MOUNT WINNECKE PROSPECT

AF 3223

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October, 1971

CR 71/100
MOUNT WINNECKE PROJECT

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MOUNT WINNECKE PROJECT

INTRODUCTION

The Mount Winnecke project involves a potential uraniferous area in the Northern Territory of Australia. Trend Exploration Pty. Ltd. acquired an Authority to Prospect* over 2000 square miles in the Mount Winnecke area in May, 1971. The area was acquired because we believe that its geology is similar to the geology of uranium-bearing areas elsewhere in Australia.

The Mount Winnecke area is in a remtoe part of Australia about 500 miles south of Darwin and 450 miles north-east of Alice Springs. From Darwin, it is accessible by 400 miles of bitumen road to Wave Hill, thence 70 miles of graded road to Hooker Creek Aboriginal Settlement and then fifty miles of four-wheel-drive track. From Alice Springs, it is reached by 200 miles of formed road to Yuendumu Native Settlement, by a further 200 miles of graded road to Tanami (the abandoned site of old gold workings), and then by 60 miles of four-wheel-drive track. Air services to Hooker Creek are available twice a week from Darwin and once a week from Alice Springs.

A four-wheel-drive track crosses the area from north to south and in the southern part of the area several fire-ploughed tracks give access to bores and waterholes.

The climate is arid (less than 15 inches rain per year) and the area is semi-desert. Rainfall is generally between the months of January to April but may occur any time throughout the year. Temperatures are high (80-120°F) during the summer months (November-March) but are relatively mild during the winter. Frosts sometimes occur on winter nights but generally a moderately strong easterly wind blows throughout the day and night in the winter. Most of the vegetation is spinifex and wattle scrub with scattered eucalypts; however, some parts are covered by Mitchell grass, which is good cattle feed and in recent years a small cattle station, Supplejack Downs, has been developed in the area. There are no permanent streams or waterholes but underground water is used on Supplejack Station and the prospects for underground water throughout most of the area are good.

* An Authority to Prospect in the Northern Territory gives the holder exclusive prospecting rights over the area nominated for a period of twelve months from date of issue. The authority is renewable after twelve months if a reasonable work programme has been undertaken. New legislation will require progressive halving of the area each year.
The area is mainly flat and sand-covered with low, rocky sandstone, granite and volcanic hills, rising to a maximum height of about 300 feet above the general plain level.

Previous Work

No record exists of visits to the Mount Winnecke area until the early part of this century, when gold diggers passed through on their way to the newly discovered Tanami goldfield. Geologists visiting the goldfields noted the presence of granite and sandstone in the Mount Winnecke area but did not do any mapping. Traves (1955) visited the northern part of the area and noted the presence of granophyre and sandstone on his map. In 1960, Phillips for Consolidated Zinc Pty. Ltd. prepared a sketchy geological photo-interpretation of the southern part of the area which was later used by Spence (1964) in his geophysical report. In 1962, the southern part of the area was flown as part of an aeromagnetic survey by the Bureau of Mineral Resources (Spence, 1964). Radiometric results were also recorded. In 1965, I visited the area for the BMR preparatory to planning future mapping programmes (Dunn, 1965) and prepared a geological sketch map of the area at 1:1,000,000 scale which incorporated all available geological data to that date. An aeromagnetic survey was carried out for the BMR over the northern part of the area in 1969; the results have not yet been published. In 1969, the photogeological section of the BMR prepared photogeological maps at 1:250,000 which covered the Mount Winnecke area.

Until 1971, no systematic geological mapping or prospecting had been undertaken in the area held by Trend Exploration.

In 1971, the Bureau of Mineral Resources sent a team of three geologists into the region to map the Birrindudu and Tanami 1:250,000 sheet areas at 1:250,000 scale. They are about to leave the region at the time of writing (October, 1971) after five months work in the field supported by 150 hours of helicopter flying. Their work area covers the Mount Winnecke area and results available to us to the end of July have been incorporated into this report.

Present Survey

Trend Exploration applied for an Authority to Prospect over 2000 square miles in the Mount Winnecke area in January, 1971, and the Authority was granted on 11th May, 1971. In the meantime, all available data, including aerial photographs on the area had been acquired and compiled and an initial mapping programme planned.

This initial mapping programme, which is the basis of this report, was undertaken to establish the geology of the area to the extent where we were convinced that we had rocks with the age and stratigraphy to compare with those in the other uranium-bearing areas in Australia.
On the 28th June, 1971, I arrived in Darwin and spent three days provisioning, visiting local authorities and arranging for helicopter support. After visiting another prospect area, I reached the project area on the 15th July and proceeded to visit the BMR party at Tanami. David Blake, the BMR party leader, had already commenced mapping in the Mount Winnecke area and was able to provide much useful information. However, because of a delay in positioning the helicopter, field work was not started until 7th August; I had returned to Sydney in the meantime. From the 7th August, Don Henderson and I, each alternately using the helicopter and vehicle, visited what we considered to be the key outcrops. A scintillation counter was used in the helicopter and readings taken at each landing site. We left the field on 15th August and returned to Sydney. Since returning from the field, the geological information has been compiled at 1:100,000 scale together with available radiometric and aeromagnetic data.

A hired Nissan Patrol 4x4 vehicle was used for transport in the field. An extra 12-gallon drum of petrol and 15-gallons of water were carried in the vehicle. Although the vehicle was basically adequate for the survey, it was not mechanically sound because of poor servicing. Larger quantities of extra petrol (30 gallons) and water (30 gallons) are preferable, carried if possible, in built-in tanks.

The helicopter used was a Bell 47G2 belonging to Helicopter Utilities. It proved incapable of lifting two passengers under the conditions and was inadequate for the survey. A Scintrex Model MSIA portable scintillation counter was used. It proved perfectly adequate for ground observations, but was not sensitive enough for use while flying in the helicopter.

**GEOLOGY** (Plate 1)

Outcrop in the Mount Winnecke area is generally better than that elsewhere in the general region but sand and laterite obscure much of the Precambrian rocks, particularly the rock types more susceptible to erosion. However, sufficient outcrop is present to allow a reasonably accurate reconstruction of the geology throughout most of the area.

Briefly, the region consists of a basement of Lower Proterozoic granite and folded low-grade metamorphic rocks unconformably overlain by a Carpentarian sequence of interbedded sandstone and acid volcanics. (The Carpentarian is a chronostratigraphic unit defined by Dunn et al (1966) and represents the rocks formed over a large part of northern Australia between about 1800 m.y. and 1400 m.y. ago). The sandstone and volcanics are overlain, probably unconformably, by a sandstone, siltstone and chert sequence.
The eroded Precambrian rocks are overlain by Cambrian basalt which in turn is unconformably overlain by Tertiary sediments. Laterite, sand, soil and alluvia form a superficial cover over a large part of the area.

The general relationships of the units are illustrated in Plate 2.

