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GUIDE TO PROSPECTING FOR URANIUM, DARWIN-KATHERINE AREA, NORTHERN TERRITORY

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CANBERRA.

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INTRODUCTION

(The following notes should be read in conjunction with Pamphlet No. 3 (Radioactive Mineral Deposits) of the Bureau of Mineral Resources, Geology and Geophysics and a copy of the Mineral Map (NT32B-4) would greatly aid in their understanding.)

Since 1949 a considerable amount of geological and geophysical investigation as well as diamond drilling and some underground development has been undertaken in the search for uranium ore in the Darwin-Katherine region, and in the course of this work information has been gained which, it is thought, may be of interest to prospectors and companies who are now beginning to pay considerable attention to the possibilities of the area, but have had little or no experience of prospecting for uranium in the Katherine-Darwin region.

Investigations of the area by the Bureau, by private companies, and by prospectors is now proceeding more vigorously than ever, and without doubt a good deal more remains to be found out concerning the uranium deposits of this province. In these circumstances the notes supplied below are put forward tentatively as being some facts known to the present writer at this time (July, 1953) as well as some more controversial opinions. It is expected that more information will be made available as the investigation proceeds.

SIGNIFICANCE OF GRANITES.

The broad granite distribution in the Darwin-Katherine region, and the principal mineral-bearing localities, are shown on the Mineral Map (NT32B-4) which is available from the Mines Department of the Northern Territory and from the Bureau.

The limited airborne scintillometer investigations so far carried out in this region have shown that certain granitic areas are unusually radioactive whereas others are not. In general, the discontinuous granitic masses extending from Rum Jungle south-easterly to the Edith River are found to be radioactive, and are thought to be of much the same age. Commonly these granitic masses occupy domal structures in the pre-Cambrian sediments, although the Edith-Ferguson granites are commonly quite transgressive to the surrounding sediments.

In contrast with this granitic belt is that known as the Litchfield Granite (Noakes, 1949) which extends in a southerly direction from the vicinity of Bynoe Harbour to about Lat. 14° S. The small amount of investigation which has so far been carried out appears to indicate that this granite is not as radioactive as is the group described above and there is some evidence also that this granite is quite different in type and may be considerably older. It is characterized by masses of pegmatites which contain tin, tantalum, and columbium, and it is not uncommon to find in other parts of the world that, where this is the case, no important deposits of uranium occur. However, uneconomic quantities of uranium are commonly present in the pegmatite dykes.

The important Rum Jungle deposits mostly occur within about half a mile of the Rum Jungle granite, which itself is quite radioactive; however, no deposits of economic size have yet been found within the granitic mass itself and search is largely concentrated in the surrounding sediments.

In the Edith River and Ferguson River areas, belts of discontinuous shears have been found to contain uranium - the uranium commonly being associated with quartz and hematite. It has previously been stated that the Ferguson and Edith Granites are somewhat different from those occurring around Rum Jungle and Brocks Creek for example, and it has been found, in fact, that there are two markedly different types of granite in the Edith-Ferguson region. One of these granites is a massive coarse-grained rock in which large pink crystals of felspar are clearly visible. The second type of granite is finer-grained and is possibly older than the coarse granite. A porphyritic granite intermediate in texture between the two mentioned above also occurs in places. Shearing has occurred within the granites in certain areas but at the time of writing only narrow veinlets of radioactive material have been found in these shears.

In Canada, in South Australia, and in several other parts of the world, important uranium deposits have been found in banded granitic gneisses, which shows that granitic areas cannot be ruled out for the occurrence of this metal; but it is general experience that, where a massive homogeneous granitic body occurs, important deposits are not found within the granite, and are more likely to be found within the surrounding sediments. Exceptions to this do occur, however, and an interesting deposit has recently been found in South Australia in massive granite. Highly radioactive granite may be a guide to ore occurring in its vicinity.

