in the general supervision of the field work in the various camps.

Of the two American geologists, on loan to the Bureau from the American Atomic Energy Commission, it has already been pointed out that F.J. Frankovich was attached to the Waterhouse party from the beginning of July, but P.H. Dodd remained seconded to Territory Enterprises Pty. Ltd. throughout the year.

The geochemical team comprised A. Debnam and D. White.

The reconnaissance geophysical team, operating the vehicle mounted scintillometer, consisted of Geophysicists J. Barlow and L. Hawkins.

Geophysicist D. McCarthy was in charge of the airborne party until about the end of September, when he returned to headquarters Melbourne, and was replaced by P. Goodeve.

W. Rae of the Mining Engineering Section of the Bureau was in the field for a few months during the year supervising the diamond drilling operations.

FIELD WORK

From the beginning of January until the end of March, four geologists and one geophysicist of the staff of the Bureau of Mineral Resources were seconded to Territory Enterprises Pty. Ltd., and assisted in the investigations and development work at Rum Jungle.

Field operations by the Bureau in 1953 were commenced about the beginning of April, when Geologist D.N. Smith and a party of Bureau drillers were released from Rum Jungle and commenced camp preparations and diamond drilling in the Brodribb area.

The four main geological parties, namely, the Brodribb party, the Waterhouse party, the Edith River party and the Arnhem Land party arrived in the area at the end of April, their entry to the field being governed by the closing of the "wet" season.

The airborne geophysical party arrived in the area about the middle of May, and the ground geophysical personnel about the middle of June.

Field work was discontinued in three of the areas about the end of October, but the Brodribb Camp continued to act as a base for the personnel carrying out restricted activities over the "wet" season.

The geological parties were engaged in both regional and detailed investigations. The regional work consisted of regional geological mapping and prospecting. The detailed work consisted of inspection of radioactive anomalies located by airborne surveys; examination of new radioactive discoveries; detailed geological mapping of encouraging radioactive prospects; laying out of costeans and diamond drill holes; and geological work and sampling in connection with drilling operations and prospect mining operations.

The geophysicists attached to the four geological parties were engaged in detailed radiometric, magnetometer and self-potential surveys, and were also responsible for providing preliminary instrumental uranium assay results of samples collected and for the Geiger logging of the diamond drill holes.

The airborne geophysical team carried out regional, Shoran-controlled, scintillometer and magnetometer surveys.

A reconnaissance geophysical team was also in the area, and they operated a vehicle-mounted scintillometer, which assisted in regional prospecting and in the ground location of anomalies indicated from the airborne surveys.

A geochemical team was in the field for a few months during the year and moved between camps carrying out surveys for lead, copper and cobalt around known radioactive prospects.

Bureau drillers operated two Sullivan H.D.22 drills in the area during the year.

BRODRIBB AREA.

The work carried out in this area during the year consisted chiefly of detailed geological and geophysical investigations, and little attention was paid to regional geological mapping until after the end of June. Such regional geological work as was done has been incorporated with the regional geological work of the Waterhouse party.

No important deposits have so far been found in the area, but three prospects, namely, the Brodribb, Ella Creek and Fraser prospects, all of which represent airborne scintillometer anomalies located during surveys in 1952, were considered worthy of detailed mapping and testing.

BRODRIBB PROSPECT

Detailed geological and geophysical work was carried out on this prospect towards the end of 1952 (Frankovich, 1953), and some costeans were excavated by bulldozer.

The radioactive anomaly in excess of 150 counts per minute is 1800 feet long and averages about 250 feet wide, and within it localised areas range up to 500 counts per minute. Some "hot" spots of 1000 counts per minute are recorded. The background for the area is 50 counts per minute. The radioactive anomaly follows closely the remnants of a previously much more extensive, flatly distributed capping of ferruginous laterite. The laterite overlies contorted, interbedded slates, carbonaceous slates and quartzites of the Brock's Creek Group of Lower Proterozoic age, which are intruded by quartz veins.

The mineral causing the radioactivity has not yet been identified, but it is intimately associated with iron minerals (particularly hematite).

As a result of the costeaning done in 1952 it was noted that radiometric counts tended to drop off below the laterite capping, and persisted only in the roots of the laterite cap. It seemed likely however that below the superficially enriched laterite, leaching and impoverishment of any underlying uranium deposit could occur in the oxidised zone. Drilling was therefore recommended to test the belt of country below the anomaly in the primary zone. Further weight was given to the drilling recommendations by the fact that the Brodribb anomaly was to be used as a test case to interpret the value of numerous anomalies of the same type distributed sporadically through this area, over a length of 6 miles.

During 1953, six diamond drill holes, with a total footage of 1587 feet 4 inches, were drilled at the Brodribb prospect, and were arranged to make an exhaustive test for the occurrence of a primary uranium deposit of importance in the area (Smith, 1953). Although streaks of pyrite and disseminated pyrite were encountered in the Brock's Creek meta-sediments below the anomaly, the radiometric assay results were generally low, samples generally assaying less than 0.01% eU_3O_8[x], and none exceeding 0.019% eU_3O_8. Mineralogical work indicated that pyrrhotite was associated with the pyrite in the sulphide zone.

Sludge samples of sulphide-bearing material taken at 10 feet intervals from between 230 feet and 403 feet bore depth in hole B1, and sent to the Mines Department, Alice Springs for gold assay, gave results ranging from less than 0.2 dwts to 0.6 dwts gold per ton.

The results of the diamond drilling have been disappointing and it now appears fairly definite that the anomaly at Brodribb is the result of superficial enrichment in ferruginous laterite from a very low-grade original source in the underlying Brock's Creek meta-sediments. The higher values in the drill holes appear to be associated with zones of hematised vuggy quartz and quartzite.

One rather remote chance which yet remains untested is that the mineralization occurs as a shallow basin shaped body, and the holes were drilled underneath it. There is some suggestion at Brodribb that the contorted slate beds are folded on an east-west axis into the form of a broader syncline, which would support this view if we assume mineralization is associated with a particular bed. Brodribb is on the northern flank of the Rum Jungle domal structure, and the local syncline could be part of a larger dragfold. Erosion could account for the absence of the anticlinal crest of the mineralized bed, and the northern limb of the anticlinal portion of the dragfold could be expected to reach the ground again some distance north of Brodribb. Airborne scintillometer surveys have failed to locate any radioactive anomalies in this direction however, so that there is little encouragement for further prospecting.

The superficially enriched ferruginous laterite at the Brodribb anomaly, and other similar anomalies in the area, represent small reserves of radioactive material, but further work is required to determine what mineral or minerals are causing the radioactivity, what is the grade of the laterite and whether or not this radioactive material would be acceptable, particularly from the view point of metallurgical treatment. Recent mineralogical work and chemical assay has shown that the radioactivity at Madigan's prospect, which is also associated with iron minerals, is due chiefly to the presence of thorium and not uranium. Radiation absorption and fluorimeter tests, which have recently been carried out, suggest that the radioactivity at Brodribb may also be due to thorium, and further investigations are now in progress.

ELLA CREEK PROSPECT:

Detailed geological and geophysical work was carried out at this prospect during 1953 (Smith 1953 and Mumme 1953), and some bulldozed costeaning and diamond drilling has also been undertaken.

At the Ella Creek prospect, which is situated 2.5 miles west of the 41 mile peg on the Stuart Highway, three radiometric

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x Assays in this report are radiometric assays expressed as equivalent U_3O_8.

anomalies giving readings up to 300 counts per minute, occur, over a length of 1200 feet, in anarea of slates and quartzites of the Brocks Creek Group into which quartz veins have been injected. A brecciated fault zone, which trends in a north-westerly direction is situated about 1 mile east of the prospect.

The radioactive anomalies are practically confined to areas of hematised and silicified slates, and, of the three, the anomaly situated about 600 feet south-west of the 00 peg on the base line, shows the best promise within this anomaly which extends over a length of 700 feet in a north-south direction and averages 250 feet in width, there are three areas showing Geiger counts in excess of 150 per minute (background count 50 per minute), with "hot" spots rising up to as high as 450 counts per minute. Two pits sunk to a depth of about 3 feet in this anomaly on spots showing 6 and 9 times background, showed an increase in Geiger counts to 6000 and 10,000 per minute respectively.

Following this initial work 780 feet of bulldozed costeaning was done in the area, and diamond drilling is at present in progress. To the end of December 477 feet of diamond drilling had been completed, and the results so far obtained have been disappointing but inconclusive.

In D.D.H. D1 a radioactive zone was encountered between bore depths of 85 and 150 feet, and Geiger probing results were very encouraging, showing a range from 180 to 3000 counts per minute. The sludge instrument assay results have been disappointing however, the samples from between bore depths of 100 and 145 feet showing a range of from only 0.012 to 0.027% eU_3O_8. This intersection is in the oxidised zone and D.D.H. D3, now in progress, is being drilled to intersect the radioactive zone at a deeper level in what it is hoped will be the primary zone. The occurrence of S.P. anomalies to the north of the radioactive anomaly, down the dip of the radioactive zone, gives support to the decision to test it in the primary zone. It is possible that the radioactive zone may be leached and impoverished near the surface, and that there will be an improvement in grade in the primary zone.

One rather disturbing feature about the prospect is that the mineral causing the radioactivity has not yet been identified, and radiation absorption and fluorimeter tests suggest that the radioactivity is due to thorium not uranium. Further investigations into this aspect are at present in progress.

FRAZER PROSPECT.

The Frazer anomaly occurs in association with a belt of ferruginous laterite with slate fragments and a quartz vein, in a low lying extensively soil covered area, about 3¼ miles east of the Brodribb Camp at 39¼ miles south of Darwin on the Stuart Highway. Detailed geological and geophysical work has been done at the prospect (Crank 1953 and Mumme 1953), and also some bulldozed costeaning.

The lateritised area extends in a north north-westerly direction over a length of 800 feet and has an average width of about 300 feet. Geiger readings of from 125 counts per minute to 400 counts per minute occur in this area. A costean bulldozed through the centre of the anomaly, over a length of 120 feet and to a maximum depth of 6 feet, showed that the highest radioactivity was in the thin superficial layer of ferruginous laterite, and that the underlying bleached and weathered slates had low radioactivity. The anomaly appears to be similar to the Brodribb anomaly, but sufficient work has not yet been done to properly understand or test it.

Magnetometer and S.P. surveys in the area gave no results of importance, and the mineral causing the radioactivity has not yet been identified, but as at the Brodribb and Ella Creek prospect it appears to be intimately associated with iron minerals (particularly hematite).

It is possible that the vertical section at the Frazer prospect could comprise, from the surface down, secondarily enriched laterite, then leached and impoverished slates, followed by uranium mineralization in the primary zone; but no further work is recommended here until the testing and investigations in progress on the Brodribb and Ella Creek prospects are completed, and the nature of the prospects clarified.

WATERHOUSE AREA.

The work carried out in this area consisted of both regional and detailed geological and geophysical investigations.

The regional geological mapping has now been extended from the immediate vicinity of Rum Jungle to cover an area of 600 square miles, embracing portions of the Batchelor, Mt. Tolmer, Marrakai and Tumbling Waters 1 mile military sheets (Frankovich and Firman, 1954). The most significant results of this work have been the recognition of the persistence away from the Rum Jungle area of important formations in the Lower Proterozoic sequence mapped there; the recognition of what are being referred to as the "Stapleton Volcanics", consisting of tuffs, tuffaceous shales, quartz grits and lavas, ranging from acid to basic in composition, and the recognition of what may be an unconformity or overthrust in the upper part of the Lower Proterozoic sequence. The brecciated rocks in the area are of considerable interest and there appears to be three types, namely, sedimentary breccias, fault breccias and breccias formed at formation junctions as a result of movement during regional folding.

No important deposits have so far been found in the area, but four prospects, namely the Waterhouse Nos. 1, 2, 3 and 4 prospects, have been examined in detail, and may warrant some further attention.

