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REPORT ON URANIUM PROSPECTS IN THE MT. ISA-CLONCURRY DISTRICT OF QUEENSLAND

by

D. Ostle.

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CONTENTS

INTRODUCTION

During July and part of August, 1955, visits of inspection, of variable duration, were made to a number of radioactive occurrences in the Mt. Isa-Cloncurry district of Queensland. The majority of the deposits had been examined previously; by E.K. Carter, Senior Geologist of the Bureau of Mineral Resources, in August and September, 1954; by K.R. Livingston and J.H. Brooks, of the Queensland Geological Survey; and by C.B. Campbell, Principal Geologist of the United Kingdom Geological Survey, in October, 1954. Reports covering these activities were subsequently issued by the respective Government Departments. The aim of the enquiries under review was threefold, namely to provide independent appraisals of the properties already examined; to carry out assessments of those deposits which had not already been inspected by representatives of the Australian Atomic Energy Commission; and to attempt an appraisal of the potential of the Queensland uranium field as a whole.

Since several hundred uranium leases have been pegged in the area during the past year, it was impossible and unnecessary to examine them all. Consequently, only those properties were visited which were considered, in the light of earlier work, to be the most significant or to represent a particular type of deposit. Especial attention was devoted to the deposits on the Mary Kathleen and Counter leases and separate reports have been submitted on those prospects, which are undoubtedly the most promising in the district. In this report a brief section is concerned with an attempted classification of the several types of deposit, a longer one with observations on the deposits which were selected for inspection and a third with an appraisal of the field. Regional geology is dealt with more authoritatively than would be possible here, by E.K. Carter (1955), whose report also includes detailed measurements of areas and count rates of the radioactive anomalies. Except where it is considered necessary, therefore, this information is not duplicated. Some petrographic and mineragraphic data are taken from Mr. Carter's report, as well as from C.B. Campbell's, which incorporates results of laboratory studies of specimens conducted by R.K. Harrison and J.M. Miller at the Atomic Energy Division of the U.K. Geological Survey in London.

ACKNOWLEDGMENTS

The writer is indebted to Messrs. E.K. Carter and J.H. Brooks for their help in conducting him over the field and in outlining the regional and local geology. Thanks are due also to local mining and geological staffs and to lease owners, for facilitating access to their properties, and particularly to the geological staff of Mt. Isa Mines Ltd., who made available their reports on radioactivity investigations in the district.

CLASSIFICATION OF THE DEPOSITS

From the field inspections and available mineragraphic data it is suggested that the uranium deposits of the Mt. Isa-Cloncurry district may be classified into six groups. They are as follows:-

1. Fine-grained uraninite disseminations in basic rocks, e.g. Flat Tyre, Mothers Day and Easter Egg(?).

2. Brannerite on other complex uranium minerals in mineralised fracture zones of altered siliceous and calcareous sediments and basic lavas, e.g. Skal, Pile, Hopeful, Counter, and probably Duke, Batman and Queen's Gift.

3. Pyrometasomatic deposits in calc-silicate rocks. e.g. Mary Kathleen and possibly Pelican.

4. Hydrothermal replacement deposits of uraninite in altered sediments. e.g. Tinboll and Hot Rocks.

5. Uraniferous ferruginous bodies of doubtful origin, some with associated secondary mineral deposits. e.g. Mariposa, Milo, Helafells.

6. Davidite in calc-silicate rocks. e.g. Three Brunettes (not inspected) and probably Elaine Dorothy.

Although this classification is based essentially on similarities of mineralogical and structural features between deposits which are grouped together, plotting of their position on the geological map shows that there is an areal and, to a large extent, a stratigraphic grouping of the deposits. Thus, all those deposits which can be referred to the first and second groups, (which apart from the difference in the identity of the primary uranium mineral have mineralogical features in common) occur in an area to the north and north-west of Mt. Isa and in rocks which are grouped together on the geological map. Similarly, the deposits belonging to group five occur in the eastern central part of the district, although the stratigraphic relationship is here not so apparent. The reason for this spacial distribution is not obvious at this juncture, as the evidence suggests that the majority of the deposits examined were introduced by epigenetic processes, and that deposition was controlled by a conbination of structure and lithological or chemical composition of the host rocks. The answer may be simply that the abundance of a favourable host rock in one stratigraphic unit, e.g. of basic rocks in the area of the Flat Tyre and Mother's Day etc., has increased the chances of a greater number of a particular type of deposit being developed within that unit. It must be realised, however, that knowledge of the mineral assemblages in many of the radioactive deposits is incomplete (and in many cases entirely lacking), and further that only a small proportion of the known occurrences has been inspected. The rough zoning, and even the classification, of the deposits, as outlined above, might therefore be drastically modified by prolonged studies in the district.

THE URANIUM PROSPECTS

FLAT TYRE

The Flat Tyre lease, held by United Uranium, N.L., is located about 7 miles northwest of Mt. Isa. Radioactivity is confined to an amphibolite member of a series of regionally metamorphosed basic rocks which, in the environs of the uraniferous deposit, are now represented by micaceous schists. The relationship of the amphibolite to the enclosing schists is regarded by C.B. Campbell as being that of a dyke or discordant sill, and an intrusive relationship may well be assumed in view of the conformity between the dip of the amphibolite and that of the schistosity of the adjacent mica schists.