SIGNIFICANCE OF SEDIMENTARY AND VOLCANIC ROCK TYPES

In both the Rum Jungle and Brocks Creek districts uranium, copper, lead and zinc are consistently found in a group of shales or slates which are in part graphitic. Around Rum Jungle ore commonly occurs in the graphitic shales where they overlie a rock which has been called a quartz-breccia because at the surface it is seen to consist of fragments of quartzite and quartz with an angular appearance. There is some suggestion, from drilling, that at depth this rock may be a dolomite. It is considered by the writer to be probable that much of the brecciation in this rock has been caused by movement and that much of the quartz has been introduced. The presence of this rock, which, on account of its resistant nature, commonly forms small hills and is easily identifiable, is thought to be a useful guide to ore. It may be worth mentioning that a siliceous dolomite is both underlain and overlain by copper- cobalt- uranium-bearing beds in the important Katanga metalliferous province of the Belgian Congo. For this reason it is a most important guide to ore in that area.

It has also been noted both at Coronation Hill and near Katherine that volcanic rocks (rhyolites & basalts) are closely associated with the newly discovered uranium deposits, and B.P. Walpole (personal communication) has found that, in the Coronation region, the rhyolite is radioactive, even some miles distant from the known uranium deposit.

It is thus being found by experience that uranium ore may be found by following sedimentary beds or volcanic flows containing slight amounts of uranium in disseminated form. Some geologists (Sullivan, 1949) would consider that the economic deposits were formed by the concentration into faults, shears, folds etc. (structural traps) of some of the uranium originally disseminated in sediments and volcanic flows (source rocks). The concentration is thought by the writer to require heat, and is believed to be mainly effected during the formation of granite. It is for this reason that the proximity of granite is important. However, there is evidence that uranium may be concentrated in rocks not affected by granite, and this appears to be the case to some extent in the Rum Jungle province.

It is hoped that the Bureau will be able to make available at regular intervals geological maps showing the distribution of these apparently favourable formations, as well as the known showings of mineralization and such evidence as exists of the occurrence of radioactive materials.

SIGNIFICANCE OF STRUCTURES.

Available evidence indicates that payable ore exists in the favourable formations only where drag folding or faulting has deformed them and allowed the concentration of ore: at Rum Jungle, deposits occur along the axes of folds, and some of the best ore is found in drag-folded slate. At Browns Deposit, Rum Jungle, the graphitic slate appears to have been dragged over the underlying resistant limestone.

It is thus important for the prospector to note changes in the strike of beds and other signs of folding and faulting.

LEACHED OUTCROPS OF URANIUM DEPOSITS.

The Katherine-Darwin area has a sharply defined, wet season, during which 40 to 60 inches of rain may fall, followed by a long dry season during which there is practically no rain. Temperatures are high. The climate, combined with a long period of peneplanation, has produced deep oxidation and leaching, and it is of the utmost importance to those searching for uranium deposits to attempt to understand the significance of the various types of leached outcrops.

White's Type, Rum Jungle.

At the surface White's Deposit at Rum Jungle was unimpressive. Carbonaceous shales, stained by copper carbonates (mostly malachite), could be seen in a pit about 8 ft. deep, and after considerable search a few specimens stained with yellow uranium ochres were also found. Radiometric investigations by geiger counter at the surface disclosed that an area of about 1400 square feet was radioactive to the extent of about four times background; within this, a smaller area gave a count of about eight times background.

This deposit is situated quite close to the East Finiss River and the water-table occurred at a depth of only about 28 ft. Below this the copper-stained schist passed into ore containing essentially chalcopyrite and uraninite with some pyrite, chalcocite, and bornite. Only a few veinlets of quartz are commonly present and the ore consists essentially of shale impregnated with copper-and uranium-bearing minerals. Some of the copper-stained schist at the surface, which showed only faint radioactive, is now known to represent, in the primary zone, highly payable copper-uranium ore.

The above points, whatever their explanation, are important for those attempting to assess newly discovered outcrops; but the writer's tentative explanation givěn below may be of some significance.

The oxidation of pyrite-chalcopyrite ore gives rise to the generation of sulphuric acid, in which uraninite is readily soluble. During the wet season uranium and copper are carried away in ground water as acid solutions.

If alkaline rocks such as limestone are present, acid solutions may be quickly neutralized and their power to transport uranium and copper is distinctly limited. In the case of White's Deposit, however, the shale environment does not neutralize acid solutions, and, in fact, tests of the ground water in the vicinity of this deposit have shown that they are highly acid.