WATERHOUSE NO. 1 PROSPECT.

Detailed geological and geophysical work has been carried out at this prospect (Rosenhain and Alle, 1953), which is on a hill near the southern boundary of the Hundred of Goyder, 1.7 miles on a true bearing of 105 degrees from the south end of the Gould Airfield. The prospect is a second order anomaly located during airborne surveys in 1952.

A silicified zone about 450 feet long and 100 feet wide occurs at the top of the hill, at the junction of a bed of slate and a bed of siltstone, which strike in a general north-south direction and dip steeply east. Radioactive anomalies occur on both sides of the silicified zone.

In the underlying siltstone radioactivity in excess of 100 counts per minute (i.e. twice background) extends in a north-south direction over a length of 400 feet and a width of about 150 feet, and within it there are localised patches giving Geiger readings up to 600 counts per minute.

In the slates overlying the silicified zone there are several small scattered areas of radioactivity giving between 100 and 150 counts per minute. The radioactivity occurs in the slates in a north-south direction over a length of 600 feet, and about 350 feet beyond its northern limits there are silicified outcrops of slate with copper staining. Geochemical work has detected

traces of copper in the soil southwards from the copper showing to the area of anomalous radioactivity.

The slates and siltstones in the areas of higher radioactivity show pitting and limonite casts suggestive of the weathering out of sulphides, but self potential surveys have provided no results of importance. The mineral responsible for the radioactivity has not yet been identified.

Magnetometer surveys in the area indicated two series of magnetic highs west of the radioactive prospect, which could be related to a large magnetic body at depth, but no close association of uranium mineralization with magnetic rocks is yet recognised in the district.

The surface indications at the prospect are not particularly encouraging, but it must be borne in mind that this prospect is at a higher elevation than prospects at Rum Jungle, and leaching and impoverishment of the deposit may have occurred near the surface. Some drilling at the prospect to test in the primary zone, the section from the slates, through the silicified zone to the siltstone, is considered warranted. This work would give factual information for interpretation of similar types of anomalies elsewhere in the area.

WATERHOUSE NO. 2 PROSPECT.

Detailed geological and geophysical mapping has been carried out at this prospect (Wyatt and Alle, 1953), which is situated about 5 miles south of the Batchelor railway siding, and was discovered by F. Joklik during the course of regional mapping and prospecting.

At this prospect there is a good copper showing in contorted carbonaceous slates, which dip about 45 degrees east and overlie successively a narrow belt of brecciated slate, then quartzite breccia, and then siltstone. Radioactivity of from 100 to 200 counts per minute (i.e. 2 to 4 times background) extends in a north-south direction in the carbonaceous slates over a length of about 700 feet and an average width of 200 feet. Within this area there are three smaller areas of higher radioactivity with counts up to 600 per minute, and isolated spots with radioactivity up to 1,200 counts per minute.

Indications of secondary copper mineralization occur over the whole of the anomalous radioactive area, and the prospect bears certain similarities to the surface exposure of White's deposit, Rum Jungle. No uranium minerals have so far been identified from this prospect however.

The self-potential work, although not conclusive, shows a continuous region of negative anomalies occurring roughly along the same shale beds in which the radioactive highs occur. Magnetometer results do not appear to be directly connected with the radioactive anomaly.

Costeaning has shown that the anomalous radioactivity, and also the secondary copper minerals, persist only a few feet into the carbonaceous slates. It would appear that the secondary copper and uranium minerals found at the surface have migrated from their original source, and are being transported down the eastern slope of a low rise to ground water level, which immediately following the "wet" season is only 5 to 10 feet below the surface. The most favourable channel of investigation for primary mineralization appears to be the brecciated slate belt immediately overlying the quartzite breccia, on which a small isolated radioactive area giving up to 300 counts per minute was located. Test drilling of the brecciated slate belt in the primary zone is considered warranted.

WATERHOUSE NO. 3 PROSPECT.

Detailed geophysical work has been carried out at this prospect (Alle 1953), which is situated 4.6 miles on a true bearing of 174 degrees from the southern end of the Gould Airfield. It represents a second order anomaly located by airborne surveys in 1952.

The prospect occurs in an area of folded slates and quartzites into which quartz veins have been injected and three anomalous radioactive areas are indicated.

The first area occurs in a belt of slate rubble, and shows Geiger readings in excess of 110 counts per minute (i.e. twice background) over a length of 340 feet and a width of 140 feet. Within this area is a localised area, 40 feet long by 30 feet wide, giving readings of from 3 to 4 times background.

The second area is located in a belt of hematised rocks and shows readings of 110 counts per minute, over a length of 340 feet and a width of 150 feet. Within this area is a localised area, 30 feet long by 20 feet wide, giving readings of from 3 to 4 times background.

The third area embraces a group of rocks in which much quartz has been injected. An area of 2 to 3 times background extends over a length of about 300 feet and an average width of about 50 feet.

No radioactive minerals have so far been identified in the areas, but fluorescent minerals occur as veins and spots in the radioactive high zones. Hematite is also closely associated with the areas of high radioactivity.

A magnetometer survey has been undertaken at the prospect, but there does not appear to be any correlation of the results with the radioactive highs.

A self potential survey has not yet been undertaken.

The indications for the discovery of an important ore body at this prospect are not particularly encouraging, but some further investigations appear to be warranted to properly understand this type of anomaly.

WATERHOUSE NO. 4 PROSPECT.

Detailed geological and geophysical work has been carried out at this prospect (Rosenhain, 1953 and Alle, 1953), which is situated about $3\frac{1}{2}$ miles south of the Batchelor railway siding. The prospect is on the western side of the railway line near the northern boundary of the Hundred of Waterhouse, and embraces a group of anomalies located during airborne surveys in 1952.

The area in which the anomalies occur is a flat extensively laterite covered area, but scattered outcrops of slates, quartzite breccia and quartz veins occur. Radioactivity of twice background (i.e. 100 counts per minute) covers a broad area of 1200 feet east-west by 600 feet north-south, within which occur some small localised areas about 100 by 50 feet where the radioactivity increases up to a maximum of five times background. Three of these higher radioactive areas are associated with quartz veins and well hematised zones.

The results of a magnetometer survey which has been carried out show a large number of irregular highs and lows of variable extent. The mineral responsible for the radioactivity has not yet been identified.

Two shallow costeans, one of which showed a slight increase in count rate with depth, have been bulldozed in the area, and a few pits have been sunk with hand labour. No conclusive results have been obtained from this work however.

It seems likely that the anomalous radioactivity is the result of secondary enrichment in laterite from an original source in the underlying rocks of the Brocks Creek Group. Some further testing below the localised higher radioactive areas in the laterite therefore appears to be warranted, but the prospects of encountering an important ore body are not regarded as particularly encouraging.

EDITH RIVER AREA.

Both detailed and regional geological and geophysical investigations were carried out in this area.

Regional geological mapping was completed during the year of the Katherine, Mt. Todd and Lewin Springs, 1 mile military sheets, the area covered being approximately 1560 square miles. (Rattigan and Clark, 1954). The most significant results of this work have been the recognition of three different types of granite in the Cullen Granite; the recognition that the Edith River Volcanics are of Upper Proterozoic age not Cambrian age as was previously thought; and the recognition of other volcanics in the Upper Proterozoic both above and below the Edith River Volcanics. The study of the shear patterns and their relationships in the granitic areas has also aided the detailed investigations. The regional party was also responsible for the discovery of the ABC prospect associated with volcanics in the Upper Proterozoic sequence.

Numerous prospects occur in the area, namely, the Edith River Find, Tennyson's Prospects Nos. 1 to 6, Hore and O'Connor's Prospect, the Yenberrie Prospect and the ABC Prospect, and they have all been the subject of detailed investigation. Inspections have also been made by the detailed party of airborne scintillometer anomalies and they have been involved in prospecting activities. A complete list of reports on investigations is given in the list of references.

EDITH RIVER FIND.

This prospect which is held by the Y.M.C.A. Syndicate was reported on in 1952 (Fisher, 1952).

During 1953, the detailed party kept in touch with prospecting activities carried out by the syndicate.

From work done in 1952, it was seen that several short lenses of reddish, hematitic lode material with meta-autunite, occurred in a shear zone in granite at this prospect.

It appeared that only small scattered shoots could be expected to exceed the cut off grade of 0.1% eU_3O_8 in the oxidised section of the lenses of lode material, and that mining operations of any consequence would be dependent on the lode material being leached and impoverished near the surface and an improvement in grade at depth. Prospecting activities have not yet reached the primary zone, and the Bureau intends to drill a few holes during the 1953-1954 "wet" season to test this possibility, and also to determine the nature of the primary mineralization in this type of uranium deposit.

TENNYSON'S PROSPECTS NOS. 1 TO 6. (Gardner, 1953 and Jones, 1953).

Tennyson's original discovery was made in October 1952, about 300 yards south-west of the Florina track, and 3.7 miles west of the turn off from the Stuart Highway. All his subsequent finds are embraced in a reserve of 10 square miles granted to him at that time.

The six prospects include fifteen separate lenses of lode material, all of which occur in shear zones in granite. The lode material is similar to that at the original Edith River Find, and consists of fine grained, reddish, hematised material, which often occurs as lenticular bodies, but sometimes as the matrix to brecciated quartz or sheared granite. A yellowish uranium mineral, which fluoresces under ultra-violet light, and is presumably meta-autunite, occurs in the lode material at Tennyson's No. 1 Prospect . Assay results from samples collected indicate that the lode material at the surface in general is likely to average less than 0.1% eU_3O_8, but small sections in the lodes at the Nos. 1 and 2 prospects may attain a grade of between 0.1 and 0.2% eU_3O_8. Leaching and impoverishment of the surface lode material could possibly have occurred however, and there may be an improvement in grade at depth.

At Tennyson's No. 1 Prospect, which is the best of the discoveries, there are five lenses of lode material ranging from 30 to 115 feet in length, which have an aggregate length of 328 feet. The width of the lode material ranges from a stringer up to about 15 inches.

The lenses of lode material at the other prospects are generally shorter or narrower, and are generally less encouraging for the production of any appreciable quantities of lode material.

The results from the test drilling proposed at the Edith River Find should be a guide as to what will occur in the deeper parts of the lodes at Tennyson's prospects.

HORE AND O'CONNOR'S PROSPECT

This prospect, which was discovered during the year, is situated about 3 miles north of Tennyson's prospects. Very small occurrences of radioactive lode material, of similar type to that at Tennyson's prospects, occur in a shear zone in granite at this locality. They are not considered to be of much importance.

YUNBERRIE PROSPECT (Gardner, 1953)

This prospect, which is situated about 5 miles north-east of the Edith River railway siding, was discovered by prospectors in February, 1953.

The lode formation at this prospect can be seen outcropping at intervals over a length of about 400 feet, and it occurs in a shear zone, striking N30°W and dipping 80°S.W., in medium to coarse grained "Cullen" granite.

Three pits have been sunk on the line of lode, at intervals over a length of 250 feet.

In the northern pit, which was sunk to a depth of 15 feet from the original surface (now bulldozed away) bunches of torbernite, a little malachite and what appeared to be uranium ochres were encountered a few feet below the surface, and Geiger readings of 1500 counts per minute (i.e. 15 times background) were obtained over a width of 12 inches. There was a marked decrease in counts below this level however, and assay results were low, none exceeding 0.3% eU_3O_8.

In the southern pit, 250 feet farther south and sunk to a depth of 3 feet, Geiger readings of 3000 counts per minute were originally obtained over a width of 12 inches in ironstained gossanous lode material with seams of torbernite. Samples collected from a depth of 3 feet in this pit, after much of the torbernite had been removed as specimens, showed an average value of 0.32% eU_3O_8 over a width of 17 inches.