**Lower Proterozoic**

Several small outcrops of quartzite, sheared siltstone, hematitic siltstone and weathered basic rocks are tentatively regarded as older than the acid volcanics and therefore are assigned to the Lower Proterozoic.

The quartzite is generally a grey, blocky, medium-grained silicified sandstone, which has been folded and fractured to the extent that it is not possible to trace continuous outcrops for more than a few tens of feet. It is commonly quartz-veined.

The sheared siltstone is only exposed where it has been heavily silicified and probably is representative of much more extensive but unsilicified beds.

The hematitic siltstone was observed in a wash-out in the southernmost group of Lower Proterozoic outcrops. It is similar to hematitic siltstone which is present in the Lower Proterozoic rocks of the Tanami and Tennant Creek areas and is the best evidence of the Lower Proterozoic age we have given these rocks in the Mount Winnecke area.

The weathered basic rocks are fine to-medium grained and may represent volcanics or dolerite.

At one locality, the quartzite is intruded by granite and has been replaced by massive quartz-tourmaline.

**Carpentarian**

**Wilson Creek Volcanics**

The Wilson Creek Volcanics crop out throughout the northern part of the area and isolated outcrops occur ten miles east of Supplejack Downs, homestead.

In the north, the volcanics are interbedded and intertongued with the Birrindudu Sandstone, but to the south the sandstone becomes much thinner and in places appears to lense out altogether.

The older volcanics are generally lavas and consist of pink rhyolite and dacite, most of which is porphyritic in feldspar. Some thin-bedded tuffs are present and the adjacent Birrindudu Sandstone is tuffaceous in places. Just south of Winnecke Creek, the lavas are coarsely porphyritic and may, in part, be intrusive.
The younger volcanics are mostly acid tuffs with minor interbeds of rhyolite and tuffaceous sandstone and siltstone.

Layering in the lavas is not everywhere apparent, particularly in the massive porphyritic types. In some places, the lavas are intensely sheared. The structure in the tuffs is well defined and the bedding shows up on aerial photographs. Near major regional fold axes, the tuffs are considerably contorted. The volcanics have a maximum thickness of about 15,000 feet.

**Birrindudu Sandstone**

The Birrindudu Sandstone is best developed north of Winnecke Creek where it is up to 12,000 feet thick, but it rapidly thins to the south of the creek to little more than several hundreds of feet thick.

It is composed mainly of blocky and massive medium-grained feldspathic quartz sandstone. The sandstone grades into tuffaceous sandstone and tuff in places near the Wilson Creek Volcanics. Coarse-grained sandstone and quartz pebble conglomerate are developed in places. Near the base thin conglomerate bands contain granite and volcanic pebbles.

Cross-bedding is common; near the upper reaches of Winnecke Creek, classic examples of festoon cross-bedding are exposed just below the volcanics.

The sandstone interfingers with the Wilson Creek Volcanics which are thickest in the south of Winnecke Creek while the sandstone is thickest to the north. The situation suggests the dumping of a large quantity of terrigenous sediments from the north during the early phase of volcanic activity, followed by the waning of the sand supply and the dominance of volcanically derived sediments.

**Tanami Group**

The Tanami group includes all Carpentarian sediments deposited after the final phase of acid igneous activity. Although no contacts are exposed the change in structural style from the Wilson Creek Volcanics and Birrindudu Sandstone suggest that they are separated by an unconformity.

**Ware Range Sandstone**

The Ware Range Sandstone is typically exposed in the west of the northern part of the area. It forms a massive low range of hills with an exposed thickness in the order of 10,000 feet.
It is a blocky to massive, brown or purple medium-grained quartz sandstone. It is not as feldspathic as the Birrindudu Sandstone and is somewhat more silicified. It is cut by several quartz veins, some of which can be traced for over two miles.

The sandstone dips steeply off a fault on the eastern margin of the range and the dips become shallower to the west. There is some evidence for folding of the sandstone within the central part of the range which may reduce the apparent maximum thickness of about 10,000 feet.

**Savage Siltstone**

The Savage Siltstone apparently conformably overlies the Ware Range Sandstone. It has only been recognised to the west of Ware Range in low outcrops which are mainly covered by brown flaggy fine-grained sandstone, and siltstone. In places, however, a purple and grey calcareous shaley siltstone is exposed in washouts, etc. and this may represent a large proportion of the unit which is not exposed.

The only observed structure was steep dips in the purple shaley siltstone, but these steep dips are probably only local and the general regional dip on the evidence of the underlying and overlying sandstone is of the order of 10-15%.

**'Supplejack Formation'**

The 'Supplejack Formation' probably comprises more than one formation. For this report different lithological units have been combined under the one name, partly from a lack of suitable other geographic names in the area from which each unit could be named.

The lowest unit in the formation is a sandstone about 200 feet thick. It is a flaggy to blocky, fine to medium-grained, quartz sandstone which is closely jointed and forms a rubbly outcrop in which the original attitude of the beds is difficult to determine. It is faulted and quartz-veined.

The overlying unit is not exposed. Probably it is a soft easily eroded shale or siltstone and the shallow valley formed by its erosion has been filled with Cambrian basalt.

The next unit is a series of well-exposed sandstones and siltstones which have a distinctive pattern on aerial photographs. It ranges from a brown, massive, well-jointed, friable sandstone to a white, flaggy to blocky, silicified sandstone. Each sandstone has its own weathering characteristics and together produce a striped photo-pattern. Some of the sandstone from this unit outside the Trend area contains glauconite. The unit is about 1500 feet thick.
The upper-most unit does not crop out very well and is represented by scattered outcrops of bedded and brecciated chert which appear to contain stromatolites in places. The unexposed part of the unit may be dolomitic, as chert and chert breccia are common companions of dolomites in the Precambrian of northern Australia. The thickness of the unit is not known.

Cambrian

Antrim Plateau Volcanics

Basalts which form several bare, isolated hills and fill valleys in the Precambrian rocks near Supplejack Downs are regarded as belonging to the extensive Antrim Plateau Volcanics (Dunn and Brown, 1969), which occur over more than 75,000 square miles of the Northern Territory. The basalt is generally a fine to medium-grained tholeiitic variety which has been extensively altered. It is both amygdaloidal and massive, the amygdaloidal variety often being represented on the surface by a rubble of quartz crystals and agate and jasper nodules.

The volcanics include a purple and red, coarse, feldspatic sandstone which underlies the basalt. In places the sandstone contains scattered angular fragments of fine-grained siliceous rock.

The volcanics are probably no more than 200 feet thick.

Tertiary

The Antrim Plateau Volcanics are overlain in places by a yellow, coarse calcareous sandstone about 20 feet thick. The calcareous sandstone is overlain by kaolinitic quartz sandstone and thin-bedded porcellanite.

East of Supplejack Downs the volcanics are overlain by a massive quartz-pebble and boulder conglomerate.

All these sediments are probably of terrestrial origin and, although showing some characteristics of Cretaceous sediments in the northern part of the Northern Territory, are not sufficiently similar to warrant correlation. We believe that they are Tertiary although no fossils have been found.