Distribution of gamma radiation at the surface and in exploratory openings (costeans, an inclined shaft and crosscuts) shows that the uraniferous body, which is elongated roughly north-south, has well-defined boundaries on the hanging- and foot-walls, although the highest radiometric values are concentrated near the hanging-wall, i.e. to the west, and the transition from non-radioactive to radioactive material along this margin is more sharply defined. In the shallower crosscut from the shaft (-35 ft. inclined depth) the hanging-wall is further marked by a small fault, gamma-ray intensity falling off gradually towards the east. The field observations suggest that deposition of the radioactive mineral was controlled by structural features within a host rock whose lithology and composition favoured precipitation.

Rough measurements indicate that the radioactive deposit persists over a distance of about 150 feet. Its width at the surface varies from 6 to about 12 feet, but with a dip of 25° to 30°. The average true width is probably of the order of 4 feet. The company has claimed that a true-width sample assaying 0.3% eU_3O_8 was obtained over 7 feet from the shallow crosscut, but measurement of the active zone exposed in the gallery, using a B-ray probe to delimit the mineralized rock, gave a true width of a little over 3 feet. The grade of the uraniferous zone at this locality therefore probably exceeds 0.3% eU_3O_8. Radiometric inspection suggests that grade of mineralisation does not vary appreciably with depth and that laterally material having an average grade in excess of 0.2% eU_3O_8 over a true width of, say, 4 feet, extends over a distance of about 120 feet. The deeper crosscut from the shaft has not been inspected, as it is now flooded, but it is assumed from company reports that the mineralisation lenses out between -35 and -50 feet inclined depth. Consequently it is estimated that not more than 2,000 tons of ore, of a grade above 0.2% eU_3O_8, could be recovered from the deposit, which is therefore of little significance except possibly as a 'gouging' concern.

The radioactive material from the Flat Tyre is a dark, fine-grained hornblende schist. Thin section examination by the Atomic Energy Division in London shows that it is impregnated with much magnetite and hematite and that it contains subordinate sphene. The hematite and magnetite are commonly intergrown as triangular lamella networks, suggesting ex-solution. Radioactivity can be attributed almost entirely to the presence of very finely disseminated grains of uraninite which occur mainly in narrow discontinuous veinlets, aligned along the schistosity, and which are associated with sphene and magnetite. The identity of the uraninite has been confirmed by X-ray powder photograph. The small grain-size of the uraninite would probably preclude pre-concentration by gravity treatment but, being in the form of the primary oxide, the uranium should be recoverable by simple leaching from pulped ore.

MOTHER'S DAY

Situated about 6 miles north-west of Mt. Isa, the Mother's Day radioactive deposit has similar characteristics to that at the Flat Tyre but it represents a smaller occurrence of higher grade. Radioactivity is again confined to a narrow zone within amphibolite, striking about 80° west of north, but, towards its western extremity, veering through about 30° towards the north. At the surface the active zone is well-defined by sharp radiometric boundaries over a distance of about 60 feet, with a maximum width of five feet; and in the limited underground workings (at -50 ft. inclined depth) the hanging wall of the lode is marked by a strong shear zone, containing micaceous or chloritic schist and dipping at 60° towards the south.

The shaft workings expose uranium mineralisation over a length of little more than 50 ft. and show that there is no lateral development of the lode in depth beyond that indicated at the surface. In the drives the radioactive material is seen to occur in discontinuous lenses which are frequently entirely flanked by faults, some of the latter being represented by highly sheared country rock and others being filled by calcite. Although the latest movement along these shears was undoubtedly post mineralisation, the rigid control which they exercise over the distribution of uranium values suggests that mineralisation was controlled by structures following similar lines. The average width of the lode probably does not exceed 3 ft. and, although locally the grade of uranium mineralisation may reach 1% eU_3O_8 or over, radiometric examination underground and over the slumps of broken rock from the workings indicates an average grade between 0.2 and 0.3 percent eU_3O_8. Reserves of this grade of material which could be confidently predicted as being contained in the Mother's Day lode do not exceed 1,000 tons, and there would seem to be little justification for putting the possible reserves at more than twice this amount. Except as a small-scale operation producing tribute ore, the property has therefore no economic significance.

Yellow secondary uranium minerals occur near the surface in the deposit, but the identity of the primary mineral, which contributes the bulk of the radioactivity, has not been proved conclusively. Dallwitz and Roberts suggest that the mineral is davidite-like, of hydrothermal origin, or that there may be two minerals present, one resembling davidite and the other brannerite (Carter 1955). From the similarity in appearance and field relationships between this radioactive rock and that from the nearer Flat Tyre Lode, however, it might be supposed that the uranium mineral would be the same in each case. Consequently, the identity of the Mother's Day mineral should be substantiated by means of X-ray examination.

SKAL

The Skal lease covers one of a group of radioactive deposits in the Paroo Creek area, approximately 25 miles by road north of Mt. Isa. It was held under option by Mt. Isa Mines Ltd. and a competent appraisal of the economic potential of the property was made by the geological department of the mine. Conclusions reached on the basis of costeaning, and diamond drilling to a depth of -200 feet, were that the grade of the deposit was too low to support profitable mining of rather more than 200,000 tons of ore at a grade of 0.18% (f.o.r. Mt. Isa) which was estimated as being contained in a zone of enrichment below the surface. The value of inferred ore was also regarded as being too low to justify the erection of a treatment plant. The property must therefore be relegated to the category of those which could probably produce a few thousand tons of ore exceeding 0.25% U_3O_8 content, by small-scale selective mining, at least to a depth of -200 feet.