The third pit is sunk centrally between the northern and southern pits to a depth of 15 feet. Small outcrops of ironstained gossanous material with radioactivity of 500 counts per minute originally occurred at this locality. Assay results from samples taken from the pit were generally low, but samples taken from depths of 4 feet 6 inches and 6 feet 6 inches on north wall averaged 0.19% eU_3O_8 over 19 inches and 0.56% eU_3O_8 over 6 inches respectively.

The Yenberrie lode formation differs from other lodes in the Edith River area, in the presence of torbernite, copper staining and ironstained gossanous material, the latter obviously resulting from the weathering out of sulphides. The lode is narrow and values are erratic near the surface, but it is possible there could be leaching and impoverishment of the lode in the oxidised zone, with a better and more uniform grade prevailing in the primary zone. It is considered that the grade and nature of mineralization in the primary zone should be tested.

The Yenberrie shear zone has been traced in a south easterly direction for a distance of about 4 miles, and within it have been found sporadic occurrences of uranium and copper mineralization.

ABC PROSPECT (Matheson, 1953 and Jones, 1954)

This prospect was discovered by Geologist A.B. Clark of the Bureau of Mineral Resources on the 3rd September, 1953, at a point 11 miles distant and on a bearing of 33 degrees from the Katherine Post Office.

The prospect occurs in a belt of basic to intermediate lavas interbedded with quartzites and grits of the "Mt. Callanan Group" (part of the sequence previously grouped under Buldiva Quartzite) of Upper Proterozoic age. These volcanics and sediments have a general strike of N30°W and a general dip of 40 to 45°N.E., but there is a local steepening in dip to about 70° N.E. near the prospect, due to faulting. This fault strikes in a north-easterly direction and appears to dip steeply. The horizontal displacement thereon is about 1 mile, the eastern side having moved south.

Hematite occurs as coatings on the quartzite underlying the volcanics, and a network of steep and flatly dipping, reddish, hematite stained, silicified veins occurs in the volcanics at the find.

The nearest exposed granite is approximately 20 miles distant.

Autunite and phosphuranylite are present in the outcrops at the site of the original discovery, where readings of 8000 and 10,000 counts per minute were recorded, with an Austronic Geiger Counter. Two grab samples, of what appeared to be the richest material, taken from the outcrop, assayed 0.59 and 0.45% eU_3O_8 respectively.

Radiometric contouring in the vicinity of the find with a scintillometer has shown that the anomalous radioactivity in excess of 40 counts per second extends in a north east direction

over a length of about 340 feet and a width of 200 feet, and corresponds more or less with the area of volcanics outcropping through the sandy soil. Within the 40 counts per second contour is a restricted area extending north easterly over a length of 200 feet and a width of 70 feet, which shows counts ranging from 75 to 500 per second. The 500 counts per second contour is 80 feet long and 20 feet wide. The background scintillometer reading for the area is 15 counts per second.

During the year 1400 feet of bulldozed costeaning and 540 feet of hand costeaning were carried out at the find, but prospecting to define the extent of mineralization on the surface is by no means completed.

The bulldozed costeaning, which has been carried out in soil covered areas, has not yet yielded any important results, but the hand costeaning, which was done on the outcropping area, has provided valuable information. Six parallel hand costeans (A to F) on a north westerly bearing have been sunk to shallow depths across the outcrop of the lode at intervals over a length of 180 feet.

Sampling done in costeans A, C and F, gave the following results:-

Costean	Width	Average Value
A	12'6"	0.305% eU_3O_8
C	37'	0.75% eU_3O_8
F	15'	0.511% eU_3O_8

Costeans B, D and E have not yet been deepened or extended sufficiently to obtain representative samples and obtain a proper idea of the width of the lode material, but high radioactivity already occurs in sections of them.

No primary uranium minerals have yet been identified at the prospect, and no copper minerals are present, but secondary copper minerals have been noted in the volcanic belt elsewhere along its strike.

The reason for the localisation of uranium mineralization in the volcanics at the find is not yet clear, and further work will have to be done to establish it. It is possible that the north east striking fault, which cuts through the area, may have a bearing on mineralization.

Further work will also have to be undertaken to determine the shape, size and attitude of the orebody, which is not yet well-defined. With a view to determining this, it is proposed to drill a series of vertical holes over the deposit during the "wet" season.

The deposit occurs in association with a belt of volcanic rocks well above the base of the section of rocks belonging to the Upper Proterozoic sequence. This in itself is an important discovery in opening up the Upper Proterozoic sequence as a potentially favourable province for prospecting for uranium deposits. It is hoped that further geological work will lead to establishing structural controls for uranium mineralization within it.

ARNHEM LAND PARTY

Both detailed and regional geological and geophysical investigations were carried out in this area.

Regional geological mapping was completed during the year for portions of the Goodparla North, Goodparla South and Mt.

Evelyn, 1 mile military sheets, the area covered being approximately 730 square miles (Walpole, 1954). The most significant results of this work are the recognition that the sequence of rocks of Upper Proterozoic age, previously grouped under Buldiva Quartzite, can be subdivided into three groups, namely, the Mt. Callanan Group, the Edith River Group and the Gerowie Group; the recognition of a possible subdivision in the Lower Proterozoic sequence; the recognition of a major fault zone along the valley of the South Alligator river; and the recognition of mineralization in the Upper Proterozoic rocks. The Mt. Callanan and Edith River Groups are separated by an unconformity, and an unconformity is suspected between the Edith River and Gerowie Groups, but the evidence as yet is inconclusive. A belt of high grade metamorphics in the Lower Proterozoic sequence, is suspected of being older than the Brocks Creek Group, and the name Barramundi Group has been proposed for it. Further fieldwork is necessary to substantiate this subdivision.

During the course of regional mapping, a uranium prospect, now being referred to as the Coronation Hill Prospect, was discovered by Geologist B.P. Walpole of the Bureau of Mineral Resources, at a point about 24 miles distant on a bearing of 109 degrees from Goodparla Homestead.

Following its discovery detailed geological and geophysical investigations were undertaken, as well as costeaning and diamond drilling. (Allen, 1954).

The radioactive anomaly occurs on the northern slope of Coronation Hill between quartzite cliffs of the Mt. Callanan Group to the south, and a copper-bearing quartz-filled shear 600 feet farther north, which strikes in a westerly direction. Sediments of the Mt. Callanan Group also occur to the north of the copper-bearing shear, and, in the light of present information, appear to be down-faulted.

Geophysical work has shown that the radioactive anomaly at the surface gives Geiger readings of from 125 to 175 counts per minute over an area of about 50,000 square feet, within which are some local high spots with readings up to a maximum of 700 counts per minute. The background reading for the area is 50 counts per minute.

Chloritic schists and slates, which strike in a north-westerly direction and dip about 65 degrees southwest, occur as a discontinuously outcropping belt along the north-eastern side of the anomaly, and also outcrop sporadically on the hill slope farther to the south-east. There are differences in opinion regarding the age of these rocks but, due to their schistosity and steeper dip, the writer regards them as belonging to the Brocks Creek Group of Lower Proterozoic age. It is also considered that quartz injection in the shear is of Lower Proterozoic age, but later movements on it could have occurred.

The south-western side of the anomaly occupies an area which is extensively covered by soil and scree, but pit-sinking and costeaning has shown that a kaolinised angular conglomerate or breccia occurs as the underlying rock. Slate and quartzite fragments, typical of some of the rocks in the Brock's Creek Group, are present in the breccia, and it is considered to be part of the acid volcanics occurring at the base of the Mt. Callanan Group in this area. These acid volcanics are considered to have been deposited on a very irregular eroded surface of Brocks Creek rocks.

The costeaning and pit sinking which has been done and which has so far been concentrated chiefly along the western side of the anomaly indicated an increase in radioactivity with depth. In the

pit G and at the western end of Costeans Nos. 2, 3 and 4, the secondary uranium minerals autunite and torbernite occur in the kaolinized brecciated material. Assay results of samples taken from the south wall of the pit ranged from 0.022% e U_3O_8 to 0.88% e U_3O_8, while grab samples from "hot" areas in some of the costeans assayed 0.97%, 3.92% and 0.15% e U_3O_8.

Secondary uranium minerals also occur in the sections of costeans sunk in the chloritic schists, and is present chiefly as torbernite.

The occurrence of secondary uranium minerals near the surface has already been shown to extend in a southerly direction up the hill slope over a length of 200 feet.

Following the initial investigations arrangements were made for drilling two holes in the area. These diamond drill holes are now completed and a summary of results is given below.

D.D.H. No. 1.

Co-ordinates	240'S, 185'W
Bearing	230 degrees
Depression	35 degrees
Bore length	503 feet 4 inches

GEOLOGICAL LOG:

0' - 48' Chloritic Schists belonging to Brock's Creek Group.

UNCONFORMITY

48' -305' Angular conglomerate with fragments Brock's Creek sandstones and slates. Matrix is sandy and may be tuffaceous. Reddish Amygdaloidal acid volcanics between 278' and 288'.. Pyrite present in section between 239' and 278'.

305'-436' Chloritic shales with serpentine and talc and sandstones. Red earthy hematite and some specular hematite veinlets in this zone. Core crumbly and regarded as transitional stage into overlying Mt. Callanan sediments.

436'-503'4" Reddish brown sandstone showing fine bedding and pebbles in places. Obvious Mt. Callanan sediments.

This hole passes from lower to upper beds in the Mt. Callanan Group as the hole progresses. No precise break between the volcanics and the sandstones of the Mt. Callanan Group has been recognised but the section between 305' and 436' is regarded as a transitional stage from one to the other.

The following assay results giving values of 0.01% e U_3O_8 or greater have been obtained from core and sludge samples.

Core Samples		Sludge Samples		
Depth	Value	Depth	Value	
68'6" to 70'6"	0.014% eU_3O_8	75' to 80'	0.015% eU_3O_8	Autunite Zone
70'6" to 72'6"	0.011	85' to 90'	0.011	
72'6" to 74'6"	0.019	90' to 95'	0.013	
90' to 95'	0.011	100' to 105'	0.030	
95' to 97'	0.013			
97' to 100'	0.017			
102' to 105'	0.017			
248' to 250'	0.045	245' to 250'	0.058	Pyrite Zone
250' to 252'	0.103	250' to 255'	0.014	
252' to 254'	0.025	255' to 260'	0.090	
254' to 256'	0.028	260' to 265'	0.086	
256' to 258'	0.126	265' to 270'	0.063	
260' to 262'	0.033	270' to 275'	0.017	
262' to 264'	0.117	275' to 280'	0.021	
264' to 266'	0.073	280' to 285'	0.014	
266' to 268'	0.068	285' to 290'	0.058	
268' to 270'	0.071	290' to 295'	0.014	
272' to 274'	0.013			
274' to 276'	0.014			
276' to 277'6"	0.046			

No primary uranium minerals were recognised in the pyritic zone. Mineragraphic investigations of the small quantities of sulphide minerals present in cores from a depth of 257'6" in No. 1 hole, revealed the presence of pyrite, marcasite, chalcopyrite, bravoite, galena and possibly sphalerite.

D.D.H. No. 2

Co-ordinates	360'S, 90'W.
Bearing	224 degrees
Depression	35 degrees
Bore length	503 feet 3 inches.

GEOLOGICAL LOG.

0' - 163'	Chloritic Schist with some fine siltstone. Brock's Creek rocks.
	UNCONFORMITY.
163'- 247'	Tuffaceous sandstone.
247'- 282'	Sandstones and shales - partly tuffaceous and frequent angular fragments.
282'- 453'	Similar to above but core crumbly with earthy hematite and specular hematite veinlets in shale. Transitional zone into Mt. Callanan sandstone from 428' to 453'.
453'- 503'3"	Reddish brown Mt. Callanan sandstone - locally finely bedded and contains some pebbles.

