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URANIUM IN THE PINE CREEK GEOSYNCLINE

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INTRODUCTION

The evolution of the Pine Creek Geosyncline has been described by Walpole et al.(1968). More detailed regional mapping now in progress in the Alligator Rivers region has modified some of the ideas expressed in this account.* For example, it is now considered that the Myra Falls Metamorphics are not Archaean, but Lower Proterozoic, and that, like the other Lower Proterozoic sediments east of the South Alligator River, they have been metamorphosed, and contain anatectic granite and gneiss domes. Thus the Eastern Trough extends farther east than thought in 1968. It is probably the main trough of a larger geosyncline than that described by Walpole et al.

The principal uranium deposits of the Pine Creek Geosyncline are contained in low-grade metamorphic rocks of Lower Proterozoic age. In the South Alligator Valley the uranium occurs in black shale of the Koolpin Formation (Eastern Trough); the Ranger and Koongarra deposits occur in muscovite-chlorite schist which is believed to be the northerly extension of the Koolpin Formation (Needham, pers. comm.). The Rum Jungle uranium deposits are contained in black shale and chloritic schist of the Golden Dyke Formation (Western Trough). The host rock of the Nabarlek uranium deposit is muscovite-chloritic schist which is believed to be part of the Myra Falls Metamorphics. Uranium minerals also occur in the Coomalie Dolomite underlying the Golden Dyke Formation at Rum Jungle, in volcanic rock and sandstone of Carpentarian age in the South Alligator River Valley, and in fractures within granite masses elsewhere in the region.

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* Footnote: Field work is in progress, and the results have not yet been published. In due course, Bureau publications will report the results of the detailed regional mapping. The disposition of the two troughs of the geosyncline is shown in Figure 1.

AGE OF MINERALIZATION

Two papers (Hills & Richards, 1972; Cooper, 1973) report recent uranium/lead age determinations, reinterpret earlier determinations, and discuss evidence for the age of uranium mineralization. Hills & Richards consider that the best interpretation of available isotopic data fits a three-stage model: 'original' deposition of uranium around 850 m.y. ago, followed by a period of redistribution in the Lower Palaeozoic (450-500 m.y. ago). Their third stage could be due to a Recent loss of lead, or alternatively, to a continuous diffusive loss of lead. According to Cooper two periods of 'mineralization' are recognizable, the earlier between 710 and 815 m.y. ago, the second about 500 m.y. ago. However, these results may not provide a complete picture of the history of the mineralization, particularly if the deposits are the product of relocation and concentration of uranium originally contained in granite or metamorphic rocks.

Preliminary K-Ar dating of biotite and muscovite from seven gneisses and schists in the Nanambu Complex and marginal Lower Proterozoic rocks gave minimum ages of around 1800 m.y. The 1800 m.y. age was confirmed by Rb-Sr measurements on three pairs of biotite and muscovite concentrates which yielded ages of between 1800 and 1900 m.y. (R.W. Page, pers. comm.). The Lower Proterozoic rocks of the Pine Creek Geosyncline are intruded by granites dated at 1760 m.y. Volcanics at the base of the Carpentarian succession have also been dated at 1760 m.y. (Walpole et al., 1969). No known igneous or tectonic event in the region is associated with the uranium ages recognized by Hills & Richards, but further U/Pb analysis may indicate earlier ages of mineralization.

ORIGIN OF THE URANIUM

The origin of the uranium in the Rum Jungle-Alligator Rivers uranium province was briefly discussed by Dodson (1971, p.41).

He considered three modes of emplacement: syngenetic deposition in a favourable host rock, followed by mobilization and concentration; concentration from a massive source rock by leaching and subsequent accretion at the interface of the zones of oxidation and reduction; and hydrothermal deposition from an underlying igneous rock.

Interpretation of the history of mineralization must take into account the following facts:

(i) Most of the uranium deposits of the Pine Creek Geosyncline are situated on the edge of granitic complexes.

(ii) Most of the uranium is concentrated in certain lithological units: the Golden Dyke Formation at Rum Jungle, and the Koolpin Formation at South Alligator Valley. The Ranger, Koongarra, and Jabiluka deposits are associated with schist which is believed to be a northerly extension of the Koolpin Formation. We believe that similarity in lithology and stratigraphical relationships of the Golden Dyke and Koolpin Formations suggests that they are lateral equivalents.

(iii) The deposits occupy fractures, folds, breccia zones, and shears.

(iv) The tops of most of the known deposits lie within 50 m of the present landsurface. This may be due to prolonged enrichment as the landsurface was eroded, the enrichment being a product of downward solution and accretion, but it should be noted that ore has been intersected below 200 m at Ranger and in the South Alligator Valley.