Superficial Cover

The whole area has been subjected to deep weathering and the development of a laterite surface. The laterite has been subsequently eroded but large areas remain. The laterite is up to 20 feet thick and a full profile has been developed in some places.
Subsequent to the erosion of the laterite, ferricrete (iron-cemented detritus) and silcrete (silica-cemented detritus) have been formed, particularly in stream channels and below scarps of sandstone. Travertine has been formed on or near the basalt areas.

Fine-grained red sand and clay has been blown over the area and forms a shallow cover over all except the more prominent outcrops. Sand dunes occur near the eastern edge of the area.

**Winnecke Granophyre**

The Winnecke Granophyre forms most of the exposed basement to the Carpentarian sediments and volcanics. In places it appears to intrude the Wilson Creek Volcanics and Birrindudu Sandstone.

Although named granophyre by Traves (1955), the unit consists of a wide variety of granitic rock types ranging from porphyritic granophyre to coarse-grained granite and it is reasonable to assume that it represents a number of separate intrusions.

Insufficient detail is available to delineate the separate rock types but it appears that some of the rocks are older than the Wilson Creek Volcanics and some intrude the volcanics. This is a common feature of the granites associated with the Carpentarian acid volcanics elsewhere in northern Australia.

**Structure**

The rocks in the Mount Winnecke area are disposed in three broad basin or synclinal structures. The largest is centred around Mount Winnecke itself and comprises a large basin structure about 18 miles across filled mainly with sandstone in the north and volcanics in the south. The sandstone is broadly folded and extensively faulted especially near its contact with the basement. Tuffs in the volcanics are folded and contorted. The extensive minor faulting present in the sandstone is not apparent in the volcanics, but several large north-trending shear zones, some filled with quartz, are present on the southeast margin of the basin structure.

The second large structure is the syncline to the west of Ware Range and Supplejack Downs. It comprises sediments of the Tanami Group and is bounded by north-trending faults to the east of Ware Range and Supplejack Downs. In the north, the syncline involves the whole Tanami Group, but to the south only the upper 'Supplejack Formation' is involved. It is not clear what has happened to the lower part of the Tanami Group to the south. The syncline is asymmetrical with steep dips in the east and shallow dips in the west. It is cut by a number of west-north-west-trending faults.
These two major structures are separated by granite basement, but to the south of Ware Range a third less well-defined structure is present which also appears to be broadly synclinal. Lack of outcrop and obvious structure within the rocks that do crop out make it difficult to interpret the structure in this area. The best exposed structure is in a sandstone which generally dips northwards but has been crossfolded into a broad fractured anticline with a north-trending axis. The faulting and fracturing on this sandstone are easy to follow but elsewhere the scattered sandstone outcrops make the structure hard if not impossible to reconstruct.

Economic Geology

No mineral deposits have been found within Trend's area and none were found during the present survey. However, the present survey was intended to sort out and correlate the stratigraphy and was not an immediate search for mineralization. It is not surprising that mineralization has not been found; the area is very isolated and for most of the year lacks adequate surface water supplies so that conventional old-style prospecting was almost impossible. Recent explorers with more sophisticated techniques have not been interested because of a lack of any adequate geological maps of the area.

We will, however, show in the following Discussion good reason why this area has strong possibilities of being a uranium province.

Copper, tin, and possibly gold mineralization can be anticipated around the granite but probably not in economic quantities. The extensive laterite may include some bauxitic material but the area is too remote to warrant a search for bauxite.

Surface water is scarce. There are waterholes in Winnecke and Wilson Creeks which last several months after rain but generally dry up before subsequent rain. Several soaks in the bed of Winnecke Creek may be permanent except in extreme drought periods. Underground water appears to be plentiful. Three bores on Supplejack Downs give a consistently good supply from within 100 feet of the surface and many good bore sites exist below the sandstone ranges.
GEOPHYSICS

Aeromagnetics (Plate 3)

The Bureau of Mineral Resources (BMR) carried out an aeromagnetic survey of the area south of latitude 19°S in 1962. Spence (1964) attempted to interpret the aeromagnetic data but with a lack of adequate geological information was not able to go very far.

In 1969, the area north of latitude 19°F was flown by a contractor for the BMR. The results have not yet been published but we were able to obtain a preliminary plot of the data which we spliced to the older information. The survey was a regional survey used to assist in the interpretation of the geology and has little or no value in directly locating possible ore bodies.

In the northern part of the area, the magnetics are relatively flat over the Carpentarian volcanics and sandstone but they show considerable variation over the Winnecke Granophyre and Lower Proterozoic rocks. This is not a common feature of granitic rocks and a closer examination may be necessary to explain the variation. The magnetic variations in the south-east corner of the map area are interpreted as representing covered Lower Proterozoic and granite.

The north-trending linearly aligned magnetic highs close to the track in the southern part of the area follow a fault and sheared zone east of Ware Range and the axis of an anticline south of Ware Range. The magnetic highs over the Ware Range have no obvious explanation.

The north-north-westerly magnetic ridge which passes Supplejack Downs may reflect the presence of the Antrim Plateau Volcanics although these volcanics have generally not shown magnetic properties elsewhere. Alternatively it may indicate that the unexposed unit in the 'Supplejack Formation' below the volcanics is magnetic (i.e. volcanics or dolerite).

Radioactivity (Plate 4)

Radioactivity was recorded during the 1962 aeromagnetic survey of the southern half of the area. A continuous trace was recorded on an internally mounted scintillometer and spot anomalies were detected by an external unit. The continuous trace shows a rather flat profile with minor plateaux of between one and a half and two times background. The plateaux marked on the map show no obvious correlation with the geology. Four spot anomalies were detected in Trend's area during the aerial survey. Two are on or near laterite outcrops and two near the base of a sandstone unit.
The BMR radiometric survey was undertaken as a supplement to the aeromagnetic work and does not constitute an adequate survey. It was flown at 500 feet at one mile spacing in a DC-3 and would only be capable of picking up the strongest spot anomalies if it flew directly over them.

During our survey we took spot readings with a portable scintillation counter along the track and at helicopter landing sites. We also attempted to locate the BMR spot anomalies on the ground but without success. Outside Trend's area we located a spot anomaly on the ground but it was on laterite. Traverses were made with the scintillation counter in the helicopter but insufficient variation was found to make the method effective.