This hole passes from lower to upper beds in the Mt. Callanan Group as the hole progresses. Again it is difficult to fix a precise break between volcanics and overlying sandstones in the Mt. Callanan section. It is thought that the section in this hole from 163' to 453' represents stratigraphically the section from 48' to 436 feet in hole No. 1, even though it may not be very similar lithologically.

Core and sludge samples from the hole giving values of 0.01% e U_3O_8 or greater are as follows:-

Core Samples		Sludge Samples	
Depth	Value	Depth	Value
49' to 50'	0.015% e U_3O_8	65' to 70'	0.028% e U_3O_8
64'6" to 65'6"	0.071	70' to 75'	0.012
65'6" to 66'6"	0.060	95' to 100'	0.043
67'6" to 68'6"	0.117	100' to 105'	0.036
70'6" to 71'6"	0.050	105' to 110'	0.07
95'6" to 96'6"	0.013	110' to 115'	0.016
96'6" to 97'6"	0.232	115' to 120'	0.01
97'6" to 98'6"	0.019	130' to 135'	0.01
100'6" to 101'6"	0.025	170' to 175'	0.022
101'6" to 102'6"	0.032	175' to 180'	0.01
102'6" to 103'6"	0.013	185' to 190'	0.011
103'6" to 104'6"	0.287	200' to 205'	0.019
104'6" to 105'6"	0.127	295' to 300'	0.01
105'6" to 106'6"	0.085	495' to 500'	0.01
106'6" to 107'6"	0.020		
107'6" to 108'6"	0.119		
108'6" to 109'6"	0.075		
109'6" to 110'6"	0.023		
110'6" to 111'6"	0.094		
111'6" to 112'6"	0.065		
444'6" to 446'6"	0.055		

Autunite Zone

Values associated with reddish earthy hematite

The drilling has tended to confirm the existence of a belt of acid volcanics of variable character at the base of wh[ich] is at present known as the Mt. Callanan Group. The acid volcan[ics] have been deposited on an irregularly eroded surface of Brock's Creek rocks.

The drilling has not disclosed any important uranium ore bodies, but is as yet inconclusive. Some uranium mineralization is undoubtedly associated with the acid volcanics and appears to be closely connected with areas where black slate fragments are abundant. Drilling so far undertaken has not tested the possibility of uranium mineralization occurring in the underlying Brock's Creek Group. It appears that testing of the black slate bed in the Brock's Creek Group, which has shed the fragments contained in the acid volcanics, should be undertaken.

Much further drilling is required to test the Coronation Hill area properly, and the following work is recommended:

(a) Vertical drilling to delineate properly the junction between the acid volcanics and the underlying rocks (tentatively referred herein to the Brock's Creek Group)

(b) Angle-hole drilling in the "Brocks Creek Group" below the acid volcanics, in order to test the whole of the section from the vertical cliff face northwards to the copper-bearing quartz-filled fault (See plate 2).

The Coronation Hill discovery is important in that it draws attention to the occurrence of uranium in the acid volcanics at the base of the Mt. Callanan Group, and indicates scope for widespread prospecting wherever these rocks cropout.

MINERALOGICAL AND PETROLOGICAL INVESTIGATIONS.

Where it was found necessary for the guidance of field work, samples were forwarded to the Bureau laboratory in Canberra for quick petrological and mineralogical determinations. Additional investigations are being carried out during the inter field season.

Messrs. W. Dallwitz and W. Roberts have ably supported the field parties in this work.

GEOCHEMICAL WORK.

Geochemical work was carried out during the year in the vicinity of the known prospects in the four areas of investigation, and additional work was done at Rum Jungle at the request of Territory Enterprises Pty. Ltd.

The work involved tests for the presence of copper, cobalt and lead, and the results are described in detail in a separate report (Debnam and White, 1954).

The results obtained outside the Hundred of Goyder can be summarised as follows:-

Brodribb area - Negative results for Cu, Co and Pb.
Some positive results for Pb at Ella Creek but may be disintegration product of uranium or thorium.

Waterhouse area- Positive results for Cu at the Waterhouse Nos. 1 and 2 Prospects.

Edith River area - Positive results for Cu in regional prospecting south of Yenberrie.
Some positive results for Pb at Driffield.

Arnhem Land area - Positive Cu and Pb over part of Coronation Hill.

Miscellaneous - Positive Pb at Madigan's Prospect, but low, widely dispersed and of little interest. May be due to disintegration of thorium minerals.

DIAMOND DRILLING.

Two Bureau Sullivan H.D.22 hydraulic feed machines were in operation during the year, and an additional Sullivan HD22 machine was obtained for the contract drilling of one hole in the Coronation Hill area.

During the year, surface diamond drilling in the area amounted to 3071 feet carried out in three different areas as indicated below; further details are given in a later table.

Brodribb Prospect	1587 feet 4 inches
Ella Creek Prospect	477 feet -
Coronation Hill Prospect	1006 feet 7 inches
Total	3070 feet 11 inches

Much better core recovery was obtained during the drilling operations than in previous years, and this is attributed mainly to the sole use of Sullivan hydraulic feed machines and the use of larger bit sizes namely NX, NM and BX. The experience of the operators and the more settled nature of the country than at Rum Jungle were also contributing factors.

Details of the average core recovery and rate of drilling per week, in the three areas, are as follows:-

	No. of Holes	Average Core Recovery	Footage per week
Brodribb	6	71.9%	43 feet. (one shift per day)
Ella Creek	2	46%	50 feet. (one shift per day)
Coronation Hill	2	87%	100 feet (2 shifts per day)

The drilling completed during the year fell far short of the 18,000 feet originally planned, and this was due partly to a change in policy restricting drilling in some areas, and partly to a shortage of machines and crews.

Of the machines an order for the Bureau, only two of the four Ideco portable drills were delivered in Darwin by the end of the year, and the Raydraulic machine was still undelivered.

Drilling operations in the area are restricted over the "wet" season, but it is hoped that it will be possible to carry out some additional test drilling at the ABC prospect and in the Edith River area.

DIAMOND DRILLING KATHERINE-DARWIN AREA 1953.

DEPOSIT	DRILL SITE	CO-ORDS SITE	RED LEVEL SITE	BEARING MAGNETIC	DEPRESSION	BORE DEPTH	INSTRUMENT ASSAY % e U_3O_8	REMARKS	DRILL
Brodribb	B1	50N 726W	196'	180°	45°	403'	30'-35' - 0.01% 85'-90' - 0.01% 115'-120'- 0.01% 135'-140'--0.013% Remainder 0.01%		Sullivan HD22
"	B2	80N 1402W	207'	180°	45°	118'10"	40'-45' 0.015% Remainder 0.01%	Hole abandoned	" "
"	B3	150S 1400W	205'	360°	60°	269'	60'-65' 0.01% Remainder 0.01%		" "
"	B4	300S 711W	187'	360°	45°	250'	45'-50' 0.013% 50'-55' 0.019% Remainder 0.01%		" "
"	B5	370S 1412W	198'	360°	60°	246'6"	All samples 0.01%		" "
"	B6	265S 1075W	186'	360°	45°	300'	All samples 0.01%		" "
Coronation Hill	1	240S 185W	360'	230°	35°	503'4"	Core samples showed 250' to 252' 0.10% 256' to 258' 0.12% 262' to 264' 0.11% Remainder 0.1%		" "
"	2	360S 90W	360'	224°	35°	503'3"	Core samples showed (67'6" to 68'6" 0.11% (96'6" to 97'6" 0.23% (103'6" to 104'6"0.28% (104'6" to 105'6"0.12% (107'6" to 108'6"0.12% Remainder 0.1%	D.D.H.2 drilled under contract by Enterprise Exploration Ltd.	" "
Ella Creek	E1	327S 367W	567'	175°	35°	300'	Sludge samples between 100 and 145 feet showed range from 0.012 to 0.027%		" "
"	E2	502S 377W	587'	-	vert-ical	28'	Probing showed radioactivity throughout with counts up to 1800 per minute.	Drilled while testing machine	Mindrill E100
"	E3	227S 387W	570'	175°	65°	149'	Assay results unavailable	Hole in progress	Sullivan HD22

AIRBORNE SURVEYS.

The airborne investigations involved regional, Shoran-controlled, scintillometer and magnetometer surveys, using a D.C.3 aircraft VH-BUR. During 1953 the airborne section operated in the area from May until October.

Difficulties were experienced during the year in establishing Shoran beacons south of Adelaide River, as the major hills have flat cappings of rocks of the Mullaman or Buldiva Groups, which form cliff faces preventing access to the hill tops for the Shoran trucks. As a result the best hills could not, in many instances, be used for Shoran stations, and this limited the range for survey flights from the stations, and resulted in a reduction of the coverage anticipated for 1953.

Some revision of the order of flying areas as originally planned was also found necessary, due to the prolonged "wet" season, the roads in the northern part of the area leading to the old beacon sites were inaccessible until later in the season than usual.

The accompanying map (Plate 1) shows the area covered by airborne surveys to the 31st December 1953. The following areas (based on the 1 mile military grid) were flown during 1953, and the total area covered amounts to approximately 2,900 square miles.

	Burnside Sheet Reynolds River Sheet Ban Ban " Tipperary "	Approx. 1700 sq. miles
Parts of	Lewin Springs Mt. Todd Florina Katherine	Approx. 1200 sq. miles.

The airborne scintillometer anomalies located in the Brocks Creek district (i.e. the eastern side of the Burnside sheet) were made available to the ground parties in the field, and preliminary inspections of them were made towards the end of 1953.

Details of the anomalies located in other areas were not to hand until the end of 1953, and inspections of them will have to be undertaken during 1954.

Practically all the airborne scintillometer anomalies located during the surveys in the Rum Jungle district in 1952 have now been investigated on the ground, and inspectional reports on them are available. A plan showing the location of these anomalies has recently been published.

From the follow up ground investigations to date, it appears that, as used at present, the airborne scintillometer has certain definite limitations.

The investigation of anomalies has not yet led to the discovery of any important uranium deposits but it cannot be said that thorough testing of them has been undertaken. On the other hand, the airborne scintillometer has failed to detect some uranium deposits located by prospecting on the ground (e.g. the ABC prospect, Katherine and the Fleur de Lys prospect, Brock's Creek). This may be due to the background radioactivity in some beds, giving a mass effect which masks small local areas of high radioactivity. In any case, the conclusion arrived at is that, at present, exhaustive prospecting is only possible by

ground coverage. The airborne scintillometer may however be a useful tool in leading to likely areas for investigation.

A list of anomalies located during airborne surveys during 1953 by coordinates on their respective military sheets is given as Appendix I.

RADIOACTIVE DEPOSITS

The investigations carried out by the Bureau during 1953 have led to the recognition of other types of radioactive deposits than those occurring at Rum Jungle (Matheson, 1953). Although the deposits are not yet fully understood, it is considered it will be of advantage to the mining public to describe briefly the types and circumstance of occurrence of those already known in the Katherine-Darwin region.

WHITE'S TYPE DEPOSIT.

The White's type of deposit is a mixed copper-uranium deposit associated with carbonaceous slates and graphitic schists of the Brock's Creek group of Lower Proterozoic age. Lead minerals are associated with some deposits of this type. At White's deposit, the primary ore consists chiefly of primary copper sulphides, pyrite and uraninite occurring as selective replacements of bedding and cleavage in the carbonaceous slates and graphitic schist, but quartz veinlets with these minerals also occur in the ore body. Torbernite, phosphuranylite, saleeite, kasolite and uranium ochres occur in association with secondary copper minerals in the oxidised zone. Johannite occurs as an efflorescence on the wall in the underground workings at the 100 ft. level.

The deposit is considered to be of hydrothermal origin.

Other prospects, which are considered to fall into this category, are Brown's Prospect, White's South Prospect, Intermediate Prospect, Mt. Fitch prospect, Mt. Shoobridge Prospect, "Fleur de Lys" Prospect (Brock's Creek) and Waterhouse No. 2 Prospect.

