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INTERNATIONAL URANIUM RESOURCES EVALUATION PROJECT

I U R E P

NATIONAL FAVOURABILITY STUDIES

AUSTRALIA

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AUSTRALIA

INTRODUCTION AND GENERAL GEOGRAPHY

Australia, an island continent of 7,686,855 km^2, is situated in the southern hemisphere between latitudes 10S and 44S and longitudes 112E and 156E.

The continent is relatively flat and consists physiographically of the Great Western Plateau, Central Eastern Lowlands and the Eastern Highland Belt. The Great Western Plateau, one-third of which is desert, has an average elevation of 300 m and dominates the States of Western and South Australia and the Northern Territory. Eastwards there is the Central Eastern Lowlands and then the Eastern Highland Belt which covers Tasmania and the seaward halves of the States of Queensland, New South Wales and Victoria. The elevation above sea level of these two units is less than 150 m and 1,000 m respectively.

About 60% of Australia is temperate and the remainder is tropical. The annual rainfall ranges from 400 to over 1,600 mm for Tasmania and the coastal areas of northern, eastern and south-western Australia. The remaining 75% of the continent receives less than 400 mm. North of the Tropic of Capricorn most of the rainfall is during the summer monsoonal season. Snow falls in Tasmania and in the southern portion of the Eastern Highland Belt.

The population of 13,987,600 (December 1976) is essentially urban, approximately 85% residing in coastal cities or towns. These are linked by road and rail but there is little access to vast areas of inland Australia.

EXPLORATION MANAGEMENT

Australia is a Commonwealth consisting of six individual States and areas administered by the Commonwealth Government such as the Northern Territory. In general, minerals are the property of the Crown and exploration and mining are controlled by the individual States under their respective mining acts which do vary in several aspects. The export of minerals is controlled by the Commonwealth Government.

Neither the Commonwealth Government nor any of the State Governments are active in uranium exploration. The Commonwealth Government's Bureau of Mineral Resources, Geology and Geophysics (BMR) carries out regional and semi-detailed geological mapping in the Commonwealth territories and from time to time does similar work in particular States with the cooperation of the Mines Department of that State. The BMR conducts regional airborne radiometric surveys.

Exploration for uranium is conducted by companies and to a very limited extent by individuals. The Commonwealth Government has announced guidelines relating to equity by foreign companies in the development of uranium deposits. Any project not in production as at 1st April 1976 involving investment by foreign interests will only be allowed to proceed provided it has a minimum of 75% Australian equity and is Australian controlled.

STATUS OF EXPLORATION

In Australia most exploration for uranium has been conducted by companies and individuals. The geological mapping and airborne radiometric surveying conducted by the BMR is made available to interested persons. Exploration for uranium in Australia can be divided into two periods - 1947 to 1961 and 1966-1977.

During the first period the Commonwealth Government introduced measures to encourage uranium exploration including a system of rewards for the discovery of uranium ore. This reward system resulted in extensive activity by prospectors particularly in the known mineral fields. Equipped with a geiger counter or scintillometer, individuals with little or no experience in prospecting could compete with experienced prospectors and geologists. During this period several relatively small uranium deposits were discovered generally by prospectors who found outcropping mineralisation.

The second phase of uranium exploration in Australia began in 1966 at which time reserves amounted to only 6,200 tonnes of uranium and by 1977 reserves had been increased to 289,000 tonnes. Most of the exploration was done by companies with substantial exploration budgets utilising more advanced geological and geophysical techniques. In the field of airborne radiometrics the development of multi-channel gamma ray spectrometers with large volume crystal detectors increased the sensitivity of the tool as a uranium detector and resulted in several major discoveries. Expenditure on exploration for uranium increased from 1966 to 1971 but has declines in recent years.

MAJOR GEOLOGICAL ELEMENTS OF AUSTRALIA

Australia has been divided into four orogenic provinces mantled by four platform covers (Figure 1). The Arnhem, Litchfield, Arunta and Georgetown Blocks have not been assigned to an orogenic province.

The West Australian Orogenic Province (3,050 my) is the oldest and contains the Pilbara, Yilgarn and Rum Jungle Blocks

which are belts of metamorphosed sediments and volcanics in predominantly gneiss and granite terranes. The West Australian Platform Cover, consisting principally of the Hamersley Basin, mantles the Pilbara Block and comprises Lower Proterozoic basic volcanics and pyroclastics followed by chemical and clastic sediments.