Whether the two mineralized shoots at the Skal prospect retain any economic possibilities at greater depth may depend on the correct interpretation of the controlling factors in mineralisation. The radioactive deposits occur within a series of metamorphosed basic lavas, fine-grained siliceous sediments and calcareous sediments in which evidence of structure is masked by fracture cleavage and silicification. The deposits appear to be developed along the flanks of zones of shearing which have been heavily silicified. The uranium mineral, along with abundant calcite and iron oxides, quartz, pyrite, chalcopyrite and traces of galena, was deposited in chemically favourable beds adjacent to the main silicified body. That the main introduction of quartz occurred prior to deposition of calcite, iron oxides, uranium mineral, copper, lead and iron sulphides, and later quartz is well demonstrated by the occurrence of a breccia, which is well-exposed at the northern end of the northern ore-shoot, in which vitreous vein quartz is highly fragmented and recemented by a matrix of fine grained ferruginous and calcareous material containing sulphide minerals and uranium. There would seem to be no reason why these fracture zones, which have formed the loci of mineralisation, should not persist in depth, but from the results of exploration at the Skal lease itself, and at other prospects nearby, it seems more doubtful that the grade of uranium mineralisation over a mineable width will improve.

Examinations of specimens of radioactive rock from the surface, by the U.K. Atomic Energy Division, have shown that the radioactivity at this level is due largely to a yellow-brown secondary mineral occurring in veinlets and stringers in close association with magnetite, quartz, calcite and goethite. X-ray photographs have failed to provide a positive identification of this mineral. The primary mineral has been identified by the C.S.I.R.O. (using X-ray methods) as brannerite, and macroscopic specimens of a refractory uranium mineral, in hematitic, calcareous rock containing chalcopyrite are obtainable in a shallow pit on the northern mineral shoot. Apparently the material presents little difficulty in the extraction of uranium as Mount Isa Mines record that 95% recovery was obtained by using a cold acid leach to remove calcite, followed by a hot acid leach to remove uranium.

HOPEFUL

The radioactive deposit on the Hopeful lease is probably located on the same stratigraphic horizon as those on the Skal. As at the Skal, the uraniferous formation forms a distinct ridge feature. It consists of a fine-grained calcareous rock, heavily impregnated with hematite in which radioactive material is sporadically concentrated. Fracture cleavage has obliterated any evidence of original structure in the metamorphosed sediments and there is little indication of the structive control seen at the Skal deposits, although the type of mineralisation is the same.

Distribution and intensity of radioactivity at the surface shows that the deposit could not be worked profitably because of the patchiness and low grade of uranium mineralisation. Few localities produce ratemeter readings which indicate an equivalent uranium content exceeding 0.1%.

PILE

The lease is located in the same general area as the Skal and Hopeful but about 3 miles to the north-west, and, like the deposits on those other leases, that on the Pile forms a small ridge of outcropping radioactive rocks. Regionally, the occurrence is situated on the western limits of the same south-pitching anticline as that on which the Skal, Hopeful and other deposits occur, and the local succession therefore includes limestone, calcareous sandstone and quartzite (Carter, 1955).

The radioactivity is apparently due to disseminated mineral in a fine-grained calcareous rock which contains abundant hematite. The overall grade as indicated by radiometric inspection is low, but higher-grade zones or leases occur within the mineralised body. This observation is borne out by sampling, a bulk sample obtained by chip sampling over the exposed surfaces (carried out by M.I.M. Ltd.) assaying only 0.06% eU_3O_8. Diamond drilling has shown that the grade does not vary appreciably with depth and on the results of the exploratory work the deposit must be regarded as being sub-economic under present conditions. It is doubtful even whether selective small-scale mining could produce more than a few hundred tons of ore with a grade exceeding 0.2% eU_3O_8. Explanatory drilling carried out by Mt. Isa Mines has also adequately tested the deposit and no further work could be justified.

Controlling factors in the deposition of the mineralised bodies on the Pile lease remain obscure and are probably a combination of fracturing and chemical or lithological control. That transcurrent structures have played a part is suggested by the presence of an offshoot of the mineralised zone which cuts the chloritic schists on the south side of the main deposit. Yet within the hematitic body, fairly sharp radiometric boundaries to high-grade material cannot be related to structural or lithological breaks. Studies of thin sections of uraniferous rock in London, (A.E.D. Report No. 175) show that metamorphism of what was possibly an argillaceous sandstone has produced a rock containing sillimanite and chlorite but consisting mainly of a groundmass of quartz coloured by finely-divided hematite and containing microcline porphyroblasts. Calcite and hematite have been introduced into this rock, the former replacing both quartz and microcline. Oligoclase and orthoclase are also recorded from the siliceous groundmass. The radioactive mineral in these specimens is entirely secondary, being tentatively identified as carnotite. Brannerite has been identified by McAndrew and Edwards (Carter 1955) as the primary uranium mineral, and mineralogically the Pile deposit can therefore be classified with those of the Skal and Hopeful leases.

DUKE

Two radioactive deposits occur within the Duke lease which is located in the Calton Hills area about 47 miles N.N.E. of Mt. Isa. The more southerly of the two bodies is developed along the southern flank of a large quartz below trending about 120° east of north, a direction which is almost normal to the strike of bedding in the basic country rocks. The altered lavas generally exhibit blocky fracture cleavage. Uranium mineralisation is restricted largely to a zone of shearing in the basic rock, which is also locally grouted by quartz, the most highly radioactive material being a compact black rock in which the uranium mineral must be very finely disseminated. No mineragraphic work has been carried out on this material however, and the nature of the uranium mineral cannot be determined macroscopically, but it is suggested that the primary mineral is of the same type as that occurring in the Skal and Pile deposits i.e. brannerite type.