The Waterhouse No. 1 Prospect, which has not yet been tested however, could possibly be a more leached and impoverished equivalent of the same type of deposit.

DYSON'S TYPE DEPOSIT

At Dyson's deposit the uranium mineralization occurs in close association with thin beds of carbonaceous slate interbedded with quartzites and some limestone, and these rocks also belong to the Brock's Creek Group of Lower Proterozoic age. The secondary uranium minerals autunite, saleeite, sklodowskite, uranosphaerite (?) and probably uranium ochres occur at the deposit and are known to persist to a depth of 100 feet from the surface. No primary uranium mineral has yet been identified. Pyrite is abundant at depth in some of the beds of carbonaceous slate, but chalcopyrite is of rare occurrence.

Quartz veins some of which contain pyrite are present in the area, and the deposit is considered by the writer to be of hydrothermal origin.

White's Extended Prospect is considered to be a similar type of deposit.

CRATER TYPE DEPOSIT.

The Crater Prospect is situated approximately $3\frac{1}{2}$ miles south-east of White's Deposit, and is a type locality for low-grade radioactive conglomerate beds, occurring in The Crater Grit Formation of the Brock's Creek Group. Three separate radioactive conglomerate beds, with lenticular habit, occur in this formation and they extend around the southern end of the Rum Jungle domal structure for a distance of 6 miles.

Mineralogical work done to date has failed to identify the mineral responsible for the radioactivity, but it appears to be intimately associated with iron minerals (particularly hematite). The quantities of zircon and monazite present in the conglomerate are quite insufficient to account for the radioactivity. Radiation absorption tests and chemical assays have suggested that the radioactivity is due to uranium, not thorium.

The occurrence of these radioactive conglomerate beds in the same area, and in the same rock group, in which hydrothermal deposits are known, suggests that the mineralization is of hydrothermal rather than detrital origin.

The beds are too low-grade at the surface to warrant mining, but they may possibly be leached and impoverished in the oxidised zone, and they might improve in grade at depth.

EDITH RIVER TYPE DEPOSIT.

Short lenses of fine-grained, reddish, hematised lode material with meta-autunite occur in steep, north north-westerly trending shear zones in the Lower Proterozoic Cullen Granite in the Edith River area. Several prospects are known, and the lode material sometimes occurs as the matrix to brecciated quartz or fragments of sheared granite. No gossanous material, suggestive of the weathering out of sulphides, is associated with the lode material, and, as the workings are still in the oxidised zone, the nature of the primary mineralization is unknown. It appears that only small scattered shoots can be expected to exceed the cut off grade of 0.1% e U_3O_8 in the lode material at the surface, but it may be leached and impoverished in the oxidised zone.

There have been three major periods of shearing, in different directions, in the Cullen Granite, and the entry of the radioactive lode material appears to have followed the last period of shearing. The uranium mineralization is regarded by the writer as of hydrothermal origin, and tentatively as emanating from the Cullen granite, but it could possibly be younger in age.

The known deposits of the Edith River type are the Edith River Find, Tennyson's Prospects and Hore and O'Connor's Prospect.

YENBERRIE TYPE DEPOSIT.

This deposit, which represents a variation from the Edith River type of deposit, is situated about 5 miles north-east of Edith River Siding.

The lode material at this prospect also occurs in a steep north-north-westerly trending shear zone in the Cullen Granite, but torbernite and secondary copper minerals are present in the oxidised zone. Ironstained gossanous material, indicative of the weathering out of sulphides, is also associated with the lode.

The Perguson River prospect is a similar type of deposit.

CORONATION HILL TYPE DEPOSIT .

At the Coronation Hill Prospect, secondary uranium mineralization occurs near the unconformable junction of the Mt. Callanan Group of Upper Proterozoic age and the Brock's Creek Group of Lower Proterozoic age.

In the vicinity of the Prospect the rocks of the Brock's Creek Group consist of steeply dipping chloritic schists, which are intruded by a cupriferous quartz vein a short distance north of the radioactive anomaly. The overlying rocks of the Mt. Callanan Group, which rest flatly on the irregular surface of the Brock's Creek Group, show an angular conglomerate with a matrix of kaolinised rhyolitic ash at the base, and pass upwards through aqueous tuffs and acid lava into sandstone and pebble beds. The sandstone and pebble beds are part of what has previously been referred to as the Buldiva Quartzite.

The secondary uranium minerals autunite and torbernite have been recognised at the deposit in the oxidised zone, chiefly in the angular conglomerate, but partly in the underlying chloritic schist. Sulphide mineralization, consisting of pyrite, marcasite, chalcopyrite, bravoite, galena and possibly sphalerite, occurs in association with radioactivity in the angular conglomerate at depth. No primary uranium minerals have yet been identified however, and the radioactivity present is considered to be due to a finely divided secondary uranium mineral, apparently not intimately associated with the sulphides. The so-called secondary mineral could perhaps represent a primary occurrence of a uranium mineral usually found in secondary deposits (e.g. autunite).

Based on available drill hole information, pyrite mineralization appears to have a selective preference for fragments of black shale in the angular conglomerate, which are thought to have been derived from the Brock's Creek Group. It is considered that good concentration of uranium mineralization may occur where abundant fragments or lenses of black shale occur in the conglomerate or in black shales in Brocks Creek Group adjacent to the unconformity.

The nature and circumstance of occurrence of primary mineralization at this prospect is as yet not clear, but available evidence supports a hydrothermal origin. The alternative modes of occurrence are that the volcanics at the base of the Mt. Callanan Group are responsible for the primary mineralization, or that primary mineralization occurred in the underlying Brock's Creek Group and that fragments of lode material are included in the volcanics.

ABC TYPE DEPOSIT

This deposit occurs in a belt of basic to intermediate lavas interbedded with quartzites and grits of the Mt. Callanan Group of Upper Proterozoic age. This volcanic formation is higher in the sequence than that at Coronation Hill.

Autunite and phosphuranylite are present in the outcrops at the site of the original discovery, and are also present in a number of costeans. No secondary copper minerals are present at the find, but they have been noted in the volcanic formation elsewhere along its strike.

Only superficial prospecting operations have so far been undertaken at the deposit, and the nature and manner of occurrence of the primary uranium mineralization is still unknown. It is thought that the primary uranium mineralization may eventually be found to be closely connected with a network of steep and flatly dipping, reddish, hematite stained, silicified veins, intersecting the volcanics at the deposit.

It is at present not clear whether or not the primary uranium mineralization is associated with the volcanics themselves, or has been injected into them along a northeasterly trending fault, which strikes through the area. It is hoped that the source

of the mineralizing solutions will be established during future work in the area, but in either case mineralization is regarded by the writer as hydrothermal.

It is possible that the Coronation Hill and ABC deposits may eventually prove to be of the same type, but at this juncture the ABC deposit is the only one which can be definitely said to be due to primary deposition within the Upper Proterozoic rocks themselves.

LATERITIC DEPOSITS.

Areas of anomalous radioactivity in ferruginous laterite are fairly widespread in the Rum Jungle district, and the Brodribb, Ella Creek, Fraser and Waterhouse Nos. 3 and 4 deposits can be regarded as falling into this category.

Fairly extensive costeaning and diamond drilling has been done at the Brodribb and Ella Creek deposits, which has provided information on which to base a reasonable interpretation of this type of deposit.

The ferruginous laterite occurs as a superficial capping over rocks of the Brocks Creek Group and in places high radioactivity has been recorded over extensive areas. Prospecting activities have shown that the radioactivity generally falls off below the laterite cap, and it was originally thought that this could be due to leaching and impoverishment of the underlying country rocks in the oxidised zone. Test drilling in the primary zone has shown that this is not the case however, and it now appears that there is superficial enrichment of radioactive minerals in the laterite from an original low grade source.

The mineral causing the radioactivity in the ferruginous laterite has not yet been identified, but it is intimately associated with the iron minerals (particularly hematite). It has already been described (Rankama and Sahama, 1949) that soluble uranium and thorium compounds are readily absorbed on the hydroxide gels of iron, aluminium or manganese, and this process would account for the concentration of radioactive minerals in the laterite.

Radiation absorption and fluorimeter tests recently carried out suggest that the radioactivity at the Ella Creek and Brodribb deposits is due chiefly to the presence of thorium, not uranium, and further investigations are now in progress.

MADIGAN'S TYPE DEPOSIT.

This deposit, which is situated on a ridge about $3\frac{3}{4}$ miles south south-east of Observation Hill occurs in an area of interbedded quartzites, grits and pebble beds of the Brocks Creek Group.

Very strong radioactivity occurs in places in these rocks in association with ferruginous material occurring partly in the joint system, but also as part of the matrix of the grits in proximity to the joints. Some narrow quartz veinlets also occur in the joint system. The ferruginous material is composed of hematite, partly altered to limonite, and it is intergrown with an earthy material giving strong orange-red internal reflections. Absorption tests fluorimeter tests and chemical assays have shown that the radioactivity is due chiefly to thorium, there being only a trace of uranium present. It is thought that the earthy material intimately intergrown with the iron oxides is responsible for the radioactivity, and it is

believed to be an altered hydrated form of thorite (thorium silicate), probably of the nature of orangite or ferrothorite. It seems likely that in addition to the thorium silicate some thorium is also present.

The deposit as known is a secondary one, and its origin is not yet clear. It could have resulted from redistribution of thorium minerals originally contained in an overlying ferruginous laterite capping, remnants of which are still present in the area; or alternatively could have resulted from the oxidation of thorium-bearing material of hydrothermal origin injected into the joint system.

Until its origin is better understood it is necessary to separate it from the lateritic type of deposits.

SPRING DEPOSITS

A deposit of this type occurs at Howard Springs about 3½ miles north-east of the 16 mile peg on the Stuart Highway.

Howard Springs is a seepage spring which issues from below a laterite capping and flows only during the wetter part of the year. There appears to be a thin section of rocks of the Mullaman Group of Cretaceous age immediately below the laterite, which in turn overlies rocks of the Brocks Creek Group of Lower Proterozoic age.

At the point of issue of the Spring the laterite ledge and also the black clay deposit in the vicinity gives Geiger counts of 400 per minute and readings gradually drop off in a down-stream direction. Readings up to 100 counts per minute are obtained in the surrounding laterite.

The highest radioactivity appears to be associated with the black clay deposit, which has a thickness of about 1 foot.

The mineral causing the radioactivity has not been identified, but it appears that a radioactive mineral has been precipitated by organic matter from the spring water.

The deposit is too low-grade to be of commercial interest, but it does represent a different type of deposit.

RESERVATIONS

The following reservations were held in the Katherine-Darwin region by the Bureau of Mineral Resources at 31st December 1953.

Locality	Area square miles
Hundred of Colton-Frazer Prospect	1
Hundred of Cavanagh-Ella Creek Prospect	4
Hundred of Goyder	entire area
Coronation Hill	147
Mt. Shoobridge	5
ABC Prospect	252

A reduction of the size of the reserves at the Coronation Hill and ABC prospects to areas of 30 and 36 square miles respectively, is pending.

NEW DISCOVERIES

The following new radioactive prospects were discovered in 1953 and fuller information concerning them can be obtained from reports listed in the references.

Several discoveries of small uranium-bearing lodes were made by Mr. S.B. Tennyson in the Edith River area in the early part of 1953. They are in the vicinity of his original find, and fall within the reservation originally granted to him by the Northern Territory Administration. The discoveries consist of small bodies of reddish, hematised, lode material occurring in shear zones in granite, and the lode material is similar to that at the original Edith River Find.

Another small lode of the same type was discovered in the area, about 3 miles north of Tennyson's discoveries by Messrs. Hore and O'Connor.

