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(A. K. Denmead, M.Sc., Chief Government Geologist)

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THE URANIUM DEPOSITS OF NORTH-WESTERN QUEENSLAND

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View of Mary Kathleen open-cut looking north towards the treatment plant, 1959.

[Photo. by C. H. Shapway.]

PREFACE

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During the progress of periodic inspections of the uranium occurrences in North-Western Queensland over the past five years Mr. Brooks has amassed a wealth of detailed information on this important uranium province. This information, now presented in consolidated form, should prove of interest to a wide variety of readers.

The paper is in two parts : Part I. deals generally with the geology and other aspects of the deposits ; Part II. contains detailed descriptions of all the more important known occurrences.

Perhaps the most striking feature revealed by the paper is the persistent occurrence of uranium mineralization over a very wide area ; and, even though only one commercial deposit has so far been proved, it is believed that further investigation may well show some of the known prospects to be of commercial significance ; while the possibilities of further commercial discoveries can by no means be ruled out.

A. K. DENMEAD,
Chief Government Geologist.

Brisbane, 6th November, 1959.

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By J. H. BROOKS, B.Sc., Geologist

ABSTRACT

The uranium mineralization occurs in the Precambrian mineral province of North-Western Queensland along the north-eastern margin of the Australian Precambrian shield. A prospecting boom in 1954 led to the discovery of the important *Mary Kathleen* deposit and open-cut mining of this deposit commenced late in 1956. Extensive airborne and ground search has been made by mining companies and the Commonwealth Government but most of the significant discoveries have been made by independent prospecting parties.

The great majority of the uranium deposits is confined to the Lower Proterozoic Eastern Creek Volcanics and Corella Formation. The distribution bears little relation to that of other metalliferous deposits although minor amounts of copper are commonly associated with uranium in some areas. Information is given on 180 occurrences of uranium and nearly all of these are distributed over an area of 11,000 square miles in the Cloncurry-Mount Isa district. The main features responsible for ore localization are favourable beds and fault structures. Various metamorphosed

arenaceous and calcareous sediments and basic igneous rocks constitute the favourable bed in different deposits. An affinity between uranium and iron minerals is a noticeable feature in some groups of deposits. Secondary minerals are unimportant except in deposits in the Upper Proterozoic Westmoreland Conglomerate and the small *Milo* torbernite deposit near Cloncurry. Disseminated uraninite is the most important primary uranium mineral. It occurs associated with rare-earth minerals at the *Mary Kathleen*. The deposits are of the pyrometasomatic, hydrothermal replacement, and pegmatite types or are supergene concentrations. In some cases the deposits are clearly epigenetic and related to granite intrusion but for the most part evidence of genesis is not conclusive.

Apart from the *Mary Kathleen*, *Counter*, *Skal* and *Elaine Dorothy*, the deposits have not been extensively tested at depth. The *Mary Kathleen* is the only deposit with proved ore reserves exceeding one million tons and the *Counter* and *Skal* are the only other deposits with reserves of more than 250,000 tons. There are at least 14 deposits which might contribute smaller quantities of ore if a local market becomes available.

PART I.—HISTORY, GENERAL GEOLOGY AND RESOURCES

INTRODUCTION

The object of this paper is to give a concise but comprehensive account of the uranium deposits of North-Western Queensland. All the reliable information available at the Geological Survey of Queensland has been used, in addition to the writer's field notes compiled during intermittent field work totalling 11 months between 1954 and 1959. The sources of information referred to are mentioned in the Acknowledgements.

Location

The uranium deposits of North-Western Queensland are confined to part of the Precambrian which crops out in a region extending from the Northern Territory border near latitude 17 deg. S. to near latitude 22 deg. S., south of which the Precambrian is overlain by Cambrian and younger sedimentary rocks. The outcrop area of the Precambrian is elongated in a north-north-west direction and extends in Queensland over a length of nearly 400 miles and an average width of roughly 60 miles.

Topography

The topography of the Precambrian is marked by the occurrence of groups of low, rugged hills which usually rise 200 to 400 feet above the surrounding country. Many groups of hills are elongated parallel to the north to north-north-westerly regional strike and are commonly composed of quartzites, metamorphosed acid volcanics and igneous complexes. The intervening valleys are commonly underlain by metamorphosed argillaceous and calcareous sediments and basic volcanics.

The Selwyn divide which separates the inland from the coastal river system, occurs towards the southern limit of the Precambrian. The elevation of the divide ranges from 1,000 to 1,500 feet. South of the divide the streams drain towards Lake Eyre and the coastal rivers drain north into the Gulf of Carpentaria.

Climate, Vegetation and Water Supply

The region lies wholly within the tropics. For the most part the climate is semi-arid, merging to sub-humid

in the extreme north of the region. The rainfall ranges from 17 inches at Cloncurry which is typical of the Cloncurry-Mount Isa area in the south, to 27 inches at Burketown which is typical of the Westmoreland area in the north. More than 80 per cent. of this rain falls in the monsoonal "wet" season from November to March. The mean maximum temperature at Cloncurry ranges from 100·4 deg. in December to 76·4 deg. in July but the mean humidity is low (18 to 34 per cent.).

The vegetation over much of the region consists of spinifex grass and stunted species of eucalypt, baubinia and acacia trees and shrubs. Flinders and Mitchell grasses occur on the river flats and tall gums and ti-tree along the main river channels. North of the 19 deg. S. parallel pandanus and cabbage palms occur long the permanent, spring-fed streams.

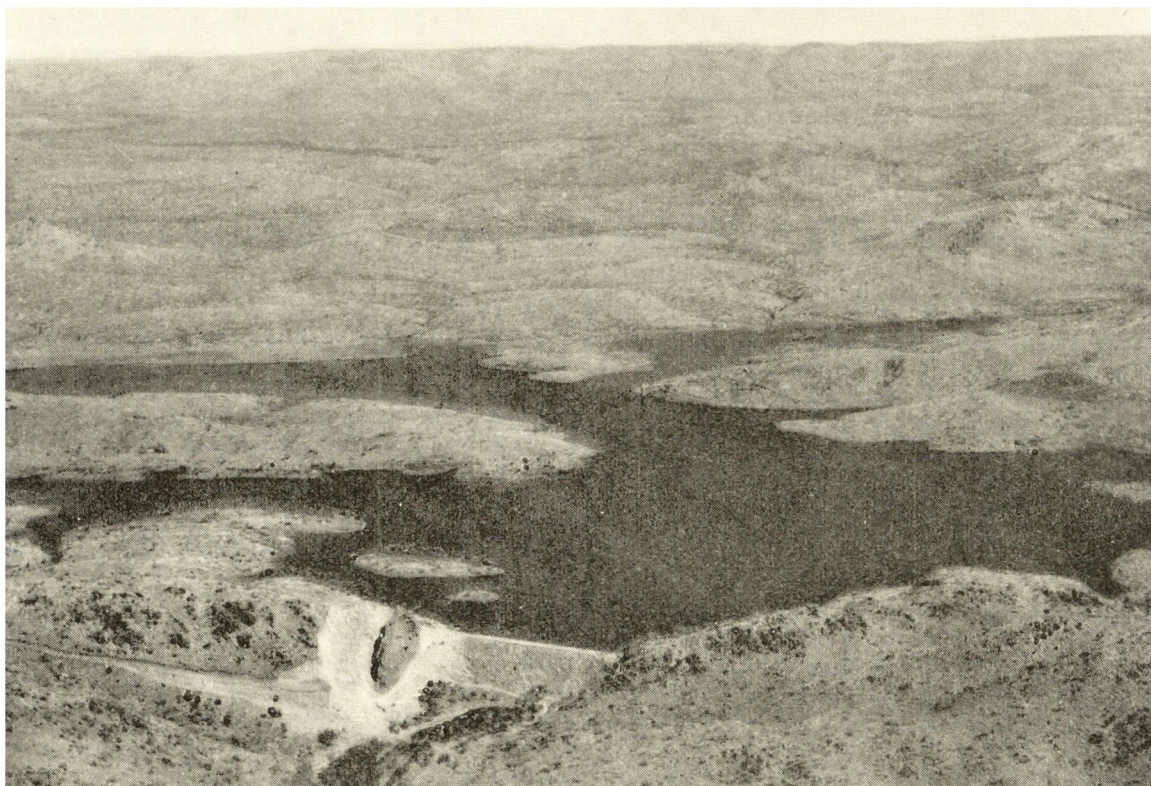
With the exception of these spring-fed streams in the Lawn Hill area there are no permanently-flowing water courses in the region. Mount Isa and Mary Kathleen obtain an ample water supply from dams across the Leichhardt and Corella Rivers, respectively. Until recently Mount Isa was dependent on the small Rifle Creek dam and a series of bores along the Leichhardt River for its water requirements. Cloncurry obtains a rather inadequate water supply from bores along the Cloncurry River. Elsewhere water is obtained from earth tanks, permanent and semi-permanent water holes and sub-artesian bores.

Population, Communications and Industries

At the 1954 census the population of the Cloncurry-Mount Isa district was 10,512. The population is largely centred in the towns of Mount Isa (7,432) and Cloncurry (1,955). The population of Mount Isa has continued to increase since 1954 and the new town of Mary Kathleen has a population of 1,200.

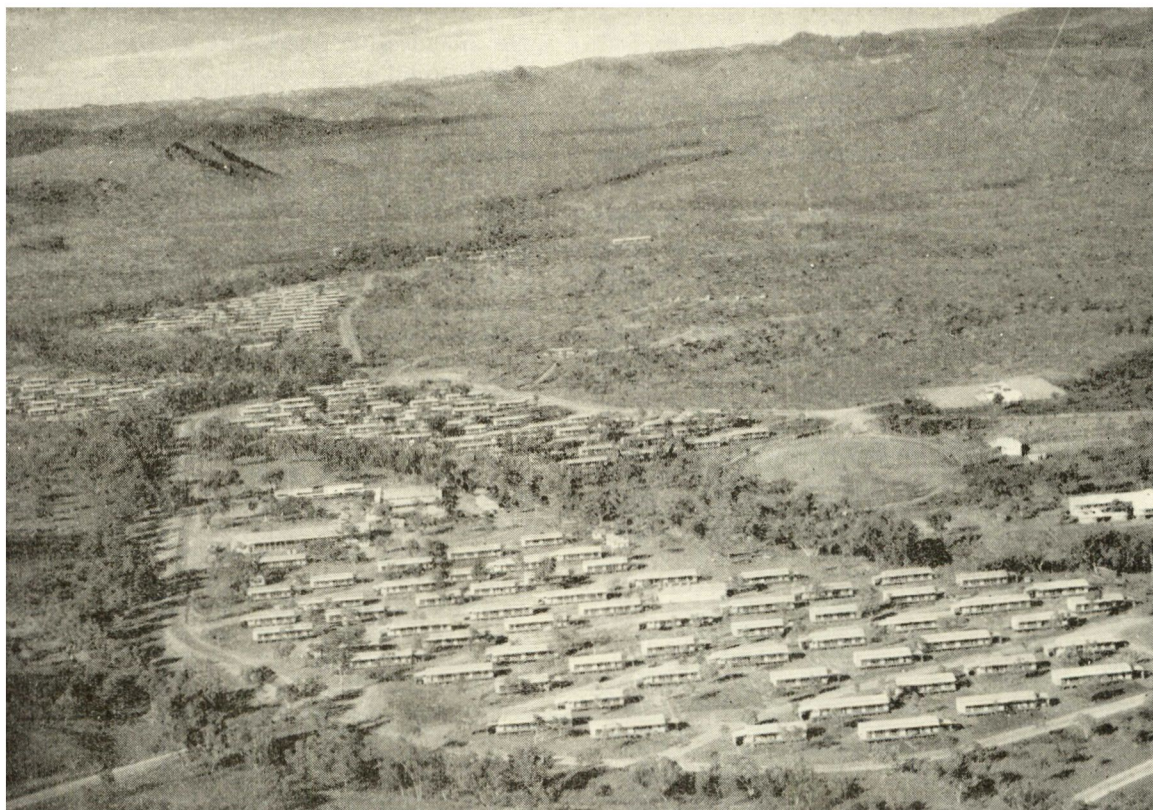
Cloncurry is 481 miles, and Mount Isa 603 miles, by railway from the port of Townsville. Both these towns have commercial airfields and are connected with Brisbane and the Southern States by daily air services. Mary Kathleen has a landing strip for light aircraft as have several of the cattle stations in the area. The only sealed surface roads are the Barkly Highway which connects Mount Isa with the Northern Territory, and the 40-mile stretch between Cloncurry and Mary Kathleen. Other roads become impassable following heavy rain.

Mining and cattle-raising are the industries of the region. Up to 1957 the Cloncurry-Mount Isa Mineral Fields have produced 264,622 tons of copper, 860,711 tons of lead, 67,064,301oz. of silver, 422,090 tons of zinc and some gold and cobalt. The mining of silver-lead-zinc and copper at Mount Isa was the only major mining industry at the time of the discovery of uranium.



Aerial view of the Corella dam which provides the water supply for Mary Kathleen.

[Photo by 'Courier-Mail'.



Aerial view of Mary Kathleen township, 1958.

[Photo by "Courier-Mail".]

ACKNOWLEDGEMENTS

The assistance given by Mr. D. Ostle, Senior Geologist, of the United Kingdom Geological Survey, Mr. E. K. Carter, Senior Geologist and Mr. B. P. Walpole, Supervising Geologist, both of the Commonwealth Bureau of Mineral Resources, and Mr. D. S. Carruthers, Assistant Geologist of the Geological Survey of Queensland, who accompanied me at various times on field inspections was greatly appreciated. Geologists of mining and exploration companies co-operated readily during inspections of their leases. Companies which provided data used in this paper include Mount Isa Mines Ltd., Rio Tinto Australian Exploration Pty. Ltd., Australasian Oil Exploration Ltd., Mary Kathleen Uranium Ltd., Queensland Mines Ltd., United Uranium N.L., Mineral Ventures N.L., Gold Mines of Australia Ltd., Mining Corporation (Australia) N.L., Uranium Search Pty. Ltd., and Isa Uranium Syndicate N.L. Information was also obtained from unpublished reports to the Chief Government Geologist, Geological Survey of Queensland, by T. H. Connah, District Geologist, K. R. Levingston, Geologist, and D. S. Carruthers, Assistant Geologist. Research organizations which have contributed to the knowledge of the mineralogy of the uranium deposits include the South Australian Department of Mines, the University of Queensland Department of Mining Engineering, the Commonwealth Scientific and Industrial Research Organization, the Commonwealth Bureau of Mineral Resources, the New South Wales University of Technology Department of Mining, the United Kingdom Atomic Energy Authority and the Geological Survey of Queensland.

HISTORY OF EXPLORATION

Prior to the discovery of significant quantities of uranium at the *Skal* on 14th March, 1954, the search for uranium had been on a very limited scale and no overall coverage of the region had been attempted. Joint Bureau of Mineral Resources and Geological Survey of Queensland field parties carried out a regional geological survey of the Precambrian from 1950-1954 but no specific search for uranium was made. In view of the association of copper and cobalt with uranium in some other uranium provinces, it was expected that if uranium was present in quantity it would be associated, at least in part, with the copper and cobalt deposits of the Cloncurry-Mount Isa area. Accordingly, all known deposits of copper and cobalt were tested for radioactivity without any marked success. Subsequent intensive prospecting for uranium revealed only one occurrence of copper-uranium mineralization of any significance. This was on the long-forgotten *Monakoff* copper freehold.

The mining companies carrying out exploration in the Cloncurry and Mount Isa Mineral Fields in the 1953-54 period were Mount Isa Mines Ltd., Titanium Alloy Manufacturing Co. Pty. Ltd. (a subsidiary for the National Lead Co. of U.S.A.) and Mines Exploration Pty. Ltd. (a subsidiary of Broken Hill South Ltd.). These companies were primarily concerned in the discovery of copper and silver-lead-zinc deposits. The private miners and prospectors were largely pre-occupied with the "gouging" of copper ore for which a high price was ruling at the time.

The discovery of the first uranium deposit was made by a party of "week-end" prospectors headed by Birger Schildt. This party was prospecting for copper but they carried a geiger counter and made tests for radioactivity concurrently. The *Skal* was found half a mile south of the small *Royal George* copper workings, 20 miles north of Mount Isa.

Mount Isa Mines Ltd. geologists immediately followed up this find and several other deposits were located within a radius of a few miles of the original discovery. All these early discoveries were made in a similar type of sedimentary rock in the Eastern Creek Volcanics and as a basis for prospecting this Company decided to thoroughly prospect the Eastern Creek Volcanics as a whole. A scintillometer mounted in an



Auster aircraft, the type used extensively in the airborne exploration for radioactive deposits.

[Photo. by N. A. H. Symmonds.]

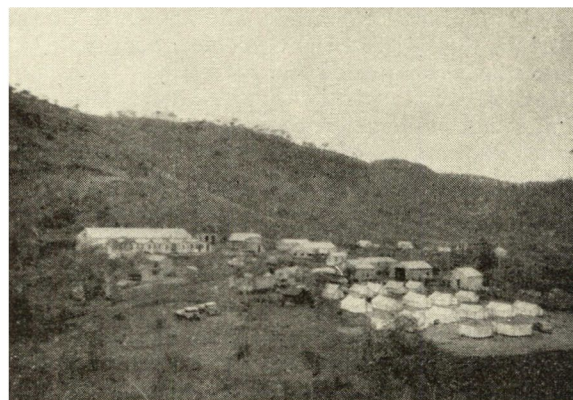
Auster aircraft was used in conjunction with ground prospecting parties. This led to the discovery of many more deposits but though some of these were of considerable size (up to 250 tons per vertical foot) the grade was usually in the vicinity of 0.1 per cent. U_3O_8 or less. The Company extended its search over 5,027 square miles in the Eastern Creek Volcanics and its equivalents, the Marraba Volcanics and Soldiers Cap Formation. An airborne scintillometer survey was also made of the Mount Cobalt area and some of the Corella Formation was flown following the discovery of the *Mary Kathleen*. However, only small deposits of the davidite type were found.

Meanwhile scores of amateur and experienced prospectors, and prospecting teams organised by the mining companies, extended the search for uranium to all accessible parts of the region and the uranium "fever" was maintained till the onset of the wet season at the end of 1954. United Uranium N.L. and North Australia Uranium Corporation used airborne scintillometers in conjunction with ground parties and Australasian Oil Exploration Ltd., Gold Mines of Australia Ltd. and Uranium Search Pty. Ltd. were prominent in buying leases or obtaining options from prospectors.

In May, 1954, the *Counter* deposit, 9 miles north-east of Mount Isa, was discovered by Anderson and party, and on 6th July, 1954, the Walton-McConachy prospecting party discovered the *Mary Kathleen*.

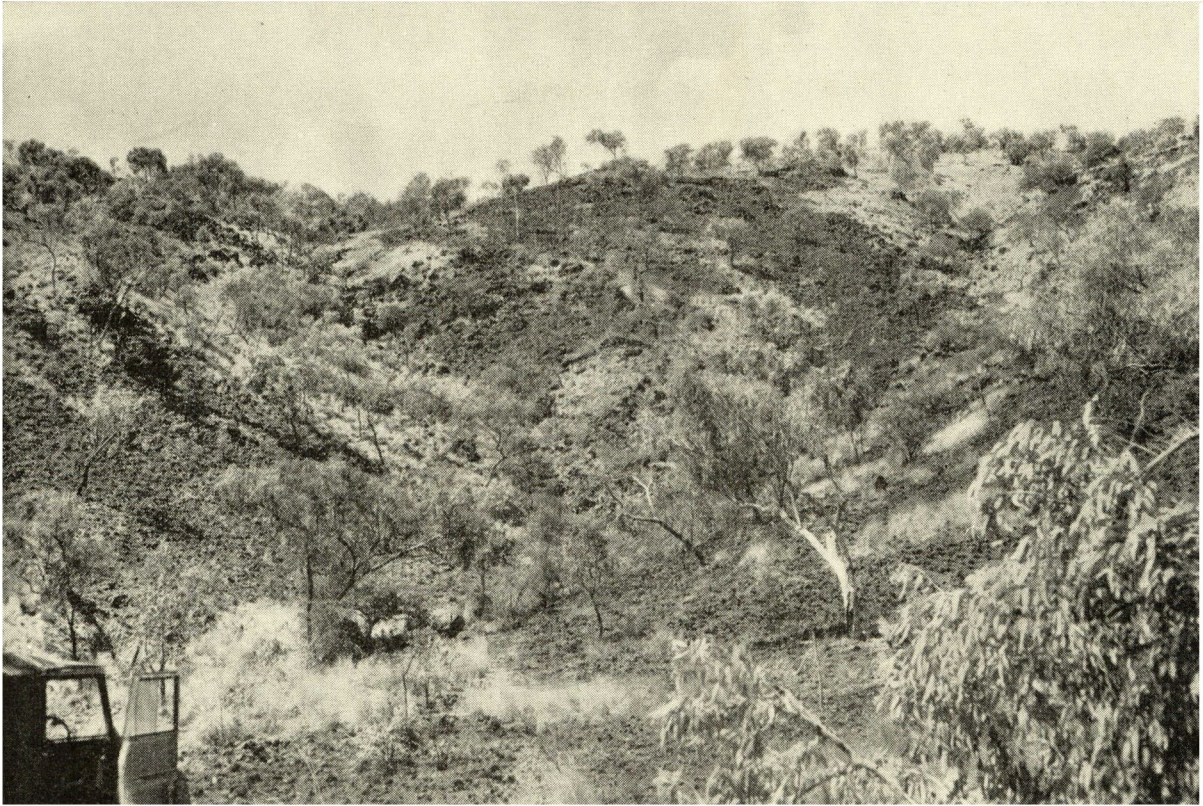
It was soon realised that this was the most promising uranium deposit discovered to that time and that it held a possibility of being large enough to justify the erection of a treatment plant. Several mining companies negotiated with the Walton party for the purchase of the leases which were finally sold to Australasian Oil Exploration Ltd. for £250,000 in cash, a 20 per cent. share interest in the Company (face value £250,000) and 5 per cent. of the gross proceeds of the ore mined. No developmental work had been done on the deposit at this time and most negotiating companies based their assessment of the deposit on a very limited number of surface samples. Subsequent systematic costeaning and diamond drilling justified the early confidence of the geologists of Australasian Oil Exploration Ltd. in the potential of the *Mary Kathleen*.

Late in 1954 Mineral Ventures N.L. and Metals Exploration N.L. became prominent in uranium exploration but none of the prospects tested by these companies proved to be worth developing. Early in 1955, Rio Tinto Co. Ltd. London, through its wholly owned subsidiary, Rio Tinto Mining Co. of Australia Pty. Ltd., negotiated a controlling interest in Mary Kathleen Uranium Ltd., the company formed to develop the *Mary Kathleen* deposit. An extensive programme of diamond drilling was then undertaken with the objective of proving sufficient reserves to justify the erection of a treatment plant. This objective was reached in February, 1956, and an agreement for the sale of £40 million worth of uranium oxide to the United Kingdom Atomic Energy Authority was concluded. Work then commenced on the erection of the town, water-storage dam and treatment plant. Open-cut mining commenced in October, 1956, and the ore was stockpiled till the completion of the treatment plant in June, 1958.



Exploration camp, Mary Kathleen, 1956.

Many claims for rewards were made under the Commonwealth Government's offer of a maximum of £25,000 for the discovery of uranium. Rewards paid for North-Western Queensland discoveries were *Mary Kathleen* (£25,000), *Skal* (£500), *Milo* (£500), *Counter* (£200), *Tinboll* (£200), *Helafells* (£100), *Eldorado-Easter Egg* (£50), *Duke* (£50) and *Ballara* (£50). With the exception of the *Mary Kathleen* the rewards were paid very largely on the discovery value of the deposits. The full £25,000 was paid in the case of the *Mary*

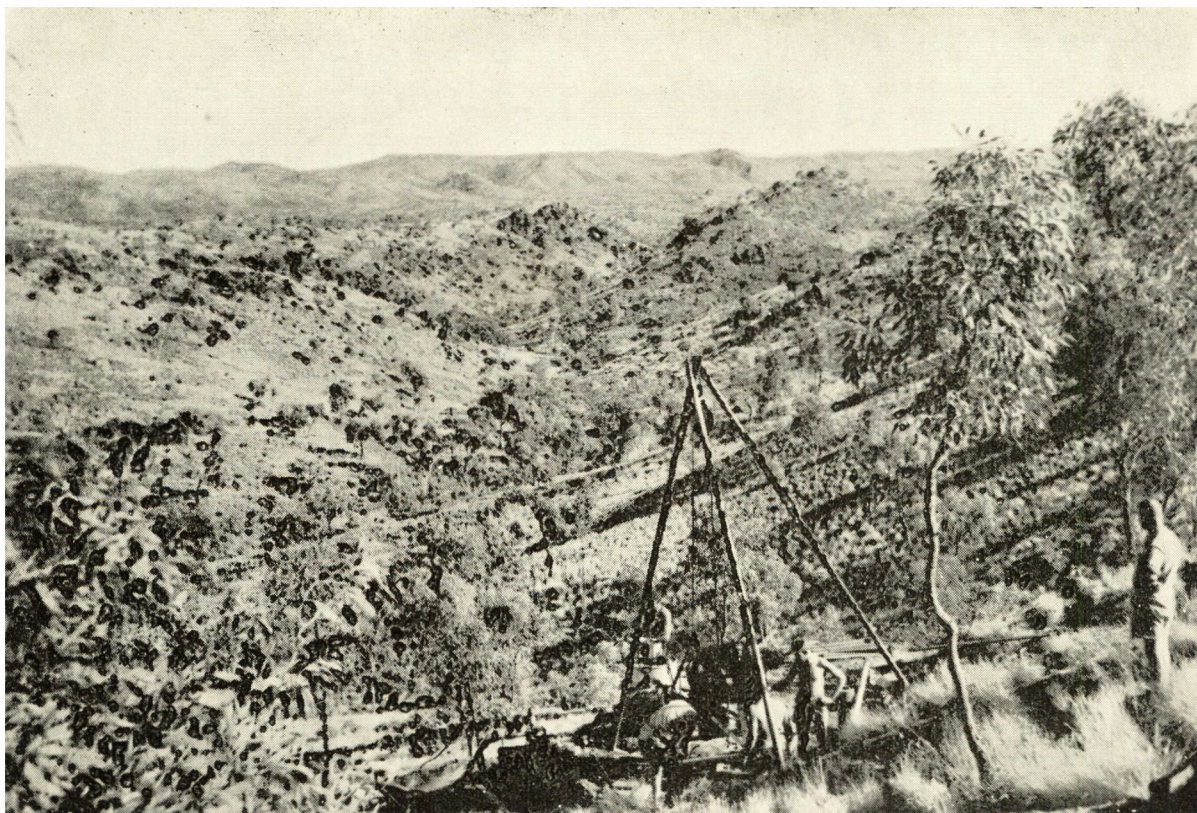


Outcrop of Mary Kathleen deposit, 1954.



Exploration of the Mary Kathleen deposit by costeaning, 1954.

{Photo by L. Thiess.



Exploration of the Mary Kathleen deposit by diamond drilling, 1955.

Kathleen when its extent had been determined by diamond drilling and a decision to develop the deposit had been made. In the majority of cases the purchase or option prices paid by mining companies to the discoverers for the leases far exceeded the rewards granted but the existence of a reward offer did give an added incentive to prospecting particularly in the early stages before the large number of mining companies were attracted to the area.

Apart from the Mary Kathleen area the tempo of prospecting declined rapidly in 1955 and remained at a low level until 1959 when Queensland Mines Ltd. commenced an extensive programme of diamond drilling at the *Counter* and *Skal* leases. In the Mount Isa area many leases which had lapsed were taken up again as there were prospects that a treatment plant would eventually be erected and would treat custom ore in addition to ore from the *Counter* and *Skal* deposits.

As a result of an airborne scintillometer survey of the Westmoreland area in 1956 by the Commonwealth Bureau of Mineral Resources, uranium mineralization was found at five localities by Mount Isa Mines Ltd. One of these occurrences, known as the *Redtree*, warranted detailed exploration. In the 1958-59 period an airborne scintillometer survey was made over much of the outcrop area of the Eastern Creek Volcanics, using an Auster aircraft. This did not result in the detection of new radioactive anomalies of any economic significance.