Dimensions of the deposit have been measured by J.H. Brooks. It is 82 feet long with a maximum width of 13 feet and an average width of about 5 feet. These surface measurements, taken in conjunction with the grade of uranium mineralisation as suggested by ratemeter inspection, show that the deposit cannot be considered as an economic source of uranium ore.

The northern deposit, which is situated a few yards from the northern limit of the quartz blow, is elongated in a direction about 40° east of north i.e. at a wide angle to the trend of the southern deposit. It has a length of 40 feet and swells to a maximum width of 14 feet, though generally it has a width of between 6 and 10 feet. It has been partly explored by means of costeans and two shallow pits. Radiometric examination shows that this deposit, although smaller, is of higher grade than the southern body and that the uranium occurs within a more compact and well-defined structure, dipping steeply to the south-east and bounded on the footwall side by a strong shear. The degree of uranium mineralisation is not consistent across the structure, but a zone or lens of high-grade material (probably exceeding 0.4% eU_3O_8 over 3 or 4 feet) appears to persist for more than 20 feet along the hanging-wall side of the lode. A lens of radioactive material of similar grade occurs on the footwall in the northern pit but it does not persist to the southern pit. From surface evidence therefore, there is no reason to suppose that this deposit could produce more than two or three thousand tons of ore exceeding a grade of 0.25% eU_3O_8, while its remoteness from Mt. Isa must seriously detract from its value as a small gouging prospect.

The most intensely radioactive rock within the mineralised structure is a fine-grained, strongly hematised siliceous and calcareous material which is grouted by numerous fine calcite veinlets and dark dolomitic material along fractures. Of different aspect is the active zone along the hanging wall, which is composed of a dark grey massive rock of indeterminate composition which grades into a more schistose variety, paler in colour and of lower radioactivity, in the central zone of the lode. Small amounts of secondary uranium minerals are present as coatings on fracture surfaces of the hematite rock, but the principal source of radioactivity must be a very finely disseminated primary mineral, probably of a refractory nature. The deposit would appear to have been developed along a line of shearing in the basic country rocks, since there is no apparent lithological control of mineralisation. The strength of this shear zone would be the only factor on which further exploration of the deposit in depth could be recommended but the records of other similar deposits in the area show that their limited extent is quite general.

BATMAN

Situated close to the Duke lease, the radioactive deposit on the Batman is similar in most respects to those described above. Uranium mineralisation is intimately associated with calcareous and siliceous hematised lode material developed along structural breaks in metamorphosed lavas. Radioactivity of variable intensity can be traced over a distance of about 160 ft. and over widths ranging from 1.5 ft. at the south-eastern extremity to a maximum of 10 or 12 feet in the region of the prospect shaft about 110 ft. further to the north-west. Ratemeter readings indicate that locally, and over widths not exceeding 2 feet, the grade reaches values between 0.5 and 1.0% eU_3O_8 but that the equivalent urania content of the major part of the exposed lode is less than 0.2%. A chip sample taken by J. Brooks, over what he considered to be the highest grade material, gave an assay of 0.14% eU_3O_8 over a lode width of 10 feet. The deposit therefore lacks the requirements of grade and tonnage necessary for extraction of urania ore to be profitable, as well as suffering from the same disadvantages as the Duke deposits, namely remoteness and the improbability of being able to produce a higher grade ore by preconcentration.

The uraniferous zone is less well-defined than that of the northern deposit on the Duke lease. The average strike of the radioactive anomalies exposed in costeans is about 70° west of north, but local trends may indicate that the deposit is made up of a number of lenses arranged en echelon along a line with this east-north-easterly trend. Exploratory work in the form of costeaning and shaft sinking has been indifferently directed towards elucidation of the structure, but no further work could be recommended on the strength of the grade of uranium mineralisation or the areal extent of the deposit.

QUEEN'S GIFT AND QUEEN'S GIFT NO.2.

The Queen's Gift radioactive deposits are located about 45 miles north-north-west of Mt. Isa within the succession of volcanic and sedimentary rocks which are known as the Eastern Creek Volcanics. Several anomalously radioactive areas occur on the Queen's Gift lease (of which one was examined) while one deposit of larger dimensions was inspected on Queen's Gift No.2.

The radioactive zones on the Queen's Gift leases are very similar to those on the Duke and Batman, with which they can no doubt be related genetically. Uranium mineralisation is for the most part restricted to strongly hematitic, siliceous, and to some extent calcareous, bodies distributed along the flanks of quartz blows which form the crests of ridges. This hematite rock is rather more siliceous than that from the Duke but it is similarly cut by numerous fine calcite veinlets. Traces of chalcopyrite occur also in the fractures in the hematitic matter from the Queen's Gift.

In the deposit which was inspected on the Queen's Gift lease the uraniferous hematite rock occurs in irregular bodies on lenses which have a general alignment of about 11° east of north. This direction is transcurrent to the very marked cleavage direction of the volcanic country rock, although the irregular outline of the mineralised area may be due to subsidiary control exercised by the cleavage. The overall trend of the mineralised zone is attributed to the influence of major fractures during deposition and one such line of shearing can be seen at outcrop with narrow zone of uraniferous hematite along each side of it.