Needham et al. (1972) observed that the more important uranium deposits lie adjacent to the margins of the Nanambu and Nimbuwah granitic complexes, and suggested that the uranium may have been 'sweated out' of the sediments during migmatization.

The proximity of most of the uranium deposits of the Pine Creek Geosyncline to the present-day unconformity surface between

the Lower Proterozoic rocks and the Carpentarian Kombolgie Formation suggests that the uranium may have been derived from a massive source rock such as the sandstone which forms the bulk of the formation, or from the interbedded volcanics. However, the sandstone is typically a compact quartz sandstone which contains few other minerals, and is therefore considered unlikely to have contained much uranium. At present, little is known of the geochemistry of the basic volcanics interbedded with the sediments of the Kombolgie Formation.

THE URANIUM CONTENT OF THE GRANITIC ROCKS

Comparatively little is known of the geochemistry of the granitic rocks in the Pine Creek Geosyncline. Heier & Rhodes (1968) determined the uranium and thorium contents of 32 samples of granitic rock in the Rum Jungle and Waterhouse Complexes and 14 from Carpentarian granites in the geosyncline. Their results show that the uranium content of samples from the Rum Jungle complex ranges from 3.2 ppm, which is slightly below the content of average granitic rock (4 ppm; Heinrich, 1958, p.8) to 28 ppm, seven times greater than average. The uranium content of the younger granites ranges from 5.2 ppm to 35 ppm.

At the Ranger deposit, pegmatitic rock is known to contain narrow veinlets of pitchblende (Dodson, 1972, p.40).

MINOR URANIUM PROSPECTS

CULLEN GRANITE

Several minor uranium prospects such as those at Ferguson River, the Edith River, and the Tennyson, lie in the Cullen Granite. Descriptions by Fisher (1952) and Gardner (1953), indicate that the uranium is present in quartz veins and in siliceous breccias in shear-zones dipping steeply northward to north-north-westward. The main minerals are torbernite and meta-autunite, coating cracks and partings in hematite-bearing sections of the lodes.

ADELAIDE RIVER MINE

The Adelaide River mine is about 4km south of the township of Adelaide River. About 3860 tonnes of ore averaging 0.5 percent U_3O_8 were extracted up to 1957, when the mine closed down. Walpole (1957) concluded that about 1500 tonnes of broken ore, averaging 0.5 percent U_3O_8, remain in the stopes. In 1960 four drill holes were put down by the Bureau of Mineral Resources, and as a result, additional reserves of 5600 tonnes of possible ore averaging 0.22 percent U_3O_8 were indicated (Plumb, 1960).

The uranium is contained in sediments of the Lower Proterozoic Burrell Creek and Noltenius Formations. At the mine, the Burrell Creek consists of siltstone and greywacke, and the Noltenius of conglomerate, sandstone, and siltstone. The uranium occurs in five minor lodes in north-trending shears. In the primary zone the ore consists of veinlets of pitchblende, and in the oxidized zone the main ore mineral is torbernite.

GEORGE CREEK

About 14 km south of Adelaide River a small prospect on George Creek has yielded about 120 tonnes of ore averaging about 0.26 percent U_3O_8 (Arkin & Walpole, 1960). Reserves are estimated to be about 250 tonnes of ore of similar grade.

The geological environment of the George Creek prospect is similar to that of the Adelaide River mine; uranium ore is contained in a steeply dipping north-trending shear in interbedded siltstone and greywacke of the Burrell Creek Formation

FLEUR DE LYS MINE

The Fleur de Lys mine is situated about 8 km southwest of Brocks Creek siding, and is the only uranium prospect in a line of old gold mines extending for about 21 km. Precise figures of production are not known; the only recorded production is about 200 kg of

U_3O_8 (Walpole et al., 1968, p.187).

According to Firman (1955) uranium and copper minerals are contained in concordant lodes in siltstone of the Golden Dyke Formation. In the oxidized zone, torbernite is the uranium mineral, and malachite, azurite, and cuprite are the copper minerals. The unoxidized ore contains pitchblende and the sulphides pyrite, chalcopyrite, and chalcocite. The uranium minerals occur mainly as coatings on bedding planes, shear planes, and joints.

THE ABC PROSPECT

The ABC Prospect is situated about 17 km northwest of the Katherine township. Ore reserves were estimated to be 1060 tonnes averaging 0.4 percent U_3O_8 (Matheson, 1953).

The uranium minerals autunite and phosphuranylite are present in shears and as coatings on joints and fractures in interbedded tuff and basalt of the Carpentarian McAddens Creek Volcanics. The minerals are also disseminated through the parts of the tuff.