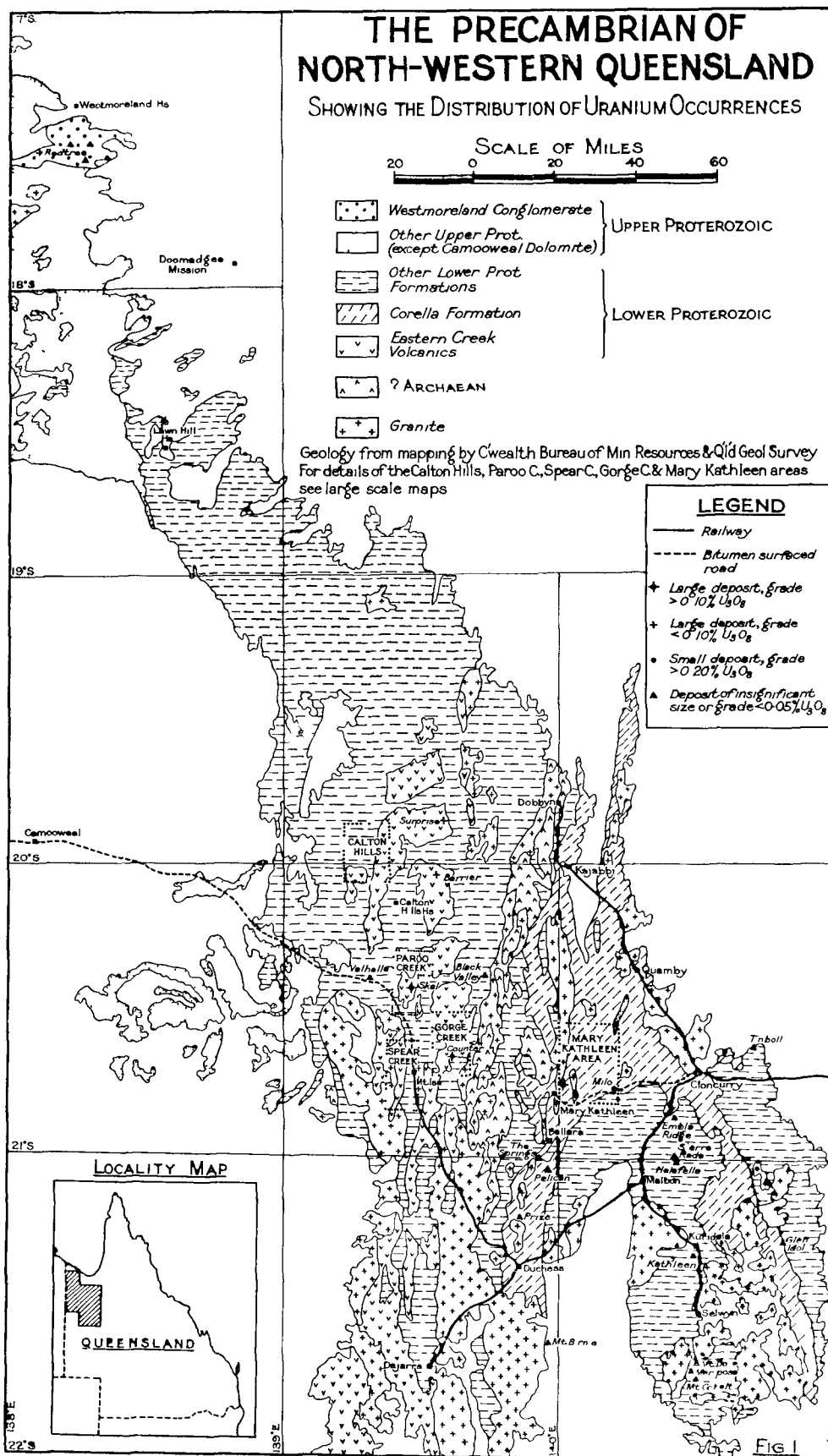
In 1957 Rio Tinto Finance and Exploration Ltd. carried out a helicopter-scintillometer survey of the Corella Formation. The survey covered an area of 3,200 square miles but no significant deposits were found. This Company has also carried out an intense search in the Corella Formation within a radius of several miles of the *Mary Kathleen* deposit without any marked success.

To summarise the history of discovery of uranium in North-Western Queensland it may be said that airborne scintillometer surveys by low-flying, light aircraft have been responsible for the location of several deposits worthy of detailed investigation but that all the more important discoveries have been made by private prospecting parties and can be attributed to their thoroughness and persistence and in some cases to their good fortune.

REGIONAL GEOLOGY

Only a brief summary of the regional geology will be given here. For a detailed description reference may be made to Carter *et al.* (in press).

The Precambrian of North-Western Queensland is situated along the north-eastern margin of the Australia Precambrian Shield. The greater part of the succession is assigned to the Lower Proterozoic. The extent of the Archaean is somewhat uncertain but the formations at present referred to this era are restricted in outcrop area. The mineralized Upper Proterozoic is developed principally in the northern part of the region



near the Northern Territory border (see Fig. 1). A programme of granite sampling for absolute age determinations by the Commonwealth Bureau of Mineral Resources may result in the removal of much of the uncertainty which exists regarding the assignment of formations to divisions of the Precambrian.

Archaean

Migmatite, gneiss, mica schist, recrystallized acid lavas and amphibolite of the Leichhardt and Yaringa Metamorphics are tentatively assigned to the Archaean. These formations are largely devoid of mineral deposits although some small copper deposits occur in rocks included in the Leichhardt Metamorphics.

Lower Proterozoic

There are three broad divisions of Lower Proterozoic formations and for convenience these will be referred to as lower, middle and upper divisions. At the base of the lower division there is a development of acid lavas with some basalt and sediments. Above the acid lava succession there is an extensive development of basic lavas with interbedded sediments (principally quartzites). The pene-contemporaneous Eastern Creek Volcanics, Marraba Volcanics and Soldiers Cap Formation are included in this sequence. Important deposits of copper, uranium and gold occur in these formations. The sediments and lavas were laid down in two northerly trending geosynclinal troughs and crop out extensively over a length of 200 miles in the southern portion of the Precambrian.

The formations of the lower division of the Lower Proterozoic were affected by a minor orogeny and were followed by a sequence of calcareous and arenaceous sediments with minor basic volcanics. The principal formations are the Corella Formation, Judenan Beds, Myally Beds, Marimo Slate and Kuridala Formation. These were subjected to strong folding on meridional axes and were extensively faulted. Overthrusting occurred near the western and eastern margins of the depositional area. Granite intrusion may have accompanied the orogeny. There is a wide range of metamorphism in the lower and middle divisions of the Lower Proterozoic but, in general, it is low to moderate, with local areas of high grade metamorphism. Important uranium, copper-gold, cobalt and silver-lead-zinc deposits occur in the Corella and Kuridala Formations and the Marimo Slate.

The upper division of the Lower Proterozoic consists of shale and dolomite with some siltstone, sandstone and greywacke. The sedimentation took place mainly along the north-western and western margin of the main depositional area. Only minor volcanics occur in the succession. The principal formations are the Mount Isa Shale, the Lawn Hill Formation, Surprise Creek Beds, and the Paradise Creek and Gunpowder Creek Formations. These formations contain important copper and silver-lead-zinc deposits but no significant uranium deposits. Metamorphism is slight compared with that in the middle and lower divisions of the Lower Proterozoic. A major orogeny with folding and faulting and the extensive intrusion of granite took place towards the close of the Lower

Proterozoic. The folding was in part on meridional axes. However, to the north-west of the geosynclinal area deposition took place in a shelf environment and here the sediments have been folded into gently-dipping, basin-dome structures without strong linear trends. It is considered that silver-lead-zinc, copper, cobalt and gold mineralization accompanied this orogeny and the associated granite intrusions.

Upper Proterozoic

The most important deposition in the Upper Proterozoic was in the Westmoreland-Lawn Hill area. There were three cycles of acid to intermediate vulcanicity and in the intervening periods of sedimentation dolomite, siltstone, sandstone, conglomerate, arkose and greywacke were deposited. These were laid down in an east-west trending depositional area north of the Nicholson River and extending into the Northern Territory. The associated shelf deposits, consisting of sandstone, siltstone and shale, occur to the south of the Nicholson River. Sedimentary iron deposits occur in the Mullera Formation south of the Nicholson River and relatively minor deposits of uranium, tin and copper occur in the sedimentary and volcanic formations to the north. A minor unconformity with an associated granite intrusion occurs near the base of the geosynclinal succession. The Upper Proterozoic in this area has been gently folded and faulted, but is unmetamorphosed.

There are other formations unconformably overlying the Lower Proterozoic succession which belong to the Upper Proterozoic or Lower Cambrian. No description of them will be given here as they are practically devoid of mineral deposits. The occurrence of a weakly-uraniferous cap rock on the Lower Cambrian Birnie Arkose is of some mineralogical interest.

Igneous Intrusions

Seven major outcropping areas of granite occur in the Lower Proterozoic geosynclinal areas. The dominant type is a coarse-grained, porphyritic, microcline-biotite granite which is commonly somewhat gneissose. A less extensive, later phase, microcline-biotite granite is fine to medium-grained and of even texture. Small, widely separated intrusions of albitite and sodic granite also occur. Uranium minerals have been found associated with derivatives of all but one of the seven major granite intrusions. The association is usually with pegmatite dyke swarms as at Mica Creek, south-west of Mount Isa, and at Florence Creek north-east of Kuridala on the Selwyn branch railway line.

The Nicholson Granite in the Westmoreland area is a red, massive, even-grained to porphyritic, microcline granite. It is probably genetically related to the earliest cycle of acid volcanics in the Upper Proterozoic succession.

At least three cycles of basic intrusion occurred during the Proterozoic. Numerous dykes of the first cycle intrude the basal acid lava sequence and these dykes have been metamorphosed to varying degrees. They are probably related to the extensive development of basic volcanics in the Eastern Creek volcanics and its equivalents. A second cycle intrudes formations

TABLE 1—DATA ON FORMATIONS IN WHICH URANIUM OCCURRENCES HAVE BEEN FOUND
(Stratigraphic nomenclature as defined by Carter *et. al.* (in press)).

Formation	Division	Lithology	Distribution	No. of U. Occurrences	Remarks
Birnie Arkose	Lower Cambrian ..	Arkose, arkosic and shaly sandstone	Crops out discontinuously over a distance of 25 miles in a narrow meridional belt from the Malbon-Duchess road southwards	3	Ferruginous cap rock is weakly uraniferous. The deposits are of no economic significance
Westmoreland Conglomerate	Upper Proterozoic	Conglomerate, coarse sandstone, arkose	From Northern Territory border SW. of Westmoreland homestead for 30 miles easterly over a width of 1 to 12 miles. Part of geosynclinal sedimentation which extended into the Northern Territory	5	Deposits of secondary U. minerals occur in horizons of coarse sandstone. The only important occurrences later than the Lower Proterozoic
Surprise Creek Beds	Lower Proterozoic	Sandstone, siltstone, quartzite, dolomite, conglomerate	In a meridional belt extending for 90 miles north of the Cloncurry-Mount Isa road from 11 miles E. of Mount Isa	4	U. occurs in highly ferruginous, arenaceous sedimentary rocks. They are probably superficial concentrations
Judenan Beds	Lower Proterozoic	Quartzite, argillaceous sandstone, siltstone shale and a few thin basalt flows	In a narrow meridional belt from 80 miles north of Mount Isa to 30 miles SSW. Adjacent to Eastern Creek Formation on the west for the most part	2	The main occurrence is a low grade torbernite deposit in shales
Kuridala ..	Lower Proterozoic	Carbonaceous slate, mica schist, quartzite. Amphibolite dykes and sills	In a meridional belt with a maximum width of 19 miles from 22 miles N. to 38 miles S. of Selwyn	5	This formation has important Cu and Co deposits in it. The small U. occurrences have Cu associated with them
Marimo Slate	Lower Proterozoic	Interbedded arenaceous slate, quartzite and quartz siltstone	South of Cloncurry in a meridional belt 28 miles long and 11 miles wide. More or less contemporaneous with the Corella, Kuridala and Staveley Formations	8	U. occurs in ferruginous beds of arenaceous or argillaceous type. The deposits are very low grade
Corella ..	Lower Proterozoic	Calc-silicate granulite, gneiss and hornfels (recrystallized impure limestones and dolomites). Some interbedded quartzite metabasalt, calc-breccia and slate	Crops out extensively over a meridional length of 170 miles in the eastern geosynclinal area from 108 miles N. of Mary Kathleen to 70 miles south	40	Includes <i>Mary Kathleen</i> and <i>Mulo</i> . Most of the other occurrences are of the davidite-type, usually with pegmatitic associations
Soldier's Cap	Lower Proterozoic	Mica, garnet, andalusite schist, quartzite, metabasalt and slate	Confined to an area on the SE. margin of the outcropping Precambrian E. and SE. of Cloncurry. Equivalent in part to the Eastern Creek Volcanics	3	U. occurs in ferruginous arenites. The formation has small Au-Cu deposits and only important U. deposit is the <i>Monakoff (Timboll)</i> where U. is associated with Cu
Eastern Creek Volcanics	Lower Proterozoic	Meta-basalt with interbedded quartzite, slate and altered limestone	Crops out extensively over a meridional distance of 175 miles from 83 miles N. to 92 miles SSW. of Mount Isa. Occurs over most of the western section of the geosynclinal area	91	Includes <i>Counter</i> , <i>Skal</i> , <i>Queen's Gift</i> , <i>Duke</i> , <i>Easter Egg</i> and numerous low grade deposits. U. is usually in arenaceous or calcareous meta-sediments but it has also been found in the metabasalt
Granitic Rocks	Lower Proterozoic	Pegmatite, aplite, hybrid granite	Six major intrusions of granite which usually crop out in meridional belts	18	The refractory minerals davidite, brannerite and absite have been found in these occurrences. None is of economic significance

overlying the Eastern Creek volcanics but is earlier than the major granite intrusion at the top of the Lower Proterozoic. A third cycle of relatively unaltered dolerites intrudes the major bodies of granite.

Faulting

As a result of the orogenies which affected the Lower Proterozoic formations they have been extensively faulted. High angle overthrust faulting and strike faulting took place along meridional or north-north-westerly striking planes. The best example of overthrusting from the west is the Mount Isa Shear which occurs between the Judenan Beds and the Mount Isa Shale just west of Mount Isa. The Cloncurry Shear along which the Soldier's Cap Formation is upthrust against the Corella Formation is an example of overthrusting from the east. Compressional faulting also took place along north-easterly and north-westerly striking complementary fault planes. The north-easterly striking faults are very prominent and individual faults of this type can be traced for distances of up to 30 miles. The horizontal displacement can sometimes be measured in miles. Post-granite movement has taken place in some cases. Block faulting is fairly widespread in the Eastern Creek Volcanics and adjacent sedimentary formations. Tension faulting along roughly east-west planes is of common occurrence in some areas. The resistance to weathering of the quartz introduced along many of the fault planes facilitates their delineation. Faulting is also widespread in the Upper Proterozoic but the displacement is usually small.

DISTRIBUTION

Nearly all the recorded occurrences of uranium are distributed in a north-north-westerly trending belt 130 miles long and 85 miles wide extending from 15 miles east of Cloncurry to 7 miles west of Mount Isa, and from Eastern Creek, 60 miles north of Mount Isa, to Dajarra and Mount Cobalt in the South. This is the southern section of the Precambrian of North-Western Queensland (see Fig. 1). The northern section is devoid of known deposits except for the Westmoreland Conglomerate deposits which occur in the extreme north near the Northern Territory border. However, small pitchblende deposits occur a short distance across the Northern Territory border from the Westmoreland area.

With few exceptions the uranium occurrences are confined to seven formations in the lower and middle divisions of the Lower Proterozoic. Over seventy per cent. of the deposits occur in two formations, the Eastern Creek Volcanics (51 per cent.) and the Corella Formation (22 per cent.). There are few deposits of any importance in the other five formations (see Table 1). The restriction of the majority of uranium deposits to two Lower Proterozoic formations indicates the importance of stratigraphic distribution in the exploration for uranium deposits. However, when considering the genetic implications it must be remembered that these two formations crop out over far more extensive areas in the strongly mineralized section of the Precambrian than any of the other 26 Lower Proterozoic formations recognized by Carter *et al.* (in press) and that 10 of the

21 non-uraniferous formations do not contain mineralization of any kind. The Corella Formation crops out over an area of nearly 2,000 square miles and the Eastern Creek Volcanics over an area of more than 1,500 square miles.

The uranium occurrences are not as extensively distributed areally or stratigraphically as the copper deposits of the Cloncurry-Mount Isa mineral province (fifteen of the 28 Lower Proterozoic formations contain copper deposits of some significance). Minor amounts of copper are commonly associated with the uranium occurrences but it is uncommon to find even minor amounts of uranium in the copper and other base metal deposits of the region. The exceptions are the small *Monakoff* and *Mount Dore* copper deposits and the *Mount Cobalt* cobalt-copper deposit. The grouping of the uranium deposits in no way reflects the grouping of the copper and other metalliferous deposits. No uranium deposits have been found in the isolated Lawn Hill silver-lead field (Burketown Mineral Field). The Eastern Creek Volcanics in which numerous uranium deposits occur, contain none of the important copper, silver-lead-zinc, gold, and cobalt deposits of the Precambrian mineral belt. However, important copper deposits and minor silver-lead-zinc, gold and cobalt deposits occur within the Corella Formation in addition to the important *Mary Kathleen* deposit and numerous minor uranium deposits. The Mount Isa Shale and the Argylla, Gunpowder Creek, and Kuridala Formations which have important base metal deposits have only a few, unimportant uranium deposits.

From the virtual absence of uranium mineralization in the formations deposited late in the Lower Proterozoic (including the Mount Isa Shale) it is inferred that uranium mineralization in the Cloncurry-Mount Isa mineral province probably took place earlier than the main silver-lead-zinc-copper mineralization. It may have been associated with the minor orogeny and granite intrusion which is thought to have followed the deposition of the Judenan Beds and Corella Formation. The Westmoreland uranium deposits are of Upper Proterozoic age and occur in a mineral province of relatively minor importance which extends from the Westmoreland area to the Wollongorang and Macarthur River areas of the Northern Territory.

The only occurrences of uranium in Post-Precambrian formations are minor ones in the Lower Cambrian Birnie Arkose and the Lower Cretaceous Toolebuc Member of the Wilgunya Formation. A yellowish-green uranium mineral occurs in association with fossil fish remains in the Toolebuc Member of the Wilgunya Formation (Casey *et al.*, 1960).

Uranium mineralization has been found in a wide range of lithological types, including hematitic and calcareous quartzite, sandstone, and siltstone, calcareous granulite, recrystallized limestone, magnetite greywacke, meta-basalt, allanite and hornblende schist, slate, shale and a variety of granitic rocks. Deposits are absent from the massive quartzites, and the altered acid volcanics, and are of infrequent occurrence in the dolomitic, carbonaceous and graphitic shales and slates which are by far the most important host rocks for the copper and silver-lead-zinc deposits of the

Precambrian mineral belt. In addition to the small deposits associated with pegmatites and other granitic rocks, the granites as a whole commonly exhibit two to five times background radioactivity (Geiger-counter readings).

MINERALOGY

The mineralogy of the uranium deposits is quite complex and although a considerable amount of research has been carried out on the ores, the mineralogy, in many cases, has not been fully resolved. The *Mary Kathleen* and *Counter* ores are the only ones to have been subjected to an intense study. Identification of uranium minerals has been made for 50 of the deposits described, but in several instances positive identification could not be made and sometimes mineragraphic reports from different sources have given conflicting results. This can be attributed largely to the very fine grain-size of the primary uranium mineral in many of the ores.

Secondary Minerals

With the exception of the deposits in the Westmoreland Conglomerate and the *Milo* deposit, there are no significant concentrations of secondary uranium minerals. Small amounts of secondary uranium minerals occur in most of the deposits as thin films on joint and fracture planes to a shallow depth. Quite often primary ore minerals are present at the surface and exhibit only superficial alteration. The absence of spectacular occurrences of secondary uranium minerals at the surface probably has a bearing on the fact that the discovery of significant uranium deposits in Queensland came much later than the initial discoveries in South Australia and the Northern Territory.

Meta-Torbernite.—This mineral is of common occurrence in deposits in the Cloncurry-Mount Cobalt area and is also present in the Westmoreland deposits. It is recorded from a total of 16 localities. The most interesting occurrence is at the *Milo* where a lens of meta-torbernite ore containing 80 tons per vertical foot occurs in a white clay rock which is the end product of the weathering of an acid igneous rock or possibly a feldspathic calc-silicate rock. In the deposits in the Westmoreland Conglomerate meta-torbernite occurs as disseminated, interstitial grains in a coarse, feldspathic sandstone. A small quantity of meta-torbernite is associated with cobalt-copper-tungsten mineralization at the *Mount Cobalt* deposit, and at the *Monakoff* deposit it is associated with copper carbonates, hematite, fluorite, barytes and garnet.

Small quantities of uranophane have been identified in the *Mary Kathleen*, *Pelican*, *Counter* and *Clear Waters* deposits and it is likely that the unidentified, yellow uranium mineral commonly seen on joint and fracture planes in other deposits is also uranophane in a number of cases. Carnotite is of somewhat less frequent occurrence than uranophane but it has been identified at the *Easter Egg*, *Skal*, *Pile* and *Rosie Bee* deposits and it is present in some quantity in the *Redtree* deposit, Westmoreland. In the davidite-brannerite type of deposit in the Cameron-Corella River area there is a commonly-occurring, yellow alteration product around the primary mineral and this may be carnotite. Other secondary

uranium minerals identified are gummite, beta-uranotil, autunite, saleeite (?), renardite, soddyite, zeunerite, and phosphuranylite.

Primary Uranium Minerals

Uraninite, davidite, brannerite and absite occur in that order of abundance. Uraniferous magnetite, ilmenite and columbite have also been identified. The uraninite and some of the brannerite are finely disseminated through the host rock and cannot be identified in the hand specimen. The davidite, absite and the remainder of the brannerite occur as medium to coarse-grained blebs or crystal pseudomorphs. Detrital grains of these minerals are usually present in the soil in the vicinity of the lode material.

Uraninite.—The principal occurrence of this mineral is at the *Mary Kathleen* where aggregates of fine grains are included in allanite and to a lesser extent in the rare-earth minerals stillwellite (a boro-silicate of the lanthanons), caryocerite (complex hydrated borosilicate of calcium and rare-earth minerals) and rinkite (silicate of iron, titanium, sodium, calcium and cerium) (Whittle, 1955b). The allanite itself is practically non-uraniferous. Some uraninite is associated with pyrrhotite, pyrite and chalcopyrite which occur as irregular bodies in the *Mary Kathleen* deposit. Uraninite has also been identified from the *Flat Tyre*, *Clear Waters* and *Janelle* deposits and doubtfully from the *Elaine Dorothy*, *Easter Egg* and *Tinboll* (*Monakoff*) deposits. At the *Flat Tyre* the uraninite occurs as aggregate of very fine grains. At the *Monakoff* minute inclusions which are thought to be uraninite occur in fluorite (Campbell *et al.* 1955 unpub.).

Brannerite is present as finely disseminated grains in a calcareous, hematitic siltstone at the *Skal* and *Pile* deposits (McAndrew and Edwards, 1954 a and b). Isolated crystals of brannerite occur in a mica schist adjacent to pegmatite at the *Comfort* deposit (Lawrence, 1955). Absite, the thoria-rich variety of brannerite (Whittle, 1954) has been found in small quantities at the *Doris Norelle*, *Three Inkspots*, *Why Not-Gumbardo* and *Lady Rachel* deposits in the Cameron River-Corella River and Ballara areas, and also between Mica Creek and Sybella Creek, south-south-west of Mount Isa. The occurrences consist of small pockets of granitic rock containing grains of absite. The granitic rocks include pegmatite, greisen, aplite and graphic granite.

A large number of occurrences of davidite-type mineral are known but most are only of mineralogical interest. Isolated occurrences are known in such widely separated localities as Kuridala, on the Selwyn branch railway line, Quamby, on the Dobbryn branch railway line and Dajarra in the far south of the region. However, most of the davidite-type mineral occurrences are in pegmatite or calcareous meta-sediments in the Cameron River-Corella River and Ballara areas, the most important being on the *Three Brunettes* and *Six Kangaroos* leases. As with the South Australian davidite, inclusions and intergrowths of ilmenite, rutile and hematite are common (Lawrence *et al.*, 1957). The ilmenite may also be uraniferous in some cases. The U_3O_8 content of davidite from different localities ranges from 2.17 per cent. to 20.16 per cent. It often

occurs as irregular to rounded blebs or shapeless masses but elsewhere a cuboidal form is exhibited. The lustre of the davidite increases from vitreous to metallic with an increasing amount of inclusions.

Specimens of uraniferous columbite have been obtained from a pegmatite in the *Mica Creek* area $6\frac{1}{2}$ miles south-west of Mount Isa. Beryl and biotite have been mined in adjacent pegmatites. One specimen of columbite was found to contain 0.7 per cent. U_3O_8 (chemical analysis, Qld. Govt. Analyst).

The primary uranium mineral in many of the deposits in the Eastern Creek Volcanics, and in the torbernite-ironstone type of deposit in the Cloncurry area, is closely associated with iron oxide minerals. Hematite is usually the iron mineral in outcrop but magnetite is the most common primary iron mineral. In several ores with uranium-iron associations which have been subjected to mineragraphic study, no discrete uranium mineral has been identified. Dallwitz and Roberts (1955 unpub.) have attributed the uranium contents of samples to the magnetite in such deposits as the *Impassable* and the *Elaine Mary*. Uranium was found to be intimately associated with octahedra of magnetite in a specimen of altered felspathic siltstone from the *Pile* submitted to the Geological Survey of Queensland. A study of a polished section did not reveal the presence of any inclusions or coatings which could account for the observed radioactivity.

The ore from the *Counter* deposit contains abundant euhedral grains of magnetite but here a very fine-grained uranium mineral is closely associated with biotite, sphene and rutile. Various attempts to identify the uranium mineral have given conflicting results. The uranium has been attributed variously to pitchblende, xenotime, a davidite-like mineral, an iron ore-uranium mixture and a mineral with some properties corresponding to uraninite. After a detailed study, McKeague and Hockin (1957 unpub.) concluded that the primary uranium mineral is a non-homogeneous, crystalline complex that may have resulted from the replacement and alteration of sphene. Its properties do not correspond with any known uranium mineral and it is estimated to contain 15 to 25 per cent. U_3O_8 .

TYPES OF DEPOSIT

1. Mary Kathleen Type

The occurrence of this type of deposit is confined to a meridional belt of highly metamorphosed and metasomatized calcareous and arenaceous sediments, five miles long and two miles wide, situated between two major concordant intrusions of granite. The deposits are characterized by the presence of zones of intensely garnetized rocks and by the occurrence of uraninite principally as fine-grained inclusions in allanite and other rare earth minerals which have replaced the garnet. The deposits are highly irregular in outline and grade, and it is only at the *Mary Kathleen* where mineralization has been intense that a large deposit of economic grade has been found. Other zones of intense garnetization occur at the *Elaine Dorothy* and *Armstrong North* prospects but the associated uranium

mineralization is weak and sporadic. The *Mary Kathleen* is regarded by Matheson and Searl (1956) as a pyrometasomatic type of deposit derived from a late-stage emanation from granite intrusion. No comparable deposits of this type in which uranium is the principal metal are known either within Australia or elsewhere.

2. Eastern Creek Type

All the deposits of this type are in the Eastern Creek Volcanics. Typically the ore-shoots are well-defined and individual deposits are located in a particular horizon in the Formation. The mineralized horizons show a considerable range in rock type and in degree of metamorphism. Where determined, the finely-disseminated primary uranium mineral has been found to be uraninite, brannerite or uraniferous magnetite. A noticeable feature is that in most cases introduced gangue minerals make up only a small proportion of the ore rock. The deposits are considered to be of the hydrothermal replacement type. Uranium mineralization was introduced along faults or shear zones and deposited in the adjacent favourable beds. However, a sedimentary origin with subsequent redistribution of the uranium may also be postulated. The following sub-types can be distinguished:—

(i.) **Skal type** deposits are confined to the Paroo Creek-Calton Hills area north of Mount Isa. The very fine-grained, primary uranium mineral occurs in arenaceous sediments which are interbedded with altered basalt. The sedimentary rock is usually a siltstone which has been carbonated and impregnated with iron oxide minerals. Brannerite has been identified at the *Skal* and *Pile* deposits. Other deposits of this type include the *Hopeful*, *Queen's Gift*, *Batman*, and *Duke*.