The larger radioactive deposit on Queen's Gift No.2 occurs in close association with a siliceous reef which is again flanked by a hematite zone in which the uranium occurs. This occurrence is situated about 1000 feet southwards from the deposit inspected on the Queen's Gift. It has a length of rather more than 100 feet and an average width of about 10 feet, the alignment again being slightly transgressive to the cleavage direction of the basic country rock. The core of the siliceous formation is of white or pinkish quartz which, unlike the quartz blow on the Duke lease or further north on the Queen's Gift, contains uranium values. There is evidence of brecciation and recementing of this siliceous material, suggesting that there have been two generations of mineralisation, iron, uranium and possibly traces of copper having been introduced during the second phase, as is apparently the case at the Skal deposit already described.

Radiometric values obtained over the surface of the Queen's Gift deposits indicate an average grade of less than 0.1% eU_3O_8 while the highest reading recorded represents a urania content of only about 0.2%, over a very small area. J. Brooks has taken chip samples from the deposits, all of which assayed less than 0.15% eU_3O_8. This grade is, of course, too low to support economic mining of the Queen's Gift deposits and there are no high-grade zones on which selective minging could be practised. As the deposits are naturally well exposed, no further information can be obtained by surface prospecting, and exploration in depth is not warranted.

TINBOLL

The principal mineralised formation which occurs on the Tinboll leases has a strike length of about 2,500 feet and a width varying from 6 to 25 feet, and it exhibits remarkably persistent radiometric anomalies along the whole of the exposed length. The low level of gamma-ray intensity recorded at the surface was originally assumed to be due to leaching of uranium by ground waters and the possibility of an improvement of grade in depth made this deposit an extremely promising one.

Shaft sinking and diamond drilling, however, proved that values below the surface were not appreciably higher than those at outcrop and it could only be supposed that, apart from local higher-grade concentrations of secondary minerals, uranium had either become "fixed" in the ferruginous material of the gossanous outcrop, a phenomenon not unknown in the writer's experience, or that the uranium mineral was refractory. Examination of a specimen of radioactive material from the surface (A.E.D. Report No.175) has confirmed that the activity is due partly to meta-torbernite and partly to radioactive elements adsorbed by the secondary iron minerals. Movement of uranium within the zone of oxidation appears to have been quite restricted therefore, an observation which laboratory studies have substantiated insofar as they suggest that meta-torbernite may have been derived in situ from primary uraninite. Thus, it can be assumed that grade at the surface is a reasonably good indication of probable grade in depth, and considering the great strike length over which no material of possible ore grade occurs, it seems fairly certain that deeper drilling than has been carried out already will be unlikely to discover similar grade ore. Except where local small deposits of secondary minerals occur, ratemeter readings over the outcrop of the mineralised formation and over broken rock from the 90 foot shaft, indicate that the equivalent urania content is consistently lower than 0.1% and frequently less than 0.05%.

It has been pointed out already (Carter, 1955) that movement has occurred along the strike of the interbedded lavas and sediments, which form the country rocks near the deposit, resulting in small-scale drag folding. That this drag folding has had some influence on both uranium and copper mineralisation is indicated by the fact that the highest uranium values occur about the shaft where drag folding is apparently most intense. Specimens from the shaft show marked concentration of sulphide minerals in the small folds.

Microscopic examination of radioactive specimens (A.E.D. Report No. 175) shows that the mineralised rock is a hydrothermally altered sediment which has been further metamorphosed until the original rock has been completely replaced. One specimen consists chiefly of barite and magnetite, with sphalerite, pyrite and subordinate chalcopyrite and rare covellite. Crystals of albite are also recorded. Fluorite replaces barite and takes on a deep purple colouration around minute inclusions of an opaque mineral which appears to be cube-shaped and has a reflectivity similar to that of uraninite. It seems reasonable to suppose, therefore, that the deposit was formed by hydrothermal mineralisation of a lithologically favourable host rock along a line of shearing and intra-formational contortion in what must have been a slightly incompetent bed lying between more competent formations.

MARIPOSA

Radioactive deposits on the Mariposa leases, which are located about 64 miles south of Cloncurry in the Mt. Cobalt area, are amongst those of most recent discovery in the Mt. Isa-Cloncurry field. They have caused what appears to be unwarranted enthusiasm amongst local mining interests, probably because of the small but high-grade concentration of secondary minerals which occurs at one of the two prospects on the property. To date, however, only small-scale exploration in the form of costeaning has been carried out.

The two deposits occur within the same horizon of a series of fine-grained siliceous rocks and carbonaceous slate. A band of hematite rock which forms an outcropping feature to the west of the mineralised formation constitutes a good marker bed from which it can be seen that a flexure occurs between the deposits which offsets the southern one to the east. The general trend of the bedding is about N. 30°E. but in the vicinity of the southern occurrence the beds are striking about 25° west of north.