ROCKHOLE - EL SHERANA - SLEISBECK AREA

The Rockhole mine, about 100 km northeast of Pine Creek, is the most northwesterly of a line of uranium deposits in the South Alligator River Valley. To the southeast, along the upper part of the valley, are El Sherana, Palette, and Coronation Hill. Sleisbeck lies on the same line, about 50 km from Rockhole. Uranium was discovered in the South Alligator River valley in 1953, and between 1956 and 1964 eleven minor deposits were mined in the area. Total production was 146478 tonnes of ore yielding approximately 840 tonnes of U_3O_8.

TABLE 1.

URANIUM OXIDE PRODUCTION OF THE SOUTH ALLIGATOR VALLEY DEPOSITS

Deposit	Ore (Tonnes)	Grade ($\%U_3O_8$)	Content (Tonnes U_3O_8)
El Sherana	39052	0.55	216.5
El Sherana West	21657	0.82	177.6
Scinto 5	5804	0.37	21.3
Scinto 6	1741	0.15	2.7
Saddle Ridge	30340	0.25	74.6
Coronation Hill	26122	0.27	69.2
Palette	4849	2.5	119.1
Koolpin Creek	2327	0.13	3.1
Skull	531	0.5	2.6
Rockhole Mine	13418	1.12	150.9
Sleisbeck	637	0.34	2.2
Total	146478	0.57 (average)	839.8

(After Taylor, 1968).

Prichard (1965) and Taylor (1968) have given brief accounts of the geology of the uranium deposits. Almost all the uranium ore in the Lower Proterozoic rocks is in steeply dipping Koolpin Formation composed of black carbonaceous shale, dolomite, silicified dolomite, and minor chert. Uranium is also contained in volcanics of the Carpentarian Edith River Formation at Coronation Hill, Carpentarian sandstone of the Edith River Volcanics, and in sandstone of the Carpentarian Kombolgie Formation. Where pitchblende occurs in Carpentarian sandstone, the latter is mostly in contact with black shale of the Koolpin Formation.

As can be seen from Table 1, about 96% of the uranium came from six deposits in the South Alligator River valley; these are briefly described below.

El Sherana and El Sherana West

The El Sherana and El Sherana West deposits are situated next to each other along the regional strike of about 300°. Pitchblende occurs in cherty ferruginous siltstone in contact with carbonaceous shale. The siltstone and shale, both within the Koolpin Formation, are almost vertical, and trend about 300°. At El Sherana massive pitchblende was also mined in sandstone, and relatively minor pitchblende and secondary minerals were recorded in the volcanics above the unconformity. The ore from both lodes contained gold in significant quantities, together with small amounts of copper and lead sulphides.

Rockhole Mine

Three separate surface prospects, Rockhole, O'Dwyers, and Sterrits, are linked by mine workings. Production was not recorded separately as the mineralization extended over the full distance of about 800 m.

In the Rockhole (northwest) end of the mine, most of the ore came from cherty ferruginous shale and carbonaceous shale of the Koolpin Formation along a shear face.

Towards the southeast end of the mine (Sterrits Prospect) most of the ore was in Koolpin Formation, but some was obtained from Carpentarian sandstone faulted against carbonaceous shale. The ore was lower grade where volcanic rocks are in contact with the carbonaceous shale.

Palette mine

The Palette mine is situated in a closely faulted part of the South Alligator fault zone. Pitchblende occurs both above and below the unconformity between carbonaceous or bleached shale of the Koolpin Formation and Carpentarian Kombolgie sandstone, and roughly half the ore was won from each type of host rock. Both free gold and telluride are present in the ore.

Coronation Hill

At Coronation Hill pitchblende occurs in volcanic agglomerate and adjacent tuff of the Edith River Formation. The agglomerate forms a neck which penetrates the Koolpin Formation, and contains blocks of carbonaceous shale. Pitchblende is the primary uranium mineral; gold was also present in the ore, but localized enrichment of gold did not coincide with higher uranium content of the ore.

Saddle Ridge

Saddle Ridge is the only mined orebody which contained secondary minerals only. The host rocks are deeply weathered, and probably consist of the Edith River Volcanics and shale of the Koolpin Formation. This orebody may be either a supergene concentration of secondary uranium minerals derived from a nearly pitchblende deposit which has been entirely removed by erosion, or the oxidised product of a primary lode. Torbernite, autunite, and saleeite were the most common uranium minerals.

Sleisbeck mine

At Sleisbeck, uranium was present both in shale of the Koolpin Formation and in quartz-hematite breccia which is regarded as a product of the silicification of carbonate rock. Minor phosphate was associated with the uranium mineralization.

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