(ii.) **Counter type** deposits are confined to the Gorge Creek area north-east of Mount Isa. Finely disseminated uranium mineralization occurs in fine to medium-grained, meta-greywacke or quartzite. Magnetite or hematite is commonly present but calcite, if present, usually occurs in minor amounts. The *Counter* deposit is somewhat exceptional in being a comparatively regular, compact orebody of considerable size. The uranium mineral has not been identified but it is refractory in type. Other deposits of this type are usually long, narrow and irregular in width, and of low, erratic grade. These include the *Geiger*, *Carol*, *New Ring* and *Gorge* deposits.

(iii.) **Easter Egg type**. Finely disseminated uraninite occurs in horizons of hornblende, biotite, quartz and allanite schists. The schists crop out a few miles west of Mount Isa in a belt 12 miles long and 2 miles wide from the Mica Creek area in the south to the Spear Creek area in the north. The deposits usually consist of long, narrow orebodies of irregular width and grade. They are situated in a pronounced embayment in the margin of the major Sybella Granite. The Mica Creek pegmatites which have tin, tantalum, thorium and uranium minerals associated with them occur to the south in the same belt of schists and the uranium deposits may be closely related to late stage granitic

intrusions. The *Flat Tyre*, *Mother's Day*, *Eldorado*, *Folderoll*, *Nevercantell*, *Mighty Glare*, *Midnight* and *Perseverance* deposits are included in this sub-type.

(iv.) **Surprise type.** Deposits of this type are relatively few in number and occur in the Calton Hills-Paroo Creek area north of Mount Isa. Very little mineralogical work has been carried out on the ores but in some cases the uranium is attributed to uraniferous magnetite which occurs in altered basalt. The basalt has been carbonated, chloritized and albitized to varying degrees. Deposits in this sub-type are the *Surprise*, *Elaine Mary*, *Impassable*, *Barrier* and *Mount Rover*.

3. Torbernite-Ironstone or Monakoff Type

The deposits of this type are characterized by very low-grade, disseminated, primary uranium mineralization in massive siliceous ironstone or ferruginous sandstone, and the presence of small concentrations of a secondary mineral, usually torbernite, in the zone of weathering. Weak copper mineralization is commonly associated with the deposits, all of which are in an area extending from Cloncurry to Mount Cobalt near the southern limit of the Precambrian. Occurrences are located in the Soldier's Cap Formation, Corella Formation, and Marimo Slate. The primary uranium mineral has not been identified but it occurs in a very finely-divided state as inclusions in fluorite at the *Monakoff*. The limonitic jasper gossans often associated with the deposits are indicative of sulphide mineralization at depth. In individual deposits the uranium is usually confined to a particular sedimentary horizon or occurs along lithological contacts. The association of magnetite, chalcopyrite, garnet and fluorite in the *Monakoff* ore is taken to indicate moderate to high temperature, hydrothermal deposition.

In some deposits the association of uranium and iron oxides at the surface is probably due to a process of supergene concentration in which the uranium has become "fixed" by the iron oxides. In such cases no primary source of any economic significance can be expected.

4. Davidite Type

Numerous small deposits have been found containing refractory uranium minerals and of these, davidite is by far the most common. Usually the minerals are associated with pegmatite, aplite, greisen or other granitic rock-types. They exhibit the usual coarse-grained pegmatitic features with the erratic distribution of metallic mineral constituents. In a number of cases the davidite-type mineral occurs in calcite-actinolite-felspar rocks of the Corella Formation which may be adjacent to the granitic rocks as at the *Three Brunettes* deposit, or it may occur in a recrystallized calcite lens as at the *Six Kangaroos* deposit. Some uranium-thorium mineral associations occur in the Mica Creek, Corella River-Cameron River and Ballara areas. Absite and monazite have been found in pegmatites and the adjacent meta-sediments.

5. Westmoreland Type

Deposits of secondary uranium minerals occur in horizons of coarse-grained, felspathic sandstone towards

the top of the Westmoreland Conglomerate. Torbernite and carnotite are the main uranium minerals and these are present as pore-space fillings and coating mineral grains of the sandstone. Pitchblende veins have been found in the volcanic sequence which overlies the Westmoreland Conglomerate in deposits across the Northern Territory border from the Westmoreland area and this provides a possible source for the secondary uranium minerals. This supergene origin is considered more likely than that of sedimentary deposition with the sandstone. The *Redtree* is the only important deposit of this type which has been located.

6. Superficial Types

Fairly extensive, weakly uraniferous areas occur in the outcrop of the Birnie Arkose, south-south-east of Duchess. They are considered to be superficial concentrations in a cap-rock, and the origin of the uranium is uncertain. It may originally have been deposited with the arkose or derived from deposits in adjacent Lower Proterozoic formations. The *First Try*, *Mother's Hope* and *Mary Lou* occurrences are of this type.

Very weak uranium mineralization is associated with limonitic cappings in the Glenroy group of deposits north-north-east of Mount Isa. These deposits also appear to be superficial concentrations.

CONTROLS IN ORE LOCALIZATION

In only a small proportion of the uranium deposits described has any close study been made of the controls in ore localization. Usually the control can be attributed to a combination of factors and those mentioned here will, in most cases, be the most obvious ones.

The controls of uranium mineralization at the *Mary Kathleen* are favourable host rocks, structures (including faults, shears, and joints) and garnetization (Matheson and Searl, 1956). A group of calcareous granulite beds containing a "breccia-conglomerate" horizon forms the host rock. North-easterly and west-north-westerly faults and joints provided channels for the extensive introduction of garnet which was followed by uranium-bearing hydrothermal solutions. These solutions were probably derived from the granitic magma which was intruded to the east of the deposit. Selective replacement of the calcareous granulite by the garnet took place and the garnet was replaced in turn by uraninite and allanite. Mineralization was confined on the east and west by north-north-westerly trending strike faults, and west-north-westerly faults influenced the southern and northern extent of deposition. Replacement has taken place to such an advanced stage within the orebody that the structures in the original meta-sediments have been extensively or completely obliterated. However, from the configuration of the individual lenses of ore it appears that mineralization took place along joint or fault planes and the adjacent garnetized granulite was replaced to varying degrees. A system of northerly trending joints which dip west at 40 deg. to 70 deg. seem to have been of particular importance in this regard.

In a large number of deposits it is concluded that the uranium mineralization was introduced along a

fault plane or shear zone and deposited in the most favourable adjacent rock type. Typical of these is the *Skal* where a large body of white lode quartz marks a prominent strike shear zone. The quartz is slightly radioactive in part but significant mineralization is confined to an adjacent calcite and hematite-bearing siltstone. The interbedded chloritized basalt is unmineralized.

At the *Counter* deposit there are east-west strike faults and north to north-north-east transgressive faults. One prominent east-west fault marks the hanging-wall of the orebody. A transgressive fault intersects the outcrop of the orebody towards the eastern limit and a dolerite dyke was intruded along this fault plane. Another north-north-easterly fault appears to control the western limit of the orebody. Uranium mineralization occurs in a lens of cross-bedded meta-greywacke and, as at the *Skal*, the interbedded chloritized basalt is unmineralized. The north-north-easterly faults may have been responsible for the introduction of uranium mineralization, as the small *Battery* and *Father's Day* deposits to the north and the *Geiger* deposit to the south of the *Counter*, occur in meta-sediments along roughly the same north-north-easterly trending line.

The *Pelican* deposit in the Ballara area is another example of the fault-favourable bed association in ore localization. A regional, quartz-filled strike fault occurs adjacent to the deposit on the east. The uranium mineralization is confined to crumpled beds of calc-silicate rocks and slate.

The shearing of incompetent rock types, sometimes with accompanying drag-folding has provided a favourable locus for uranium deposition in some localities. At the *Monakoff (Tinboll)* a bed of ferruginous sandstone which is interbedded with amphibolite has been sheared and drag-folded, and where this has been most intense, copper and uranium deposition has taken place. In the *Duke* group of deposits in the Calton Hills area, the meta-basalt-quartzite succession has been subjected to local shearing of considerable intensity. Small deposits of uranium occur in less competent quartzite and other meta-sediments which are extensively fractured. As a general rule altered basic volcanics are unfavourable host rocks but if they are highly fractured and altered, as at the *Surprise* deposit, uranium deposition may take place in them. A somewhat different control of ore localization is evident at the *Mother's Day No. 3* deposit. Shearing, which resulted in intense fracturing on the nose of a small fold in amphibolite and chlorite schist, produced a favourable locus for uranium deposition. The higher grade ore is confined to the nose of the fold and the grade decreases as the beds are traced to the limbs of the fold.

The association of hematite and calcite with uranium is particularly noticeable in the deposits of the Paroo Creek-Calton Hills-Gorge Creek areas. In many cases the extent of the radioactive anomaly could be outlined by reference to the reddish coloration imparted to the rock by disseminated hematite. There appears to be a definite affinity between the iron and uranium minerals in such cases. Calcite may have acted as a precipitating agent for the uraniferous solutions.

Petrological work by Dallwitz and Roberts (1954) indicates that the hematite and calcite represent introduced gangue minerals. The fact that they occur in altered basalts as well as meta-sediments supports this view.

In the deposit of secondary uranium minerals in the Westmoreland Conglomerate it is thought that joints and earthy bands between the sandstone beds acted as solution channels (Syvret, 1957). Iron and manganese oxide may have acted as precipitating agents for the uranium. No particular stratigraphic control was in evidence nor did the mineralization appear to be related to lithology, grain size or current bedding.

The broad stratigraphic control of the uranium deposits has been referred to in the section on Distribution and in Table 1. The lithological and structural controls of uranium mineralization bear little relation to those of the other metalliferous deposits of the region. For instance, the quartz-filled faults and shear zones with which so many of the copper deposits of the Cloncurry-Mount Isa area and the silver-lead deposits of the Lawn Hill area are associated, very rarely carry uranium mineralization. However, the main systems of compressional faulting are important controls in all the metalliferous deposits.

ORE GENESIS

The question of the mode of origin of the uranium deposits came into prominence soon after the initial discovery in 1954. Geologists of Mount Isa Mines Ltd. based their early airborne scintillometer surveys on the assumption that uranium deposits occurred in certain horizons of the Eastern Creek Volcanics as a result of deposition during sedimentation. Subsequently a large number of deposits were found in the Eastern Creek Volcanics but it is considered that this has not substantiated the concept of syngenetic deposition. The uranium has been found in a variety of arenaceous and calcareous sediments and also in altered basalts. The iron oxide minerals which are commonly associated with uranium mineralization have been shown to be introduced gangue minerals in the small number of ores examined. The complexity of faulting makes it almost impossible to correlate sedimentary beds from one deposit to another except over short distances, and no reliable marker beds are available. In most deposits well-defined structural controls are evident and these have been described in the previous section. Granites intrude the Eastern Creek Volcanics but the deposits in the Paroo Creek-Calton Hills area show no obvious relationships to intrusive igneous activity and individual deposits are as much as 25 miles away from the nearest outcropping granite. However, the Spear Creek-Mica Creek deposits appear to be genetically related to the Sybella Granite (see section on Easter Egg type deposits, page 12).

With regard to the *Mary Kathleen*, Matheson and Searl (1956) state "The mineralization is regarded as epigenetic, the mineralising solutions being a late stage emanation from the granitic magma." The granite referred to occurs some two miles to the east of the deposit and a number of acid dykes radiate from the western margin of the granite. In the same area, and

as far west as the *Mary Kathleen*, garnetization of the Corella Formation is extensive. Several minor occurrences of uranium have been found in areas of garnetization in addition to the *Mary Kathleen*. Thus, the field evidence indicates a close genetic relationship between the eastern granite and the *Mary Kathleen* deposit.

Very little is known about the torbernite-ironstone type of deposit. However, the occurrence of a fluorite gangue associated with sulphide mineralization at the *Monakoff* and *Milo* deposits is suggestive of an epigenetic origin and a genetic relation to granitic intrusions even though no granite intrusions crop out near the deposits.

Lawrence *et al.* (1957) considers that the davidite deposits of the Cloncurry-Mount Isa area were deposited syngenetically with the calcareous sediments of the Corella Formation and redeposited in their present form by regional metamorphism. In the deposits examined by Lawrence no direct evidence of an association with igneous activity could be found. The fact that, with few exceptions, the davidite deposits occur in the Corella Formation is suggestive of a depositional relationship. However, taking the davidite-type deposits as a whole, more than half occur in or adjacent to pegmatite and other granitic rocks, and in no case is granite far removed from them. At the *Six Kangaroos* where davidite occurs in a lens of recrystallised calcite it appears that the davidite has been redeposited with the calcite but the original mode of deposition cannot be conclusively determined.

The stratigraphic distribution and the importance of lithological control of uranium mineralization give some grounds for a syngenetic theory of origin. However when the geology of the deposits is considered in detail it is found that this theory is difficult to support. This is in agreement with the conclusion reached by Carter (1955). There is fairly strong evidence for an epigenetic origin and a relationship to granitic intrusion in the case of the *Mary Kathleen* and Davidite Type deposits. For the other groups of deposits there is meagre evidence which is suggestive of a similar origin. The probable supergene, epigenetic origin of the deposits in the Westmoreland Conglomerate has been referred to in the previous section on controls in ore localization.

DEVELOPMENT AND RESERVES

In 1954 five hundred and ninety-one uranium leases were taken up totalling 17,670 acres and distributed over an area of approximately 10,000 square miles. Information is given on 180 leases or localities which contain radioactive anomalies known or assumed to be due to the presence of uranium. Of these, 128 have been confirmed as uranium occurrences by the analysis of samples. Many leases were taken up to cover the possible extension in depth or along the strike of known uranium deposits. On many others the radioactivity is so restricted in extent or so weak in intensity that the leases would merit no further attention even if the economics of uranium mining changed radically in favour of the producer. Most of the leases taken up in 1954 have since been forfeited and in some cases the original lease areas have been taken up later under different names.

D

Table 2 gives information on 73 leases on which surface or sub-surface exploration has been carried out in addition to radiometric mapping. Of these, the exploration on 43 leases consisted only of costeaning to remove soil cover or to enable sampling to be carried out. Seventeen deposits have been tested by drilling. The total number of diamond drill holes put down to the end of 1958 was 176 with a total footage of 62,382. One hundred and thirteen diamond drill holes with a total footage of over 46,000 have been put down at the *Mary Kathleen* so that the amount of drilling elsewhere has not been very great. Further exploratory drilling is being carried out on the *Counter*, *Skal* and *Mary Kathleen* deposits. Eleven deposits have been tested by shaft-sinking, driving and crosscutting. Most of the workings are to a depth of less than 50 feet and the deepest shaft has been sunk on the *Helafells* to a depth of 240 feet. Of the prospects tested, only the *Mary Kathleen* has so far proved to be of major economic importance. Two other deposits, the *Counter* and *Skal*, have good prospects of development on a smaller scale than the *Mary Kathleen*. In addition, there are 14 deposits which may contribute small quantities of ore if a buying point is established on the field.

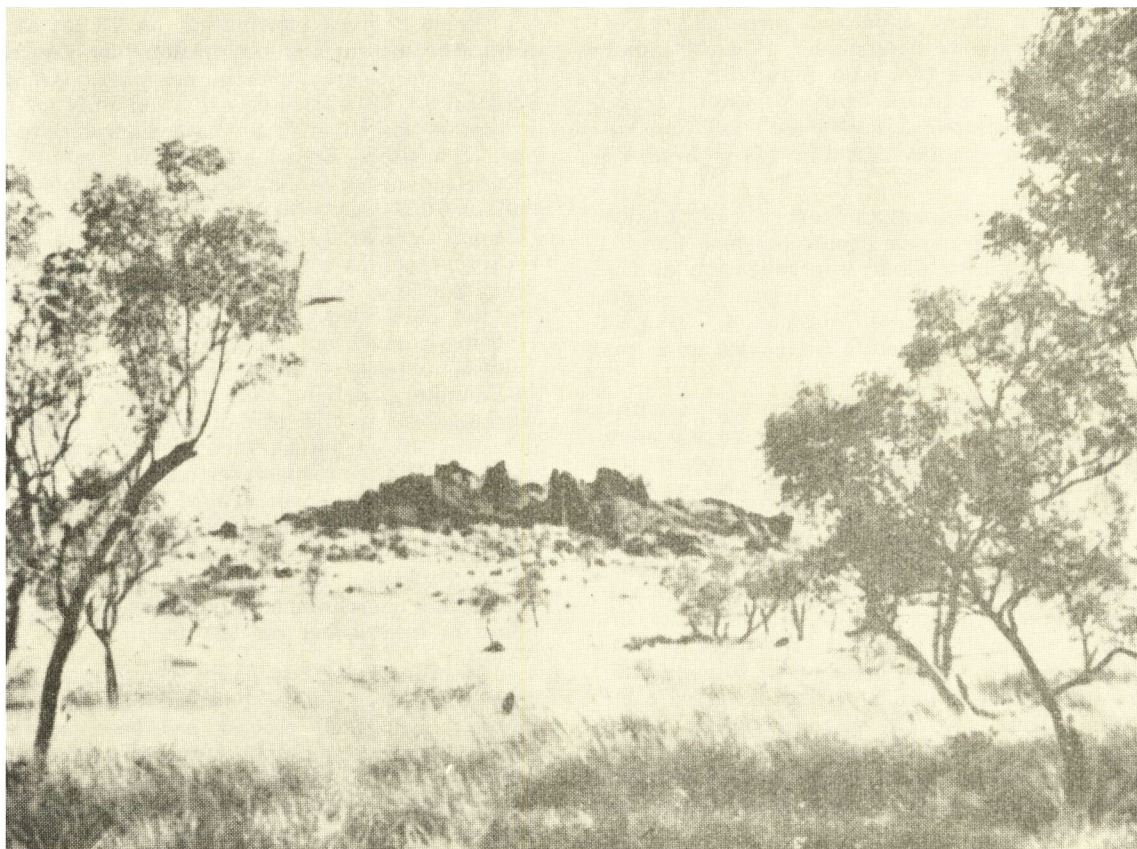
Metallurgical tests have been carried out on ores from the *Mary Kathleen*, *Counter*, and *Skal*. A satisfactory acid leach process has been applied to the *Mary Kathleen* ore and an 86 per cent. recovery is being obtained. The *Counter* ore constitutes a difficult metallurgical problem but an economic process of treatment may be possible using an alkali leach under pressure. The *Skal* ore is amenable to a hot acid leach after the removal of the calcite from the ore.

For the purposes of discussion of the exploration, development and future prospects, the uranium are here divided into several geographical groups.

1. Calton Hills

The largest known deposits in this group are the *Surprise* which has 180 tons per vertical foot with a grade of 0.13 per cent. U_3O_8 and the *Barrier* with 190 tons per vertical foot of 0.10 per cent U_3O_8 . The highest grade ore occurs in a small ore-shoot on the *Duke* lease which has 30 tons per vertical foot with a probable grade of the order of 0.30 per cent. U_3O_8 . In few of the deposits does the grade greatly exceed 0.10 per cent. U_3O_8 . Practically nothing is known of the nature of the deposits at depth. No diamond drilling has been carried out and the only shaft sinking has been at the *Duke* and *Batman* leases to a maximum depth of 17 feet. The deposits range from 50 to 80 miles by road from Mount Isa and the distance to *Mary Kathleen* would exceed 90 miles. It may be possible to develop small, higher grade ore-shoots such as the one on the *Duke* lease but the prospects are not particularly good.

The Calton Hills area has been fairly well prospected by both airborne scintillometer surveys and ground parties although some localities are difficult of access and may not have been fully tested. Further exploration of such deposits as the *Elaine Mary* and the *Duke* is warranted.



Outcrop of the "Pile" one of the earliest uranium deposits to be discovered in North-Western Queensland.

2. Paroo Creek

Deposits on the *Skal* lease were investigated by Mount Isa Mines Ltd. because there seemed some prospects that the deposits would be large enough to warrant the erection of a treatment plant. In addition, other deposits within a few miles of the *Skal* such as the *Hopeful* and *Pile* were expected to be able to contribute substantial additional tonnages of ore. The deposits are rather conveniently situated in regard to access. Mount Isa is 25 miles distant by road, including 19 miles via the bitumen-surfaced Barkly Highway.

The surface grade of the two ore-shoots on the *Skal* was found to be only 0.05 per cent. U_3O_8 but the grade indicated by the 100 feet drill intersections is 0.16 per cent. U_3O_8 . Ore reserves are of the order of 300,000 tons. The best section of the *Pile* deposit has 500 tons per vertical foot of 0.07 per cent. U_3O_8 and the best section of the *Hopeful* has 170 tons per vertical foot of 0.06 per cent. U_3O_8 . Thus with the exception of the *Skal*, the average grade of the Paroo Creek deposits is less than 0.10 per cent. U_3O_8 . It may be possible to selectively mine the higher grade sections of such deposits as the *Skal* and small isolated deposits such as those at *Mount Spring No. 2*.

Being convenient of access, the area came under careful scrutiny during the prospecting boom of 1954, and it is unlikely that outcropping deposits of any significant size have been overlooked.

3. Spear Creek

All the deposits of this group are small and usually consist of elongate ore-shoots of erratic width. They are all situated within 10 miles of Mount Isa. The *Flat Tyre* and *Mother's Day No. 3* have been partly explored by shaft-sinking, driving and crosscutting and the *Midnight-Easter Egg* has been diamond drilled. Preliminary work on ore from the *Flat Tyre* indicates that it would be amenable to an acid leach process of extraction after very fine grinding.

The largest deposits of the group are the *Mighty Glare* which has 130 tons per vertical foot of 0.08 per cent. U_3O_8 , and the *Perseverance* which has 65 tons per vertical foot of 0.22 per cent. U_3O_8 . Usually the deposits have less than 50 tons per vertical foot and the grade is commonly within the 0.10 per cent. to 0.20 per cent. U_3O_8 range. It is possible that deposits such as those on the *Perseverance*, *Flat Tyre*, *Easter Egg-Midnight*, *Nevercantell*, *Folderol No. 2*, and 3, and *Eldorado No. 1* leases may be economically developed by small scale, selective mining. The area has been subjected to thorough prospecting.

4. Gorge Creek

Of the deposits in this group, the *Counter* is by far the largest and is the only deposit to be systematically tested by diamond drilling. The deposits are readily accessible, being 5 to 20 miles by road from Mount Isa.

and from 35 to 50 miles from Mary Kathleen. The *Counter* has 650 tons of ore per vertical foot of 0.19 per cent. U_3O_8 at the surface and diamond drilling has indicated that the mineralization persists strongly to a depth over 800 feet. Other known deposits in the Gorge Creek area are usually irregular, small and lenticular and have a grade of less than 0.19 per cent. U_3O_8 . The more promising deposits are the *Geiger* (65 tons per vertical foot of 0.13 per cent. U_3O_8), the *Depression* (30 tons per vertical foot of 0.37 per cent. U_3O_8) and the *Gorge* (15 tons per vertical foot of 0.21 per cent. U_3O_8). The further exploration of known deposits in the Gorge Creek area is considered to be more likely to produce favourable results than the search for new deposits. A diamond drilling programme on the *Counter* deposit is in progress to prove the deposit to a depth of 1,000 feet.

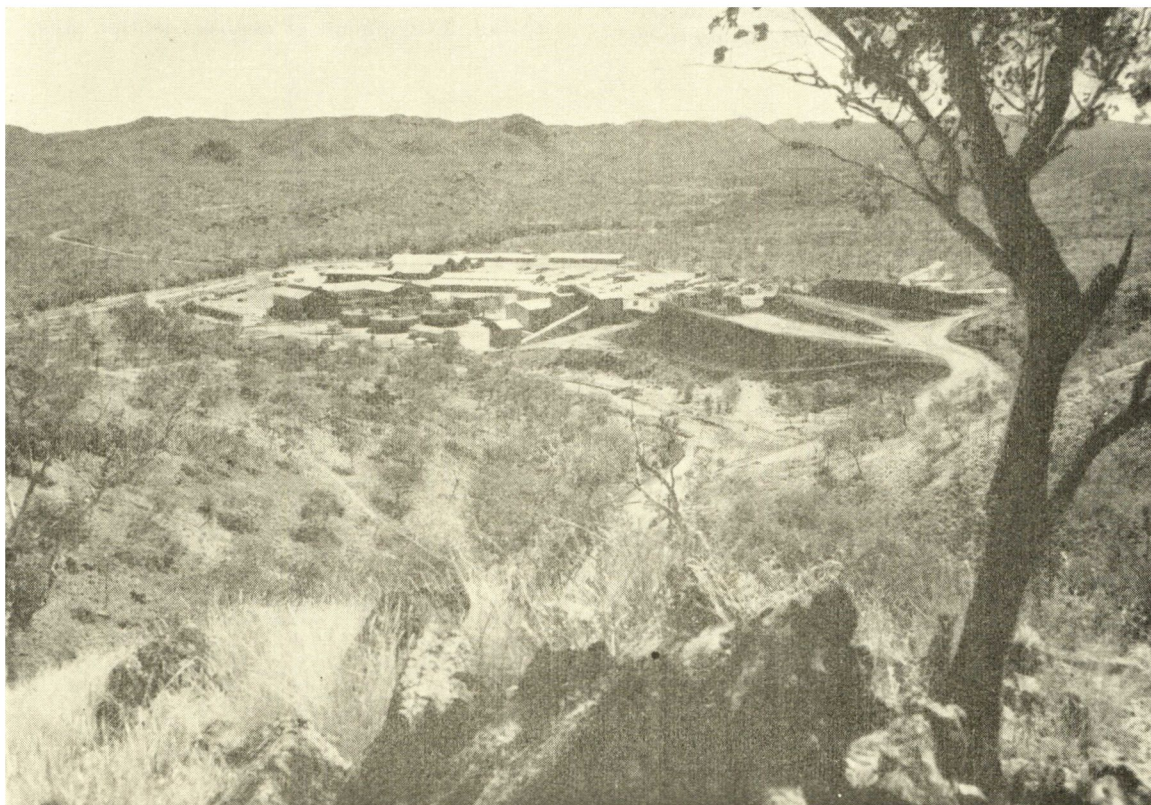
5. Mary Kathleen

The *Mary Kathleen* is the only operating uranium mine in the region. In 1958 it was estimated by the operating Company to contain nearly 6 million tons of ore with an average grade of 0.143 per cent. U_3O_8 , and diamond drilling has since shown extensions of ore values at depth. Intensive prospecting of the Mary Kathleen area for similar deposits has not met with success outside the *Mary Kathleen* leases. On the

Elaine Dorothy leases, the best deposit is estimated to contain only 5,000 tons of 0.28 per cent. U_3O_8 . Other prospects have been test-drilled but only very low grade mineralization has been found. The Corella Formation in which the *Mary Kathleen* occurs has been subjected to a considerable amount of airborne and ground prospecting but no significant deposits of the *Mary Kathleen* type have been found. In spite of the amount of exploratory work which has already been carried out the best prospect for the discovery of new deposits still appears to be the area of garnetized Corella meta-sediments between the granites to the east and west of the *Mary Kathleen*.

6. Cameron River-Corella River

The davidite-type deposits of this group aroused the interest of private prospectors because of the very high radio-activity exhibited by specimens of davidite which commonly occurred in considerable abundance in the soil around the outcrop of the deposits. The amount of material in situ was usually found to be quite small and was commonly scattered through the host rock in a sporadic fashion. The largest of the deposits is the *Three Brunettes* which has 400 tons per vertical foot of 0.013 per cent. U_3O_8 . Thus the davidite is too sparsely distributed to constitute a mineable deposit.



View of Mary Kathleen treatment plant. Stockpiles of uranium ore on right.

[Photo by 'Courier-Mail'.



Mary Kathleen open-cut bench shows the classification of the rock face into A and B class ore, and waste (indicated by crosses) to enable selective mining.

[Photo by "Courier-Mail".]

7. Cloncurry-Mount Cobalt

The four deposits of this group which have been tested by underground exploration (*Monakoff*, *Embla Ridge*, *Helafells*, and *Milo*) have shown that though the deposits may be of considerable size, the grade is usually well below 0.10 per cent. U_3O_8 . The *Monakoff* has 350 tons per vertical foot with a grade of less than 0.05 per cent. U_3O_8 . There is a small deposit of torbernite ore at the *Milo* but no significant primary uranium mineralization was intersected by diamond drilling.