The southern anomaly is due to the presence of green secondary uranium mineral distributed throughout fine-grained banded quartzite and carbonaceous shale, over a width of about 8 ft. Marked concentration of meta-torbernite occurs locally along the sheared contact between the siliceous rock and the slates, which has a dip of 60° to the east, where the surfaces of fragmented quartzite are liberally coated with the secondary mineral. Ratemeter readings taken along the sheared zone indicate that equivalent urania content approached 1 percent over a few inches laterally and vertically. Values fall off rapidly to the west into the siliceous rock but they are maintained, at a level probably of the order of 0.2% eU_3O_8, over a width of 5 or 6 feet into the slate on the eastern or hanging wall of the shear. This disposition of uranium mineral shows fairly conclusively that deposition has been effected by circulating ground waters, the open structure of the fracture, along which they were introduced, and of the slates, being more favourable for precipitation of uranium minerals than the massive, compact quartzitic rock. Exploratory work aimed at location of the primary source of the uranium in the environs of this deposit is not considered to be warranted and it is probable that the deposit could produce only a few tons of secondary ore averaging above 0.25% eU_3O_8. Along the strike to the north and south of this pocket of mineralisation no indications of similar deposits is evident, although they may occur in the sub-surface zone of oxidation. To locate and mine them would be economically impracticable.

A second radioactive deposit is located five or six hundred yards north of the first and may well be a representative of the source of uranium which gave rise to the secondary deposit at the latter. It forms a small cliff outcrop below the crest of a ridge, trending about N. 25°E, i.e. parallel to the bedding, and with a length of 125 ft. and a maximum width of 20 ft.

Radioactivity is confined largely to a wide, apparently lenticular, ferruginous body of doubtful origin. E.K. Carter has suggested (personal communication) that such structures may be due to local overthrusting caused by adjustment along the limb of an overturned anticline. That movement of this nature has in fact taken place is indicated by the presence in the ferruginous body of large fragments of banded siltstone or fine-grained sandstone similar to the sediments adjacent to it, and by extensive slickensiding within the structure. For the most part, however, and particularly on the footwall, structure is masked by the abundant ferruginous matter, which appears to form the matrix of the formation. Locally, brecciated quartzitic material is seen to be recemented by hematite which is regarded as having been introduced along with uranium and copper of which traces occur in the form of malachite staining. Radioactivity is associated with the iron minerals, ratemeter readings being rather constant over much of the outcrop and suggesting a grade ranging between 0.05 and 0.1% eU_3O_8. No discrete uranium minerals were located, however, and it is suggested that a large proportion of the radioactivity is due to adsorption of radioactive elements by the iron minerals. Although some leaching of uranium has probably occurred, it is not to be expected that the grade in depth will be appreciably higher than that at the surface, in view of the formation of radioactive elements in the iron-rich outcrop, whether such elements include uranium or whether they are entirely daugter products from which uranium has been leached. Considering its small areal extent, also, the radioactive structure probably does not persist to any great depth. The grade and tonnage are therefore not sufficiently high to constitute an economic uranium deposit.

HELAFELLS

The Helafells leases, and the nearby Sierra Rada lease, are situated about 20 miles south of Cloncurry, in hilly country which makes them difficult of access by motor vehicle. In the absence of a guide, some difficulty was experience in locating the leases and only one radioactive occurrence on the Helafells lease was examined briefly. It is believed to be the most significant deposit, however.

This anomaly occurs near the crest of a ridge, in a **ferruginous** body markedly similar to that described above on the Mariposa lease, and developed in slaty, siliceous sediments which on the regional stratigraphic map are referred to the same group of undifferentiated rocks as those of the Mariposa succession. The radioactive body has a length of 60 ft., a true width of about 8 ft, a strike of approximately N. 20°W. and an apparently shallow dip to the east. Coarse fragments of slate are cemented by a hematitic matrix which may be highly siliceous. Grouting by quartz is common and boxworks of indeterminate origin (not from sulphides) occur in the iron-rich material. As at the Mariposa occurrence, radioactivity of low intensity is associated with the hematitic matter, being concentrated slightly towards the footwall. Here, however, small amounts of secondary mineral (probably meta-torbernite) occur in cavities and along fractures. The highest ratemeter reading recorded is indicative of a grade of about 0.1% eU_3O_8, but the overall grade is much lower than this.

The officials of the company holding the Helafells leases (Metals Exploration N.L.) are optimistic of the possibilities of finding workable uranium deposits there, and they intend to drill the structures. The writer does not regard them as having any supply significance, however, and believes that the only value of diamond drilling will be to furnish useful information regarding the structure, composition and origin of the unusual type of uranium deposit.

MILO

Because they were discovered towards the end of the Queensland uranium "rush" in 1954, the radioactive occurrences on the Milo leases have not been explored to the same extent as others which show less favourable features. Mt. Isa Mines Ltd. undertook a limited amount of costeaning and shallow shaft-sinking on a deposit of secondary uranium mineral, but, although the company relinquished its option on the basis of results from those near-surface excavations, the potential of the leases cannot be said to have been adequately tested.

The Milo leases lie about 22 miles west of Cloncurry and 10 miles east of the Mary Kathleen rare earth-uranium occurrences. Country rocks are of black carbonaceous shales belonging to the Corella Group and their strike in this localtiy is roughly east-west. Dips are steep to vertical. So far as can be seen without detailed mapping, the shales are cut by faults which have a general north-easterly trend, and one which occurs close to the eastern side of the main body of secondary mineral on the lease appears to have offset the eastern block to the south.

Exploratory work has been restricted largely to a deposit of metatorbernite which is developed within a sill-like formation of highly kaolinised rock, apparently of igneous origin, striking north-east and dipping at about 45° to the south-east. The uranium mineral is disseminated throughout the porous kaolinite and concentrated along fractures and in cavities as well-formed bright green crystals. Thin-section examination of the host rock (carried out by M.I.M. Ltd.) show that it is a gritty clay containing very little iron, the clay mineral probably being the variety of kaolinite, nacrite. Felspars are mostly kaolinised but undecomposed crystals have been identified as albite-oligoclase. The micro-texture is reported as being that of a felspar porphyry. The kaolinised formation is cut by numerous shears, some of them impersistent, which have dips ranging between about 20° and 60° to the south-east.