The North Australian Orogenic Province contains the Pine Creek, Tennant Creek, Granites-Tanami and Nicholson Blocks and the Halls Creek Belt and consists generally of low to moderately metamorphosed Lower Proterozoic sediments and volcanics which in some cases are intruded by granites. The North Australian Platform Cover was deposited in the Middle Proterozoic and is preserved in the Kimberley Basin, the McArthur Basin and around the Tennant Creek, Granites-Tanami and Nicholson Blocks. This platform cover is largely pelitic with minor dolomites and volcanics.

The Central Australian Orogenic Province consists of several moderately to highly metamorphosed sedimentary-volcanic blocks and belts of Lower to Middle Proterozoic age. In the west there are the Ophthalmia-Gascoyne, Northampton and the Albany-Fraser Blocks, in the centre there are the Musgrave and Gawler Blocks and to the east the Mount Isa Belt and the Willyama, Mount Painter and Wonaminta Blocks. The Central Australian Platform Cover was deposited over a wide area of Western and Central Australia from the Middle Proterozoic through the Palaeozoic. In the west there are the Carnarvon, Bangemall and Canning Basins, in the centre the Officer, Amadeus and Ngalia Basins and in the east the Georgina Basin and the Adelaide Geosyncline.

Several orogenic blocks have not been assigned to any province. The Arnhem and Litchfield Blocks in northern Australi appear to be Archean in age. The Arunta Block is poorly exposed and may be associated with the North and Central Australian Orogenic Provinces. The Georgetown Block is Middle Proterozoic and contains high grade gneiss intruded by granite and a younger less deformed sequence also intruded by granite.

The East Australian Orogenic Province or Tasman Geosyncline from Cambrian to late Triassic, consists of low to medium grade metamorphosed sediments and volcanics intruded by acid plutonic rocks. The Kanmantoo Belt is the oldest part of the province. Other belts within this province are the Lachlan Belt and its time equivalent, the North Queensland Blocks, and the Hodgkinson and New England-Yarrol Belts. The Trans-Australian Platform Cover consists of Permian to Tertiary sedimentation which was deposited over much of the eastern third of Australia.

URANIUM DEPOSITS AND POTENTIAL

The Alligator Rivers Uranium Province covers an area of about 25,000 km^2 within the Pine Creek Geosyncline. The region comprises complexes of granitoid rocks, gneisses and migmatite mantled and surrounded by a sequence of Lower Proterozoic sediments which are overlain by Middle Proterozoic sandstone and interbedded volcanics to the east and south. Mesozoic sandstone and Cainozoic sand and alluvium cover much of the central and northern parts of the region. The Jabiluka, Ranger, Koongarra and Nabarlek deposits occur in the Cahill Formation - a Lower Proterozoic sequence of schist, amphibolite, carbonate rock and chert - which has a maximum thickness of about 3,000

metres. In the vicinity of the orebodies, biotite, garnet and amphibolite have been completely converted to chlorite but in the adjacent country rocks there is a gradual reduction in the intensity of retrogressive metamorphism. The rocks in the vicinity of the orebodies have been subjected to magnesium metasomatism - chlorite replaces potash feldspar in gneiss and pegmatite particularly at Ranger and Koongarra. The principal host rocks are quartz-chlorite schist, massive haematite-chlorite rock and less commonly graphitic schist. The deposits occur within the transitional zone of migmatite complexes and occur within or adjacent to post migmatisation structures - brecciated fault zones, shear zones or faulted collapse structures. Other characteristics common to the deposits are the presence of the Oenpelli Dolerite in or near most deposits and the spatial distribution of the deposits near the Arnhem Land escarpment. This escarpment forms the western edge of a plateau of flat to gently dipping Middle Proterozoic sandstones lying unconformably over the relatively steep dipping Lower Proterozoic sediments. In the unweathered parts of these orebodies the principal uranium mineral is pitchblende. The average grades range from 0.2% to 0.3% U_3O_8 at Ranger to 2.37% U_3O_8 at Nabarlek. The province contains about 83% of Australia's low cost reserves. It is estimated that the Cahill Formation extends over an area of about 6,000 km^2 but less than 1% outcrops. The limited exploration completed to date has resulted in the discovery of large reserves and it is considered that there is a potential of the order of five to ten times the known reserves.