The Corella Formation, part of the Soldier's Cap Formation and the formations in the Mount Cobalt area have been explored by airborne scintillometer surveys, but the Cloncurry-Mount Cobalt area as a whole has been less thoroughly tested for uranium than the areas previously described.

8. Westmoreland

The Westmoreland deposits are among the most important to have been located as a result of airborne scintillometer surveys. The *Redtree* deposits are fairly extensive but the grade is very low (probably less than 0.05 per cent. U_3O_8). Pits to a depth of 11 feet and wagon-drill holes to a depth of 120 feet have been put down but no accurate estimate of ore reserves can be made. The remoteness of the area and lack of communications would create formidable obstacles to the development of deposits in this area.

TABLE 2.—EXPLORATION AND MINING DATA (Up to 31/12/1958)

Company or Lessee	Lease	Locality	Trenching and Costeaning	Diamond Drilling		Shaft Sinking	Driving	Cross- cutting	Ore Raised	Remarks
				No. of Holes	Footage					
Australasian Oil Exploration Ltd.	Queen's Gift No. 2 ..	Calton Hills ..	Feet 72	Shallow sampling costeans One costean
	Thanksgiving ..	Spear Creek ..	?	..	..	..	..	..	..
	Easter Egg ..		75	One costean
	Eldorado No. 1 ..		139	..	..	..	..	..	..
	Eldorado No. 2 ..		110	..	..	..	..	..	..
	Eldorado No. 3 ..		?	..	..	..	..	..	..
	Mighty ..		46	Also 20 pits. Length 155' Depth 105'
	Counter ..		500	8	2,483	..	..	..	..
	Geiger ..	Gorge Creek ..	59	See also Mary Kathleen Uranium Ltd.
	Battery ..		50	..	..	..	..	..	..
	New Ring ..		217	..	..	..	..	..	..
	Mary Kathleen ..		2,500	5	2,702	..	..	..	..
Brown, R. G. and party ..	The Springs ..	Ballara ..	44	
Gold Mines of Australia Ltd. ..	Monakoff and Tinboll No. 1-5 ..	Cloncurry	3	1,225	93	..	46	..	3 small opencuts worked for copper in early days
	Tinboll No. 6 ..		..	1	248	..	..	..	..
	Janet Maude ..	Cameron River	?	4 costeans 1 costean
	Mount Harold ..		?	..	..	..	..	..	..
Isa Uranium Syndicate ..	Devils Marbles ..	Calton Hills ..	?	3 costeans
MacLeod and party ..	Amy and Diane ..	Cameron River	10	
Mary Kathleen Uranium Ltd. ..	Mary Kathleen	113	43,663	..	136	250	384,173	Open-cut mining com- enced in 1956 Also small open-cut 10 feet deep
Merridale Minerals Pty. Ltd. ..	Utah ..	Mount Cobalt ..	48							
	Mariposa ..		32							
Mineral Ventures N.L. ..	Elaine Dorothy ..	Mary Kathleen	?	11	2,323	22 short costeans
	Armstrong North ..		..	2	679	..	..	..	..
	Millicent Martha ..	Gorge Creek ..	?	1	256					1 costean 6 shallow costeans Some costeaning Some costeaning Some costeaning
	Yvonne Theresa ..		?	1	341					
	Broken Horseshoe ..	Spear Creek ..	?							
	Janelle ..		?							
	Pamela ..		?							
Mining Corporation N.L. ..	Helafells ..	Cloncurry ..	10	240	..	101	..	23 wagon drill holes footage 1,736
	Sierra Rada ..		22							
Mount Isa Mines Ltd. ..	Barrier ..	Calton Hills ..	75	
	Impassable ..		315	..	..	..	..	..	..
	Bikini ..		15	..	..	..	..	..	..
	Hopeful ..		60	..	..	..	..	..	..
	Isotope ..	Paroo Creek ..	55	..	..	..	..	..	..
	Pile ..		390	4	1,280	..	..	..	..
	Skal ..		1,211	9	2,964	..	..	..	..
	Skal Again ..		1,220	..	..	..	..	..	..
	Mighty Glare ..	Spear Creek ..	161	..	..	..	..	..	..
	Folderol ..		30	..	..	..	..	..	..
	Nevercantell ..		50	..	..	..	..	..	..

TABLE 2.—EXPLORATION AND MINING DATA (Up to 31/12/1958)—*continued*

Company or Lessee	Lease	Locality	Trenching and Costeaning	Diamond Drilling		Shaft Sinking	Driving	Cross- cutting	Ore Raised	Remarks
				No. of Holes	Footage					
Mount Isa Mines Ltd.— <i>continued</i>			Feet			Feet	Feet	Feet	Tons	
	Perseverance	Spear Creek ..	26	..	..	..	..	..	..
	Bambino		20	..	..	..	..	..	..
	Bitmore		15	..	..	..	..	..	..
	Hobby No. 2	Cameron- Corella River	172	..	..	..	..	..	..
	Leydin's Ridge		15	..	..	..	..	..	..
	Three Brunettes		1,055	..	..	..	..	..	..
	Verpat No. 1	Cloncurry ..	110	..	..	..	..	..	..
	Milo		170	..	..	30	..	20	..	See also Paringa Wheel Fortune Pty. Ltd.
	Mount Cobalt	Westmoreland	..	1	310	..	..	..	..
	Redtree .. ..		..	..	..	69	..	..	..	900' of wagon-drilling
Paringa Wheel Fortune Pty. Ltd.	Milo	Cloncurry ..		4	1,366	120	..	..	..	See also Shiel and party
Queensland Mines Ltd.	Counter	Gorge Creek ..	..	See "Remarks" ditto		..	..	..	..	Diamond drilling in progress (1959)
	Skal	Paroo Creek ..	..			..	..	..	..
Rio Tinto Australian Exploration Pty. Ltd.	Rita	Mary Kathleen	..	4	469	..	..	..	..
	Rary .. ..		..	1	147	..	..	..	..
Shiel and party	Milo	Cloncurry ..	?	..	..	..	25	..	10	Also several shallow pits and trenches
United Uranium N.L.	Flat Tyre	Spear Creek ..	1,100	..	..	54	..	78	100	Also 8 feet of rising Soil cover bulldozed off
	Lucky Boy .. ..		?	..	..	..	..	..	..
	Lucky Break		900	..	..	..	..	..	..
	Midnight .. ..		..	5	1,091	..	..	..	..
	Mother's Day No. 1 .. ..		?	..	..	..	..	..	..	Soil cover bulldozed off
	Mother's Day No. 3		50	..	..	50	79	17	250	
	Jeanie		2,000	..	..	..	..	..	..
	Patch .. ..			..	..	..	..	..	..
	Repair .. ..			..	..	..	..	..	..
	Riddle .. ..			..	..	..	..	..	..
	Sleeve .. ..			..	..	..	..	..	..
	Rewa		500	..	..	..	..	..	..
	Valhalla	Paroo Creek ..	1,200	1	395	54	..	51	..	Also 13 feet shaft by lessees
	Pelican	Ballara ..	660	..	..	12	..	..	..
	Ballara No. 1, 2 .. ..		?	..	..	..	..	..	..	A few shallow pits
	Embla Ridge	Cloncurry ..	..	2	440	..	..	..	..
Uranium Search Pty. Ltd. ..	Six Kangaroos	Cameron River	90	..	..	..	..	..	..
	Comfort .. ..		?	..	..	..	..	..	..	4 short costeans
Walton Syndicate	Batman	Calton Hills ..	54	..	..	21	..	6	..	
	Duke		50	..	..	18	..	..	..

PART II-INDIVIDUAL URANIUM DEPOSITS

CALTON HILLS GROUP (see Fig. 2)

In this Group the *Barrier*, *Elaine Mary*, *Surprise*, *Mount Rover*, and deposits on adjacent leases are of the Surprise sub-type but the remainder are of the Skál sub-type. All the deposits are in the Eastern Creek Volcanics. The primary uranium mineral has not been positively identified but Dallwitz and Roberts (1955 unpub.) attribute the radioactivity in ore from the *Impassable* and *Elaine Mary* leases to uraniferous magnetite.

Barrier

Location : 13 miles north-east of Calton Hills homestead and 46 miles north of Mount Isa. The *Impassable* and *Conquest* are adjacent leases to the south and north respectively.

The regional strike is N. 20 deg. W. and the dip is to the east. Carbonated, chloritized and albitized basalt is the host rock and quartzite, epidote quartzite, argillaceous sandstone, and slate occur interbedded with the altered volcanics. Fracture cleavage is not strongly developed.

At the surface the deposit is 190 feet long by 30 feet wide and the average grade is 0.10 per cent. U_3O_8 . Mount Isa Mines Ltd. took up the lease and carried out 75 feet of costeaning.

Batman

Location : 11 miles north-north-west of Calton Hills homestead and 52 miles north of Mount Isa. It is adjacent to the *Duke* lease on the east.

The host rock is a fractured siltstone which contains a considerable amount of introduced calcite and quartz. The siltstone strikes approximately east-west and dips steeply to the south. It is interbedded with chloritized, schistose basalt and calcareous quartzite. Exposures in the prospecting shaft indicate that the uraniferous siltstone has been disturbed by strike faulting and this is expected to create difficulties if the development of the deposit is attempted. Assuming the lode is continuous between outcrops and exposures in costeans and the shaft, it would have a total length of 160 feet and a width of 5 feet. Assays of representative samples have ranged from 0.09 per cent to 0.33 per cent. U_3O_8 and have averaged 0.18 per cent. U_3O_8 . However, the number of samples is insufficient for this to be taken as the grade of the deposit. The lessees, Walton and party, have sunk a shaft to a depth of 17 feet and excavated three costeans.

Conquest

The deposit on this lease which is situated adjacent to the *Barrier* lease on the north was mapped and sampled by Mount Isa Mines Ltd. It is 120 feet long and 20 feet wide and has a grade of 0.013 per cent. eU_3O_8 .

Devil's Marbles

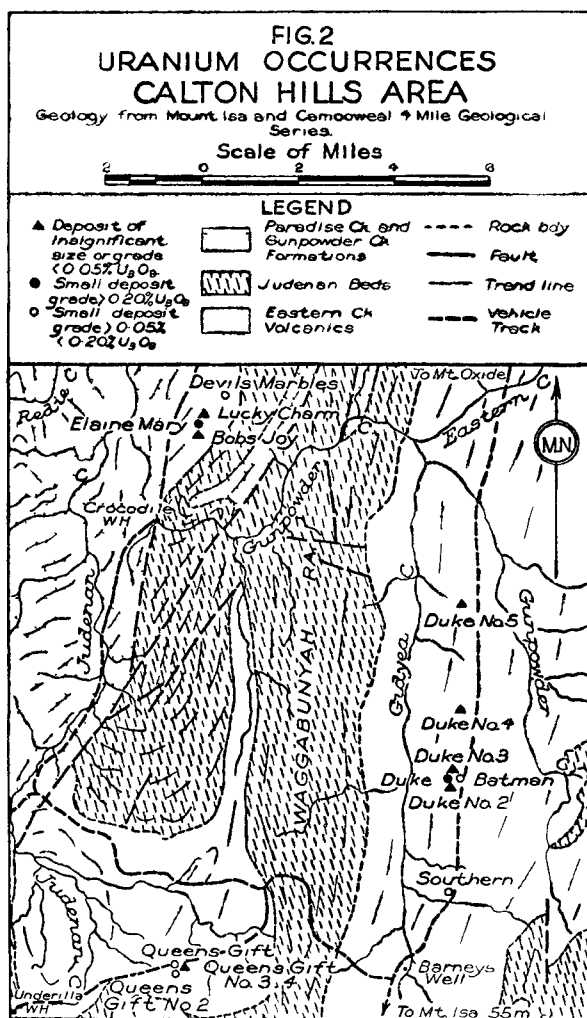
Location : 3 miles north of Crocodile waterhole on Gunpowder Creek and 60 miles north-north-west of Mount Isa.

The uranium mineralization occurs in hematitic quartzite interbedded with chloritized basalt of the Eastern Creek Volcanics. Costeans at 110 feet, 155 feet, and 215 feet north of the lode datum showed a narrow width of highly radioactive lode with an envelope exhibiting less intense radioactivity. A sample taken by Isa Uranium Syndicate N.L. assayed 0.64 per cent. U_3O_8 . The average grade is not known.

Duke

Location : 52 miles north of Mount Isa and on the eastern side of Top Gidyea Creek 6 miles north of Barney's Well. The track to the *Mount Oxide* copper mine passes a short distance east of the deposit. The *Batman* lease is adjacent on the east and the *Duke No. 2* lease is adjacent to the south.

Uranium mineralization occurred where faulting shattered the metabasalts against the more competent lenticular beds of quartzite. Considerable amounts of quartz, hematite, and calcite have been introduced.



Radioactivity is almost confined to the quartzitic beds. The highest grade ore occurs in a dense, hematitic, jasperoid quartzite. Samples of the material have assayed as high as 1.11 per cent. U_3O_8 (chem.).

Four separate areas of radioactivity occur on the lease. Two exhibit only weak, sporadic radioactivity and appear to be of no commercial significance. The most important deposit strikes N. 54 deg. E., and has a length of 40 feet and an average width of 9 feet. The lessees, Walton and party, have explored the deposit by three costeans and two pits to a depth of 10 feet and 8 feet. Only two representative samples have been taken and these averaged 0.30 per cent U_3O_8 . The other deposit strikes N. 68 deg. W., and has a length of 82 feet and a width of 5 feet to 6 feet. One representative sample assayed 0.18 per cent. eU_3O_8 . A yellow secondary uranium mineral coats the joint planes in the high grade ore but the primary uranium mineral is evidently finely disseminated and it has not been determined.

Duke No. 2

The lease is adjacent to the *Duke* on the south. One radiometric anomaly occurs on this lease over a length of 30 feet. Samples taken by the lessees assayed 0.16 per cent. eU_3O_8 and 0.35 per cent. U_3O_8 (chemical) but it is considered that the average grade is probably lower than either of these assays indicate.

Duke No. 3

This lease is a short distance north of the *Batman* and *Duke* leases. Only one small area of weak radioactivity occurs on it and this is not considered to be of any economic significance.

Duke No. 4

Location : 2 miles north of the *Duke* and *Batman* leases.

Radioactivity occurs in two parallel lodes 100 feet apart. The lodes strike N. 5 deg. E. The larger exhibits intermittent radioactivity over a length of 120 feet and an average width of 5 feet. The other is 36 feet long and has a maximum width of 7 feet. No assay data are available, but the intensity of radioactivity is much lower than in the main deposits on the *Duke* and *Batman* leases.

Duke No. 5

Location : 4 miles north of the *Duke* and *Batman* leases.

There are three parallel, *en echelon*, radiometric anomalies with a strike of N. 5 deg. E.—approximately the regional strike of the Eastern Creek Volcanics in this area. The dimensions of the three anomalies are 100 feet by 4 feet, 45 feet by 3 feet and 72 feet by 3 feet. The intensity of radioactivity is weak in comparison with the main deposits in the *Duke* and *Batman* leases.

Elaine Mary

Location: $2\frac{1}{2}$ miles north-north-east of Crocodile water-hole on Gunpowder Creek and 60 miles north-north-west of Mount Isa. The track to Crocodile waterhole leaves the *Mount Oxide* copper mine track a few miles south of Barney's Well.

The regional strike is north-north-east and the dip is steeply east to vertical. Arenaceous sediments are dominant in the area but the uranium occurs in strongly

fracture-cleaved and altered vesicular basalt which is interbedded with quartzite. The interbedded, metamorphosed volcanics and sediments form part of the Eastern Creek Volcanics. The lode strikes N. 35 deg. E. and is parallel to the strike of the bedding. Radioactivity occurs in five areas over a length of 225 feet. Extensive faulting has affected the area and the lode has been displaced by cross-faulting at two places. Small quartz-tourmaline veins occur at these places. The altered basalt host rock has a distinct reddish coloration due to finely-divided hematite in calcite. These gangue minerals were introduced during the process of uranium mineralization. The primary uranium mineral has not been positively identified but may be uraniferous magnetite (Dallwitz and Roberts, 1955).

The five radioactive anomalies have areas of 100 square feet, 240 square feet, 2,500 square feet, 324 square feet and 176 square feet. Samples taken by Isa Uranium Syndicate N.L. at intervals over a length of 290 feet assayed 0.16 per cent., 0.48 per cent., 0.15 per cent. and 0.14 per cent. U_3O_8 (chemical). This deposit is remote and virtually unexplored but it is one of the more promising of this type.

The *Lucky Charm* and *Bob's Joy* leases adjoin the *Elaine Mary* on the north and south respectively. The small radioactive anomalies on the leases are on the same line of strike as those on the *Elaine Mary*. The *Teddies' Gift* lease adjoins the *Elaine Mary* lease on the east.

Impassable

This lease is adjacent to the *Barrier* on the south. Two main radioactive anomalies occur on a north-north-westerly line of strike. The southern anomaly is 110 feet long by 40 feet wide and has a surface grade of 0.01 per cent. eU_3O_8 . The northern anomaly which consists of eastern and western sections, is 200 feet long by 25 feet wide and has a surface grade of 0.035 per cent. eU_3O_8 . Radiometric mapping and sampling was carried out by Mount Isa Mines Ltd.

Mount Surprise

Location : 53 miles north of Mount Isa, 14 miles north-east of Calton Hills homestead and south of the *Surprise* lease.

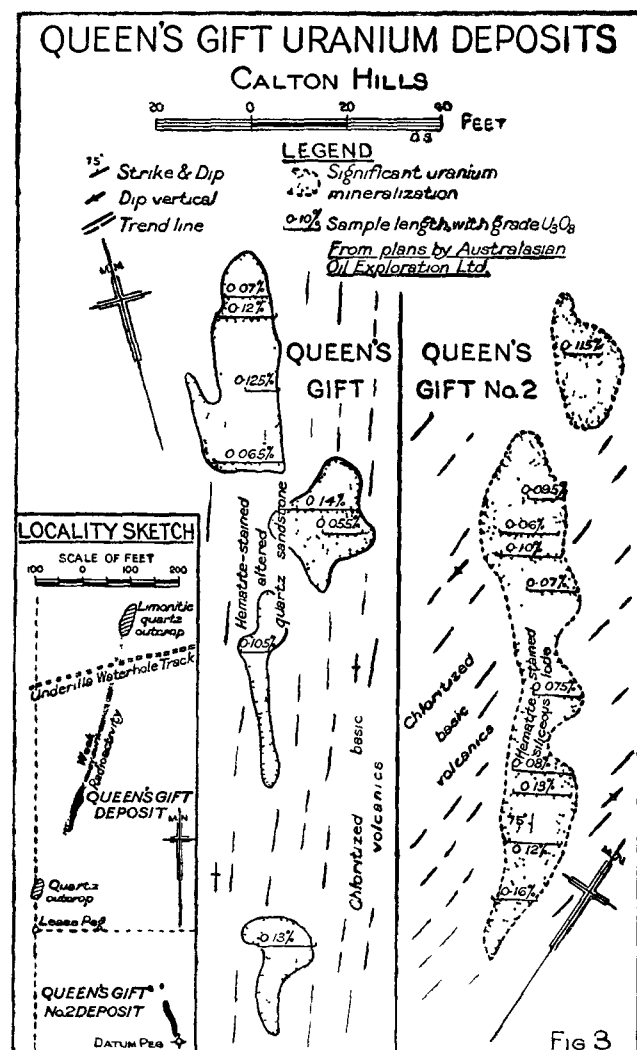
The Eastern Creek succession strikes north-south and dips west. It consists of meta-basalt with interbedded quartzite and slate. The host rock is a hematite-stained, quartz siltstone. Radioactivity can be traced over a distance of 600 feet but no deposits of significance have been found. The *Pickwick* and *Shiny's Luck* are 4 miles north-east of *Mount Surprise*. The geology and uranium mineralization is similar to that on the *Mount Surprise* lease.

Queen's Gift

Location : 5 miles west-south-west of Barney's Well and 50 miles north-north-west of Mount Isa. The track to the lease leaves the Crocodile water-hole track on the western side of the Waggabunyah Range.

The principal rock types in the area are chloritized basalt, and quartzose and calcareous sandstone. The uranium mineralization occurs within a zone of strike faulting which is marked by a prominent outcrop of quartz at the southern end of the lease and an outcrop of limonitic quartz lode material at the northern extremity of the lease. The fault, which parallels the fracture cleavage, strikes N.15 deg. E. and dips vertically. Uranium mineralization is confined to a fine-grained, hematite and calcite-bearing, quartzose sandstone. The hematite and calcite appear to have been introduced with the uranium. No primary uranium mineral has been determined.

Four small radioactive anomalies occur over a strike length of 1,000 feet. The dimensions of the anomalies are 23 feet by 8 feet, 58 feet by 4 feet, 28 feet by 11 feet and 45 feet by 12 feet. The average surface grade is 0.08 per cent. U_3O_8 . The *Queen's Gift* leases were mapped and sampled by Australasian Oil Exploration Ltd. (see Fig. 3).



Queen's Gift No. 2

This lease is adjacent to the *Queen's Gift* on the south. Three areas of radioactivity occur on this lease but only one of these is of possible economic significance. The main occurrence is in a quartz lode carrying some hematite. The strike of the lode is N. 25 deg. W. so that it transgresses the strike of the chloritized basalt country rocks which strike N. 15 deg. E. The dip of the lode appears to be 75 deg. west. It is 110 feet long and 9 feet wide and has an average surface grade of 0.09 per cent. U_3O_8 . Coatings of a yellow secondary uranium mineral are visible on some joint planes but no attempt has been made to determine the primary uranium mineral.

There are other radioactive anomalies of weaker intensity on the adjacent *Queen's Gift* No. 3 and 4 leases.

Slance

This lease is in the Surprise group, 20 miles north-east of Calton Hills homestead. The radioactive anomaly is 210 feet long and 20 feet wide and has a grade of 0.02 per cent. eU_3O_8 . It was mapped and sampled by Mount Isa Mines Ltd.

Southern

This is the southernmost of the Duke sub-group of leases and is 2 miles north of Barney's well. Radioactivity occurs in beds of calcareous and hematitic quartzite over a length of 155 feet and an average width of 3 feet. The principal anomaly is 65 feet long and 4 feet wide. A representative sample assayed 0.12 per cent. U_3O_8 .

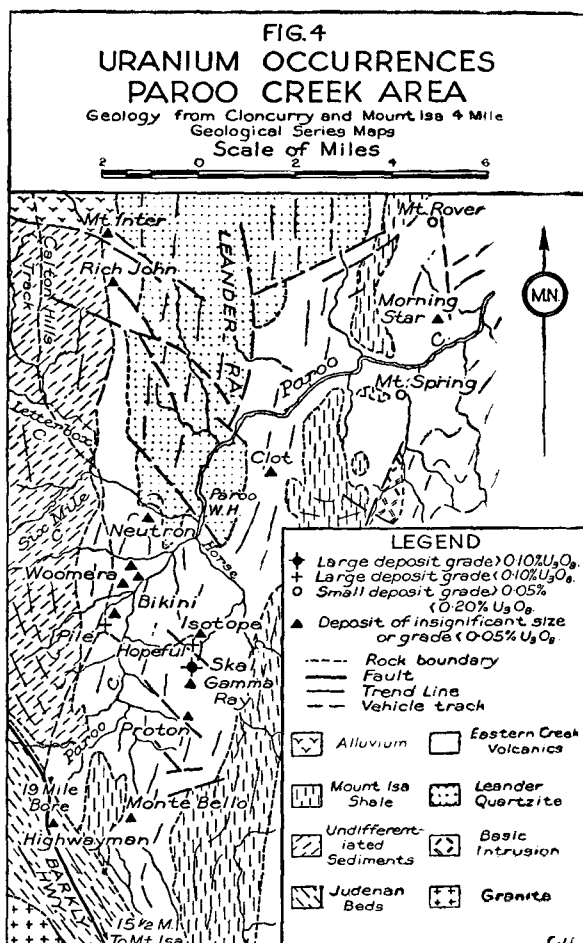
Surprise

Location: 21 miles north-east of Calton Hills homestead and 57 miles north-north-east of Mount Isa.

The *Surprise* is typical of a sub-group within the Eastern Creek type of deposit. The host rock is a chloritized and carbonated basalt. The uranium mineralization is conformable with the N. 20 deg. W. strike of the country rocks. The dip is 30 deg. to 60 deg. E. Fracturing is more pronounced within the area occupied by the radioactive anomalies. No uranium minerals have been identified. The main deposit is 150 feet long by 18 feet wide and has a surface grade of 0.13 per cent. eU_3O_8 . A second deposit is 180 feet long by 2 feet wide and has a grade of 0.054 per cent. eU_3O_8 . There is a third group of radioactive anomalies but these are of little significance. The lease was mapped and sampled by Mount Isa Mines Ltd.

PAROO CREEK GROUP (see Fig. 4)

All the deposits in this group with the exception of the *Valhalla* and *Mount Rover* are in the *Skal* sub-type of the Eastern Creek deposits. The only determinations of primary uranium minerals have been made in ores from the *Skal* (brannerite) and the *Pile* (brannerite and uraniferous magnetite).



Betatron

The *Betatron* is adjacent to the *Womera* lease on the south-western side. A small deposit* on the lease has a grade of 0.013 per cent. eU_3O_8 . It was sampled by Mount Isa Mines Ltd.

Bikini

This lease is adjacent to the *Pile* on the north-east. The uranium deposits are on the same line of strike as those on the *Pile*. There are six main radioactive anomalies with dimensions of 200 feet by 10 feet, 20 feet by 12 feet, 90 feet by 20 feet, 70 feet by 30 feet, 20 feet by 10 feet and 60 feet by 10 feet. The average grade is 0.027 per cent. eU_3O_8 . The lease was sampled by Mount Isa Mines Ltd.

Clot

This lease is 23 miles north of Mount Isa and 4 miles north-east of the *Skal*. Uranium mineralization occurs in two lenses of chloritic and calcareous siltstone which are quartz-veined and impregnated by magnetite and hematite. Strike shearing has taken place in the meta-sediments which strike north to N. 18 deg. E. and dip vertically. The eastern lens is 120 feet long and 1 to 3 feet wide. The western lens which is 75 feet from the eastern lens, is 50 feet long and 1 to 2 feet wide. Some highly radioactive floaters were found on the lease but

* "Small" deposit means less than 40 tons per vertical foot.

the outcrop material was considered too low grade to warrant sampling. A selected sample submitted by the lessees assayed 0.10 per cent. eU_3O_8 .

Gamma Ray

This lease is adjacent to the *Skal* on the south and the radioactivity on the two leases is on roughly the same line of strike. The radioactive anomaly is small* and the grade is 0.022 per cent. eU_3O_8 . It was sampled by Mount Isa Mines Ltd. The *Proton* lease is situated to the south of the *Gamma Ray*. A radioactive anomaly on the lease was considered too small to warrant sampling. The original *Gamma Ray* and *Proton* leases lapsed and the area has recently been taken up as the *Muster No. 3* lease.

Highwayman

The *Highwayman* lease is situated near the *Barkly Highway* 18 miles north-north-west of Mount Isa. The radioactivity is of weak intensity and the only significant feature about the occurrences is that it is one of the few to be located in the Judenan Beds.

Hopeful

Location: Half-a-mile north of the *Skal* and 21 miles north of Mount Isa.

Radioactivity occurs in a hematite-stained, massive, calcareous meta-sediment. The fracture cleavage strikes N. 10 deg. W. A small quantity of a yellow secondary uranium mineral is visible in the outcrop but the primary uranium mineral is not known. The radioactive anomaly has overall dimensions of 400 feet by 55 feet. Within this there are two parallel ore-shoots one of which contains 850 tons per vertical foot with a surface grade of 0.031 per cent. eU_3O_8 , and the other contains 170 tons per vertical foot with a surface grade of 0.058 per cent. eU_3O_8 . The deposit was mapped and sampled by Mount Isa Mines Ltd. Two costeans are the only exploratory workings on the deposit.

Isotope

This lease is to the north-east of the *Hopeful*. It contains a small* uranium deposit with a grade of 0.10 per cent. eU_3O_8 . It was sampled by Mount Isa Mines Ltd.

Monte Bello

The *Monte Bello* is situated 18 miles north of Mount Isa and 2 miles east-south-east of the 19 mile bore on the *Barkly Highway*. It contains a small deposit with a grade of 0.036 per cent. eU_3O_8 . The sampling was carried out by Mount Isa Mines Ltd.