In February, 1953, another discovery was made in the Edith River area at Yenberrie, situated about 5 miles north-east of the Edith River railway siding, by Messrs. S. Mazlin and A. Young. The Yenberrie discovery consists of a narrow copper-bearing lode formation in a shear zone in granite, and it differs in some respects from the other radioactive lodes in the Edith River area.

A new discovery was made on 2nd June at Coronation Hill by Geologist B.P. Walpole of the Bureau of Mineral Resources, Arnhem Land party. The prospect is situated on a bearing of 109 degrees and is about 25½ miles distant from Goodparla Homestead. The radioactive anomaly appears to be associated with a belt of acid volcanics of variable character occurring at the base of the Mt. Callanan Group of Upper Proterozoic age. Some investigations and diamond drilling have already been undertaken at the prospect, but results to date are inconclusive.

In June, Geologist P. Joklik of the Bureau of Mineral Resources located a radioactive anomaly not previously recorded about 5 miles south of the Batchelor railway siding. The anomaly showed Geiger counts up to 1200 per minute and occurs in an area of copper stained carbonaceous slates. This prospect is now being referred to as the Waterhouse No. 2 Prospect.

Early in July Prospector M.J. Madigan located a radioactive deposit at coordinates 787757, Southport, 1 mile military sheet. The prospect which is associated with rocks of the Brock's Creek Group, occurs near the headwaters of the Charlotte River about 18 miles north westerly from the point where the road crosses the railway line near Southport siding. Strongly radioactive material was encountered at the find during prospecting activities, but subsequent chemical assays showed that this was due chiefly to the presence of thorium, there being only a trace of uranium present.

On 3rd September 1953, a uranium prospect was discovered by Geologist A.B. Clark of the Bureau of Mineral Resources during regional mapping, at a point 11 miles distant, and on a bearing of 33 degrees, from the Katherine Post Office. This prospect, which is associated with a belt of volcanic rocks well above the base of the Mt. Callanan Group, is being referred to as the ABC prospect. Preliminary investigations have given encouraging results, but further work is required to properly understand the nature of the mineralization.

In October 1953, Mr. E. Macdonald, a representative of Territory Uranium N.L. located a new uranium prospect about 1 mile north of the Cosmo Howley mine, Brock's Creek area. At this prospect torbernite and probably uranium ochres occur in association with copper mineralization in bleached carbonaceous slates of the Brock's Creek Group. Prospecting activities are in progress.

In October 1953 Geophysicist I.A. Mumme detected radioactivity in the vicinity of some old copper workings in Brock's Creek meta-sediments near Mt. Shoobridge (Rosenhain & Mumme, 1953). Spot counts up to 7 times background were recorded on the dumps and some specimens showing torbernite were obtained. The radioactive anomaly is on an existing lease for copper.

In November 1953 discoveries of radioactive minerals were reported to the N.T. Mines Dept. from the Hayes Creek and Mt. Wells areas.

These alleged discoveries have not yet been geologically examined.

MINING ACTIVITY

Twenty one Authorities to Prospect for uranium, had been granted by the N.T. Mines Department, at the 31st December 1953, and seven were pending.

The mining companies and syndicates listed by the N.T. Mines Department as engaged in uranium mining or prospecting in the Northern Territory at the 31st December 1953 are as follows:-

Australian Mining and Smelting Co. Ltd.
North Australian Uranium Corporation
Enterprise Exploration Co. Pty. Ltd.
Northern Mines Development N.L.
Northern Territory Prospecting and Development Co.Ltd.
Northern Uranium Development N.L.
Territory Uranium Syndicate
Uranium Mines N.L.
Uranium Oxide N.L.
Uranium Prospecting and Development
Y.M.C.A. Syndicate.

Only the Territory Uranium Syndicate, Brock's Creek and the Y.M.C.A. Syndicate, Edith River, are actively engaged in mining operations at present.

In addition, Territory Enterprises Pty. Ltd. is carrying out mining and development work at Rum Jungle ~~and~~ on behalf of the Commonwealth Government.

CONCLUSIONS AND RECOMMENDATIONS.

Much valuable information concerning the regional geology and the radioactive mineralization in the Katherine-Darwin Region has been obtained as a result of the surveys carried out during 1953, and the information has been a stimulus to prospecting in the area. Several new radioactive mineral discoveries were made during the year, and the Bureau was directly responsible for three of the finds. Several different types of radioactive mineral deposits are now recognised in the area. The discovery of uranium mineralization in Upper Proterozoic rocks during the year has greatly increased the scope for prospecting.

Much more work remains to be done in the region however, and it is considered that investigations during 1954 should be on at least a similar scale to those carried out in 1953. Consideration should be given to the following recommendations:-

1. Provision should be made for one geologist of the detailed staff to be available to keep in touch with developments on prospects by private enterprise and give advice to them in the field.

2. The Darwin laboratory should be equipped to determine quickly whether radioactivity in samples submitted is due to thorium or uranium.

3. Prospectors and Mining companies in the prospecting stage should be able to submit samples to the Bureau laboratory, Darwin to test for radioactivity and for instrument assay while they are in the prospecting stage. It is suggested that this work be done free of charge while work is in the prospecting stage, provided that the volume of work does not attain unreasonable proportions. Facilities for minor repair work to Geiger counters at the Darwin laboratory would also greatly assist the mining public.

4. Further assistance to the mining public could be given by making plans and reports of investigations by the Bureau available immediately after completion of the work. These would only be preliminary plans and reports of investigations subject to later amendment, but would be of considerable help in prospecting activities at a time when they are most needed. There would be a limited demand for this information and plans could be in the form of prints and the reports roneoed.

5. There are now several known uranium deposits in the region and several potential areas for prospecting, and it seems an opportune time to commence geobotanical investigations. The Forestry Bureau has indicated that it would cooperate in this work.

6. Facilities should be readily available for the Geologist in Charge, Darwin and party leaders to make geological observations by light plane when circumstances warrant it.

7. It is part of the Bureau's duties to obtain a proper understanding of uranium mineralization in the region, and it should be realized that in order to do this, it may at times be necessary to do test drilling on private leases, or of unusual types of deposits with not very encouraging prospects.

8. It is recommended that efforts be made to obtain better temporary office accommodation in Darwin, as the conditions and facilities in the present temporary office are very poor, and the permanent office is unlikely to be ready for occupation before the end of 1954.

9. The strip of Pre-Cambrian rocks extending south south westerly from Rum Jungle through Daly River is regarded as a particularly favourable area for prospecting.

ACKNOWLEDGMENTS

The writer is greatly indebted to his colleagues in the Bureau of Mineral Resources for their willing cooperation and assistance during the radioactive surveys in the Katherine-Darwin region throughout the year. The results of their work have been freely used in the preparation of this report.

The assistance of the N.T. Administration and of Territory Enterprises Pty. Ltd. is also very much appreciated.

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PLATE I

RADIO-ACTIVE SURVEYS
KATHERINE-DARWIN REGION N.T.

Base Camps, Main Prospects, Regional Geological Mapping and Airborne Surveys to 31st. Dec. 1953.

Scale
10 5 0 10 20 30 40 Miles

Bureau of Mineral Resources, Geology and Geophysics 1953

Legend

- Regional Mapping carried out by Radioactive Group to 31st. Dec. 1953
- Airborne Survey carried out to 31st. Dec. 1953
- MT. TODD — Military 1 Mile Sheets
- Main Radioactive Prospects outside Hundred of Goyder
- Base Camps of Field Parties
- Formations overlying Pre-Cambrian Rocks
- Buldiva Group - Upper Proterozoic
- Granitic Rocks
- Brocks Creek Group - Lower Proterozoic

Based on Geological Plan by L.C. Noakes and G.A. Stewart 1948.

NT 32B-9

PLATE 2

KATHERINE - DARWIN REGION NORTHERN TERRITORY

REGIONAL GEOLOGICAL MAPPING 1950 — 1953

SCALE IN MILES
10 0 10 20 30 40

REFERENCE

LOWER CRETACEOUS — Mullaman Group

MIDDLE CAMBRIAN — Daly River Group

UPPER PROTEROZOIC — Mt Callanan Group

UPPER PROTEROZOIC
- Edith River Group
- Gerowie Group
- Chambers River Sandstone
- Maiwok Sandstone