Radiometric traversing along costeans which have been cut normal to the strike of the sill shows the presence of lenses of high grade mineralisation within a roughly lenticular area of lower grade. Highest grade material is most abundant towards, but not on, the hanging wall of the kaolinised structure, and ratemeter readings taken from a shallow adit drive in one of these high zones indicate local concentrations exceeding a urania content of 1% and widths of up to three feet carrying material of between 0.5 and 1 percent eU308. In spite of the locally spectacular display of secondary minerals, however, sampling by M.I.M. has shown that the overall grade of the uraniferous kaolinite is not high. The company estimates that the deposit contains 350 tons per vertical foot of material of average grade 0.05% eU308, or 90 tons per foot at a grade of 0.16% eU O . High-grade material is currently being 'gouged' by the owners of the property, who are attempting to hand-pick a concentrate assaying above 1% U308 equivalent, for shipment to Rum Jungle. It was suggested that mining should be continued down the underlie of the kaolinised body, in order that information regarding the extension in depth of the secondary deposit could be obtained.

For lack of evidence to the contrary, it may be assumed that this uranium deposit has been formed by deposition of secondary mineral in the kaolinite by ground waters enriched in uranium ion, since the porous rock forms a most favourable medium for such a process. It is suggested that the source of the uranium ion is in the ferruginous matter, of somewhat similar aspect to that on the Mariposa and Helafells leases, which is extensively developed in the shales to the east of the meta-torbernite occurrence. That this may be true is further indicated by the occurrence, some 150 ft. to the north-east, of a separate body of limonitic rock on the footwall (and downhill) side of which secondary uranium mineral has been deposited both in kaolinitic rock and in the ferruginous body itself. Patchy uranium mineralisation is also present in association with the limonitic formation which persists for several hundred feet along the hillside eastwards from the kaolinised sill. Along the ridge west of the sill, there is a narrower but more defined limonitic gossan which apparently represents the outcrop of a steeply-dipping mineralised bed within the shales. Well developed boxworks occur within this horizon, which in places is flanked by hematised shales, while slight radioactivity is associated with it. Leaching has obviously been intense from these extensive ferruginous deposits and, as stated, they may well have been the source of the uranium subsequently redeposited as secondaries. There are also indications of copper, lead and zinc from these deposits.

From the above considerations it is apparent that several high-grade, but probably small, deposits of secondary uranium minerals may occur along the flanks of the ridges east and west of the known deposit, but this type of deposit is not always readily detected from the surface. If the source of the secondary uranium is in fact the limonitic formations, then drilling to determine the grade of those deposits below the leached zone might be warranted. In any case, detailed geological mapping and radiometric gridding would establish the distribution of uranium in relation to existing structure and provide a basis on which further exploration could be planned, should finance become available for such a project.

PELICAN

This property is located about 25 miles south-south-east of the Mary Kathleen deposits, the host rocks being calc-silicate types and sandy and carbonaceous ribbon shales which are highly contorted against the flanks of a regional fault which is quartz-filled, forming a prominent ridge. The fault is reputed to be traceable over a distance of 15 miles.

The bulk of the radioactivity is restricted to the western side of the fault (hangingwall side) and is due to dispersions of secondary mineral, mainly in calc-silicate rocks, frequently just west of, or at, their junction with the carbonaceous slates. One small anomaly occupies the crestal region of a small anticline but there is generally no evidence of a structural control of the secondary mineralisation, deposition of which has probably been effected merely because of the greater porosity of the calc-silicate formation. Secondary copper staining is also widespread on the west side of the fault but its distribution is not apparently sympathetic with that of the uranium minerals. Uranium mineralisation is of trace grade except for small, scattered concentrations, one of which contains small veinlets of a yellow mineral which has been identified by X-ray methods as uranophane. Although the primary source of the uranium is not apparent, this uranium prospect is regarded as having no economic potential.

OTHER PROPERTIES

ELAINE DOROTHY

Numerous small and low-intensity radiometric anomalies occur within the property, which is located about the nose of the overturned syncline along the western limits of which the Mary Kathleen deposits occur. Some of the anomalies are associated with a folded band of garnetite which outcrops round the shoulder of a bill and which has been prospected by at least three diamond drill holes, with indifferent results. Inspection of core from one radioactive intersection showed the presence of a few coarse grains of a black mineral which resembles davidite. Uraninite has also been reported. Drilling of a folded structure further north has also intersected discontinuous radioactive zones, the highest grade material containing 0.31% eU_3O_8 over 5 ft. A nearby hole cut material assaying 0.19% eU_3O_8 over a small width, while a further one close by failed to intersect uranium mineralisation. Drilling is being continued on the property but there is no indication of the presence of a large body of radioactive rock; and if laboratory tests confirm that the uranium mineral is davidite, it would seem unlikely that more than patchy mineralisation will be discovered. Its proximity to the Mary Kathleen deposits might seem to enhance the prospects at the Elaine Dorothy, but the structures which the writer believes to have influenced mineralisation at the former are nowhere in evidence over those parts of the Elaine Dorothy lea[illegible] which were examined.