Morning Star

Location: 27 miles north of Mount Isa and 9 miles north-north-east of the *Skal*. It is in the Mount Rover sub-group.

The Eastern Creek succession in the area consists of meta-basalt with small lenses of calcareous quartzite. The strike is meridional and the dip is vertical. A micro-gabbro dyke occurs to the east of the deposits and is conformable with the strike of the meta-basalts and the uranium lodes.

Uranium mineralization occurs in two lenses of calcareous quartzite on the same line of strike and separated by 200 feet. The quartzite is impregnated with hematite and magnetite and is cut by numerous intersecting veinlets of quartz. Coatings of a yellow secondary uranium mineral can be seen on some joint faces but no primary uranium mineral is visible.

The southern mineralized lens is 80 feet long and 3 feet wide. The northern lens is 145 feet long and $1\frac{1}{2}$ feet wide. Representative samples indicate that the grade is of the order of 0.04 per cent. U_3O_8 .

Mount Inter

Location : 31 miles north of Mount Isa and 4 miles north of the Letterbox Creek crossing on the Calton Hills homestead track.

The regional geology in this locality has not been fully resolved but the mineralization is of the Skal sub-type. The host rock is a dark calcareous quartzite which strikes N. 20 deg. W. to N. 12 deg. W. Crossfaults displace the meta-sediments horizontally up to 20 feet. A yellow secondary uranium mineral is present as coatings on joint and fracture surfaces.

Five lenticular radioactive anomalies occur over a strike length of 19 chains and an average width of 2 feet. The anomaly exhibiting the highest radioactivity is 70 feet long and 6 feet wide. Soil-covered areas separate the radioactive anomalies. No assay data are available but the intensity of radioactivity suggests that the grade is comparable with other deposits in the Paroo Creek area which have a grade of less than 0.1 per cent. U_3O_8 .

Mount Rover Nos. 1-5

Location : 29 miles north of Mount Isa and 11 miles north-east of the Skal.

The deposits on the Mount Rover leases are assigned to the Surprise sub-type of the Eastern Creek type. The Eastern Creek Volcanics in the area consist of amygdaloidal meta-basalt with small lenses of fine-grained, calcareous quartzite heavily impregnated with magnetite and hematite. Chlorite is abundant and interlaced quartz veins occur in the uraniferous lodes. Sparsely disseminated crystals of pyrite and chalcopyrite are also present. However, these sulphides are of very widespread occurrence in the Eastern Creek Volcanics and are probably not related to uranium mineralization. The host rock is a chloritised, magnetite-bearing meta-basalt, and uranium deposition appears to have been controlled by fracturing along the strike of the meta-basalt.

On *Mount Rover No. 1* a radioactive anomaly strikes N. 10 deg. E. and dips steeply to the west. It is 70 feet long and 2 feet wide. A representative sample assayed 0.05 per cent. U_3O_8 . Small isolated areas of weak radioactivity occur on *Mount Rover Nos. 2, 3 and 4*. On *Mount Rover No. 5* the radioactive anomaly strikes N. 5 deg. W. and the dip is vertical. The anomaly is 40 feet long and $1\frac{1}{2}$ feet wide. A representative sample assayed 0.07 per cent. U_3O_8 .

Mount Spring Nos. 1 and 2

Location : 25 miles north of Mount Isa and 4 miles from the Mount Rover leases.

The geology is similar to that at the Mount Rover leases but the uranium mineralization occurs in lenses of calcareous quartzite, impregnated with magnetite and hematite.

On the *Mount Spring No. 1* lease discontinuous lenses occur over a length of 300 feet and a width of 6 inches to 1 foot. The strike is meridional and the dip is vertical. The adjacent meta-basalt shows signs of shearing and small-scale, north-pitching drag folds also occur. A representative sample assayed 0.04 per cent. U_3O_8 (chemical).

On the *Mount Spring No. 2* lease there are two radioactive anomalies. The southern anomaly is 35 feet long and 1 foot wide; a representative sample assayed 0.14 per cent. U_3O_8 (chemical). The northern anomaly which is 90 feet to the north-west, is 30 feet long and 1 foot wide; a representative sample assayed 0.20 per cent. U_3O_8 . The grade of the northern anomaly is considerably higher than most of the Paroo Creek deposits but the very small size of the deposit makes it of little economic interest.

Neutron

The *Neutron* is 24 miles north of Mount Isa and 2 miles north-north-east of the *Pile*. A radioactive anomaly on the lease was considered to be too small to warrant sampling.

Pile

Location : 22 miles north of Mount Isa and 2 miles west-north-west of the Skal.

The rock succession in the area consists of sheared and chloritized basalts and altered calcareous and arenaceous sediments. Uranium mineralization occurs in a prominently-outcropping siltstone containing introduced quartz, calcite, magnetite, hematite and chlorite. The strike ranges from N. 30 deg. E. to N. 55 deg. E. and the dip is 75 deg.-80 deg. to the south-east. Some coatings of a pale greenish uranium mineral which is believed to be autunite, are visible on joint surfaces. Mineragraphic studies have not led to uniform conclusions on the identity of the primary uranium mineral but it is believed to be finely-disseminated brannerite.

Several radioactive anomalies occur on the lease (see Fig. 6). The largest and highest grade of these is 165 feet long and 40 feet wide. The surface grade is 0.07 per cent. U_3O_8 . Mount Isa Mines Ltd. drilled two holes to intersect the lode in the vicinity of 100 feet and a further two holes to intersect the lode in the vicinity of 200 feet. The grade of the 100 feet drill hole intersections was comparable with that at the surface and the 200 feet intersections showed a considerable decrease in grade. Three other smaller radioactive anomalies are on the same line of strike, to the south-west of the main anomaly, but the uranium content decreases in this direction and these anomalies are of no economic significance.

Rich John

This lease is 29 miles north of Mount Isa near the Calton Hills homestead track. It occurs in a lenticular bed of altered sandstone interbedded with meta-basalt. Uranium mineralization at the surface is confined to an outcrop 7 feet long and 5 feet wide. A pothole 3 feet deep exposed a patch of highly radioactive material which assayed 0.73 per cent. and 1.20 per cent. U_3O_8 . However, there are no indications of the occurrence of significant amounts of such material.

Skal

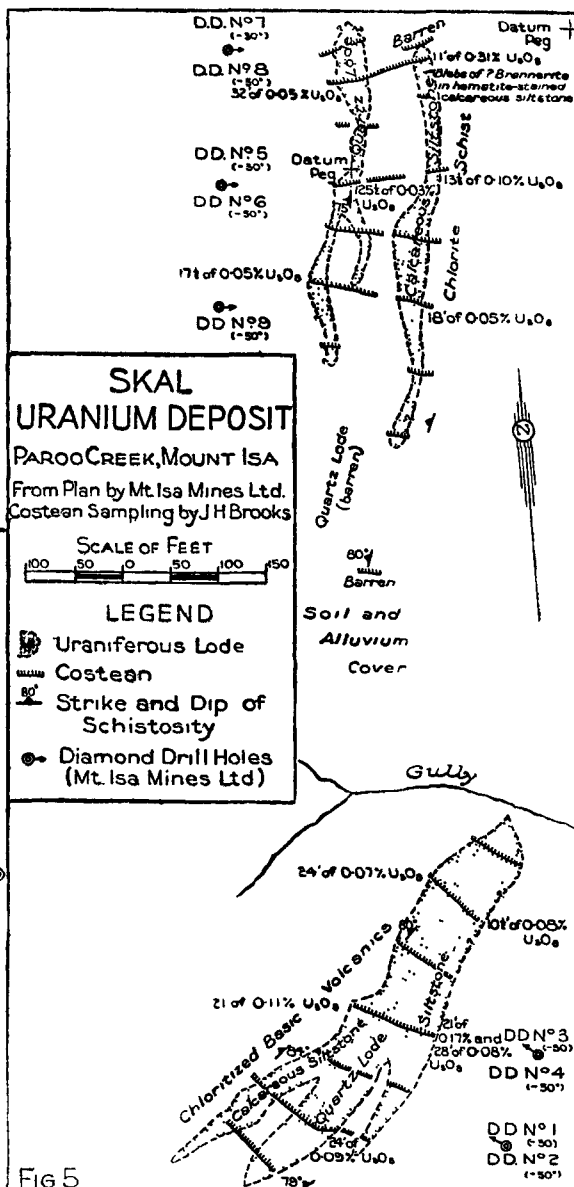
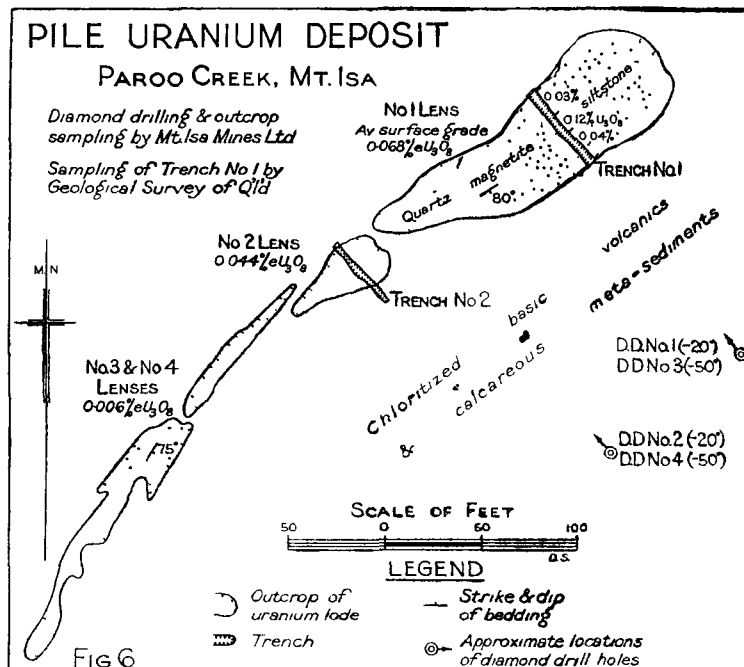
Location and Access: 21 miles north of Mount Isa.

Access is from the Calton Hills homestead track which leaves the Barkly Highway at the 19 mile bore. Distance by vehicle track from the 19-mile turnoff is $6\frac{1}{2}$ miles.

The Skal is typical of a rather large group of deposits in the Eastern Creek Volcanics. The rock succession in the area consists of chloritized and sheared basic volcanics with some altered calcareous sediments and quartzite. Fracture cleavage is only well developed in the vicinity of shear zones. Uranium mineralization is associated with a zone of strike shearing. Much quartz has been introduced along the zone of shearing and the quartz crops out along prominent ridges. The uranium is located principally in quartzose and felspathic siltstone which is brecciated in part. Abundant calcite, magnetite and hematite and minor chalcopryrite and pyrite have been introduced with uranium mineralization. The primary uranium mineral has been determined as finely-disseminated brannerite. There appears to be an affinity between the brannerite and the iron oxide minerals. Carnotite associated with hematite has been identified in specimens from the outcrop. Blebs of a black uranium mineral thought to be brannerite are visible in the most highly radioactive section of the outcrop near the northern extremity of the lease.

There are two radioactive anomalies on the lease separated by a distance of 400 feet (see Fig. 5). A faulted relationship probably exists between the radiometric anomalies. The southern anomaly strikes N. 45 deg. E. and the dip is 80 deg. to the north-west. The total length of the uranium lode is 500 feet but the significant section is 370 feet long and 60 feet wide. The surface grade is 0.06 per cent. U_3O_8 . Two drill holes intersected the lode at approximately 100 feet and a further two holes intersected it at 200 feet. The grade of the 100 feet intersections was 0.16 per cent. U_3O_8 and the grade of the 200 feet intersections was 0.09 per cent. U_3O_8 .

The northern anomaly strikes N. 12 deg. E. and dips steeply to the west. The total length of the anomaly is 400 feet, but the significant section is 300 feet long by 76 feet wide and has a surface grade of 0.04 per cent. U_3O_8 . The two 100 foot drill intersections indicated a grade of 0.17 per cent. U_3O_8 , and the three 200 feet



intersections indicated a grade of 0.06 per cent. U_3O_8 . The northern anomaly contains eastern and western ore-shoots. Of the two, the eastern ore-shoot is of considerably higher grade and the grade decreases from the northern to the southern end of the ore-shoot. If the deposits cannot be developed on a large scale it may be possible to selectively mine the higher grade sections.

In 1954, Mount Isa Mines Ltd. put down 9 diamond drill holes, excavated 19 costeans and carried out systematic surface sampling and mapping. However, the Company did not exercise its option to buy the lease. The lease was purchased by Queensland Mines Ltd. in 1959, and further diamond drilling is being carried out.

Skal Again

This lease (now forfeited) is adjacent to the *Skal* on the east. Fairly extensive costeaning was carried out by Mount Isa Mines Ltd. but no significant extensions to the outcropping radioactive deposit were exposed. A narrow belt of weak radioactivity extends over a length of 900 feet and is roughly parallel to the uranium lodes on the *Skal*. The deposit is now included in the *Muster* lease.

Valhalla

Location: 25 miles north-north-west of Mount Isa and a short distance to the north of the Barkly Highway.

This is an isolated deposit in the Judenan Beds. It cannot be conveniently grouped with any of the major types of deposit. Surface and near-surface radioactivity is due to the presence of disseminated, sporadically-distributed flakes of meta-torbernite. Trenching has exposed an area of weak radioactivity 200 feet by 130 feet in weathered, ferruginous shales. The highest chemical assay from these trenches was 0.06 per cent. U_3O_8 . In the prospecting shaft which was sunk to 54 feet the average grade was 0.04 per cent. U_3O_8 . A diamond drill hole intersected radioactive material from 333 feet to 357 feet and the section from 341–349 feet assayed 0.10 per cent. U_3O_8 .

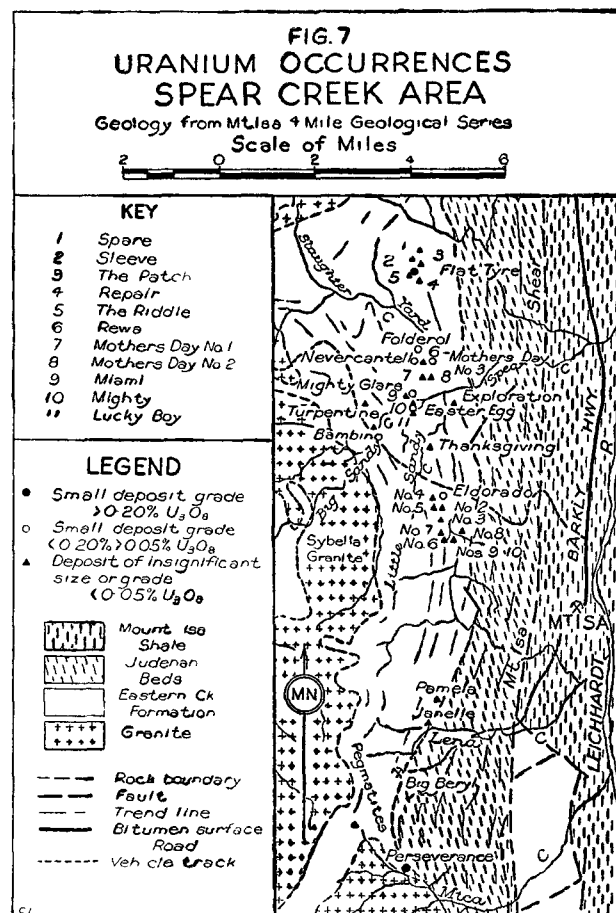
Woomera

The *Woomera* lease is in the Pile sub-group, 22½ miles north of Mount Isa. Uranium mineralization extends over an area 95 feet long by 6 feet wide but the grade is only 0.013 per cent. eU_3O_8 . The host rocks are hematite-stained, fine-grained quartzite and meta-siltstone.

Adjacent to the *Womera* on the north is the *Cyclotron* lease. The radioactivity on the *Cyclotron* is too weak to be of any economic significance.

SPEAR CREEK GROUP (see Fig. 7)

All the deposits in this group are included in the Easter Egg sub-type of the Eastern Creek type. The deposits occur in a succession of hornblende, biotite, allanite and quartz-mica schists. These are considered to be more highly metamorphosed equivalents of the meta-basalt with interbedded calcareous and arenaceous



meta-sediments which occur in the Calton Hills-Paroo Creek areas. Uraninite has been determined in ore from the *Flat Tyre* deposit and doubtfully in ore from the *Easter Egg* deposit, but elsewhere the identity of the primary uranium mineral is not known.

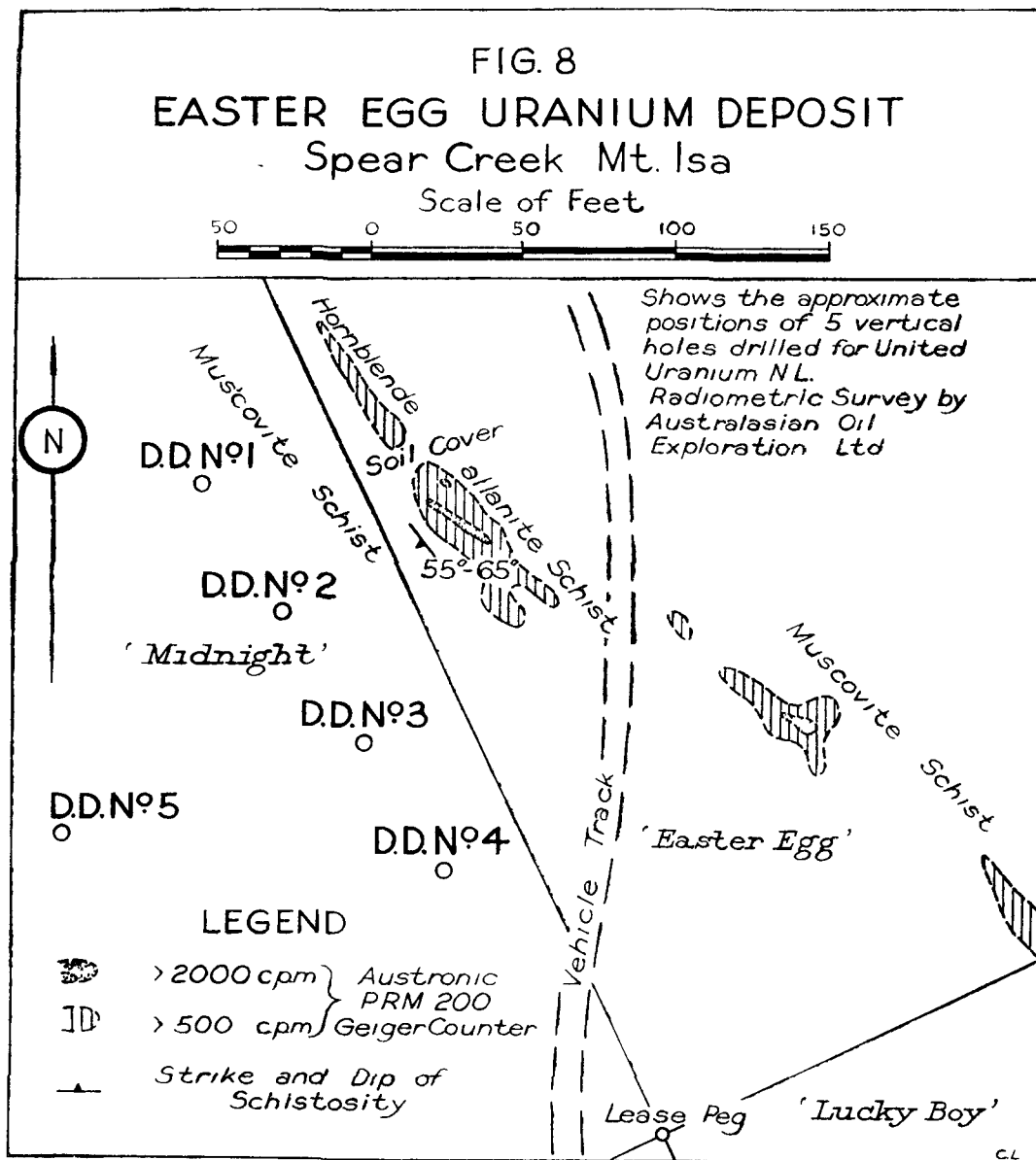
Bambino

This lease is situated near the old May Downs track, 6 miles north-west of Mount Isa. Several small uranium deposits occur on the lease and the average grade of these is 0.062 per cent. eU_3O_8 . The deposits were costeaned and sampled by Mount Isa Mines Ltd.

Easter Egg

Location: 5 miles north-west of Mount Isa and 1½ miles north of the turnoff from the old May Downs track.

The uranium mineralization occurs in quartz-allanite schist and hornblende schist which are interbedded with muscovite schist and quartzite. Some quartz and calcite have been introduced and some copper-staining is also present. Coatings of a yellow uranium mineral on joint planes have been determined as carnotite. The primary uranium mineral is probably uraninite, but positive identification has not been possible. The schists range in strike from N. 45 deg. W. to N. 36 deg. W. and the dip is to the west at 55 deg. to 65 deg.



Several radioactive anomalies occur on this lease (see Fig. 8). The main anomaly is 110 feet long by 8 feet wide but included in this is a soil-covered area 10 feet long which may represent a break in the lode. Smaller anomalies occur to the south-east of the main anomaly and the largest of these is 40 feet long and 7 feet wide. There may be a faulted relationship between the main anomaly and the south-eastern anomalies. The grade at the surface calculated from a limited number of costean samples taken by Australasian Oil Exploration Ltd., is 0.18 per cent. U_3O_8 . However, the width and grade of the uranium mineralization is very erratic and assay data must be regarded with some caution.

The *Midnight* lease is adjacent to the *Easter Egg* on the west and the deposits which crop out on the *Easter Egg* pass into the *Midnight* lease at a depth of 50 feet to 100 feet. Test drilling was carried out on the *Midnight* by United Uranium N.L. Two of the four drill-hole intersections at a depth of approximately 100 feet were of significant width and grade and the intersection at a depth of 233 feet-240 feet was also of a grade comparable with that at the surface. The deposit has not been fully tested but there appears to be some possibility of small scale, selective mining being carried out on an economic basis. The original *Easter Egg* and *Midnight* leases were taken up in 1959 as the *Citation* lease.

TABLE 3—DIAMOND DRILLING DATA: MIDNIGHT LEASE (supplied by United Uranium N.L.)

D.D. No.	Location	Total Depth	Declination	Lode Intersection	True Width	Grade U_3O_8
1	15 ft. west of Easter Egg boundary opposite the northern end of the main anomaly	Feet 150	Vertical ..	Feet 72-79 89-94	Feet $3\frac{1}{2}$ $2\frac{1}{2}$	Not assayed. Weakly radioactive
2	50 ft. south-east of D.D. No. 1. Opposite the most highly radioactive section of the outcrop	185	Vertical ..	66-86	10	0.29% (chemical)
3	50 ft. south-east of D.D. No. 2. Opposite the southern end of the main anomaly	204	Vertical	84-102 124-129 134-137	9 $2\frac{1}{2}$ $1\frac{1}{2}$	0.26% (chemical) } Weakly radioactive
4	50 ft. south-east of D.D. No. 3. Opposite small, irregular anomalies	180	Vertical .	102-110 114-118 140-142 147-149	4 2 1 1	0.16% eU_3O_8 } Weaker radioactivity. Not assayed
5	Approximately 100 ft. south-west of point midway between D.D. Nos. 2 and 3	349	Vertical	233-240 260-265	$3\frac{1}{2}$ $2\frac{1}{2}$	0.25% eU_3O_8 Not assayed

Eldorado Nos. 1-10

Location: The leases extend in a north-south belt for over a mile south of the old May Downs track near Draper's farm. They are $3\frac{1}{2}$ miles west-north-west of Mount Isa.

The rock succession consists of hornblende-allanite schist, Mica schist and quartzite and the uranium mineralization is confined to the hornblende-allanite schist. The strike is north-north-west and the dip is steeply to the west. Strong folding and strike faulting has affected the schists. Some coatings of a yellow-green uranium mineral occur in the more highly radioactive sections.

On the *Eldorado No. 1* a radioactive anomaly near the northern end of the lease is 60 feet long and 6 feet in width. The average of two assays of representative samples was 0.19 per cent. U_3O_8 . Some costeaning was carried out by Australasian Oil Exploration Ltd. but soil cover obscures the full extent of this anomaly. Towards the southern end of the lease, weak radioactivity can be traced over a length of 300 feet but this is of little significance.

Eldorado No. 2 is adjacent to *Eldorado No. 1* on the south. Uraniferous hornblende-allanite schist is exposed over a length of 30 feet and a width of $1\frac{1}{2}$ feet. The intensity of radioactivity is not as high as on *Eldorado No. 1*.

Eldorado No. 3 is adjacent to *Eldorado No. 2* on the south. The radioactivity is much weaker and more restricted in extent than that on *Eldorado No. 2* and it is not considered to be of any economic significance. Similarly, the radioactivity on *Eldorado No. 4* and *5* which are located to the west of *Eldorado Nos. 1* and *2* is of no significance.

Eldorado No. 6 is adjacent to *Eldorado No. 3* on the south. Radioactivity can be traced discontinuously over a length of 300 feet, and a maximum width of 3 feet. The intensity of radioactivity is weak except for isolated points of strong intensity. Some copper-staining is associated with the uranium mineralization. The uraniumiferous schists on *Eldorado Nos. 1-3* and *6* are at approximately the same horizon in the succession.

On *Eldorado No. 7* which is adjacent to *Eldorado No. 6* the strike of the schists is N. 2 deg. W. and weak radioactivity is restricted to small infrequent outcrops over a length of 100 feet.

Eldorado Nos. 8-10 are a little to the south-east of the other *Eldorado* leases and contain small areas of weak radioactivity. Discontinuous, weak radioactivity occurs over a length of 100 feet and a maximum width of $1\frac{1}{2}$ feet on *Eldorado No. 8*. On *Eldorado No. 10* weak radioactivity extends over 100 feet and to a maximum width of 5 feet.

Exploration No. 1

Location: 7 miles north-west of Mount Isa and $\frac{3}{4}$ mile easterly from the *Easter Egg*.

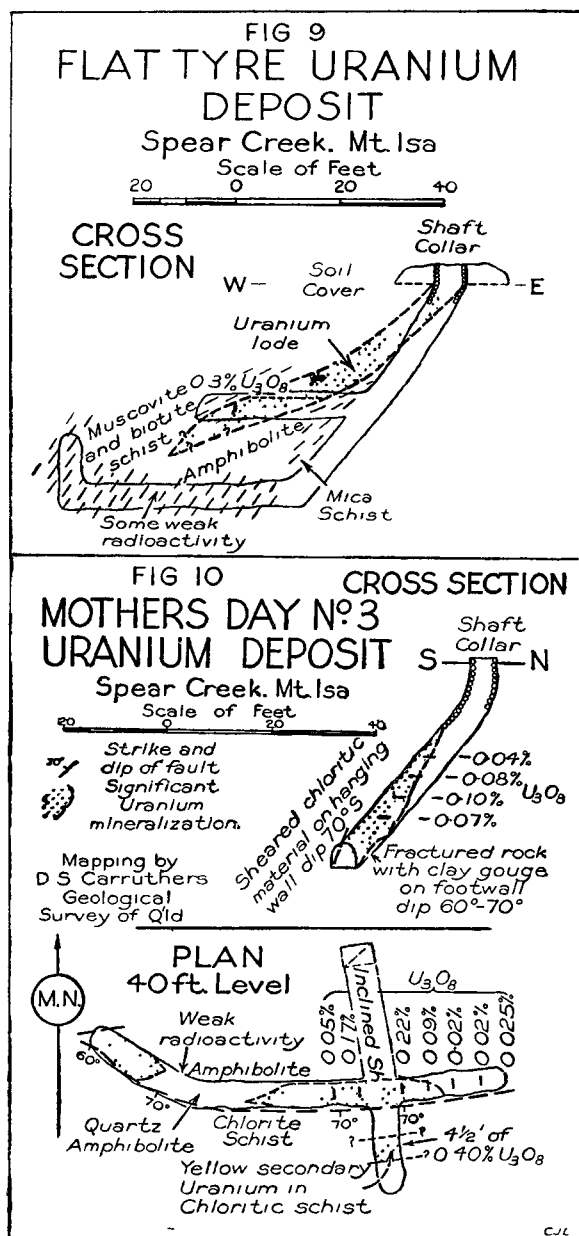
The pattern of radioactivity is similar to most other deposits in the area—weak average intensity with a few small areas of strongly radioactive material. The strike is N. 7 deg. E. and the dip is steeply to the west. A vertically-dipping quartz vein occurs 40 feet west of the radioactive anomaly and this may have some effect on the uranium lode at depth.