The ground readings were taken on the x300 scale and the results for various rock units are summarized below:

<table>
<thead>
<tr>
<th>Rock Unit</th>
<th>Reading</th>
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<tbody>
<tr>
<td>Lower Proterozoic</td>
<td>1.2-2.8; Mean 1.9 (5 readings)</td>
</tr>
<tr>
<td>Winnecke Granophyre</td>
<td>1.7-3.0; Mean 2.7 (4 readings)</td>
</tr>
<tr>
<td>Birrindudu Sandstone</td>
<td>1.0-1.2 (2 readings)</td>
</tr>
<tr>
<td>Wilson Creek Volcanics</td>
<td>0.9-2.4; Mean 1.7 (11 readings)</td>
</tr>
<tr>
<td>Tanami Group</td>
<td>0.9-1.1 (6 readings)</td>
</tr>
<tr>
<td>Ware Range Sandstone</td>
<td>0.8-1.0 (7 readings)</td>
</tr>
<tr>
<td>Savage Siltstone</td>
<td>2.0 (1 reading)</td>
</tr>
<tr>
<td>'Supplejack Formation'</td>
<td>0.8-2.0; Mean 1.1 (6 readings)</td>
</tr>
<tr>
<td>Antrim Plateau Volcanics</td>
<td>1-1.1 (3 readings)</td>
</tr>
<tr>
<td>Laterite</td>
<td>0.9-2.2; Mean 1.4 (4 readings)</td>
</tr>
<tr>
<td>Others</td>
<td>0.6-0.9 (5 readings)</td>
</tr>
</tbody>
</table>

These data are insufficient to make more than a broad generalization but they show that the granite generally has a radioactivity two to three times that of the sediments and the acid volcanics one and a half to two times.

The high reading in laterite is not surprising; laterite is well-known for its retention of radioactivity but unfortunately has never proved to contain economic deposits.
DISCUSSION

Trend chose the Mount Winnecke area in its search for uranium because it appeared to have rocks of similar age and lithology to those which are associated with most of Australia's uranium deposits. A brief description of the individual uranium deposits is given in the Appendix but here we shall present a broad synthesis of the inter-relationship of these deposits.

Geological relationships of Australian uranium deposits

This account is based on a paper by Dunn which was presented at the Australian and New Zealand Association for the Advancement of Science Congress in Brisbane this year. It was entitled "The Economic Significance of Carpentarian Rocks in Australia".

Plate 5 shows the known extent of rocks of Carpentarian age in Australia and the positions of all the major uranium deposits. Except for Rum Jungle each deposit is within or close to Carpentarian rocks.

Plate 6 illustrates the general sequence of Carpentarian rocks in each of the main localities where uranium deposits are present and shows the relative stratigraphic position of the rocks in which each deposit occurs.

Generally the Carpentarian sequence consists of - i) a basal acid volcanic unit which may be intruded by granite; ii) a sandstone- basic volcanic unit and iii) a carbonate-shale sequence. Each unit is separated by an unconformity or disconformity. No stratigraphic column is available for the Mount Painter and Radium Hill areas where metamorphism and tectonics have obscured the stratigraphy.

In the west Arnhem Land area, the main deposits are in siltstone and micaceous schist which immediately underlie the Carpentarian volcanics and sandstone. Some smaller bodies are within the Carpentarian volcanics and one newly discovered prospect is within granite underlying the sandstone.

The relative positions of the deposits in plan and the regional geology are shown in Plate 7, together with a more detailed diagrammatic cross-section.

In the Westmoreland area the Carpentarian sequence is much thicker than that exposed in Arnhem Land and the known deposits are within the sequence itself. The largest deposit, the Westmoreland deposit, is associated with an andesite dyke - a feeder to the overlying andesitic and basic volcanics which intrudes the sandstone. Plate 8 illustrates the regional geology of the area.
The deposits near Mount Isa are in sedimentary lenses entirely within the andesitic and basic volcanics and the Mary Kathleen deposit has been metasomatically introduced into the carbonate sequence high in the Carpentarian succession by a nearby granite intrusion.

Plate 9 illustrates the relative positions of the uranium deposits in a highly diagrammatic cross-section through the Carpentarian rocks between Darwin and Broken Hill. With increase in depth of burial and metamorphism the uranium deposits are found higher in the sequence until in the Radium Hill area the deformation is too intense to expect the uranium to be stratigraphically controlled and it is emplaced by granitic action alone.

Despite what is an obvious association with stratigraphy, each of these deposits is localized in or near shear zones, and has definite hydrothermal characteristics. Some of those in the basement may also have been localized by nearby carbonaceous sediments.

In looking for a source for the uranium the first thought might be to suggest that the carbonaceous sediments in the basement may have been responsible for original concentration of the uranium during sedimentation and diagenesis (Condon and Waipole, 1955). This of course, seems logical in the west Arnhem Land area but we believe that the presence of all the uranium deposits in or near Carpentarian rocks is not fortuitous and as we do not have the same basement rocks everywhere we must look for a source in the Carpentarian rocks themselves.

We believe that the acid volcanic rocks at the base of the Carpentarian sequence and their associated granitic intrusions are the source of the uranium. Some of the volcanics and the granites are notably radioactive (Stewart, 1965). The uranium was introduced into the system by the volcanics and was naturally concentrated in shear zones and carbonaceous rocks immediately below the volcanics and in sandstone lenses within the volcanics. Subsequent intermediate and basic volcanic activity remobilized the uranium and deposited it higher in the sequence. Granites and metamorphism were also responsible for remobilizing and re-depositing the uranium at an even later stage. The funnel shape of many of the deposits - they are mainly concentrated within 300 feet of the surface (Plate 10) - suggests that supergene enrichment may have been responsible for final concentration of some of them. Plate 10 illustrates the proposed genesis and emplacement of the ore-deposits.
Where Mount Winnecke Fits

The mapping at Mount Winnecke has shown that we have the sequence: basement-unconformity-acid volcanics - sandstone which is typical of the lower part of the Carpentarian sequence throughout northern Australia. We are convinced that the rocks at Mount Winnecke are Carpentarian in age and are similar lithologically to the Carpentarian elsewhere.

Although intermediate to basic volcanics present in all the sections illustrated in Plate 6 have not been mapped at Mount Winnecke, they are absent in at least one other area of undoubted Carpentarian (eastern Arnhem Land). Even so, they may still be present below the Antrim Plateau Volcanics as suggested by the aeromagnetic work.

The Prospects of Uranium Mineralization

At Mount Winnecke we have a large thickness of those acid volcanics which are the suggested source of all the major uranium mineralization in Australia. We have shown that the volcanics are more radioactive than the country rocks and that the associated granites are even more radioactive. (This is to be expected from most acid volcanics and granite but we cannot be more definitive about their radioactivity, relative to other volcanics and granite until we have more data). We have a number of situations similar to those in which known uranium deposits occur. They are:

i. sandstone, interbedded with the acid volcanics (i.e. Pandanus Creek, Palette, etc).
ii. Sheared basement sediments - (i.e. Nabarlek, Ranger, Jim Jim)
iii. sheared basement granite (i.e. Beatrice).

The absence of basic volcanics higher in the sequence and of post-Carpentarian granites indicates that there has been no major igneous activity to remobilize the uranium mineralization and redeposit it higher in the sequence.

In the Trend area we have the best outcrop and almost all the acid volcanic rocks present in the Tanami region, and consider that this is the most prospective uranium-bearing area in the whole region.