The transportation of dissolved uranium and copper is believed to take place mainly in the wet season. In the dry season water containing some uranium and copper in solution is drawn towards the surface where it evaporates leaving thin films of uranium ochres. The amount of transportation of this type which takes place varies from season to season and it has now been found that areas in the Rum Jungle district which showed a radioactivity corresponding to say four times background in 1950 and 1951 might show a count of eight times background with the same instrument in 1952. These changes are thought to be due to the differences in seasonal conditions in these years.

A further point of possible interest in connection with the interpretation of a deposit such as that at White's, is that this deposit cropped out close to present creek level. Physiographic evidence shows that much of the Katherine-Darwin district was formerly a peneplain, the level of which is now marked by a number of flat-topped hills or mesas, many of them capped by laterite. During the present erosion cycle, creeks have cut down through this old peneplain, and, in some places, have eroded away most of the 150 to 250 ft. of thickness of oxidized and leached soil and rock which normally underlie the lateritized peneplain surface.

This means that, near present creeks, primary ore may exist at no great distance below the surface, and signs of the presence of mineralization may be far more plentiful than they would be on the peneplain where deep oxidation still exists. This was found by the writer to be the case in Northern Rhodesia, where many important copper discoveries were made close to creeks, although it was extremely difficult to detect at the surface the extension of these deposits beneath the lateritized plateau: these were found only by drilling based on geological mapping.

<u>Hematite-Limonite Gossans.</u>

The outcrops of deposits such as White's contain very little of what could be described as typical ferruginous gossan, and, superficially, it is difficult to decide whether or not the outcrop really represents the oxidized equivalent of primary ore.

A contrasting type of deposit in the Katherine-Darwin province is that in which, at the surface, oxidation produces accumulation of iron oxide minerals. These gossans may, in places, contain up to 50 per cent. iron, and commonly contain both hematite and limonite, which may be botryoidal in type. The botryoidal hematite and limonite are characteristically produced by precipitation from solution. Their presence means that the iron has not formed in situ but is what Blanchard (1939) calls "transported iron".

In the Brocks Creek district, where typical deposits of this type were investigated (Sullivan and Iten, 1952), the more massive hematite-limonite deposits were found to be underlain by lime-rich rocks containing about 5 per cent. pyrite and, in places, small amounts of chalcopyrite.

Similar surficial deposits are known to exist in the Brodribb area on the northern side of the Rum Jungle Granite;

these are radioactive, in places, to the extent of 20 to 30 times background by ratemeter.

Near Mt. Fitch in the Rum Jungle district, nodular masses of limonite and hematite were also found to be radioactive but when these were trenched by means of bulldozers they were found to be underlain by leached limestone containing a very small proportion of iron and only minor radioactivity.

This type of deposit is therefore a capping resulting from the accumulation at the surface of iron which occurs only in a disseminated form, commonly as pyrite, in the underlying rock. The important point from the uranium prospector's point of view is that, during the accumulation of this iron at the surface, there also appears to be surficial accumulation of uranium (Matheson, 1953). These iron-rich beds may thus give quite spectacular signs of radioactivity, but they may be underlain by extremely poor uranium deposits. This point has not yet been proved in the Brodribb area, but at Mt. Painter, South Australia, flat sheets of hematite 1 to 3 feet in thickness, occurring at the surface, are commonly found to contain quite appreciable quantities of uranium whereas they are underlain only by very low-grade pyritic mineralization. The evidence of laterites described below bears out the writer's view that where secondary iron oxide minerals accumulate at the surface, there is a tendency for uranium to accumulate with them.

Laterites.

A considerable number of the radiometric anomalies detected by the airborne scintillometer surveys around Rum Jungle have been found to correspond to flat sheets of pisolitic laterite. Ground radiometric investigations have generally shown that the pisolitic ferruginous zone of the laterite is 2 or 3 times as radioactive as other rocks in the vicinity. In Rhodesia also it was found that the ferruginous zone of the laterite, even where it was not known to overlie uranium deposits, was commonly quite radioactive. This phenomenon is thought to be connected with the type of uranium enrichment described immediately above.