LOWER PROTEROZOIC — Brocks Creek Group

IGNEOUS
- Granite
- Mt Harvey Porphyry

UPPER PROTEROZOIC — Volcanics

CAMBRIAN
- Volcanics
- Syenite
- Dibase

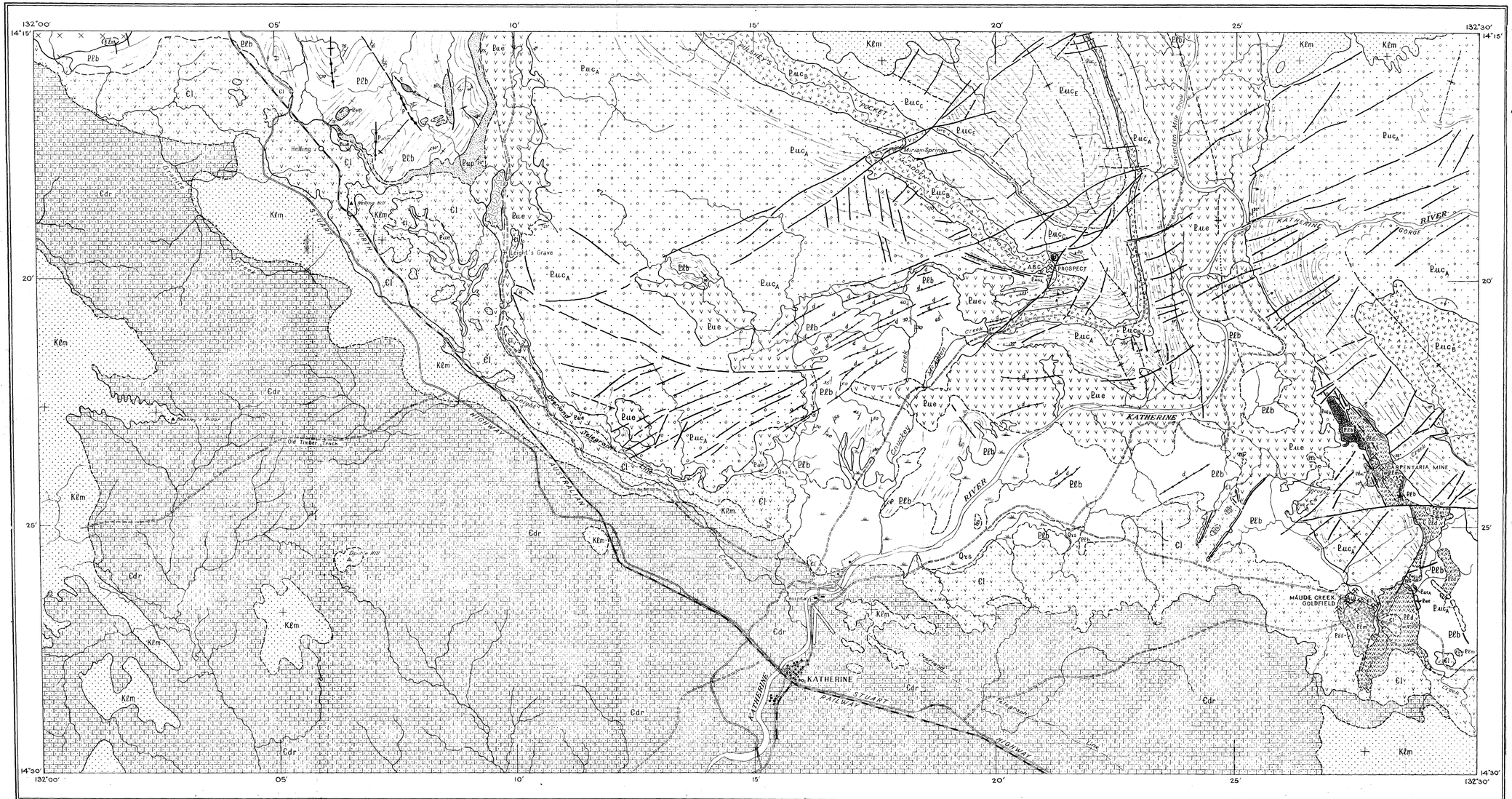
KATHERINE

NORTHERN TERRITORY

AUSTRALIA 1:63,360

1 MILE GEOLOGICAL SERIES SHEET D53-9-97

FIRST EDITION MARCH 1954



REFERENCE

QUATERNARY		Qta	Soil cover
CRETACEOUS	Mullaman Group	Kℓm	Silty sandstones, grits and claystones
	Unconformity		
CAMBRIAN	Daly River Group	Cdr	Algal limestones, limestone, calcareous siltstone, calcareous sandstone and sandstone
	Leight Ck. Volcanics	Cl	Basalt, dolerite and interbedded brown sandstone
		d	Dolerite dyke
UPPER PROTEROZOIC	Mt. Callanan Group	Puc_E	Sandstone
		Puc_D	Basalts, dacites and pyroclastic rocks
		Puc_C	Well bedded sandstone and thin red siltstones
		Puc_B	Basalts and pyroclastic rocks
		Puc_A	Massive, jointed, conglomeratic sandstone
	Undifferentiated	Pue	Massive sandstones
	Unconformity in some places		
		p	Acid porphyry dyke
	Fergusson Volcanics	Puv	Dacite and felsenitic flows with associated sills and dykes
	Edith River Volcanics	Pue	Andesites, dacites, basalts, pyroclastics and tuffaceous sediments
	Phillips Creek Sandstone Member	Puv	Sandstone, conglomerate and shale
LOWER PROTEROZOIC	Maude Ck. Diorite	PEm	Coarse diorite intrusive
	Unconformity ?		
	Dorothy Ck. Volcanics	PEd	Basic volcanics, pyroclastic rocks and tuffaceous sediments
		q	Quartz vein
		g	Greisen
	Cullen Granite	PEg	Fine-grained granite
		PEg	Fine and hybrid granite
		PEg	Coarse porphyritic hornblende granite
		PEg	Coarse discordant granite
	Unconformity		
	Bracks Creek Group	PEb	Tuffaceous sandstones, slates, phyllites and hornfels

Geological Boundaries
- Established boundary, position accurate
- Established boundary, position approximate
- Probable boundary

Strike and dip of strata
- Inclined
- Horizontal
- Vertical

Faults
- Position accurate
- Position approximate

- U — Uranium
- Au — Gold
- Cu — Copper
- Sn — Tin
- W — Wolfram
- Mine workings
- Railway
- Road
- Vehicle track

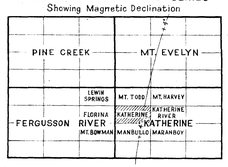
Geology by: J.H. Rattigan and A.B. Clark

Compiled by: J.H. Rattigan and A.B. Clark

Drawn by: K. Matveev

Compiled by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development. Air photography, complete vertical coverage at medium scale by the Royal Australian Air Force. Printed for the Bureau of Mineral Resources by the Royal Australian Survey Corps. Transverse Mercator Projection.

INDEX TO 4 MILE & 1 MILE SERIES
Showing Magnetic Declination

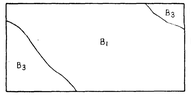


Scale
1 Mile to 1 Inch

1 0 1 2 3 4 5 Miles

1 0 1 2 3 4 5 Kilometres

GEOLOGICAL RELIABILITY DIAGRAM



B1 *Detailed reconnaissance - numerous traverses with photo interpretation*

B3 *Reconnaissance - traverses with photo interpretation*

KATHERINE
D53-9-97
AUSTRALIAN NATIONAL GRID

Copies of this map may be obtained from Director of Mines, Darwin N.T. or Bureau of Mineral Resources, Geology and Geophysics Canberra A.C.T. and Darwin N.T.

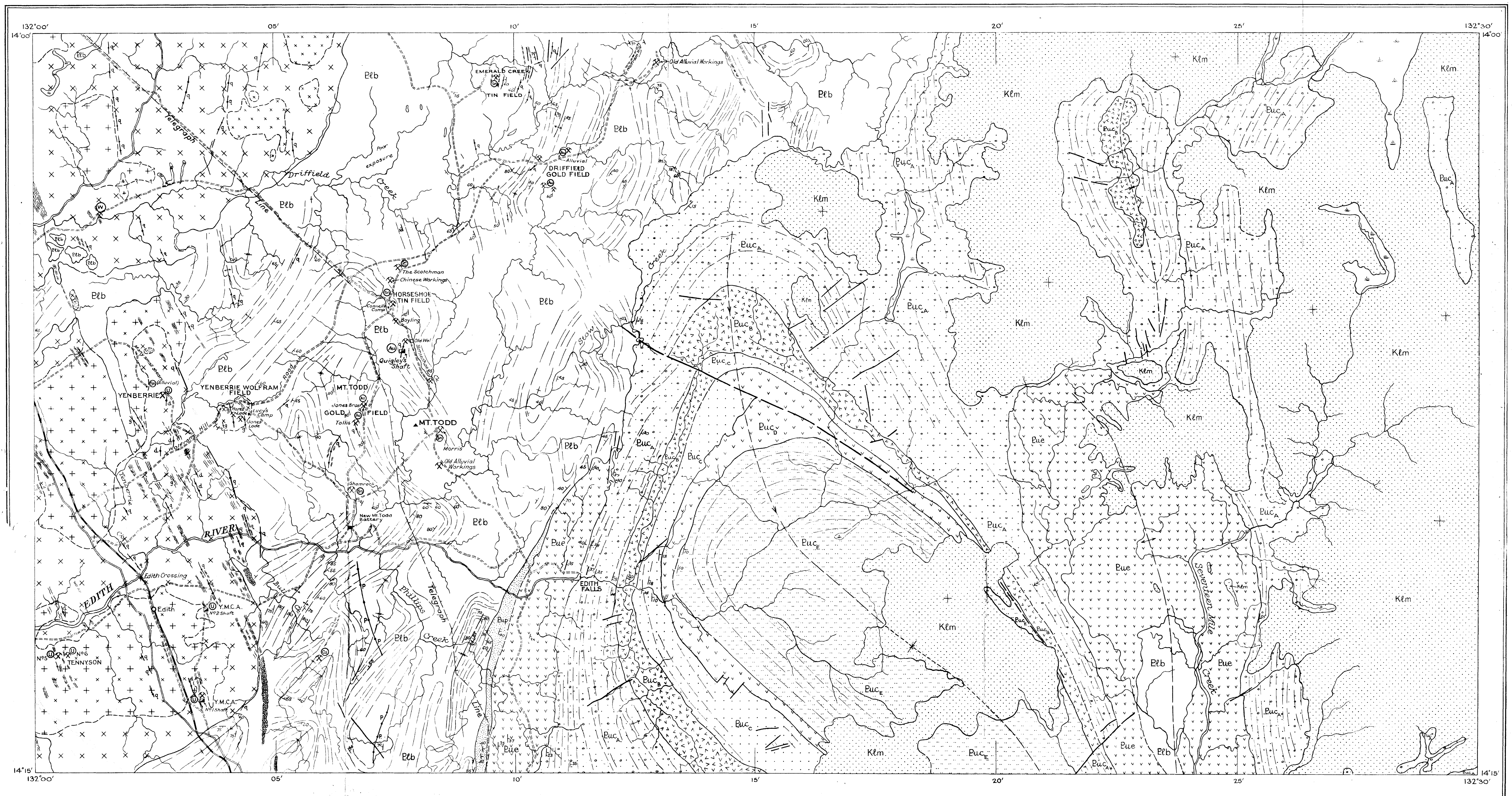
MT. TODD

NORTHERN TERRITORY

AUSTRALIA 1:63,360

1 MILE GEOLOGICAL SERIES SHEET D53-9-88

FIRST EDITION MARCH 1954



REFERENCE

QUATERNARY — Qrs — Soil cover

CRETACEOUS — Mullaman Group — Klm — Silty sandstones, grits and claystones

Unconformity

CAMBRIAN
- Daly River Group — €dr — Algal limestones, limestone, calcareous siltstone, calcareous sandstone and sandstone
- Leight Ck. Volcanics — €l — Basalt, dolerite and interbedded brown sandstone

d — Dolerite dyke

UPPER PROTEROZOIC
- Mt. Callanan Group
  - Puc_E — Sandstone
  - Puc_D — Basalts, dacites and pyroclastic rocks
  - Puc_C — Well bedded sandstone and thin red siltstones
  - Puc_B — Basalts and pyroclastic rocks
  - Puc_A — Massive, jointed, conglomeratic sandstone
- Undifferentiated — Pu — Massive sandstones

Unconformity in some places

p — Acid porphyry dyke

- Fergusson Volcanics / Edith River Volcanics / Phillips Creek Sandstone Member — Puf, Pue, Pup — Dacite and toscanite flows with associated sills and dykes (Puf); Andesites, dacites, basalts, pyroclastics and tuffaceous sediments (Pue); Sandstone, conglomerate and shale (Pup)

LOWER PROTEROZOIC
- Maude Ck. Diorite — Plm — Coarse diorite intrusive

Unconformity ?

- Dorothy Ck. Volcanics — Pld — Basic volcanics, pyroclastic rocks and tuffaceous sediments
- q — Quartz vein
- g — Greisen
- Cullen Granite
  - Fine-grained granite
  - Fine and hybrid granite
  - Coarse porphyritic hornblende granite
  - Coarse discordant granite

Unconformity

- Brocks Creek Group — Plb — Tuffaceous sandstones, slates, phyllites and hornfels

Geological Boundaries
- Established boundary, position accurate
- Established boundary, position approximate
- Probable boundary

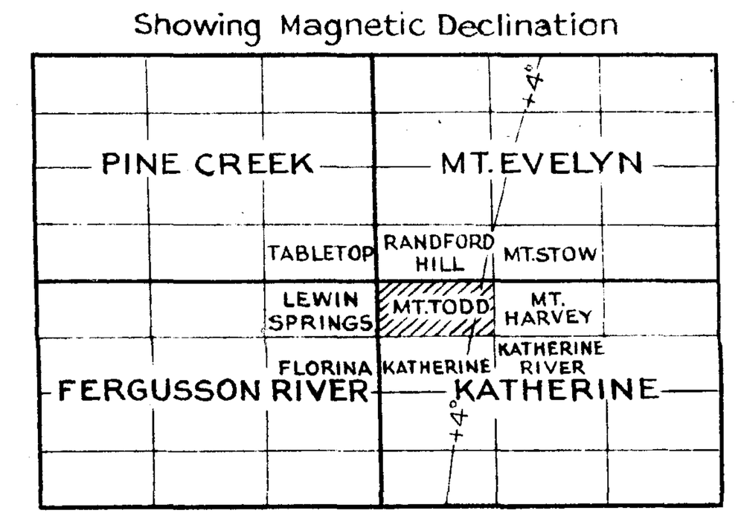
Strike and dip of strata
- Inclined
- Horizontal
- Vertical

Faults
- Position accurate
- Position approximate

- U — Uranium
- Au — Gold
- Cu — Copper
- Sn — Tin
- W — Wolfram
- Mine workings
- Railway
- Road
- Vehicle track

Compiled by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development. Air photography, complete vertical coverage at medium scale by the Royal Australian Air Force. Printed for the Bureau of Mineral Resources by the Royal Australian Survey Corps. Transverse Mercator Projection.