Carnotite mineralisation is widespread in calcrete deposi which occur as valley fill in channels in the salt lake intern drainage system on the Archean Yilgarn and Pilbara Blocks in Western Australia. A large uranium deposit has been outlined at Yeelirrie in a drainage channel that cuts a granitoid-gneis terrane in the northeast portion of the Yilgarn Block. Fill material in the Yeelirrie channel, which lies between erosion scarps of an old plateau surface, is in excess of 85 m in plac but is seldom more than 30 m in the vicinity of the orebody. The principal component of the fill material is fluvial clay w varying proportions of detrital quartz and feldspar, though aeolian sands form widespread plains together with sparse dune systems. Calcrete has developed extensively along the trunk valleys as a result of the calcification of valley fill sedime This calcrete occurs in forms ranging from small discontinuous pods to large irregular lenticular sheets up to 6.5 km in widt and 20 m in thickness. Carnotite, the only uranium mineral identified, has been deposited as thin films on cavity walls i porcellaneous calcrete; it is dispersed through the earthy cal and it also occurs as grain coatings and disseminations in the clay-quartz unit and on fractures and fault planes in any lithology. The main zone of mineralisation extends over an ar of approximately 6,000 m by 500 m and has an average depth of The average grade of this orebody is 0.15% U_3O_8. Smaller uranium deposits in calcrete have been discovered at Lake Way, Braeside and Lake Maitland. The uranium deposits in calcrete are at shallow depth and the extensive exploration conducted t date has reduced the probability of establishing further large reserves in the low cost category although there are potential large resources in the high cost category.

Several uranium deposits have been found in the Lake Frome Embayment - a Jurassic to Tertiary onlap of the Trans-Australia Platform Cover onto the Willyama and Mount Painter Blocks. The Beverley deposit is a sub-surface deposit in flat-lying Miocene sand lenses within fine unconsolidated argillaceous sediments on an arid plain about 16 km east of the Mount Painter Block which contains relatively small uranium vein deposits. The sediments containing the ore lenses at Beverley occur between overlying non-carbonaceous clays and underlying carbonaceous clays which lie unconformably on Cretaceous shales and sandstones These Cretaceous rocks lie unconformably on a Precambrian crystalline basement at a depth of about 400 m. Pleistocene(?) argillaceous and clastic sediments, with some boulder beds, overlie the non-carbonaceous sediments. The uranium-bearing sands, which vary in thickness from 1 m to over 20 m, are at an average depth of 107 m below the surface. Major variations in the thickness of the sands occur over small horizontal distances. Within a 50 km^2 sub-surface cell of anomalous radioactivity, one set of contiguous sands contains deposits of uranium that are collectively called the Beverley deposit where uranium-bearing sand lenticles have been traced over a north-south distance of 3 km and with a width varying from 900 m at the north to 100 m at the south end; interconnecting channels may be only a few metres in width. Uranium occurs as finely divided uraninite that probably is absorbed on clay. The average grade is 0.265% U_3O_8. Additional sedimentary uranium deposits occur in the southern part of the Frome Embayment in Pleistocene river channels cut into basement rocks of Precambrian to Tertiary age. Small roll front type deposits have been outlined at Gould's Dam, Honeymoon and East Kalkaroo. Exploration is continuing and further discoveries are to be expected.

The Mary Kathleen deposit occurs in a metamorphosed sedimentary sequence of Middle Proterozoic age within the Mount Isa Belt. The sediments consist of thinly bedded calcareous, siliceous and arenaceous material and near the top of the sedimentary sequence in the vicinity of the orebody there is a lenticular polymictic cobble conglomerate containing mostly acid volcanic fragments. Granites and acid and basic dykes have intruded the sequence. Folding has produced a north-plunging syncline with a large portion of the western limb of the fold removed by subsequent faulting. Metamorphism has altered the sedimentary sequence to impure marbles, schists, slates, feldspar diopside granofels, quartzites and amphibolites. The orebody is considered to occupy an altered part of the cobble conglomerate unit and the host to the uranium mineralisation is a zone of massive structureless garnet with lesser amounts of diopside, scapolite and feldspar. The uraninite occurs disseminated within the allanite in lensoid shoots which parallel the margins of the garnet zone. Other uranium occurrences have been found within this succession and to the west there are numerous occurrences with limited reserves established at the Skal and Valhalla deposits and Andersons Lode within a predominantly volcanic sequence. Exploration to date has given little indication of further significant resources.