Flat Tyre

Location: 7 miles north-north-west of Mount Isa and 2 miles north-north-west of the *Mother's Day No. 3* lease.

The uranium mineralization occurs in a silicified allanite hornblende which is in a succession of muscovite, biotite and chlorite schist and amphibolite. Uraninite occurs as aggregates of very fine grains. Magnetite, hematite and sphene are minor constituents of the hornblende. Coatings of a yellow-green uranium mineral occur frequently on joint planes in the highly radioactive lode material. The strike of the hornblende ranges from north-east to north and the dip is 60 deg. to 70 deg. westerly. Local flattening of the dip indicates flexuring in the schists.

United Uranium N.L. explored the deposit by means of trenches, costeans and a prospecting shaft with crosscuts. Uranium mineralization extends over a



total length of 170 feet but the main ore-shoot is 60 feet long and 4 feet wide. A lode intersection in a crosscut from the prospecting shaft at a depth of 32 feet assayed 0.30 per cent. U_3O_8 (chemical) over a true width of 4 feet (see Fig. 9). However, no significant radioactivity was intersected in a crosscut at a depth of 50 feet. This indicates either that the ore-shoot pinches out between the levels or that it pitches away to the north or south. Further exploration is required to clarify the position.

The *Patch*, *Repair*, *Riddle*, and *Sleeve* leases are in the neighbourhood of the *Flat Tyre*. A considerable amount of costeaning to remove soil cover was carried out on the leases but no significant radioactive anomalies were exposed.

Folderol Nos. 1-3

These leases are situated 6 miles north-west of Mount Isa in the *Mother's Day-Flat Tyre* sub-group. They were mapped and sampled by Mount Isa Mines Ltd. On *Folderol No. 1* lease there is a deposit containing 25 tons per vertical foot with a surface grade of 0.09 per cent. eU_3O_8 and on the *Folderol Nos. 2 and 3* leases there are deposits containing 25 tons per vertical foot with a surface grade of 0.19 per cent. eU_3O_8 .

Janelle

Location: Approximately 1 mile northerly from the *Big Beryl* mine and 5 miles south-west of Mount Isa.

The uranium mineralization on the *Janelle* is in the same belt of schists in which the *Eldorado*, *Easter Egg*, and other deposits occur further to the north. Finely-disseminated uraninite occurs in a fine-grained amphibolite. Mica schists with large quartz lenses, pegmatites and greisen also crop out on the lease which is near the northern limit of the Mica Creek pegmatite area. The schists strike N. 5 deg. W. and dip west at 60 deg. to 70 deg. Weak copper mineralization is associated with the uraniferous amphibolite in part. The amphibolite occurs in narrow lenses in a fold structure. The lease was costeaned and sampled by Mineral Ventures N.L. The highest of 6 assay results was 0.225 per cent. eU_3O_8 but the grade is less than 0.10 per cent. U_3O_8 .

Lucky Boy

This lease is adjacent to the *Easter Egg* on the south. Some very weak radioactivity occurs on approximately the same line of strike as the anomalies on the *Easter Egg*. Costeaning was carried out by United Uranium N.L. without exposing any significant uranium mineralization.

Lucky Break

This lease is situated between the *Easter Egg* and *Mother's Day* leases. Small amounts of a yellow-green uranium mineral are visible in the outcrop. The host rock is a calcareous quartz schist which occurs in a succession of mica and amphibolitic schist. Some areas of intense radioactivity up to 2 feet in width are known to occur but the overall radioactivity is weak.

Miami

A radiometric anomaly on this lease represents a continuation of the anomaly on the *Mighty Glare* lease. The part of the anomaly on the *Miami* is weakly radioactive and adds little to the importance of the deposit on the *Mighty Glare*.

Mighty

The *Mighty* is situated adjacent to the *Easter Egg* on the north. The lease area is largely soil-covered and some costeaning was carried out by Australasian Oil Exploration to test the possibility of the occurrence of further anomalies along the line of lode of the *Easter Egg* deposits. However, only weak radioactivity was located.

Mighty Glare

Location: 5 miles north-west of Mount Isa and $\frac{1}{4}$ mile north-north-west of the *Easter Egg*. The *Mighty* lease is adjacent to the south.

There is a radioactive anomaly 170 feet long and 12 feet wide. The anomaly strikes N. 34 deg. W. and dips south-westerly. Mount Isa Mines Ltd. mapped and sampled the deposit and estimated it to contain 130 tons per vertical foot of ore with a surface grade of 0.08 per cent. eU_3O_8 . The highest assay was 0.21 per cent. eU_3O_8 over a width of 22 feet.

Mother's Day Nos. 1-3

Location : 5 miles north-north-west of Mount Isa and 1 mile north-north-east of the *Easter Egg*.

On the *Mother's Day* Nos. 1 and 2 leases the uranium mineralization is in calc-silicate schist which occurs within mica schists. Radioactivity extends for a length of over 150 feet but the width is narrow and irregular, and the intensity of radioactivity is weak. A little copper-staining is associated with the uraniferous schist. Some bulldozing has been carried out to remove soil cover.

Mother's Day No. 3 is a short distance north-east of the No. 1 and No. 2 leases. The uranium mineralization occurs in amphibolitic schist in a succession of mica and chlorite schist. Amphibolite dykes also crop out on the lease. The regional strike is north-westerly but the uranium is associated with an anticlinal area of a fold which pitches southerly at 70 deg. The schistosity in the vicinity of a prospecting shaft strikes roughly east-west. Radioactivity is mainly confined to an anomaly 70 feet long and $3\frac{1}{2}$ feet wide. The average grade of underground samples was 0.11 per cent. U_3O_8 . Assay figures ranged from 0.02 per cent. U_3O_8 to 0.40 per cent. U_3O_8 which gives an indication of the irregular nature of the uranium mineralization. The 0.40 per cent. U_3O_8 assay was from a width of 1 foot of sheared, chloritic schist on the hanging-wall of the main deposit on the 40 feet level and the high uranium content is attributed to the presence of a yellow, secondary uranium mineral.

Costeaming and underground exploration on the lease was carried out by United Uranium N.L. An inclined shaft was sunk to a vertical depth of 40 feet and a crosscut south, and drives east and west, were extended from the base of the shaft (see Fig. 10). The assay values deteriorated as the lode was followed in drives easterly and westerly towards the limbs of the fold structure. Some small-scale, selective mining of the deposit may be possible but the erratic lode width and grade would create serious difficulties to development on an economic basis.

Nevercantell

This lease is situated to the west of the *Mother's Day* No. 3 and is 6 miles north-west of Mount Isa. A small uranium deposit on the lease was mapped and sampled by Mount Isa Mines Ltd. and was estimated to contain 35 tons per vertical foot of ore with a surface grade of 0.20 per cent. eU_3O_8 .

The *Rewa* lease is situated near the *Nevercantell* and to the west of the *Mother's Day* No. 3. It was costeamed but no significant radioactivity was exposed.

Pamela

Location : $\frac{3}{4}$ mile north of the *Janelle* and 5 miles south-west of Mount Isa.

The geology is very similar to that described for the *Janelle* lease. There are two radiometric anomalies on the lease. The northern anomaly is 30 feet long by 10 feet wide and the southern anomaly is 100 feet long by 80 feet wide. Costeaming and sampling were carried out by Mineral Ventures N.L. The highest of 30 assay results was 0.394 per cent. U_3O_8 but the grade is less than 0.10 per cent. U_3O_8 .

Perseverance

Location : 7 miles south-south-west of Mount Isa and 2 miles south of the *Big Beryl* mine.

This deposit occurs in the same northerly trending belt of hornblende and biotite schists as the mica, beryl, monazite, cassiterite and tantalite pegmatites of the Mica Creek area. Coarse gneissose granite crops out about 200 yards to the west. Uranium mineralization is confined to a folded horizon of amphibolite. The structure is not well-defined owing to the rather massive nature of the host-rock but the high grade ore appears to be associated with the nose of a north pitching synclinal structure and lower grade ore occurs along the eastern limb of the fold. Radioactivity occurs over a length of 160 feet and an average width of 5 feet but uranium mineralization of economic interest is more restricted in extent and contains 65 tons per vertical foot with a grade of 0.22 per cent. U_3O_8 . Five bulldozed costeams were put in by Mount Isa Mines Ltd. and systematic sampling was carried out. The original lease lapsed and the area was taken up in 1959 as the *Emancipation* No. 1 lease. Pits were sunk in the high grade ore at the southern end of the deposit. Samples from these pits were reported to assay 1.16 per cent. U_3O_8 and 0.42 per cent. U_3O_8 . This high grade ore consists of a dense hornblendite rock containing some allanite and iron oxide minerals. Some coatings of a yellow, fluorescent uranium mineral are present on some joint planes.

Thanksgiving

This lease is located 4 miles north-west of Mount Isa and less than 1 mile south of the *Easter Egg*. The original lease lapsed and it was taken up as the *Dalveen* in 1959. Radioactivity occurs principally in an anomaly 40 feet long and $2\frac{1}{2}$ feet wide. The strike is N. 50 deg. W. and the dip is 69 deg. to the south-west. The overall intensity of radioactivity is weaker than that on the *Easter Egg*. Amphibolitic schist constitutes the host rock. Some costeaming has been carried out to remove soil cover. A selected sample assayed 0.40 per cent. U_3O_8 .

Turpentine

Location : Adjacent to the old May Downs track, 6 miles north-west of Mount Isa.

The geology of the deposit on this lease is typical of deposits of the *Easter Egg* type. Small areas of intense radioactivity are erratically dispersed within areas of weak radioactivity which extend discontinuously over a length of 600 feet. The area sampled by Mount Isa Mines Ltd. may contain 110 tons per vertical foot with a grade of 0.042 per cent. eU_3O_8 .

Wotan

The *Wotan* lease is located in the *Easter Egg-Flat Tyre* area, 6 miles north-west of Mount Isa. The uranium mineralization on the lease is typical of the Easter Egg type of deposit. No details of the extent and grade of the deposit are available but the intensity of radioactivity indicates that preliminary testing by mapping and sampling is warranted.

GORGE CREEK GROUP (see Fig. 11)

All the deposits in this group are assigned to the Counter or Skäl sub-type of the Eastern Creek deposits. The identity of the primary uranium mineral has not been definitely determined.

Battery

The *Battery* lease is adjacent to the *Counter* lease on the north, 9 miles north-east of Mount Isa. The host rock is hematite-stained, calcareous quartzite. Two radioactive anomalies occur along a roughly east-west line of strike. They are 30 feet long and 7 feet wide and 20 feet long by 2 feet wide. No assay data are available but the overall intensity of radioactivity is weak and is in no way comparable with that in the *Counter* deposit. Three costeans were excavated by Australasian Oil Exploration Ltd.

Bess

Location : 2 miles north-east of the *Counter* and 11 miles north-east of Mount Isa.

Uranium mineralization is confined to lenses of impure, calcareous quartzite and siltstone interbedded with meta-basalt. Calcite veins are of frequent occurrence and minor amounts of chalcopryrite occur sporadically in the rocks in the vicinity of the radioactive anomalies. The area is extensively faulted and fractured. Radioactivity occurs sporadically and discontinuously over a total length of 1,500 feet. There is no well-defined uranium deposit and the overall intensity of radioactivity is weak. A grab sample assayed 0.41 per cent. U_3O_8 but this is not indicative of the grade of the deposit. The *Bess* was taken up as the *Napo* when the original lease lapsed.

Broken Horseshoe

This lease is situated a short distance south of the Mount Isa-Cloncurry road, $4\frac{1}{2}$ miles east of Mount Isa. Weak radioactivity extends over a length of 800 feet. Assays of 24 samples taken by Mineral Ventures N.L. ranged from 0.006 per cent. to 0.081 per cent. U_3O_8 .

Carol

Location : 7 miles east-north-east of Mount Isa and 2 miles west-south-west of the *Counter*.

Uranium mineralization occurs in a quartz-magnetite greywacke which is interbedded with meta-basalt and quartzite. The strike of the lode is N. 75 deg. E. and the dip is steeply to the north. The lode appears to be terminated by faults which strike N. 20 deg. W. It is 74 feet long by 9 feet wide and the surface grade is 0.04 per cent. U_3O_8 .

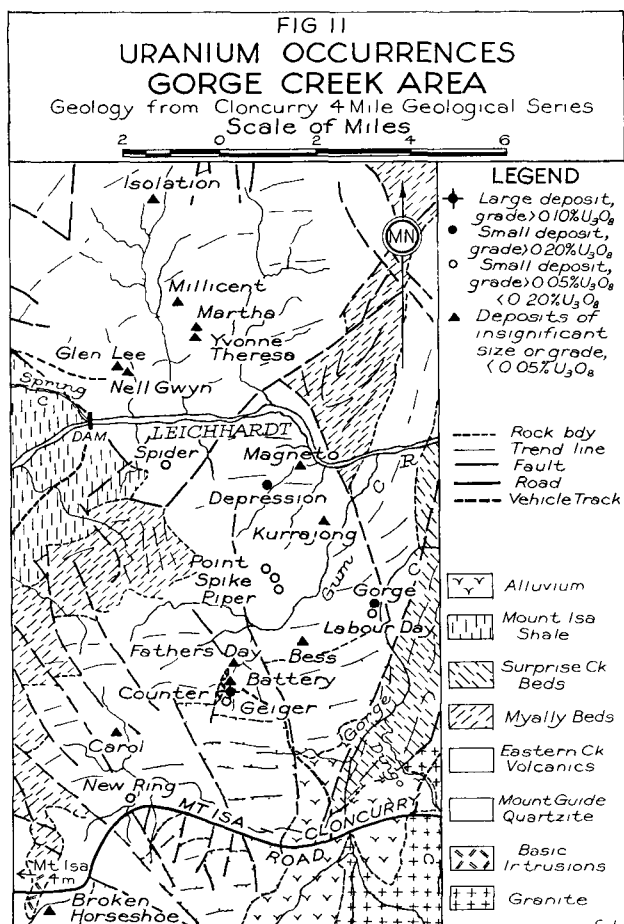
Counter (Anderson's lode)

Location : 9 miles north-east of Mount Isa and 3 miles north of the Mount Isa-Cloncurry road.

The rock succession in the area consists of sheared and chloritized basalt with some interbedded quartzite, meta-greywacke and volcanic conglomerate. Fine to medium-grained basic dykes intrude the succession. Epidote and calcite are fairly widely distributed in association with joints and faults.

The host rock is a cross-bedded, magnetite greywacke which forms a lenticular horizon in the Eastern Creek succession. It has undergone low grade metamorphism and carbonatization. The main constituent minerals are quartz, chlorite, biotite and plagioclase, and the minor constituents include muscovite, apatite, zircon and sphene. Secondary calcite is abundant. The opaque constituents are magnetite with some pyrite, hematite, ilmenite and rutile. The primary uranium mineral has not been determined but it is finely disseminated and occurs in association with sphene, rutile and biotite (see section on Primary Uranium Minerals). There is a gradation from greywacke to quartzite in parts of the orebody but the quartzite is usually weakly uraniferous or barren.

The strike of the bedding is N. 85 deg. W. and the dip is to the north at 70 deg. Strike faults occur on the northern and southern margins of the meta-greywacke



lens and the northern fault marks the hanging-wall of the orebody along part of its length (see Fig. 12). The footwall of the orebody is not as well-defined and there is usually an appreciable thickness of unmineralized or weakly mineralized greywacke between the footwall of the orebody and the southern margin of the greywacke horizon. Northerly-striking, transverse faults bear an important relation to the eastern and western limits of uranium mineralization. Along these transverse faults dolerite dykes have been intruded. The dykes are similar in composition to the adjacent meta-basalts of the Eastern Creek Volcanics but can usually be distinguished by difference in texture. On the west the orebody abuts the faulted contact of the meta-greywacke with a meta-dolerite dyke. The contact dips east at approximately 65 deg. On the east a small section of mineralized meta-greywacke is separated from the main section of the outcropping orebody by a highly fractured, meta-dolerite dyke. The dyke dips east at 56 deg. whereas the orebody pitches east at approximately 65 deg. so that the dyke passes out of the orebody at a relatively shallow depth. It appears likely that the faults provided channelways for the introduction of uranium mineralization. The adjacent greywacke was a more hospitable host rock for uranium deposition than the interbedded volcanics. Dolerite dykes were evidently intruded after the introduction of uranium mineralization. Some very weak radioactivity is associated with fractures and joints in the dolerite adjacent to the mineralized meta-greywacke but this is attributed to the movement of uranium in ground water solutions.

In outcrop the main section of the orebody is 150 feet long and 55 feet wide. The small section of the mineralized meta-greywacke on the eastern side of the meta-dolerite dyke is 30 feet long by 18 feet wide. The overall grade is approximately 0.19 per cent. U_3O_8 . From the surface dimensions the main ore-shoot is estimated to contain 650 tons per vertical foot. However, diamond drilling has indicated that the tonnage of ore increases in depth and the ore-shoot contains over 1,000 tons per vertical foot from a depth of 100 feet to 400 feet. Below a depth of 400 feet the ore-shoot decreases in width and grade but the uranium mineralization increases in length towards the east and a new ore-shoot has been located to the east and to the footwall of the ore-shoot which has been followed down from the outcrop. The outcropping ore-shoot and the eastern footwall ore-shoot appear to be linked by an attenuated section of weak mineralization. The extent of the eastern footwall ore-shoot is not known but it has been intersected from depths of 555 feet to 963 feet and the width and grade are comparable with the outcropping ore-shoot. Reserves of 0.19 per cent. U_3O_8 exceeding a half a million tons have been proved in the outcropping ore-shoot and there are good prospects that reserves to a depth of 1,000 feet will exceed 1,000,000 tons when the present drilling programme is completed.

The initial exploration of the deposit was carried out by Australasian Oil Exploration Ltd. who drilled 8 holes totalling 2,480 feet. Queensland Mines Ltd. have completed an additional 16 holes totalling more than 12,270 feet and two drill holes are in progress (September, 1959).

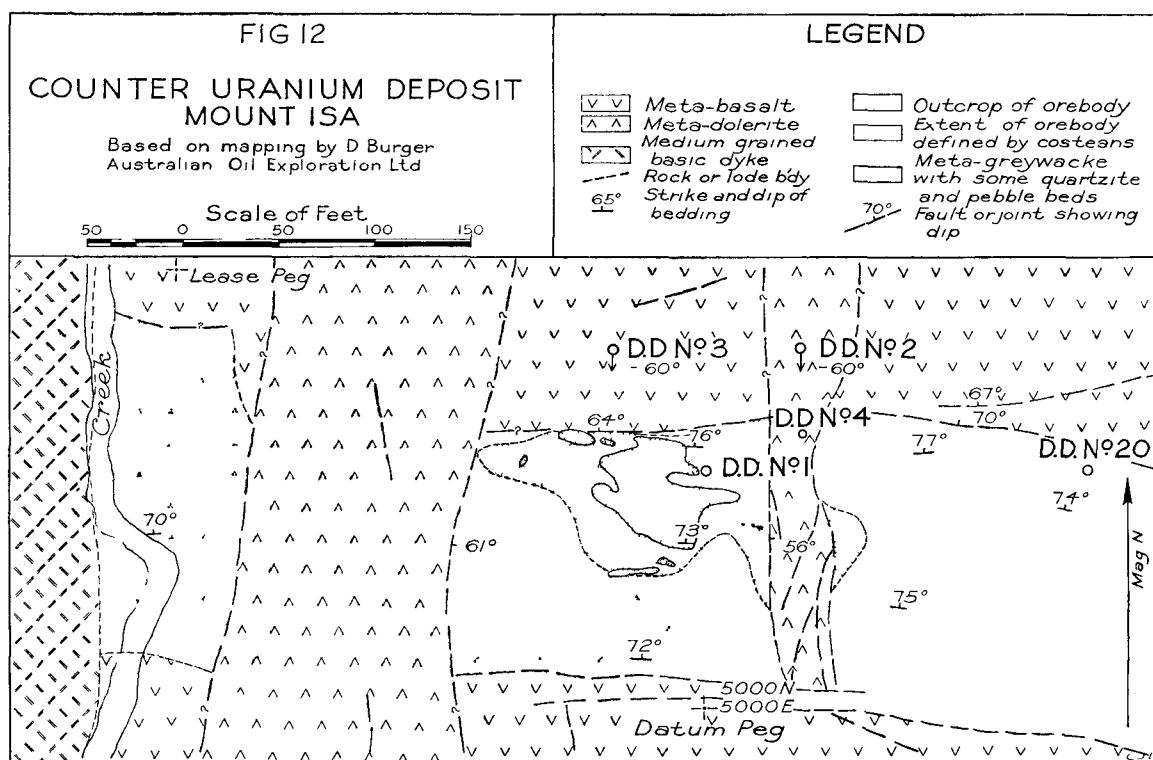


TABLE 4.—DIAMOND DRILLING DATA : COUNTER (ANDERSON'S LODE)*

D.D. No.	Location	Attitude	Total Depth	Lode Intersection	% U ₃ O ₈
1	5125N. 5002E.	Vertical	224' 6"	0'-185' (185')	0.202
2	5190N. 5050E.	60°S.	243' 4"	65'-200' (135')	0.177
3	5190N. 4950E.	60°S.	127'	52' 6"-117' 6" (65')	0.202
4	5145N. 5050E.	Vertical	327' 6"	25' 6"-180' (155' 6") 207'-307' 6" (100' 6")	0.22 0.13
5	5265N. 5100E.	60°S.	314'	175'-278' 9" (103' 9")	0.18
6	5265N. 5100E.	80°S.	399' 5"	250'-382' (132')	0.19
7	5265N. 5000E.	80°S.	320' 2"	247'-259' (12')	0.08
8	5320N. 5150E.	80°S.	523'	341' 8"-346' (4') 394'-509' (115')	0.14 0.185
9	5320N. 5070E.	78°S.	517'	24'-30' (6') 300'-376' (76')	0.12 0.188
10	5320N. 5230E.	80°S.	575'	371'-437' (66') 537'-548' (11')	0.193 0.162
11	5430N. 5230E.	80°S.	720'	565'-597' (32') 597'-637' (40')	0.025 0.21
12	5430N. 5170E.	80°S.	627'	540'-611' (71')	0.18
13	5430N. 5310E.	80°S.	749'	556'-561' (5') 640'-645' (5') 678'-684' (6')	0.15 0.095 0.14
14	5530N. 5310E.	82°S.	905'	849'-859' (10')	0.095
15	5530N. 5390E.	85°S.	1,004'	777'-787' (10') 787'-792' (5')	0.06 0.105
16	5530N. 5470E.	83°S.	1,003'	950'-953' (3')	0.155
17	5430N. 5390E.	85°S.	822'	625'-755' (130')	0.20
18	5578N. 5530E.	85°S.	1,138'	No lode intersection	..
19	5531N. 5310E.	62°S.	631'	532'-542' (10') 602'-616' (14')	0.117 0.114
20	5145N. 5230E.	Vertical	291'	No lode intersection	..
21	5430N. 5450E.	85°S.	859'	624'-632' (8') 750'-846' (96')	0.09 0.106
22	5370N. 5370E.	80°S.	769'	555'-666' (111')	0.249
23	5429N. 5510E.	85°S.	984'	928'-944' (16')	0.04
24	5381N. 5369E.	78°S.	672'	635'-672' (37')	0.137

* Data supplied by Australasian Oil Exploration Ltd. and Queensland Mines Ltd.

Depression

This deposit is situated a mile south of the Leichhardt River and 12 miles north-east of Mount Isa. The radioactive anomaly is 165 feet long by 3 feet wide and the grade is 0.37 per cent. eU_3O_8 . It was mapped and sampled by Mount Isa Mines Ltd. There are good prospects of development on a small scale if treatment facilities become available. On the adjacent *Big Dip* lease there is a radioactive anomaly 70 feet long by 2 feet wide and of comparable grade.

Father's Day

The *Father's Day* is adjacent to the *Battery* on the north. A radioactive anomaly on the lease strikes N. 5 deg. E. which is parallel to one of the principal fault directions in the area and almost at right angles to the strike of the bedding in the Eastern Creek succession. Radioactivity of comparatively weak intensity occurs over a length of 55 feet and a width of 4 feet. It was not considered to be of any economic significance.

Geiger

Location : $\frac{1}{2}$ mile south of the *Counter* lease and 9 miles north-east of Mount Isa.

Radioactivity occurs in lenses of hematite-stained, calcareous quartzite which strike N. 85 deg. W. and dip 70 deg. to 80 deg. N. The largest lens is the most westerly one and this has a length of 85 feet and a width of $9\frac{1}{2}$ feet. The grade indicated by the assay of two representative samples is 0.13 per cent. U_3O_8 . The other lenses are 78 feet long by $6\frac{1}{2}$ feet wide and 43 feet long by $6\frac{1}{2}$ feet wide but judging by the intensity of radioactivity these lenses are of considerably lower grade than the western lens.

Glen Lee

This is one of a small group of leases situated 12 miles north-north-east of Mount Isa and 1 mile north of the Leichhardt River. A number of small, irregular radioactive anomalies exhibiting weak overall radioactivity occur in a rock succession consisting of chloritized basic volcanics with some interbedded arenaceous meta-sediments. The *Nell Gwyn* lease is in the *Glen Lee* group but no significant radioactivity has been located on this lease.

Gorge

Location : 12 miles north-east of Mount Isa and 3 miles east-north-east of the *Counter*. Gorge Creek is a short distance away to the east.

The *Gorge* and the adjacent *Labour Day* lease to the south are situated in a heavily faulted area. The regional strike is approximately east-west but the bedding on these leases strikes N. 5 deg. W. (cf. *Father's Day*). A major north-north-westerly striking fault occurs to the east of the leases and this fault appears to be responsible for the anomalous strikes. Uranium mineralization is confined to a hematite-stained, calcareous quartzite. Lenses of uraniferous quartzite extend over a length of 160 feet. The main lens is 42 feet long and 5 feet wide. The grade indicated by the assay of two representative samples is 0.21 per cent. U_3O_8 .

Radioactivity on the *Labour Day* lease occurs on the same line of strike as that on the *Gorge* and has a total length of 66 feet. Significant radioactivity is restricted to a length of 40 feet and a width of $3\frac{1}{2}$ feet. One representative sample assayed 0.06 per cent. eU_3O_8 . The *Labour Day* and *Gorge* leases were taken up as the *Lolo* when the original leases lapsed.

Isolation

This is the most northerly of the Gorge Creek group of deposits. It is 16 miles north-north-east of Mount Isa. A radioactive anomaly on the lease is 80 feet long by 22 feet wide and has a grade of 0.022 per cent. eU_3O_8 . It was mapped and sampled by Mount Isa Mines Ltd.

Kurrajong

The *Kurrajong* is situated 12 miles north-east of Mount Isa and 4 miles north-east of the *Counter*. Comparatively weak radioactivity occurs in small lenses of arenaceous meta-sediments which strike east-west.

Lindsay

This lease is $\frac{1}{2}$ mile north-west of the *Yvonne Theresa* and 14 miles north-east of Mount Isa. The geology and uranium mineralization is similar to that on the *Yvonne Theresa*. Radioactivity can be traced over a total length of 300 feet but the width is quite narrow. A yellow, secondary uranium mineral has been observed at the surface.

Magneto

The small radioactive anomaly on this lease was mapped and sampled by Mount Isa Mines Ltd. It is near the *Depression* lease, 13 miles north-east of Mount Isa. A radioactive anomaly on the lease is estimated to contain 80 tons per vertical foot with a surface grade of 0.005 per cent. eU_3O_8 .

Millicent Martha

Location : $1\frac{1}{2}$ miles west of the Glen Lee group and 14 miles north-east of Mount Isa.

The host rock is a calcareous quartzite impregnated with hematite, and a yellow, secondary uranium mineral, possibly autunite, has been observed at the surface. Discontinuous lenses of radioactivity occur over a length of 800 feet but the main anomaly is 37 feet long by 15 feet wide. Even in this anomaly the surface radioactivity is comparatively weak. Of 36 samples which were radiometrically assayed, the highest result was 0.285 per cent. U_3O_8 and the average grade is probably well below 0.05 per cent. U_3O_8 . The strike of the bedding is N. 30 deg. W. and the dip is steeply to the north-east. One diamond drill hole was put down by Mineral Ventures N.L. to test the primary mineralization but no significant intersection of uranium ore was obtained.