The Best Exploration Method

Nabarlek, Ranger, Jim Jim, Westmoreland and most other uranium deposits in Australia were discovered through airborne radiometric surveys
The type of deposit we anticipate finding at Mount Winnecke should also be detectable by airborne radiometrics. The survey flown by the BMR was flown too high and on too widely spaced lines to be effective. The Nabarlek anomaly which was one of the most intense airborne anomalies flown in Australia, would only show up at 500 feet if it was more or less flown over directly and with a strike length of about 1000 feet, five Nabarleks end on end could almost be fitted between the BMR flight lines.

Trend therefore intends to fly the Mount Winnecke area with a gamma-ray spectrometer at 1/5 mile intervals, 150-200 feet above the ground. Each anomaly so detected would then be followed up on the ground, radiometrically gridded and any worthwhile anomalies further delineated by shallow percussion drilling. Diamond drilling would follow.

Cost of Exploration

Before diamond drilling is undertaken, the presence of an orebody should have been confirmed and the diamond drilling can be regarded as development expenditure, rather than exploration expenditure. To the diamond drilling stage anticipated expenses are:

- Airborne survey at 1/5-mile spacing
  - 10,000 line miles at $7.00 per mile $70,000
- Follow-up ground work
  - 1 geologist and assistant for one month plus vehicle hire, etc. 8,000
- Percussion drilling and radiometric logging
  - of 100 holes to 100 feet
  - 10,000 feet at about $4 per foot 40,000

Total: $118,000

A decision may be made to cease exploration at any time after the airborne survey if results are not up to expectations.

Economics and location

The Mount Winnecke area is remote from cheap transport and townships. The development of a mine would involve considerable infrastructure costs. For this reason, an orebody or group of orebodies containing less than 5,000 tons of U₃O₈ of a grade better than 0.4% or 10,000 tons of U₃O₈ of a grade less than 0.25 % would probably not be a viable proposition. However we are looking at a district which has the
geology to support ore-bodies of the calibre of the best already discovered in Australia (see Appendix Table 1), and therefore, the chances of finding the tonnages and grades required are high.

The Mount Winnecke area, remote as it is, would not have the logistic problems facing the Niger deposits in the Sahara. We do not have the figures on the grade of the Niger deposits but being a Colorado-Plateau-type deposit, they are not likely to exceed 0.25%. The quoted reserves are in the order of 40,000 short tons of U₃O₈, capital expenditure will be $23,000,000 for an annual production of 1,500 short tons of U₃O₈.

CONCLUSION

In the Mount Winnecke area, Trend has an area with a high potential for the discovery of uranium. We consider that the chances of finding uranium deposits are better than 50%, and the chances that they will be large enough to exploit only slightly less. Thus the chances of success for an expenditure of between $70,000 and $120,000 are exceptionally good and considering the profit potential the area is a grass-roots prospect which would be very hard to match in any other section of the mining industry.
REFERENCES


APPENDIX

URANIUM IN AUSTRALIA

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URANIUM IN AUSTRALIA

The search for uranium in Australia began in 1944 at the request of the United Kingdom Government and at that time the only occurrences which appeared promising were in the Mt. Painter and Radium Hill areas of South Australia. Demand was almost exclusively for military requirements and incentives ranging from tax free rewards for discoveries to a complete exemption of uranium income from taxation were offered to speed up the search and development of orebodies.

The discovery of uranium at Rum Jungle in 1949 gave the search some impetus until 1954 and 1955, when exploration activities reached a peak and a number of important discoveries were made (i.e. Mary Kathleen and South Alligator River valley). After 1955, exploration activity waned until by 1961 there was virtually no exploration being undertaken for uranium.

By 1964, all mining had ceased and with the exception of Rum Jungle all plants had been put on a 'care and maintenance' basis. Almost 8,000 short tons of U₃O₈ worth more than $150 million had been produced under contracts with the United Kingdom and the bulk of this production had come from Mary Kathleen, 4,500 tons; Rum Jungle, 1,600 tons; Radium Hill, 1,400 tons and the South Alligator valley, 750 tons.

In 1965, Australia's reserves of uranium oxide, which could be economically extracted, were quoted as about 11,000 short tons.

Interest in uranium exploration in Australia was revived in about 1967 and has increased to the present day. New discoveries were made in the Mount Isa, Westmoreland and Lake Frome areas and culminated in late 1970 with the discoveries made in the Alligator Rivers area (Nabarlek, Ranger and Jim Jim). The Australian reserves now stand at about 132,000 tons (Table 1.)

GEOLOGY OF KNOWN DEPOSITS

The following account of the geology of Australian uranium deposits has been extracted from a paper by Peter Dunn (of Trend) and Dr. R. G. Dodson of The Bureau of Mineral Resources. The paper is currently undergoing revision before submission to 'Economic Geology'.

Economic uranium deposits in Australia appear to be associated in one way or another with rocks of Carpentarian age - i.e. between 1800 and 1400 m.y. old (Dunn et al., 1966). Both geographically and geologically the deposits can be allocated to three main provinces; The Rum Jungle-Alligator Rivers, Westmoreland-Mary Kathleen, and Mount
# Uranium Deposits in Australia