NEW RING

This lease contains a small radioactive deposit, of no economic significance, which occurs in altered basic rocks and deposition of which may have been controlled by fracturing. The grade is such that the few tons of radioactive rock contained by the deposit could not be extracted profitably, even by small-scale selective mining methods.

EASTER EGG

A cursory examination of the radioactive occurrences on the Easter Egg lease was sufficient to indicate that they do not constitute a workable source of uranium ore. High grade material (up to an indicated grade of about 0.5% eU_3O_8) is erratically distributed but the overall grade of the radioactive lenses is probably well below 0.2 percent. Emplacement of the deposit appears to be controlled by a system of intersecting fractures. A specimen examined by the Atomic Energy Division in London was of a very fine-grained schistose rock consisting of quartz and hornblende with abundant calcite, apatite, magnetite, hematite and sphene, and minor quantities of felspar and allanite. Radioactivity was due almost entirely to small, discrete spherical cavities containing a yellow secondary mineral believed to be gummite. Similarities between the mineral assemblages and mode of occurrence suggest that the Easter Egg deposit is genetically related to those of the Flat Tyre and Mother's Day leases, and the primary uranium mineral may therefore be uraninite.

HOT ROCKS

Because of its marked similarity to the Tinboll deposit, that occurring on the Hot Rocks lease can be confidently assessed as being of too low grade to support extraction of uranium, since the grade at the surface is very probably a good indication of that in depth.

APPRAISAL OF THE FIELD

Of considerable advantage in an assessment of the supply potential of the Mt. Isa-Cloncurry uranium field is the fact that a large majority of the radioactive deposits outcrop and in fact frequently produce prominent topographic features. A further unusual characteristic is that the grade of uranium mineralisation at the surface is frequently an excellent guide to the probable order of grade in depth. Exceptions to these rules are the deposits of secondary mineral at the Milo and Mariposa leases and possibly the gossanous formations on the former. Allowing some assumptions regarding the probable extension of mineralisation in depth, therefore, it would be possible, by a programme of measuring and sampling on the surface, to obtain a reasonably accurate estimate of the minimum tonnages and grade of radioactive material contained in any or all of the deposits. From evidence provided by exploratory operations on several of the deposits it would appear safe to assume a continuation in depth of at least half the strike length of tabular deposits such as those which occur in the western part of the district, although little is as yet known of the habits of the "ferruginous deposits" in the east.

A detailed assessment such as the above could not be made during a comparatively brief inspection of only a few deposits, but much relevant information, from which estimates could be made, must be on record at the Queensland Geological Survey Headquarters, as a result of examinations carried out in respect of reward claims.

Considering that the properties which were examined during the period under review are believed to be the most important in the area, it appears to be certain that, with the possible exceptions of the Mary Kathleen and the Counter, no deposit has yet been discovered which, alone, contains sufficient tonnage of high-grade material to justify the erection of a treatment plant. Mt. Isa Mines investigations at the Skal lease show conclusively that, although this deposit contains comparatively large tonnages of mineralised rock, the overall grade is too low to support mining and haulage to Mt. Isa, yet the property is reasonably well situated compared to many others.

There remains the possible alternative, therefore, of a number of properties being operated on a small scale for the extraction of higher-grade ore to supply a central treatment plant. Preconcentration of ore before its removal from a property would seem to be impossible because of the finely disseminated nature of the uranium mineral in most deposits; therefore the success of such a plant would depend entirely on the amount of ore of high grade, say 0.2% U_3O_8, which could be won from the deposits. The variable nature of the uranium mineralisation throughout the district would also constitute a difficulty but, on the other hand, the principal occurrences of material which exceeds 0.2% eU_3O_8 are those in the western part of the field, at least until further information is available on the ferruginous type of deposit in the east. The types of mineralisation in the deposits north and north-west of Mt. Isa are probably sufficiently alike for the development of a treatment method to treat them all. The main variable appears to be calcite. If a satisfactory and inexpensive method of treatment can be found for the ore in the Counter deposit, it might be possible to treat ore from the other properties in this area along with it, after pre-treatment to remove carbonate, which is almost lacking from Counter ore, in which case a significant tonnage might be available. The writer is not qualified to give an opinion on these treatment possibilities, however, but extraction research now being undertaken by Professor White's department at the University of Queensland should provide the necessary information. If a suitable extraction method is evolved for treatment of ore from this "western" group of deposits, collation of all available information to provide estimates of probable tonnages and grades should present no difficulty.

CONCLUSIONS

Uranium deposits in the Mt. Isa-Cloncurry district may be classified on mineralogical evidence into six groups. When they are plotted on the geological map a rough spatial and stratigraphic grouping is also suggested.

With the exception of the Mary Kathleen and possibly of the Counter deposits, the average grade of the deposits is too low to support mining and treatment. In the group of deposits located to the north and north-west of Mt. Isa, however, small tonnages of material containing more than 0.2% eU_3O_8 might be recoverable by selective mining if a method could be evolved for treatment of this type of ore in conjunction with that of the Counter at a centrally situated treatment plant. Without a large assured supply of ore from the Counter, installation of such a plant would probably not be feasible on the strength of indicated reserves of mineable ore at the other properties. Further treatment research is therefore necessary, as well as an attempt to estimate the minimum tonnage of higher-grade ore which could be obtained from the western group of deposits. The latter undertaking should be facilitated by the fact that surface grade of most of the deposits appears to be an indication of the grade in depth.