It must be borne in mind, however, that there is absolutely no reason why laterites should not form over important uranium or other metalliferous deposits. In fact, within the Rum Jungle area self-potential geophysical surveys carried out over lateritized areas detected what appeared to be bodies of sulphide ore, whose existence was confirmed by drilling. It is probably to be expected that if a laterite forms over a deposit containing uranium, high radio-activity would be found in the ferruginous zone of the laterite and the laterite may therefore be a very useful guide to prospecting. Some areas of this type are being tested by the Bureau, but results are not yet available.

Autunite Deposits.

Autunite is a secondary uranium mineral described in Pamphlet No. 3 and is closely related to torbernite. Only small quantities of autunite occurred in the outcrop of White's deposit, the important oxidized product there being the yellow uranium ochres which are directly derived, commonly in situ, from uraninite-bearing ore. Some torbernite was also associated with the oxidized copper minerals.

Autunite and torbernite are, in a sense, less trustworthy as a guide to ore than are the uranium ochres, because they may be formed by precipitation from solutions in which they may have been transported considerable distances.

At Dyson's Deposit at Rum Jungle, rich specimens of autunite (much of it iron-stained and difficult to recognize) occurred at, or very close to, the surface, and autunite is also found within a bed of graphitic shale, to a depth of about 100 ft. below the surface.

The evidence available shows (importantly for the prospector) that there was little, if any, surface impoverishment of uranium and there may have been some surface enrichment.

No copper is known to be present in any significant quantity in Dyson's prospect, and considerable masses of pyrite occur in nearby rocks. The primary grade of this ore has yet to be established, and until this is done it is not possible to say definitely that this will be of payable grade.

Several other autunite showings occur in this district, and in these also, the grade of the primary ore has still to be proved. The answering of this question is of course of the utmost importance as it is only primary ore which is likely to provide really substantial tonnages.

PROSPECTING TECHNIQUES

For those who are familiar with prospecting for uranium, the following notes are probably unnecessary. However, a large number of people interested in the search for metals have not had any experience with uranium, and they may find the following notes useful.

The geiger counter or scintillometer is virtually indispensible in prospecting for uranium. The geiger counter is more widely used as it is cheaper than the scintillometer and more readily available and it is quite suitable for most purposes. The scintillometer is, however, a more sensitive instrument. The use of these instruments enables uranium, even when present in very small quantities, to be detected almost immediately, and this confers a great advantage on the prospector. Those unfamiliar with radiometric equipment are advised that geiger counters frequently break down, especially in warm climates and it may be necessary to have two or three instruments to keep one in continuous operation. Suppliers should be asked to check insulation carefully. Particular care should also be taken to check the batteries regularly and to disconnect these should the instrument break down.

The first step in prospecting a new area is widespread testing for any sign of radioactivity. It is general practice to check first all known showings of mineralization. In the Katherine-Darwin province, old copper workings receive first attention, but many other types of lodes are also checked. To the uranium prospector, the discovery of any radioactivity is equivalent to the discovery of gold by the gold prospector.

If the presence of radioactivity is detected the method used is again akin to that followed by a gold prospector. Just as the latter will systematically test the soil by "loaming" on a gridded pattern, so, uranium prospectors may test the soils and rocks in a radioactive area, by measuring the amount of activity at regular intervals, perhaps at points 25 feet apart. As a geiger counter will always register some activity, known as "the background", which is due to radiation from extra-terrestrial and other sources, it is common to express the amount of activity found in multiples of this "background". Background varies from instrument to instrument and is usually taken as the reading obtained when the counter is placed on a completely non radioactive rock in the area such as a bed of barren quartzite.

By linking up points of about equal activity, a series of contours may be plotted on a plan, and this, is good representation of uranium distribution. Such radiometric plans are usually combined with geological maps.

Because uranium is readily leached from the surface, costeaning and pitting are important in prospecting for this metal. In some cases, there is a marked change in uranium content within a few inches below the surface, though, in others, pits must be sunk several feet before useful information is obtained. In all cases, the final aim is to establish the length, width, grade and nature of the deposit in the primary zone, if it exists. Some uranium deposits are of course, purely secondary and have no sulphide zone. However, these are comparatively rare.

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