<table>
<thead>
<tr>
<th>Name, State</th>
<th>Company</th>
<th>Discovered</th>
<th>Grade</th>
<th>Tonnage (Short tons U₃O₈)</th>
<th>Gross Value $A6.00/lb.</th>
<th>Net Value (Gross less $12 per ton of ore)</th>
</tr>
</thead>
<tbody>
<tr>
<td>El Sherana, N.T.</td>
<td>United Uranium</td>
<td>1955</td>
<td>c. 10 lb/ton</td>
<td>80</td>
<td>960,000</td>
<td>768,000</td>
</tr>
<tr>
<td>Mary Kathleen, Q.</td>
<td>Mary Kathleen Uranium</td>
<td>1954</td>
<td>2.48 lb/ton, 1.91 lb/ton</td>
<td>8866, 1960</td>
<td>106,392,000, 23,520,000</td>
<td>53,196,000, 11,760,000</td>
</tr>
<tr>
<td>Pandanus Creek, N.T.</td>
<td>United Uranium</td>
<td>1956</td>
<td>10 lb/ton</td>
<td>About 310</td>
<td>3,720,000</td>
<td>2,976,000</td>
</tr>
<tr>
<td>Westmoreland, Q.</td>
<td>Queensland Mines</td>
<td>1956-68</td>
<td>+ 3 lb/ton</td>
<td>14,000</td>
<td>168,000,000</td>
<td>54,000,000</td>
</tr>
<tr>
<td>Lake Frome, S.A. Beverley</td>
<td>Exoil</td>
<td>1969</td>
<td>4.8 lb/ton</td>
<td>5600</td>
<td>67,200,000</td>
<td>39,000,000</td>
</tr>
<tr>
<td></td>
<td>37A, Petromin</td>
<td>1969</td>
<td>3.1 lb/ton</td>
<td>5500</td>
<td>66,000,000</td>
<td>23,450,000</td>
</tr>
<tr>
<td></td>
<td>38A, Transoil</td>
<td>1970</td>
<td>?</td>
<td>570</td>
<td>6,840,000</td>
<td>?</td>
</tr>
<tr>
<td>Valhalla, Q.</td>
<td>Queensland Mines</td>
<td>1969</td>
<td>3 lb/ton</td>
<td>1910</td>
<td>22,920,000</td>
<td>7,274,000</td>
</tr>
<tr>
<td>Naborlek, N.T.</td>
<td>Queensland Mines</td>
<td>1970</td>
<td>16 lb/ton, 275 lb/ton</td>
<td>3120, 7360</td>
<td>37,440,000, 88,320,000</td>
<td>32,760,000, 87,678,000</td>
</tr>
<tr>
<td>Ranger, N.T.</td>
<td>Peko-E. Z.</td>
<td>1970</td>
<td>7 lb/ton</td>
<td>78100</td>
<td>937,200,000</td>
<td>669,430,000</td>
</tr>
<tr>
<td>Jim Jim, N.T.</td>
<td>Noranda</td>
<td>1970</td>
<td>38 lb/ton**</td>
<td>5100**</td>
<td>61,200,000</td>
<td>57,900,000</td>
</tr>
<tr>
<td>Skal, Q.</td>
<td>Queensland Mines</td>
<td>1954</td>
<td>3 lb/ton</td>
<td>1700</td>
<td>Uneconomic at present because of extraction problems</td>
<td></td>
</tr>
<tr>
<td>Andersons Lode, Q.</td>
<td>Queensland Mines</td>
<td>1954</td>
<td>3.5 lb/ton</td>
<td>2300</td>
<td>Uneconomic at present because of extraction problems</td>
<td></td>
</tr>
<tr>
<td>Mt. Painter Area</td>
<td>Exoil, Transoil</td>
<td>1960-68</td>
<td>1.2 lb/ton, 2.0 lb/ton, 5.0 lb/ton</td>
<td>2400, 2000, 625</td>
<td>Too low-grade to be economic at present</td>
<td></td>
</tr>
</tbody>
</table>

* Costs taken at $6.00 per ton as plant and infrastructure have already been amortized.

** Calculated from data supplied. An optimistic estimate on present data.

<table>
<thead>
<tr>
<th>Total</th>
<th>132,476</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plus</td>
<td>10,025 (Sub-economic)</td>
</tr>
</tbody>
</table>
DISTRIBUTION OF THE MAIN DEPOSITS OF URANIUM IN AUSTRALIA

FIGURE 1
Painter-Radium Hill provinces.

In the Rum Jungle-Alligator Rivers province, the deposits are mainly in the Lower Proterozoic (2300-1800 m.y. old) rocks immediately below the unconformably overlying Carpentarian volcanics and sediments. In the Westmoreland-Mary Kathleen province the deposits are in Carpentarian sediments and volcanic rocks, and in the Mount Painter-Radium Hill province they occur in Carpentarian metamorphic rocks and granite and in Tertiary sediments directly derived from these rocks.

i. Rum Jungle-Alligator Rivers province.

Within the Rum Jungle-Alligator Rivers province, the principal uranium deposits are in Lower Proterozoic siltstone and shale which have been folded and sheared, and have developed a slaty cleavage or have been metamorphosed to low-grade micaceous schist. In most cases, the mineralization is in or adjacent to carbonaceous sediments. Each deposit is just below a recently exposed unconformity with Carpentarian rocks (at Rum Jungle the age of the unconformity has not been confirmed), and economic mineralization has so far not been proved to extend much below 100 metres from the present-day surface (which in each case roughly corresponds with the old unconformity surface). The regional geology of the area has been described by Walpole et al. (1968).

a. At Rum Jungle (Spratt, 1965; Berkman, 1968) about 64 km. south of Darwin, uranium has been mined from three deposits of moderate size and two minor ones. The mineralization is in carbonaceous shale and chloritic slate of the Lower Proterozoic Golden Dyke Formation near its contact with underlying dolomite. The deposits are in a syncline between two outcrops of Archaean basement rocks - the Rum Jungle Complex and the Waterhouse Granite. Quartz-hematite breccia outcrops near the deposits are believed to be remnants from an old Proterozoic land surface of possible Carpentarian age.

b. In the South Alligator River Valley, uranium has been mined from thirteen small mines (Taylor, 1968; Prichard, 1969), most of which are within cherty ferruginous siltstone of the Lower Proterozoic Koolpin

* The concept of uranium 'provinces' implied in these three subdivisions would not necessarily be completely acceptable to all Australian geologists.
Fig. 2 Diagrammatic cross-sections showing relative stratigraphic positions of Australian uranium deposits
Formation near the unconformity with overlying Carpentarian sandstone and acid volcanics (e.g. Rockhole, El Sherana, El Sherana West) or within the sandstone (Palette) or acid volcanics (Coronation Hill) just above the unconformity. One very small deposit (Scinto 6) was in an altered Lower Proterozoic dolerite just below the unconformity.

c. The three recently (1970) discovered deposits to the northeast of the South Alligator River valley - Nabarlek, (Queensland Mines N.L.), Ranger (Geopeko-E, Z.), and Jim Jim (Noranda)- are all in micaceous schist or shale of Lower Proterozoic or Archaean age which is just below the unconformity with Carpentarian sandstone. Other mineralization in as yet unconfirmed ore bodies in this area occurs in shales (Pancontinental) and shears in granite (Beatrice) similarly situated below the Carpentarian sandstone.

ii. Westmoreland-Mary Kathleen province

The major deposits in the Westmoreland-Mary Kathleen province lie wholly within Carpentarian rocks which range from almost flat-lying in the Westmoreland area to highly folded and metamorphosed at Mary Kathleen. The uranium mineralization appears to occur in rocks higher in the sequence with increase in the degree of deformation.

At Pandanus Creek (Morgan, 1965) in the Northern Territory, near the Queensland border, pitchblende occurs in acid volcanics (the Clifftale Volcanics) which underlie the Westmoreland Conglomerate near the base of the Carpentarian sequence. These volcanics and the conglomerate can be confidently correlated with similar rocks in the South Alligator River valley. To the north of Pandanus Creek, near Calvert Hills, minor uranium mineralization is present near the base of a sequence of basalts and andesites, the Peters Creek Volcanics, which overlie the Westmoreland Conglomerate (Newton and McGrath, 1958).

In the Westmoreland deposits, pitchblende mineralization is present in shears adjacent to a trachyandesite dyke which follows a joint plane in the Westmoreland Conglomerate, and within sandstone and conglomerate adjacent to the dyke. The trachyandesite dyke appears to have been one of the feeders for the Peters Creek Volcanics.

In the Mount Isa orogenic belt, described by Carter et al. (1961) the Carpentarian rock sequence appears to be equivalent to that occurring between the South Alligator River area and Westmoreland, but to have been deposited in a more tectonically active trough.