INDEX TO 4 MILE & 1 MILE SERIES
Showing Magnetic Declination

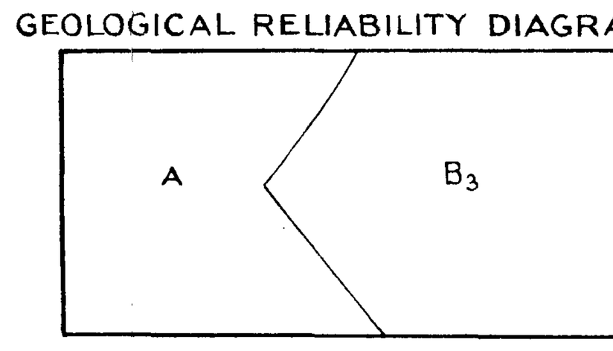


Scale
1 Mile to 1 Inch

1 0 1 2 3 4 5 Miles

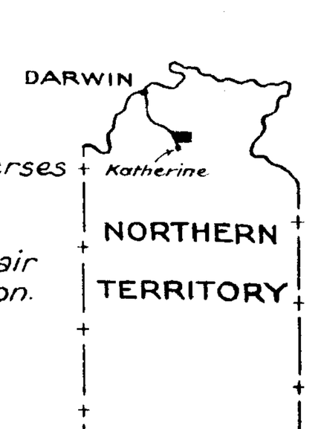
1 0 1 2 3 4 5 Kilometres

GEOLOGICAL RELIABILITY DIAGRAM



A Detailed mapping · numerous traverses

B_3 Reconnaissance · traverses with air photo interpretation.



Geology by: J.H. Rattigan and A.B. Clark
Compiled by: J.H. Rattigan and A.B. Clark
Drawn by: W.J. Buckridge

MT. TODD
D53-9-88
AUSTRALIAN NATIONAL GRID

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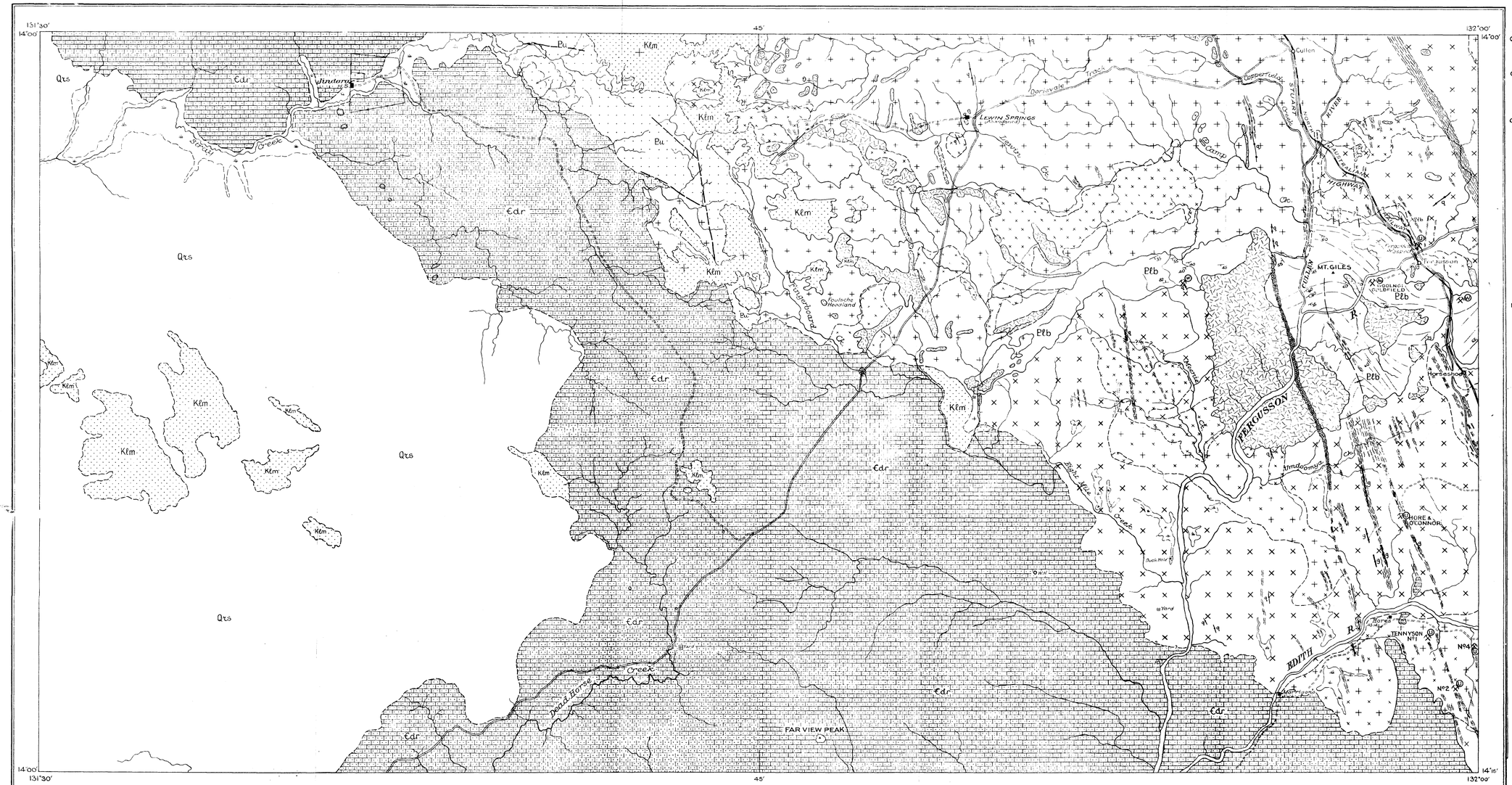
LEWIN SPRINGS

NORTHERN TERRITORY

AUSTRALIA 1:63,360

1 MILE GEOLOGICAL SERIES SHEET D52-12-87

FIRST EDITION MARCH 1954



REFERENCE

QUATERNARY		Qrs	Soil cover
CRETACEOUS	Mullaman Group	Klm	Silty sandstones, grits and claystones
	Unconformity		
CAMBRIAN	Daly River Group	Cdr	Algal limestones, limestone, calcareous siltstone, calcareous sandstone and sandstone
	Leight Ck. Volcanics	Cl	Basalt, dolerite and interbedded brown sandstone
		d	Dolerite dyke
UPPER PROTEROZOIC	Mt. Callanan Group	Pucs	Sandstone
		Pucb	Basalts, dacites and pyroclastic rocks
		Pucc	Well bedded sandstone and thin red siltstones
		Pucab	Basalts and pyroclastic rocks
		Puca	Massive, jointed, conglomeratic sandstone
	Undifferentiated	Pu	Massive sandstones
	Unconformity in some places		
		p	Acid porphyry dyke
	Fergusson Volcanics, Edith River Volcanics, Phillips Creek Sandstone Member	Pub, Pubt, Pubt	Dacite and rhyolite flows with associated sills and dykes (Pub); Andesites, dacites, basalts, pyroclastics and tuffaceous sediments (Pubt); Sandstone, conglomerate and shale (Pubt)
LOWER PROTEROZOIC	Maude Ck. Diorite	Pdm	Coarse diorite intrusive
	Unconformity ?		
	Dorothy Ck. Volcanics	Pdy	Basic volcanics, pyroclastic rocks and tuffaceous sediments
		q	Quartz vein
		g	Greisen
	Cullen Granite		Fine-grained granite
			Fine and hybrid granite
			Coarse porphyritic hornblende granite
			Coarse discordant granite
	Unconformity		
	Bracks Group	Ppb	Tuffaceous sandstones, slates, phyllites and hornfels

Geological Boundaries
- Established boundary, position accurate
- Established boundary, position approximate
- Probable boundary

Strike and dip of strata
- Inclined
- Horizontal
- Vertical

Faults
- Position accurate
- Position approximate

- U Uranium
- Au Gold
- Cu Copper
- Sn Tin
- W Wolfram
- Mine workings
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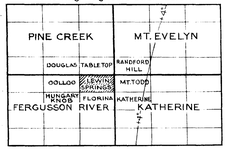
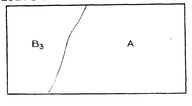


Scale
1 Mile to 1 Inch
0 1 2 3 4 5 Miles
0 1 2 3 4 5 Kilometres

GEOLOGICAL RELIABILITY DIAGRAM



A Detailed mapping - numerous traverses

B3 Reconnaissance - traverses with air photo interpretation

Geology by: J.H. Rattigan and A.B. Clark
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LEWIN SPRINGS
D52-12-87
AUSTRALIAN NATIONAL GRID

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MAP OF

RUM JUNGLE DISTRICT

REGIONAL GEOLOGY

SCALE

LEGEND

- Granite
- Covered area with few outcrops of metasediments and possibly granitised sediments
- Sequence of lenticular, irregularly bedded, felspathic quartzites grits, sericitic grits, having a top-member of hematised quartzite breccia, and containing hematised boulder conglomerate (shown in black)
- Grey, brown, and black slate interbedded with siltstone and quartzite (brecciated in places). Lenticular beds of impure and crystalline limestone. Sequence contains uranium bearing chlorite and graphitic slates at Rum Jungle
- Grey, reddish-brown, pyritic slates and shales with interbedded grey pyritic and felspathic quartzites, tuffs, sheared siltstones, limonitic silty shales and hematised quartzite breccia
- Red brown, red and grey banded slates and shales (some micaceous) and siltstones
- Grey pyritic sandstone, felspathic and micaceous sandstone with intercalated grit and shale bands. Red-brown slates and shales and dark grey arkose bands (Ark)
- Red brown slates and shales, sandy shale (micaceous in places) and dark grey arkose bands (Ark).
- Greyish-brown grits, sandstones, sandy shales, micaceous shales and dark grey arkose bones (Ark)
- Arkose felspathic sandstone and grit, sandy micaceous shale, light reddish-brown and grey slate and shale.
- Beds of impure or crystalline limestone

Brocks Creek Group — Lower Proterozoic

- Established geological boundaries - position approximate
- Probable geological boundaries
- Trend lines
- Probable anticlinal axis with direction of plunge
- Probable synclinal axis
- Established fault
- Strike and dip of strata
- Boundary of mapped area.
- Mine working
- Areas of brecciation

Compiled by F.J. Frankovich and J.B. Firman. Nov 1953. from their own work and from geological surveys by F. Joklik, B.P. Walpole, and others in 1953; and from earlier geological mapping by R.S. Matheson and others 1950-52.
Geology is based on ground surveys and aerial photograph interpretation 1950-53.

NT 47-29

PLATE 7

RECONNAISSANCE GEOLOGICAL MAP
CORONATION HILL - GOODPARLA AREA

SCALE

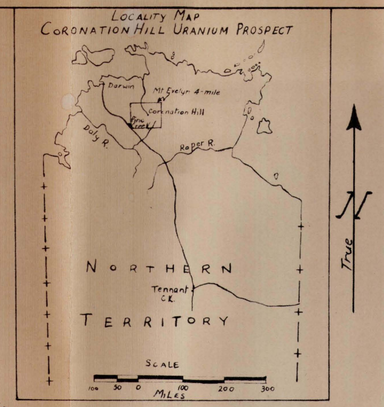
0 1 2 3 4 5 6 7 8 9 10 miles

REFERENCE

Lower Cretaceous	Klm Mullaman Group	Middle Creek Granite
Upper Proterozoic	Puc Mount Callanan Group	Diorite
	Pue Edith River Group	Basic Volcanics
	Pug Gerowie Beds	Intermediate Volcanics
Lower Proterozoic	Plb Brocks Creek Group	Rhyolite
		Porphyry sills and flows.
	Major Faults and Fractures	Dolerite

- Mineral Lease
- Track
- Homestead
- (A2) Airborne Scintillometer Anomaly.

LOCALITY MAP
CORONATION HILL URANIUM PROSPECT



Based on traverse information and photointerpretation
Geology by B.P. Walpole, B.J. Drew, D. White
and R. Britten.

Bureau of Mineral Resources Geology and Geophysics 1953

NT 63-1