New Ring

Location : 6 miles east of Mount Isa and $\frac{1}{2}$ mile north of the Mount Isa-Cloncurry road.

The strike of the meta-basalt and the interbedded arenaceous meta-sediments on the lease is N. 70 deg. E. and the dip is steeply to the north. There is a



General view of Mary Kathleen open-cut, 1959.

[Photo by C H Shipway]

prominent pattern of north-north-west and north-north-east-trending faults in the area and the strike of the uranium deposit corresponds to the former fault direction. Fracturing as a result of fault movements appears to have been a primary control of mineralization. A small amount of a yellow, secondary uranium mineral is present near the surface. The uranium deposit is 75 feet long and 10 feet wide. No assay data are available but the radioactivity is of relatively weak intensity and the grade is expected to be less than 0.10 per cent. U_3O_8 . The deposit was costeamed by Australasian Oil Exploration Ltd.

Piper

This lease and the neighbouring *Point* lease are situated near the *Spike* which is 3 miles north-north-east of the *Counter* and 12 miles north-east of Mount Isa. Radioactivity occurs in small areas of hematite-stained, fine-grained, impure quartzite or greywacke. Magnetite and calcite are also present. On the *Spike* lease there is a radioactive anomaly 42 feet long and 10 feet wide. The strike is W. 75 deg. E. There are points of strong radioactivity within the anomaly but overall it is only of moderate intensity. A selected sample from the *Spike* assayed 0.47 per cent. U_3O_8 but this is not indicative of the grade of the deposit. The *Spike* lease was taken up as the *Rico* when the original lease lapsed.

Spider

The *Spider* lease is west of the *Depression* and 4 miles north of the *Counter*. There are four irregular areas of radioactivity on the lease. Three of these are sub-parallel and strike east-west and the fourth strikes

at right angles to the other three. The most important anomaly is 2 chains long and 5 feet wide. No assay data are available.

Yvonne Theresa

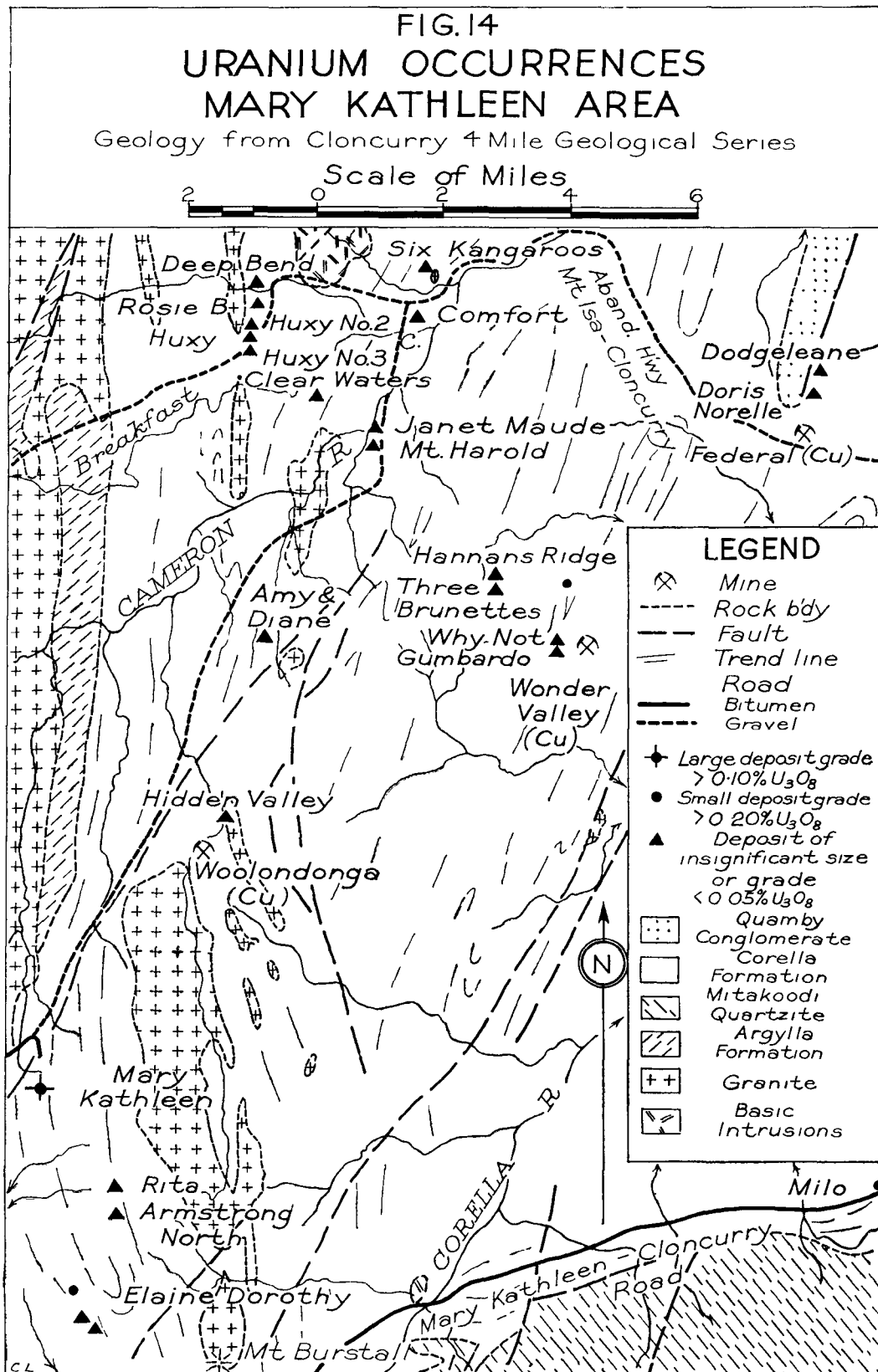
This lease is adjacent to the *Mullicent Martha* on the south and the geological setting is similar. Uranium mineralization occurs in discontinuous, narrow lenses of altered basalt which contain introduced quartz, calcite, hematite and magnetite. The strike of the lenses is N 30 deg. W. to N. 15 deg. W. and they can be traced over a total length of 730 feet. Of 30 samples assayed the highest result was 0.088 per cent. U_3O_8 and the surface grade is very low. Mineral Ventures N.L. drilled one test hole but this did not reveal any improvement in the grade at depth.

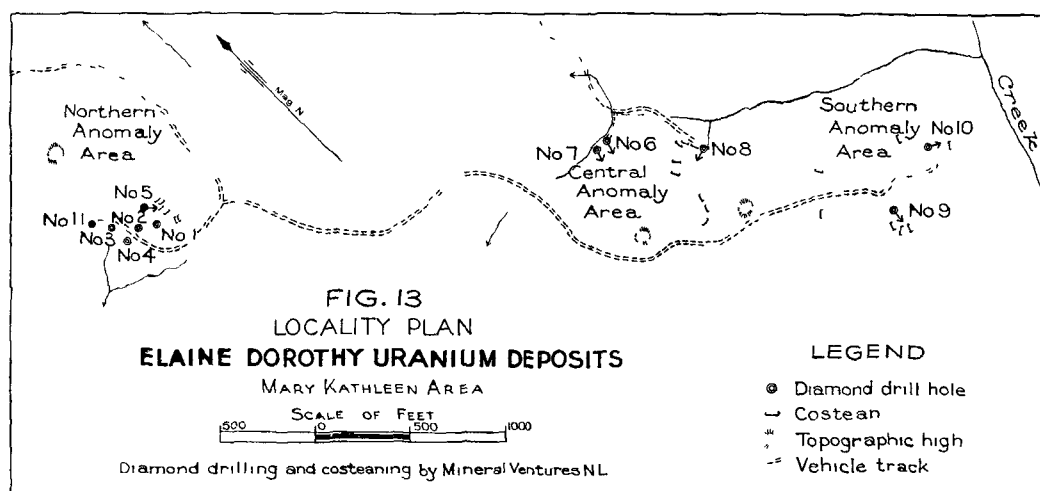
MARY KATHLEEN GROUP (see Fig. 14)

Armstrong North

Location: $2\frac{1}{2}$ miles east-south-east of the Mary Kathleen mine.

Uranium mineralization on this lease occurs in meta-sediments on the eastern limb of the major syncline with which the *Mary Kathleen* deposit is associated (see Matheson and Searl, 1956, page 534). The meta-sediments at the *Armstrong North* probably represent a lower stratigraphic horizon in the Corella Formation than those at the *Mary Kathleen*. Garnet, garnet-diopside and garnet-hematite rocks contain uranium mineralization very similar to that of the *Mary Kathleen*.





Radioactivity can be traced over a length of 800 feet but significant uranium mineralization is confined to two lenticular areas. The northern lens is 200 feet long and 30 feet wide, and the southern lens is 100 feet long and 10 feet wide. The strike of the lenses is a little east of north and the dip is 70 deg. west. The intensity of radioactivity indicates that the surface grade is low. Mineral Ventures N.L. put down two diamond drill holes and the best lode intersection was 12 feet with a grade of 0.044 per cent. eU_3O_8 .

Elaine Dorothy

The *Elaine Dorothy* is situated 4 miles south of the *Mary Kathleen* near the closure of a major syncline. Stratigraphically the *Elaine Dorothy* deposits are a little lower in the Corella Formation than the *Mary Kathleen*. The country rocks are diopside-scapolite granulites, impure quartzite and amphibolite. An irregular, discontinuous zone of garnetization occurs over a length of 4,500 feet and is roughly conformable

with the north-westerly strike of the meta-sediments. The disposition of uranium mineralization within the garnet zone appears to be related to cross-faults and zones of fracturing. The most prominent set of faults strikes north-north-east to north-east. The finely-disseminated uranium mineral occurs in an allanite-amphibole-garnet rock and is believed to be uraninite.

Three areas of radioactivity have been tested by costeaning and diamond drilling and of these the most northerly is the only one of any economic significance (see Fig. 13). Mineral Ventures N.L. who carried out a programme of exploratory drilling estimated the ore reserves to be 5,000 tons of 0.28 per cent. U_3O_8 . Of the 11 diamond drill holes put down only two had lode intersections of a grade above 0.25 per cent. U_3O_8 . Although these results were disappointing the proximity and similarity of the *Elaine Dorothy* deposits to the *Mary Kathleen* may provide inducement for further exploration.

TABLE 5.—DIAMOND DRILLING DATA: ELAINE DOROTHY (supplied by Mineral Ventures N.L.)

D.D. No.	Location	Inclination and Bearing	Total Depth	Mineralization
1	9228 N.	Vertical	200'	Garnet zones intersected to 86'. No significant uranium intersection
2	3427 E.			
	9314 N.	Vertical	225'	86'-88½' (2½')—0.007% eU_3O_8 88½'-94' (5½')—0.365% eU_3O_8 94'-95' (1')—0.044% eU_3O_8
	3396 E.			
3	9446 N.	Vertical	348'	180'-208' 6" (28' 6")—0.033% eU_3O_8 208' 6"—210' 6" (2')—0.276% eU_3O_8 210' 6"—212' 6" (2')—0.006% eU_3O_8
	3398 E.			
4	9371 N.	Vertical	127'	69' 9"—100' (30' 3")—0.03% eU_3O_8 100'-101' 3" (1' 3")—0.187% eU_3O_8 101' 3"—103' 3" (2')—0.03% eU_3O_8
	3329 E.			
5	9281 N.	60° at 173°	160'	Garnet zones to 134'. No significant uranium intersection
	3500 E.			
6	6827 N.	45° at 278°	211'	Garnet abundant 113'-211'. No significant uranium intersection
	3871 E.			
7	6887 N.	60° at 278°	115'	109'-111' (2')—0.01% eU_3O_8 111'-112' (1')—0.22% eU_3O_8 112'-115' 6" (3' 6")—0.02% eU_3O_8
	3834 E.			
8	6342 N.	50° at 310°	237'	85'-93' slightly radioactive
	3868 E.			
9	5326 N.	60° at 254°	150'	No significant uranium intersection
	3490 E.			
10	5144 N.	60° at 156°	250'	Garnet and some slightly radioactive bands to 198'
	3858 E.			
11	9554 N.	Vertical	400'	323'-329' 6" (6' 6")—0.15% eU_3O_8 344'-345' 6" (1' 6")—0.10% eU_3O_8 357'-372' slightly radioactive
	3419 E.			

Mary Kathleen (Matheson and Searl, 1956)

The history of development and some aspects of the geology of the *Mary Kathleen* have been summarily referred to in sections of Part I and will not be repeated here. The deposit is situated 33 miles west of Cloncurry, and 36 miles east of Mount Isa. Thus it is centrally situated in the Cloncurry-Mount Isa mineral belt.

The Corella Formation in the area consists of calcareous and siliceous granulite, impure crystalline limestones, quartzite, calcareous breccias and some interbedded basic volcanics and sills. Diopside, scapolite, epidote, garnet and apatite are common mineral constituents of the granulites. Quartz veins and quartz-felspar porphyry dykes and sills are of common occurrence in the area and these appear to be associated with the Mount Burstall granite to the east of the *Mary Kathleen* (see Fig. 14). This granite ranges from a coarse-grained, microcline leucogranite to a hornblende granite. A second meridional granite body occurs to the west of the *Mary Kathleen*. It is a medium-grained, gneissic, biotite-microcline granite and was probably intruded earlier than the Mount Burstall granite.

Structurally the *Mary Kathleen* is situated on the axis of a major, north-pitching synclinal structure. The synclinal axis strikes meridionally and dips steeply to the west. The main groups of faults and joints in the area strike north-easterly, northerly and west-north-westerly. The west-north-westerly group appear to be closely related to garnetization and mineralization.

The main orebody is described by Matheson and Searl (1956) as "a large boat-shaped mass, within which mineralization occurs as a network of irregular bands that are controlled by a complicated joint pattern." The most important joint system strikes north to north-easterly and dips west at 40 deg. to 70 deg. Individual ore-shoots associated with these joints rarely exceed 100 feet in length and 10 feet in width. The eastern limit of the ore zone is marked by a prominent shear with associated sulphide mineralization. The shear strikes north to north-westerly and dips to the east. Westerly to west-north-westerly faults and joints may have an important influence on the northern and southern termination of the individual ore-shoots and the orebody as a whole.

The orebody occurs in a belt of garnet-diopside-apatite granulite. Uraninite occurs finely disseminated in the rare earth minerals allanite and stillwellite. Secondary uranium minerals occur together with uraninite to a depth of 50 feet below the surface and incipient oxidation continues to a depth of 120 feet. The uranium to thorium ratio in the deposit is approximately three to one and the uranium is in equilibrium throughout. The garnet consists chiefly of almandite with lesser quantities of andradite. Uraninite preferentially replaced the andradite.

The orebody crops out on a steep hill slope and is being open cut to a height of 250 feet above the base of the outcrop. The present rate of production is 1,000 tons of ore per day and in the two years of production to the end of 1958 some 384,173 tons of ore have been produced. In 1958, two hundred and one thousand, three hundred and forty-two tons of ore were treated for a yield of

250.8 tons of uranium oxide (U_3O_8). The limestone and manganese requirements of the treatment process are obtained from local sources of supply but the sulphur for acid production is imported.

Mount Burstall

A small occurrence of a davidite-type mineral is situated 1 mile south of Mount Burstall. The occurrence is in a succession of altered basic igneous rocks, and calc-silicate rocks adjacent to a major north-north-easterly-striking fault.

Rita

This lease with the adjacent *Rary* and *Buffer* leases is situated north of the *Armstrong North* lease and 2 miles east-south-east of the *Mary Kathleen*.

Compared with the *Mary Kathleen* area the rock succession on the *Rita* is more arenaceous and less calcareous. Garnetization is associated with a horizon of granulite. Four small, irregular garnetized areas with associated weak allanite-uraninite mineralization occur over a north-south distance of 1,300 feet. Three of these are conformable with the strike of the granulite and the fourth appears to follow a prominent fracture which strikes N50 deg. W. The grade of the more highly radioactive material is less than 0.1 per cent. U_3O_8 . Five shallow diamond drill holes were put down by Rio Tinto Australian Exploration Pty. Ltd. Three of these holes obtained lode intersections ranging from 9 feet to 16 feet in length but the grade was of the order of 0.01 per cent. U_3O_8 .

CAMERON-CORELLA RIVER GROUP (see Fig. 14)

With few exceptions the deposits of this group are of the davidite type and occur in the Corella Formation.

Aittola's Claim

This occurrence is located just south of the Cloncurry-Mount Isa road via the *Federal* copper mine and 16 miles west-north-west of Cloncurry. Davidite occurs as coarse, disseminated grains in an altered siliceous limestone. A small quantity of a yellow, fluorescent, uranium mineral is associated with the davidite. Radioactivity is principally confined to boulders and surface rubble in two small areas, one adjacent to the road and the second approximately $\frac{1}{2}$ mile to the south.

Amy and Diane

Location: 28 miles north-west of Cloncurry and nearly 4 miles south-south-west of the *Janet Maude* lease.

Uranium mineralization occurs in a quartz-orthoclase pegmatite intruding calc-silicate rocks. Contamination of the pegmatite by calc-silicate minerals during the intrusion of the pegmatite has given rise to a marginal, hybrid pegmatite-calc-silicate rock. A davidite-type mineral and magnetite are present as irregularly-distributed, coarse grains in this hybrid rock type over an area 10 feet long and 3 feet wide. One shallow trench has been excavated.

Bill's Folly

Location : 35 miles north-west of Cloncurry.

This occurrence is located in a minor granite intrusion. Radioactivity of low intensity occurs in two areas 20 feet long by 6 feet and 9 feet by 5 feet. No uranium mineral could be identified. A sample from a shallow pothole assayed 0.04 per cent. eU_3O_8 .

Bitmore

This lease is situated on the eastern side of the Cameron River to the north of the abandoned Cloncurry-Mount Isa road, 26 miles west-north-west of Cloncurry. A davidite-type mineral has been found over a very restricted area.

Clear Waters

Location : $1\frac{1}{2}$ miles south-south-east of the *Huxy* lease and 12 miles north-north-east of the *Mary Kathleen*.

Uranium mineralization occurs in massive, calcareous meta-sediments composed of albite, hornblende, calcite and hematite. Uranophane and finely-disseminated uraninite have been identified (McAndrew and Edwards, 1957). Most of the radioactive material at the surface consists of floaters but a small lode one one foot wide is exposed in the adjacent outcrop. This deposit is very small but the occurrence of uraninite makes it of more interest than the davidite deposits.

Comfort

Location : 13 miles north-north-east of the *Mary Kathleen* and $1\frac{1}{4}$ miles west-south-west of the Cameron River bore near the abandoned Cloncurry-Mount Isa road.

Pegmatites intruding biotite and hornblende schist crop out on this lease but the area is largely soil-covered. Radioactivity is associated with a narrow horizon of biotite schist adjacent to pegmatite. Four costeans were excavated to remove soil cover. Highly radioactive specimens found as floaters near the lode were identified as brannerite (Lawrence, 1955, p. 70).

Deep Bend

This lease is 1 mile north of the *Huxy* and 14 miles north-north-east of the *Mary Kathleen*. A davidite-type mineral was found as detrital grains in the soil and a yellow secondary uranium mineral occurs in a small, highly radioactive area in calc-silicate rocks.

Dodge-Leane

This lease is located 21 miles west-north-west of Cloncurry and $1\frac{1}{2}$ miles north of the *Federal* copper mine. Coarse grains of a davidite-type mineral are sporadically distributed through recrystallized, impure limestone. There are three closely-spaced areas of mineralization but these would aggregate only a few square feet.

Doris Norelle

Location : 21 miles west-north-west of Cloncurry and $\frac{3}{4}$ mile north of the *Federal* copper mine.

A fine-grained, acid igneous rock on this lease is intrusive into altered impure limestones. An aureole of sericite and chlorite schists surrounds the intrusion.

A prominent fracture pattern is in evidence, the principal direction being north to N. 20 deg. E. and the dip is vertical to steeply west. Sporadic copper mineralization occurs in a belt extending from the *Doris Norelle* to the *Federal* copper deposit. In three potholes, small amounts of torbernite and malachite have been exposed on joint faces, and sparse, sporadic grains of absite are also present in the granitic host rocks.

On the adjacent *Doris Allen* lease weak radioactivity occurs in a weathered granitic rock.

Gumbardo

Location : 24 miles west of Cloncurry and $\frac{1}{4}$ mile west of the *Wonder Valley* copper mine. It is in the *Three Brunettes* sub-group.

Calc-silicate rocks and numerous small dykes of pegmatite and graphic granite crop out in this area. A few grains of a brown, refractory, uranium mineral occur in the pegmatite. This mineral is probably absite.

On the adjacent *Why Not* lease, absite, and a creamy-yellow, earthy, weathering product occur in a quartz-felspar-hematite pegmatite at the edge of a small intrusion of graphic granite. However, no significant amount of uranium is present.

Hannan's Ridge

This is another davidite type occurrence in the *Three Brunettes* sub-group 25 miles west of Cloncurry. Coarse grains of davidite are sparsely and irregularly disseminated in calc-silicate rocks and hybrid granitic rocks. Similar mineralization occurs on the adjacent *Leydin's Ridge* lease.

Hidden Valley

The location of this lease is $6\frac{1}{2}$ miles north-east of the *Mary Kathleen* and $1\frac{1}{2}$ miles from the northern tip of the Mount Burstall granite. Radioactivity is associated with allanite in a pegmatitic zone within calc-silicate rocks. The deposit is of insignificant size.

Hobby Nos. 1-2

Location : 26 miles west-north-west of Cloncurry on the west side of the Cameron River. It is one to two miles north of the river crossing on the abandoned Cloncurry-Mount Isa road.

A davidite-type mineral occurs as floaters in soil and also in association with a calcite-actinolite-albite rock. Some uranium is also associated with a 1 foot wide quartz vein exposed in one of the costeans. A radioactive anomaly is exposed in two costeans 23 feet apart over a width of 1 foot to 3 feet.

On the adjacent *Verpat* lease a few floaters of a davidite-type mineral occur in the soil but the mineral has not been found *in situ*.

Huxy Nos. 1-3

Location : 13 miles north-north-east of the *Mary Kathleen* and adjacent to the abandoned Cloncurry-Mount Isa road.

The Corella Formation in the area is represented by calcite-actinolite-felspar-hornblende-quartz rocks with lenses of coarsely-crystalline calcite and calcite-actinolite rock. Dykes and bosses of granite and granite derivatives are of common occurrence.

On the *Huxy* the main radioactive anomaly is 3 to 4 feet in diameter and a considerable amount of a fluorescent, yellow, uranium mineral is distributed over this area. This is believed to be beta-uranotil (Dallwitz and Roberts, 1955, unpubd.). No primary uranium mineral is in evidence. At least two other very small areas of intense radioactivity occur on the lease.

The *Huxy* No. 2 lease adjoins the *Huxy* on the north. There is a radioactive anomaly 20 feet long by several feet wide and a yellow uranium mineral similar to that on the *Huxy* is present.

The *Huxy* No. 3 adjoins the *Huxy* on the south. Small areas of radioactivity occur in pegmatite and the adjacent calc-silicate rocks. A davidite-type mineral weathering to yellow and orange-coloured secondary minerals is sparsely distributed in these areas.

Janet Maude

Location: 11 miles north-north-east of *Mary Kathleen* and $2\frac{1}{2}$ miles south-west of the Cameron River bore near the abandoned Cloncurry-Mount Isa road.

A davidite-type mineral and hematite occur as sparsely-distributed blebs in a medium to coarse-grained felspar-actinolite-calcite rock. Four costeans have been excavated. In one of these intense radioactivity occurs over a width of $2\frac{1}{2}$ feet and weak radioactivity extends over an additional width of 6 feet.

The *Mount Harold* and *Janet Maude West* are adjacent leases but no significant radioactivity has been located on them.

Rosie B.

The location of this lease is $\frac{1}{2}$ mile north of the *Huxy* and $13\frac{1}{2}$ miles north-north-east of the *Mary Kathleen*. A davidite-type mineral has been found as floaters in the soil. Analyses by Lawrence *et al.* (1957) showed the radioactive specimens to be a mixture of davidite, ilmenite and hematite in the ratio of 50:40:10. A davidite specimen was analysed and found to contain 20.16 per cent. U_3O_8 .

Six Kangaroos

Location: 14 miles north-north-east of the *Mary Kathleen* and a short distance west of the abandoned Cloncurry-Mount Isa road.

Davidite, magnetite and hematite occur as medium to coarse-grained blebs and crystals in a lens of crystalline calcite. The calcite lens is within calcite-actinolite-scapolite calc-silicate rocks, and pegmatite and aplitic granite crop out within a few hundred feet of the deposit. The davidite is irregularly and sparsely distributed through the calcite and most of the surface radioactivity results from detrital davidite in the soil around the calcite lens. Moderate to intense radioactivity occurs in two trenches 20 feet and 24 feet long and 8 feet apart. Apart from this the only radioactivity *in situ* was found in two other small outcrops.

There is a small amount of davidite in a magnetite-bearing, oligoclase pegmatite within an area of granite on the *Six Kangaroos* No. 3 lease to the west of the main occurrence. One specimen of davidite from the *Six Kangaroos* assayed 3.5 per cent. U_3O_8 (Lawrence, 1954) and another assayed 2.6 per cent. U_3O_8 (Whittle, Sth. Aust. Dep. Min.).

Three Brunettes

This lease is 25 miles west of Cloncurry. Blebs of a davidite-type mineral are irregularly disseminated through a belt of felspar-actinolite calc-silicate rocks. The grade over a length of 140 feet and a width of 55 feet is 0.013 per cent. eU_3O_8 . The deposit was systematically costeamed and sampled by Mount Isa Mines Ltd.

Three Inksots

Location: 25 miles west-north-west of Cloncurry and approximately 2 miles north of the abandoned Cloncurry-Mount Isa road.

Quartz-epidote-hornblende rocks of the Corella Formation are intruded by pegmatite and graphic granite. Ten shallow pits have been excavated to investigate isolated areas of radioactivity which occur in and along the edges of a pegmatite dyke over a distance of 200 feet. Intense radioactivity occurs in only three of these pits and in these there is a small amount of a yellow, earthy uranium mineral weathering from (?) absite. The mineral is brownish in colour with a vitreous lustre. It is a thorium-uranium titanate with a high thorium-uranium ratio. Magnetite is also associated with the pegmatite.

CLONCURRY GROUP

Coloured Rocks

This lease is 22 miles north of Cloncurry and $5\frac{1}{2}$ miles north-north-west of Fort Constantine homestead. Weak radioactivity is associated with coarse-grained granite in an area which is largely covered by alluvium. Hematite is an accessory mineral in the granite but no uranium mineral has been observed.

Embla Ridge Nos. 1-5

Location: 14 miles south-south-west of Cloncurry and 2 miles north-east of the Cloncurry-Malbon road at the Slaty Creek crossing.

The uranium deposits on these leases are in meta-sediments of the Marimo Formation. They have been traced discontinuously over a length of nearly two miles in a north-south direction. Extensive faulting has affected the area and drag-folding is of common occurrence. In outcrop the uranium occurs either in metamorphosed, ferruginous sandstone or in massive, siliceous ironstone which has resulted from supergene alteration of ferruginous sandstone. Sericitic sandstone, clay slate and carbonaceous slate are interbedded. The ferruginous meta-sandstone is more resistant to weathering and forms prominent outcrops.

The largest and most highly radioactive deposit is on the *Embla Ridge* No. 3. This deposit is 630 feet long and 6 feet wide. Samples taken over widths of

4½ feet and 13 feet assayed 0.01 per cent. and 0.03 per cent. U_3O_8 respectively. United Uranium N.L. drilled two holes to test this deposit. Intersections of very weakly radioactive material were obtained at a depth of approximately 200 feet. This may indicate that the uranium mineralization at the surface has been formed by supergene concentration from a very low grade primary source. At least three less significant radioactive deposits occur to the south of the main deposit. The largest of these is 500 feet long by 2 to 3 feet wide. Two other deposits occur to the north and the larger of these is 120 feet long and 4 feet wide.

Helafells

Location: 22 miles south-south-west of Cloncurry and 9 miles south-east of the Cloncurry-Malbon road at the Slaty Creek crossing.