Numerous small uranium prospects have been discovered in the Mount Isa area (Brooks, 1960) but only a few have been proved to be of potential economical interest.
The Andersons Lode, Skal, and Valhalla deposits occur in sheared sediments within the Eastern Creek Volcanics which we believe to be equivalent to the Peters Creek Volcanics at Westmoreland and Calvert Hills. The primary uranium mineralization in these deposits is in the form of minerals such as davidite and brannerite.

The Mary Kathleen mine (Hughes and Munro, 1965) is about 52 km. east of Mount Isa. It is in a metasomatized breccia conglomerate near the top of the predominantly calc-silicate Corella Formation. At the surface the orebody was of an irregular shape, and about 360 m. long and 230 m. wide. The Corella Formation is several thousands of metres higher in the sequence than the uranium deposits near Mount Isa. The host rock is composed mainly of quartzitic and feldspathic pebbles in a fine-grained matrix of garnet, diopside, and feldspar. The primary uranium mineral is uraninite, which is generally closely associated with the rare earth minerals allanite and stillwellite. The lode is close to a major shear and is a pyrometasomatic deposit related to the Burstall Granite.

iii. Mount Painter-Radium Hill province

Uranium mineralization occurs in metamorphic rocks and granites which form the basement to the Adelaide Geosyncline. No direct evidence is available for the original age of the rocks which have been metamorphosed but evidence from nearby Broken Hill suggests that the age of metamorphism and granite intrusion was mid-Carpentarian, and the original sediments are early Carpentarian in age (Pidgeon, 1967).

At and near Mount Painter, uranium occurs in breccia bodies containing gneiss, schist, and granite fragments in a matrix of chlorite and hematite. The breccias are situated in granite and adjacent high-grade metamorphic rocks, and are either in plugform or have a tabular habit; the tabular breccias normally contain the uranium mineralization. The principal uranium mineral is finely divided uraninite; torbernite, fergusonite, samarskite, and other less well known uranium minerals are also present.

In the Radium Hill mine (Parkin, 1965) the mineralization occurs as veinlike infillings in steeply dipping shears in gneiss and schist. The metamorphic rocks are intruded by pegmatites and basic rocks metamorphosed to amphibolite. The principal ore mineral is davidite which is associated with ilmenite, rutile, hematite, quartz and biotite.

At Lake Frome, the uranium is in flat-lying sediments of Tertiary age (AAEC, 1970, p. 48). The mineralization is located in poorly sorted silty sandstone, siltstone, and gravels about 100 m. below the present land surface. The uranium mineral is finely divided uraninite occurring mainly in carbonaceous and clayey siltstone.
The sediments have been derived from the granite and metamorphics near Mount Painter, and the uranium appears to have been concentrated by groundwater in a situation similar to that in many Colorado Plateau deposits.

Comment

Two broad features emerge from this discussion of the Carpentarian uranium deposits:

1. that, taking the unconformity at the base of the Carpentarian sequence as a datum, the uranium deposits occur higher in the sequence with increase in the depth of burial of the unconformity, and where tectonism was more active, and granites intrude the sequence, the uranium mineralization is controlled by the granite intrusions;

2. that most deposits in the north although generally having larger lateral dimensions, do not extend much below 100-150 metres from the surface.

From these broad features, we may assume a) that the uranium mineralization was derived from a source developed just before, or immediately following, the commencement of deposition of the Carpentarian sequence, and that mineralization migrated upwards under conditions produced by depth of burial, or was carried upwards by granite intrusions; and b) that the final concentration of uranium in many deposits was affected by groundwater movement within 100 to 150 metres of the pre-Carpentarian land-surface, and/or of the Miocene to Recent land-surface which dominates north Australian physiography.

The acid igneous activity which initiated deposition at the beginning of the Carpentarian involved a number of highly radioactive lavas and high-level intrusions and these were probably the source of the mineralization which later migrated as depicted in Plate 11 of the report on Mount Winnecke.
EXPLORATION OPPORTUNITIES

Although Australia is now well into its second uranium exploration boom, the search is still very much in its infancy. The first boom between 1949 and 1956 involved rather haphazard exploration; the casual prospector armed with a geiger counter made the most important discoveries (i.e. Rum Jungle, Mary Kathleen). In fact, ground-prospecting with a geiger-counter was the principal technique used; airborne radiometric work was sparse and often unsystematic; drilling was mainly for development and even then, totaled less than 1.1 million feet between 1946 and 1963 (compared with 29 million feet in the U. S. for 1969 alone). All together, less than 15,000 tons of U₃O₈ were discovered for an expenditure of about $20 million.

One point to arise from the early boom was that Australia's uranium deposits were in situations which did not compare with any of the major uranium mining situations elsewhere in the world. However, none of the larger deposits appeared to be sufficiently alike to allow the establishment of a working hypothesis for the discovery of new deposits in new districts.

Between 1958 and 1967 the regional mapping of all of the uranium-bearing areas had been completed and compiled and the associations described in the chapter on geology began to emerge. However, the first exploration concepts used when interest was renewed, were based on following up geological ideas associated with overseas situations, i.e., Blind River and Colorado Plateau. It was as a result of this that the Lake Frome deposits were found in a Colorado Plateau type situation. But it was the development of ideas on the already known Australian situations which led to the major discoveries at Nabarlek, Ranger, Jim Jim and Westmoreland. Let us call them Carpentaria-type deposits.

The main points to arise from the second phase of exploration (1967 onwards) are:

1. that Australia has large deposits of uranium
2. that geological reasoning can be applied on a regional scale and lead to new discoveries
3. that many of the largest deposits are near the surface
4. that airborne radiometrics are the most potent exploration tool in the search for the near-surface deposits
5. that Australia possesses Colorado Plateau-type deposits.

Thus although opportunities still exist for the discovery of Blind River-type deposits, first priority in exploration should be given to finding Carpentaria-type situations.

All the obvious Carpentaria-type areas have been acquired by various companies, but general areas with less well known associations remain. One is the Kimberley region and another is the Mount Winnecke area. Most of the prospective Kimberley region is held under old prospective rights which were taken out to investigate
a possible Blind River-type situation - the search has not proved fruitful but the areas are still held. The rest of the Kimberley region is no longer available to large-area prospecting rights; only to 300-acre blocks. As the prospecting concept is a regional one which requires large areas of ground and large expenditure on airborne work, the present land situation in the Kimberleys is not attractive. The Mount Winnecke area, however, is held by Trend and is the subject of the main report.

Second to the Carpentaria-type situation, priority should be given to the Colorado Plateau-type. Land in the Lake Frome region is all taken up but a large part of Australia is covered by terrestrial Mesozoic and Tertiary sediments and there is a very good potential for the discovery of new areas. Trend has not given priority to this search while possibilities remain of discovering the cheaper-to-find and potentially richer Carpentaria-type deposits, but a close watch is being kept on the situation and research into possible new areas is programmed.

The chances of finding Blind-River type deposits is still not dead although a certain amount of investigation has already been undertaken by a number of companies. The Blind River deposits and the Witwatersrand deposits are lithologically similar (conglomerates) and are both of Lower Proterozoic age. Lower Proterozoic conglomerates are known in Australia and have been investigated in the Hamersley and Katherine-Darwin regions.

In the Hamersley region, the conglomerates contain uranium but not sufficient to maintain interest. In the Katherine-Darwin region they contain thorium but little or no uranium. Trend does not intend spending much time on these situations in the immediate future but will not pass up any opportunities.

In conclusion, Australia is highly prospective for uranium; total expenditure since 1949 on uranium search would not match the 1967 expenditure alone in the U.S., and despite the undoubted success of airborne techniques, only a very small proportion of Australia has been flown.
THE OUTLOOK FOR URANIUM

Requirements and reserves

The future prospects for uranium are almost exclusively dependent upon usage for nuclear power generation. Demand for uranium for this purpose is currently well below the world's capacity to supply, with many plants either not producing or producing at less than optimum level. This fact has led to the essentially bearish attitudes to the uranium market as a whole, but it must be stressed that the world is at present only in the very early stages of the development of nuclear power usage. The medium term market prospects for uranium are bright, the long term prospects are exceptionally so.

It is true that the present rate of ordering of new nuclear power plants is below the high levels of the years 1966 to 1968, but this should not be considered as indicating a decline in usage of nuclear power. 1966 to 1968 were boom years in orders for nuclear plant, with demand at that time well in excess of immediate requirements. In the U.K., the expansion programme has marked time as the nuclear industry has been re-organised while in France the nuclear power construction programme has been re-evaluated. Increasing costs and construction delays have all added to the slow-down, but the Australian Atomic Energy Commission considers that this situation is merely transient, and unlikely to affect the long-range predictions for growth in the usage of nuclear power.

At present only 109 nuclear power reactors are in operation throughout the world with a total installed capacity of 24,000 MW. By 1976 there should be 298 nuclear reactors in operation with a total capacity of 147,000 MW. The U.S. Atomic Energy Commission expects that by 1980 installed nuclear capacity in the U.S. alone should be in the range of 120,000-170,000 M.W., with almost double this capacity, 240,000-340,000 MW in the rest of the Western World. Uranium requirements based on the median value of these capacity ranges suggest a total Western World usage of U$_3$O$_8$ around 80,000 short tons per year by 1980 compared with 19,600 short tons in 1968. Over the next decade total usage of U$_3$O$_8$ by the West should have reached 500,000 short tons, 100,000 short tons of which will come from stockpiles.

Cumulative requirements up to 1980 will be 500,000 short tons, compared with total present Western World proven and possible reserves recoverable in the price range up to $US 10 per lb. of about 1,400,000 short tons.
An even more severely limiting factor than the known reserves at present, is the maximum rate at which the various known deposits could be economically exploited. This has been reliably estimated at 36,000 short tons per year, a production rate which is to be compared with the requirement of 80,000 short tons per year by 1980.

Also in view of the accelerating consumption after 1970, it is quite probable that reactor operators will contract for sufficient uranium to supply the initial fuel core together with a twenty year fuel supply for each reactor. This would result in a total demand for about 1.6 million tons of U\textsubscript{3}O\textsubscript{8} over the period to 1980 - approximately 500,000 tons to meet operating needs over this period and a further 1.1 million tons to cover future fuel requirements. Such a demand would completely absorb presently available reserves of low-cost U\textsubscript{3}O\textsubscript{8}. (Fig. 3)
THE RUN-DOWN IN RESERVES

= Annual Depletion of Free-World Uranium Reserves minable at $10 per lb.

'000 TONS

1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100

1968 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 1985

Semi logarithmic scale.

FIGURE 3
Techniques of uranium usage are being constantly improved. Present nuclear power reactors get a better recovery from the fuel than from the older stations, but it is not expected that the so-called 'breeder reactors', which burn about 50 per cent of the fuel available instead of one per cent as at present, will be in operation much before 1990. It is expected that wide adoption of the breeder reactors will bring some levelling of the sharply rising demand for uranium, but this time appears at present to be at least twenty years hence.

Future Markets

There is no domestic market for uranium in Australia at the present time. It is unlikely that Australia's first nuclear power station will be in operation before 1980 and thus a significant domestic market for uranium is unlikely until the 1980's.

In the meantime, therefore, Australian producers of uranium will be looking to markets in overseas countries to dispose of their production. Export of uranium from all producing countries, including Australia is subject to destination/end use controls and, in addition, the Australian government requires that sales be made at acceptable prices.

It is generally agreed by all authorities in the field that new reserves will have to be found and brought into production by the mid 1970's to supply the fuel for the Western World's nuclear power stations. This timescale should be ideal for a company commencing vigorous exploration for uranium at the present time. The position is summarised in Fig. 4, which is based on a graph prepared by the United States Atomic Energy Commission. It will be seen that on the U.S.A. E.C.'s analysis, production capability from known deposits will not be able to meet estimated requirements from 1976 onwards. It is also clear that new orders for uranium will have to be placed soon by the electricity generating authorities to meet requirements after 1972.

With regard to potential overseas markets for uranium, the USA has already been mentioned. Both the U.K. and Japan will be substantially dependent on nuclear power and neither of these countries has significant domestic reserves of uranium. Other countries in Western Europe such as Italy, West Germany and Switzerland will also be looking to imports to fuel their planned nuclear power programmes. In Western Europe, France alone has sufficient domestic reserves for its requirements.
REFERENCES


CARPENTARIAN ROCKS

Flat lying or gently folded
Folded or severely faulted
Metamorphosed > lower greenschist

? Probable Carpentarian rocks

CR 71/100
REGIONAL GEOLOGICAL SETTING OF ALLIGATOR RIVERS URANIUM DEPOSITS
REGIONAL GEOLOGICAL SETTING OF URANIUM DEPOSITS IN WESTMORELAND AREA

DIAGRAMMATIC CROSS-SECTION

SCALE
0 5 10 miles

- Younger sediments
- Basic - intermediate volcanics
- Sandstone
- Acid volcanics
- Younger granite
- Older granite
- Fault
- Unconformity
- Uranium prospects

TREND EXPLORATION PTY LTD.
SYDNEY, AUSTRALIA

URANIUM
WESTMORELAND AREA
Uranium derived from granite source with high U, O, content (2-3 ppm mean) - introduced to surface by formating volcanics and late-stage, high-level granites.

Uranium migrates through volcanics and along unconformity. It is concentrated in favourable zones in the volcanics (sandstone lenses) and in the basement rocks (carbonaceous) sediments and shear zones.

Uranium remobilised by later igneous activity and redeposited higher in the sequence.

Uranium leached from granite and old deposits and redeposited in tertiary sediments.

Supergene processes have further concentrated the uranium deposits mostly within 300 feet of the land surface.