The deposits occur in quartzite and slates of the Marimo Formation which strike north to north-north-westerly and dip east at angles greater than 60 deg. The radioactivity occurs in discontinuous, massive deposits of ironstone over a length of ½ a mile. Stains of malachite occur in the radioactive outcrops and flakes of torbernite can be seen at points of higher radioactivity. There are several small, lenticular deposits, the largest being 50 feet long and 5½ feet wide. A second deposit is 45 feet long and 4½ feet wide. Mining Corporation N.L. carried out wagon-drilling and sank a shaft to a depth of 240 feet on the largest deposit. A true width of 30 feet of weakly radioactive material was obtained in a crosscut at this depth. A few flakes of torbernite were observed in the crosscut, indicating that the primary zone had not been reached. Small, weakly-radioactive deposits occur on the *Helafells North* and *South* leases on the same line of strike as the *Helafells* deposits.

Hot Rocks

Location: 3 miles east-south-east of Cloncurry and ¼ mile south of the Cloncurry-Julia Creek road.

The radioactivity occurs in ironstone and hematite quartzite beds within a succession of amphibolite, mica schist and quartzite in the Soldier's Cap Formation. The strike is N. 75 deg. W. and the dip is 75 deg. to 85 deg. north. Stains of malachite are associated with the radioactive deposit which is similar in type to that at the *Tinboll*. The total length of the radioactivity is 570 feet and the width is 6 feet. The intensity of radioactivity decreases along the strike with the decrease in the iron content of the bed. Surface samples indicate that the area of highest radioactivity would only average 0.04 per cent. U_3O_8 .

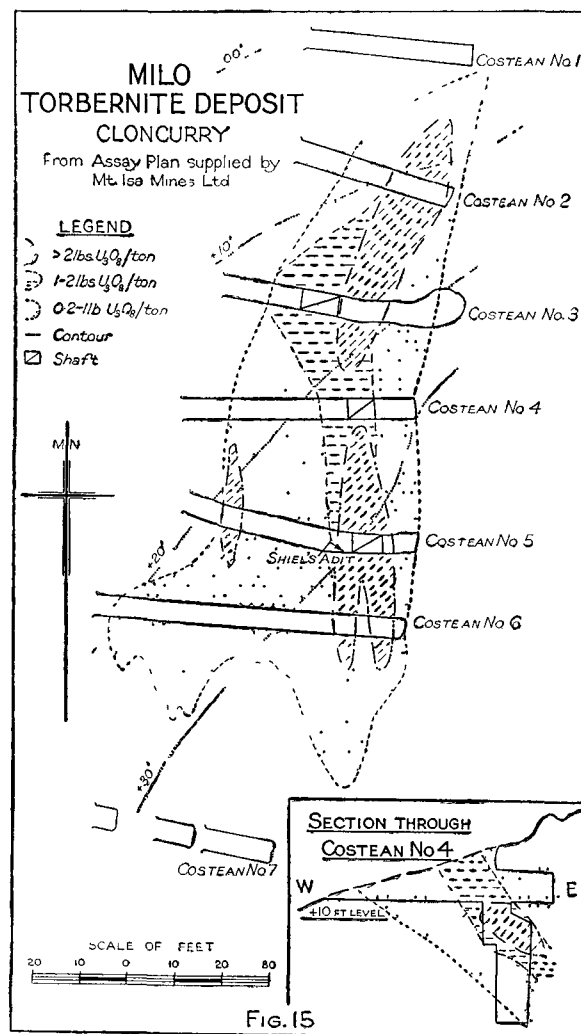
Milo

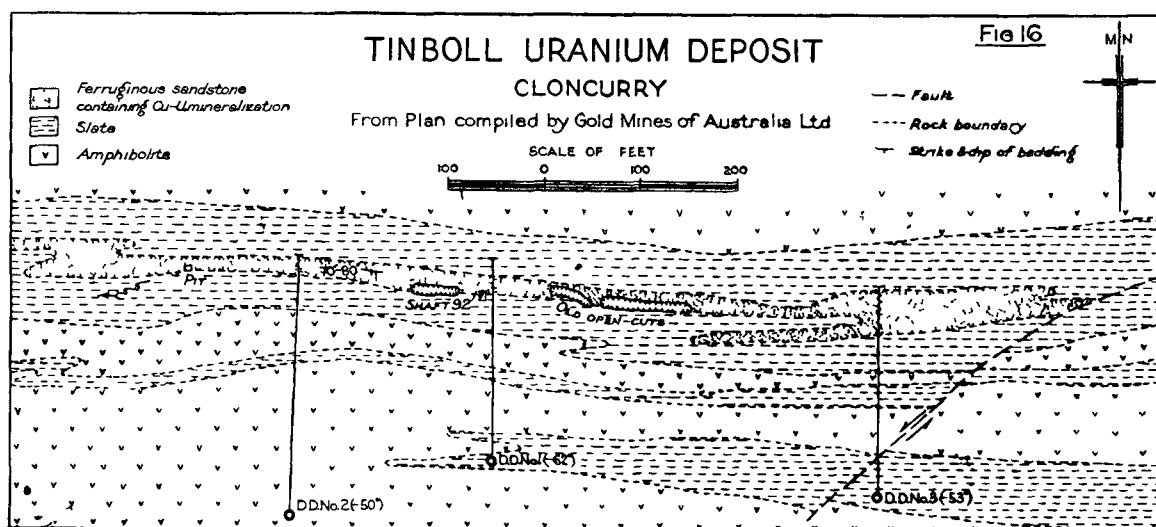
Location: 20 miles west-south-west of Cloncurry and 13 miles east-south-east of the *Mary Kathleen*. The Cloncurry-Mary Kathleen bitumen road passes ¼ mile to the south of the deposit.

The *Milo* occurs in the Corella Formation near the closure of a north-pitching regional anticline. The strike is east to east-south-east and the dip is to the north at 75 deg. Carbonaceous and siliceous slates and

calc-silicate rocks crop out on the lease. These have been highly deformed by faulting and folding and the resulting structural pattern is complex.

A siliceous ironstone and jasper gossan is exposed discontinuously along a prominent ridge over a distance of nearly one mile. It parallels the strike of the bedding. Very weak radioactivity is associated with much of this gossanous material, particularly towards the eastern end of the ridge. Scattered flakes of torbernite have been observed in the gossan at several points. The main surface radioactivity is confined to a lens of torbernite-bearing kaolinitic clay. The higher grade section of this radioactive anomaly is 110 feet long by 10 feet wide and has a grade of 0.135 per cent. U_3O_8 . It was tested by Mount Isa Mines Ltd. by costeaning and shaft sinking to a maximum depth of 35 feet (see Fig. 15). It appears to be a supergene concentration associated with a cross-fault feature. The cross-fault strikes northerly and dips easterly at 65 deg. Torbernite occurs as disseminated fine to medium flakes and as coarse flakes on joint and fracture planes. A parcel of 9.3 tons of hand picked torbernite ore sent to Rum Jungle for treatment assayed 0.76 per cent. U_3O_8 .





Shaft sinking and diamond drilling was carried out by Paringa Wheel Fortune Pty. Ltd. A prospecting shaft was abandoned at 120 feet in semi-oxidised gossanous material and none of the four diamond drill holes obtained intersections of primary uranium ore. The drilling has shown that the ferruginous gossan is the surface expression of a sulphide lode consisting very largely of pyrite with subordinate amounts of copper, lead and zinc sulphides. Fluorite is abundant in the gangue. The primary zone to the east of the torbernite-kaolinite lode has not yet been adequately tested and it is considered that this section holds the best prospect for the discovery of significant mineralization.

Olive

Location: 15 miles south of Cloncurry and $1\frac{1}{2}$ miles east of the Cloncurry River.

The Marimo Formation in this area is represented by slates and quartzites which strike N. 30 deg. E. and dip steeply to the east. Radioactivity is confined to a ferruginous replacement deposit in slates. Residual manganese oxides are present in sections of the deposit and extensive copper-staining occurs in the adjacent carbonaceous slates. Very weak radioactivity extends discontinuously over a length of $\frac{1}{2}$ a mile. The main area is 300 feet long and 10 feet wide. No assay data are available but from the intensity of radioactivity the grade is expected to be very low. The deposit is comparable with the *Embla Ridge* deposits described above.

Sierra Rada

Location: 2 miles north-north-west of the *Helafells* and 20 miles south-south-west of Cloncurry.

The geology is similar to that of the *Helafells* but the bedding here dips 70 deg. to the west. Uranium and the associated copper mineralization occur in a sandstone horizon. Torbernite is present mainly on joint planes. A radioactive anomaly on the lease is 75 feet long and 22 feet wide. No assay data from representative samples are available and the deposit has not been tested at depth. Some collapsed workings indicate that the deposit was previously tested for copper.

Tinboll Nos. 1-7

Location: 13 miles north-east of Cloncurry and 4 miles west of Mapperley Park homestead.

Radioactivity occurs in a horizon of sandstone which strikes N. 75 deg. E. and dips 70 deg.-80 deg. south. It is interbedded with amphibolite, mica schist and slate of the Soldier's Cap Formation. Strike faulting has taken place along the sandstone horizon and the beds are drag-folded. The *Tinboll Nos. 1-5* leases surround the *Monakoff* freehold which was worked for copper in the early mining days (see Fig. 16). Some torbernite and a small quantity of a yellow-green, fluorescent uranium mineral are present in the outcrop. Other minerals present in approximate order of abundance are hematite, limonite, fluorite, malachite, psilomelane, barytes, chrysocolla, quartz, azurite, and garnet. Shaft sinking and diamond drilling were carried out by Gold Mines of Australia Ltd. This showed that the mineralization in the primary zone consists of disseminated magnetite, pyrite and chalcocopyrite with fluorite, quartz and calcite. Minute inclusions, which may be uraninite, occur in the fluorite. Diamond drilling tested the deposit to a depth of 250 feet and showed no increase in the grade of the primary ore over that of the oxidised ore at the surface. The main radioactive anomaly is 360 feet long and 14 feet wide. The grade indicated by the three diamond drill holes is 0.02 per cent. U_3O_8 and 1.6 per cent. Cu. Assays of up to 0.45 per cent. U_3O_8 were obtained from the prospecting shaft which was sunk to a depth of 93 feet in the highest grade section of the lode. However, no appreciable quantity of such material was indicated by the exploratory workings. Other anomalies to the west showed weaker radioactivity over areas of 85 feet by 8 feet and 70 feet by 7 feet.

A radioactive anomaly on the *Tinboll No. 6* and 7 is $1\frac{1}{2}$ miles east of the main deposit and may be on the same horizon in the Soldier's Cap Formation. The anomaly is 200 feet long and 10 feet wide and the grade indicated by one diamond drill hole intersection is 0.04 per cent. U_3O_8 . Weak copper mineralization is again associated with the uranium in the ferruginous lode but the grade is too low to be of any significance.

TABLE 6.—DIAMOND DRILLING DATA: TINBOLL (supplied by Gold Mines of Australia Ltd.)

D.D. No.	Position	Direction	Declination	Intersection	Width	% U ₃ O ₈	% Cu
1	Opposite the prospecting shaft in the main anomaly	North	62°	Feet 237-241 241-253½ 253½-297½ 297½-310½	Feet 4 12½ 44 13	0.05 0.01 0.013 0.10	3.0 0.14 2.1 3.0
2	200 feet west of No. 1 hole	North	50°	313-318½ 318½-324 324-329	5½ 5½ 5	0.02 0.015 0.01	2.03 1.37 0.42
3	400 feet east of No. 1 hole	North	53°	250½-252 260-263 267½-272½ 272-291½	1½ 3 5 19½	0.01 0.015 0.015 0.02	1.8 1.6 0.73 1.70
4	1½ miles east of main anomaly	South	50°	170-183	13	0.037	..

BALLARA GROUP

Ballara Nos. 1-2

This is a davidite type deposit which is situated just north of the deserted township of Ballara, 11 miles south-south-west of Mary Kathleen. Pegmatite dykes, granitic rocks and calc-silicate rocks crop out in the area. A davidite-type mineral and hematite occur as irregularly disseminated, coarse aggregates in a coarsely—crystalline, massive, feldspar-amphibole rock. Quartz—feldspar—muscovite pegmatite crops out in close proximity to the occurrences, none of which are of more than a few square feet in area.

A similar occurrence of a davidite type mineral in granulite is located 3 miles south-west of the old *Wee McGregor* copper mine.

Lady Rachel

Location: To the south-east of the Mount Philp iron-stone ridge, 4 to 5 miles south of Ballara. Sixteen miles south-south-west of Mary Kathleen.

Radioactivity occurs at isolated points in granite over a length of one mile and within a zone 50 feet wide. The granite is basified in part due to contamination by the calc-silicate rocks it intrudes. Graphic granite and pegmatite are also associated with the radioactivity in part. At the points of intense radioactivity a greenish-yellow mineral is present which has been identified as absite. The U:Th. ratio in assays of samples of this material is 1:3.

Pelican

Location: 6 miles south-south-east of Ballara and 19 miles southerly from Mary Kathleen.

The Corella Formation is represented in this area by slates and calc-silicate rocks. The main structural feature is a regional quartz-filled fault which strikes N. 20 deg. E. and dips steeply to the west. The beds within 100 feet of the fault have been crumpled and drag-folded. It is in these deformed beds to the west of the fault that the uranium mineralization is localized. Copper-staining is also widespread but is not closely associated with the uranium. Surface radioactivity is weak but costeans have exposed more highly radioactive material. In two costeans narrow veins of uranophane, over a maximum total width of 3 feet, have been

exposed. Systematic costeaning was carried out by United Uranium N.L. Two ill-defined radioactive anomalies occur over a length of several hundred feet parallel to the fault but no assay data are available. The leached nature of this deposit at the surface gives some encouragement for underground exploration.

A davidite type deposit 1 mile south-west of the *Pelican* is associated with pegmatite dykes which intrude banded calc-silicate granulites. Radioactivity extends over a length of about 900 feet. A similar small occurrence is located 1½ miles south-south-west of the *Pelican*.

Prize

Location: 9 miles north of Duchess and 4 miles east-south-east of the *Mount Hope* copper mines.

The country rocks are quartz-hornblende schist and calc-silicate rocks which strike north and dip west at 50 deg. Uranium mineralization is confined to a quartz lode in a shear zone which strikes N. 15 deg. E. and dips vertically. At the points of high radioactivity the quartz and decomposed feldspar lode material contain a lemon-coloured uranium mineral. This occurs either in a powdery or soft, waxy form. The uraniferous lode is 43 feet long by 8 feet wide and a representative sample assayed 0.07 per cent. U₃O₈ (chemical).

Occurrences of a davidite-type mineral are situated near the *Prize*, 8 and 10½ miles north-north-east of Duchess. The davidite-type mineral is associated with pegmatite dykes which intrude calc-silicate granulites and metamorphosed impure limestones.

The Springs

Location: 4½ miles south-south-west of Ballara and 16 miles from Mary Kathleen in the same direction.

Radioactivity is associated with a quartz-filled fault near the eastern margin of a large area of granite and granitized metasediments of the Corella Formation. The siliceous lode strikes N. 25 deg. E. to N. 45 deg. E. and the dip is 50 deg. to 70 deg. west. Weak radioactivity is associated with bands of jasper towards the footwall of the lode. The jasper bands have an average total width of 6 feet and usually two bands are present. The surrounding granite gives readings of over twice

background radioactivity. Copper-staining is associated with the fault and an old prospecting shaft is situated a short distance north of the uranium deposit. Significant radioactivity is confined to small concentrations of secondary minerals which consist of torbernite and an unidentified, yellow, ochreous mineral. These occur with quartz, kaolin, and jasper and are best exposed in a trench at the southern end of the jasper lode. Although these supergene concentrations are of little economic significance, the association of uranium mineralization with a prominent fault structure makes the deposit worthy of a close study and possibly some underground exploration.

KURIDALA-MOUNT COBALT GROUP

Fluke

This lease is four miles east of Kuridala. Torbernite occurs in small, sporadic patches in an altered granitic rock. The country rocks are amphibolite, quartzite and mica schist of the Kuridala Formation.

Glen Idol

Uranium mineralization occurs in the Corella Formation adjacent to a branch of the Cloncurry overthrust fault, 4 miles west-south-west of Glen Idol homestead and 16 miles east of Kuridala. A yellow, secondary uranium mineral occurs in the deposit which is very restricted in extent.

Kathleen

The *Kathleen* is situated three miles south-south-west of Kuridala. Copper and uranium mineralization occur in a ferruginous lode in the Kuridala Formation. The lode consists of quartzitic material and ferruginous gossan carrying magnetite, oxides of manganese, pyrite, and chrysocolla. A green, micaceous, fluorescent uranium mineral is sparsely disseminated in flaky aggregates. It is probably autunite. Uranium also appears to be associated with the magnetite. Radioactivity extends over a surface area of 600 feet by 20 feet but the grade is low.

Mariposa

Location : 13 miles south of Selwyn and 2 miles south of the Selwyn-Toolebuc track.

The Kuridala Formation is represented in the vicinity of the lease by slates and quartzites. There are two radioactive anomalies $\frac{3}{4}$ mile apart on the lease. Mineralization in the southern anomaly has been exposed in a small open-cut. Intense radioactivity is confined to a width of 8 feet along a sheared contact between slate and fine-grained quartzite. The strike of the bedding is N. 30 deg. W. and the dip is 60 deg. east. Torbernite and (?)salmite occur in the shear zone and copper carbonates are also present. Slates adjacent to the shear have been kaolinized and somewhat contorted. Surface radioactivity is very weak and trenching along the slate-quartzite contact would be necessary to indicate the extent of significant mineralization. A shaft was sunk to test copper mineralization a little to the south of the open-cut and on approximately the same line of strike.

The northern radioactive anomaly is in a massive, limonite-quartz-jasper gossan. Fairly uniform, weak radioactivity extends over a length of 130 feet and a maximum width of 15 feet. Some radioactivity of higher intensity on the footwall or western side of the anomaly is associated with copper-staining. The strike is N. 30 deg. E. and the dip is steeply to the south-east. Supergene concentration of uranium in association with the iron oxide minerals may have taken place.

Mount Cobalt

Location : 15 miles south of Selwyn and 4 miles south of the Selwyn-Toolebuc road.

Minor uranium and tungsten mineralization is associated with copper and cobalt in the *Mount Cobalt* mine which produced 766 tons of cobalt. Mineralization occurs in a shear zone along and adjacent to the contact of an amphibolite sill with mica schist and quartzite. Torbernite was found in the vicinity of the No. 1 Adit near the southern end of the mine workings.

A diamond drill hole was put down by Mount Isa Mines Ltd. to intersect the lode 200 feet south of the Main Shaft. A lode intersection was obtained from 280-300 feet but no significant amounts of cobalt, copper or uranium were obtained.

Mount Dore

Location : 10 miles south of Selwyn and just north of the Selwyn-Toolebuc road.

The Kuridala Formation is represented here by slates which are intruded by granite to the east of Mount Dore. A prominent, north-south striking, quartz-filled fault occurs to the west of the deposit. Stainings and impregnations of copper carbonates occur over an extensive area in the slates and several shafts and pits were sunk in the early mining days to test the copper values. Visible uranium mineralization is confined to an area a few feet square where sparsely-disseminated flakes of torbernite are present. A diamond drill hole was put down to test the copper deposit but no uranium was found in association with the copper at depth.

Painted Hills

This lease and the neighbouring *Taipan* lease are situated 9 miles north of Kuridala. A small quantity of torbernite occurs in quartzite and siliceous calc-silicate rocks of the Corella Formation.

Percol Creek

The location is 21 miles west of Percol Plains homestead which is 19 miles north-west of McKinlay. A small area of granite exhibits radioactivity appreciably above background. The granite is coarse-grained and is iron-stained on joint planes. A sample taken from a pothole excavated at the point of highest radioactivity assayed 0.04 per cent. eU_3O_8 .

Robert Heg

This is a davidite type occurrence situated $5\frac{1}{2}$ miles north-east of Kuridala. The Corella Formation is represented in the area by calc-silicate rocks composed of actinolite, feldspar, pyroxene and garnet. The Williams granite crops out a short distance to the west

and a pegmatite dyke swarm occurs in the adjacent meta-sediments. Near the granite and in the immediate vicinity of the pegmatites the meta-sediments have been metamorphosed to hornblende and mica-schists. The strike of the bedding is N. 5 deg. W. and the dip is steeply west to vertical. Small patches of radioactivity (no more than a few square feet in area) occur in pegmatite and in the adjacent meta-sediments in a zone half a mile long and situated 20 to 40 chains north and north-west of the margin of the major granite intrusion. A davidite-type mineral was located in several of these areas of radioactivity.

Other occurrences of a davidite-type mineral are situated in the upper *Farley Creek* area, 7 to 9 miles south-east of Kuridala. They are confined to granite areas. Another davidite occurrence, 11 miles west of Kuridala is in a calc-silicate rock near granite.

Utah

Location : 8 miles west-south-west of Selwyn and $\frac{1}{2}$ mile south-east of the *Belgium* copper mine.

The area in the vicinity of the deposit is largely soil-covered but there are rubbly outcrops of a medium to coarse-grained granite which represents marginal material of the Gin Creek granite. The granite is poor in ferromagnesian mineral but some tourmaline was observed. Intense radioactivity occurs in boulders of a granular hematite-quartz gossan. In cavities in the gossan a pale yellowish-green, micaceous mineral (?autunite) is visible and some torbernite is also present. No definite lode has been indicated by the six shallow trenches excavated on the deposit. At the abandoned *Belgium* copper mine the quartz-hematite-copper carbonates lode material exhibits weak radioactivity and the surrounding granite is also slightly radioactive. The *Utah* deposit may represent a supergene concentration of uranium mineralization but the area surrounding the Gin Creek granite warrants a close examination since there is a possibility that significant uranium mineralization may have been associated with the intrusion of this granite.

MOUNT BIRNIE GROUP

First Try Nos. 1 and 2

Location : 20 miles south-south-east of Duchess and 1.3 miles south of Mount Birnie.

A ferruginous laterite occurs as a capping over beds of the Lower Cambrian Birnie Arkose. The beds strike northerly and dip east at 5 deg.-12 deg. Weak radioactivity is present in this cap rock over a north-south distance of 2 miles. It has a width of 20 to 40 feet. The intensity of radioactivity increases with the iron content of the rock and the occurrence appears to represent a superficial concentration. Specimens from a shallow pit assayed 0.045 per cent. eU_3O_8 . Sparsely disseminated flakes of torbernite have been observed.

Similar deposits occur on the neighbouring *Mother's Hope* Nos. 1-2 leases and the *Mary Lou* lease which is situated 3 miles south of the *First Try* leases. Selected samples from the *Mary Lou* lease assayed as much as 0.36 per cent. and 0.40 per cent. eU_3O_8 but the average grade would be less than 0.05 per cent. U_3O_8 .

WESTMORELAND GROUP

The deposits in this group have been described by Syvret (1957) and Batty (1957) in unpublished reports to Mount Isa Mines Ltd. and by Brooks (1958).

Buck Hill

This occurrence is 9 miles south of Westmoreland homestead and 12 miles east-north-east of the *Redtree* prospect. Very weak radioactivity occurs in coarse sandstone over an area of 400 square yards. A yellow, unidentified uranium mineral has been observed.

Contact

The location of this occurrence is 14 miles south of Westmoreland homestead and 12 miles east of the *Redtree* prospect. Appreciable radioactivity is confined to a small area of lithic sandstone. Torbernite is visible in two places.

Long Pocket

Location : $10\frac{1}{2}$ miles south-south-west of Westmoreland and 8 miles east-north-east of the *Redtree* prospect.

Two radioactive anomalies occur in which yellow and green uranium minerals have been observed. The larger anomaly is in fine-grained, felspathic sandstone and appreciable radioactivity extends over an area of about 250 square yards. The overall intensity of radioactivity is much lower than at the *Redtree* prospect.

Redtree

Location : 16 miles south-west of Westmoreland homestead and $6\frac{1}{2}$ miles east of the Northern Territory border.

The Westmoreland Conglomerate in which the deposit occurs has an east-north-east strike and dips northerly at 5 deg. Cross-bedding and lensing of beds is of general occurrence and correlation of horizons is only possible over short distances. There are two prominent sets of vertical joints which strike N. 55 deg. E. and N. 55 deg. W. Several areas of radioactivity are adjacent to joints of these types. The host rock is a coarse-grained, felspathic sandstone. The feldspar has been extensively kaolinized. Iron and manganese oxides are commonly present in the host rock and may have acted as precipitation agents for the uranium-bearing



Rugged outcrop of Westmoreland Conglomerate containing secondary uranium mineralization.

[Photo by K. Wolff.]

solutions. At least 12 horizons in the formation have been mineralized in part (Syvret, 1957 unpub.). Uranium is also localized in earthy bands between beds of sandstone. Yellow and green uranium minerals occur as disseminated grains. Carnotite, meta-torbernite, zeunerite and uranospinite have been identified by the South Australian Department of Mines and renardite,

soddyite and phosphuranylite were identified, in addition to carnotite and meta-torbernite, by the Commonwealth Bureau of Mineral Resources.

The deposits were mapped and sampled by Mount Isa Mines Ltd. Nine prospecting pits and 11 wagon drill holes were sunk to explore the deposits to a shallow depth.

TABLE 7.—SUMMARY OF DATA FROM TEST PITS: REDTREE (supplied by Mount Isa Mines Ltd.)

Grid Area No.	Area	Pit No.	Depth	% U ₃ O ₈	Remarks
1	1,208' x 50'	1	10'	0.58	Sunk in an area of high radioactivity. Grade decreases with depth .. } Mineralization disseminated in 3 horizons of sandstone and in narrow earthy bands
		2	11'	0.042	
		3	10'	0.051	
5 Dinner Camp	420' x 50'	4	11'	0.012	1,130' north of Pit No. 1 } Mineralization disseminated in 3 horizons of sandstone. Vertical joints associated
		5	11'	0.009	
6	4,109' x 50'	6	4'	0.07	1,840' north of Pit No. 1 } 5 mineralized horizons in sandstone
		7	4'	0.012	
		8	4'	0.004	
		9	4'	0.007	

ISOLATED OCCURRENCES

Black Valley

Locality: 2 miles west-south-west of the abandoned Glenroy homestead on the Leichhardt River and 28 miles north-east of Mount Isa. The *Black Reef*, *Kironga* and *Fisher's Gift* leases are adjacent to the *Black Valley*.

Weak radioactivity is associated with siliceous limonite lodes. Surface concentrations of manganese oxides occur in sections of the lodes which strike northerly to north-easterly and dip vertically. The country rocks consist of quartzite, slate and impure limestone of the Surprise Creek Beds. No uranium mineral has been identified and the radioactivity is thought to result from a supergene concentration of uranium in association with iron oxides.

Dajarra

Floater of davidite are reported to occur a few miles north-east of Dajarra which is the terminus of a branch railway line from Duchess (Lawrence *et al.*, 1957). Schists crop out nearby but no davidite was found *in situ*. The davidite is steel grey in colour and contains minute inclusions of ilmenite, hematite and quartz. It was found by chemical analysis to contain 6.41 per cent. U₃O₈. Ilmenite and ilmenite-hematite intergrowths occur in granite and contact metamorphic zones near the *Trekelano* copper mine north-east of

Dajarra (Rayner and Nye, 1936 and Edwards, 1938). A davidite-type mineral is associated with ilmenite at a locality nearly 2 miles north-north-east of the *Trekelano* mine.

Mount Carolian and Mount Lawler

The *Mount Carolian* and *Mount Lawler* leases are situated 4 miles west, and 9 miles north-north-east of Kajabbi, respectively. The presence of uranium has been confirmed in samples from the radioactive anomalies but the intensity of radioactivity is very weak.

Quamby

Davidite is reported to occur as rounded crystalline floaters 1 mile north-north-west of Quamby which is 28 miles north-west of Cloncurry. The floaters are thought to be derived from the adjacent schists although no davidite was seen *in situ* (Lawrence *et al.*, 1957). Tourmaline pegmatites intrude the schists. A similar occurrence of a davidite-type mineral is located 2 miles north-north-west of Quamby.

Kajabbi

Nine miles east-south-east of Kajabbi and approximately 2 miles east of the *Queen Sally* mine there is a small occurrence of a davidite-type mineral. The mineral is sparsely disseminated through granulite which is untruded by pegmatite.

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