Mineralisation has been found in several places in the Georgetown area in sediments within an acid volcanic sequence of Carboniferous-Permian age. At the Maureen deposit uranium mineralisation associated with fluorite and molybdenite occurs in a basal arkosic unit unconformably overlying high grade

metamorphics of the Georgetown Block. This area has only recently been recognised as a potential uranium province and there has been insufficient exploration to date to assess its potential.

In Central Australia the Bigrlyi deposit has been found in Carboniferous sandstones of the Ngalia Basin and the Angela deposit in Devonian-Carboniferous sandstones of the Amadeus Basin. Exploration is continuing.

In the Westmoreland area there are several uranium prospects. The mineralisation extends from the acid Cliffdale Volcanics which represent the transitional domain within the Nicholson Block into the overlying Middle Proterozoic Westmoreland Conglomerate which is part of the platform cover. The mineralisation is concentrated along dykes, faults and disconformities and in places is bedding controlled. The exploration carried out since the initial discovery some twenty years ago has reduced the prospect of further significant discoveries.

All significant Proterozoic unconformity-related deposits found to date are in the Pine Creek Block of the North Australian Orogenic Province. There is a potential for further discoveries in all the blocks of this province, in the unassigned Precambrian Metamorphic Complexes, particularly the Georgetown Block, and in the Gawler Block of the Central Australian Orogenic Province.

All the orogenic provinces have potential for vein-type mineralisation. To date most discoveries have been in or associated with granitic rocks of the Eastern Orogenic Province but have been of low grade and small tonnage.

The potential for quartz pebble conglomerate-type deposits is restricted to the West Australian Platform Cover and possibly the older units of the North Australian Platform Cover that surround blocks of the North Australian Orogenic Province. Uranium has been reported in uneconomic concentrations in the Hamersley Basin of the West Australian Platform Cover to the west of Nullagine.

Occurrences of disseminated deposits in igneous and metamorphic rocks have been found in several orogenic domains. To date the only viable deposits discovered have been in the Mount Isa and Willyama Blocks of the Central Australian Orogenic Province.

Sandstone-type occurrences are being investigated in the Ngalia and Amadeus Basins of the Central Australian Platform Cover and in the Lake Frome Embayment and Eucla Basin of the Trans-Australian Platform Cover. There is a potential for deposits of this type in sediments of the platform covers and the East Australian Orogenic Province particularly in the vicinity of Precambrian orogenic blocks.

Uranium deposits in calcrete have been discovered in the Yilgarn and Pilbara Blocks. There is potential for further discoveries of this type in arid areas on or adjacent to other Precambrian orogenic blocks.

East of the Gawler Block significant grades of uranium have been discovered at depths below 90 m (Olympic Dam Prospect). Details of this, Australia's latest discovery, are not available. Consequently it cannot be classified, but it may represent a new uranium province.

Uraniferous phosphorite deposits occur in the Georgina Basin of the Central Australian Platform Cover. In other basins of this platform cover there is potential for new discoveries of this type. Immediately adjacent to older uraniferous domains the uranium content could prove viable.

URANIUM PRODUCTION AND RESOURCES

During the period 1954-71 the total production of uranium concentrate in Australia amounted to 7,780 tonnes of uranium, and was derived from deposits at Rum Jungle (2,990 tonnes U) and the South Alligator River (610 tonnes U) in the Northern Territory, Mary Kathleen (3,460 tonnes U) in Queensland and Radium Hill (720 tonnes U) in South Australia. The only production at the present time is from the Mary Kathleen deposit which as at 30 June 1977 had produced a further 513 tonnes of uranium since it recommenced operations in 1976.

Australia's uranium resources as at 30 June 1977 are estimated as follows :

(i) Recoverable up to a cost of US$80/kg U ($US30/lb U_3O_8)

Reasonably assured resources : 389,000 tonnes U

Estimated additional resources : 44,000 tonnes U

(ii) Recoverable at a cost of US$80-130/kg U (US$30-50/lb U_3O_8)

Reasonably assured resources : 7,000 tonnes U

Estimated additional resources : 5,000 tonnes U.

The reasonably assured resource category is as defined by NEA/IAEA. In expressing Australia's resources the estimated additional resource category is defined as : "Estimated Additional Resources are confined to uranium which could be recovered within the given cost ranges from those known deposits where there are insufficient data to classify the resources as "Reasonably"

Assured", and to extensions of known deposits beyond the limits of "Reasonably Assured Resources" in those deposits".

Quantitative estimates of speculative uranium resources have not been made for Australia.

I suggest Category 5 or 6.
AG 10/11

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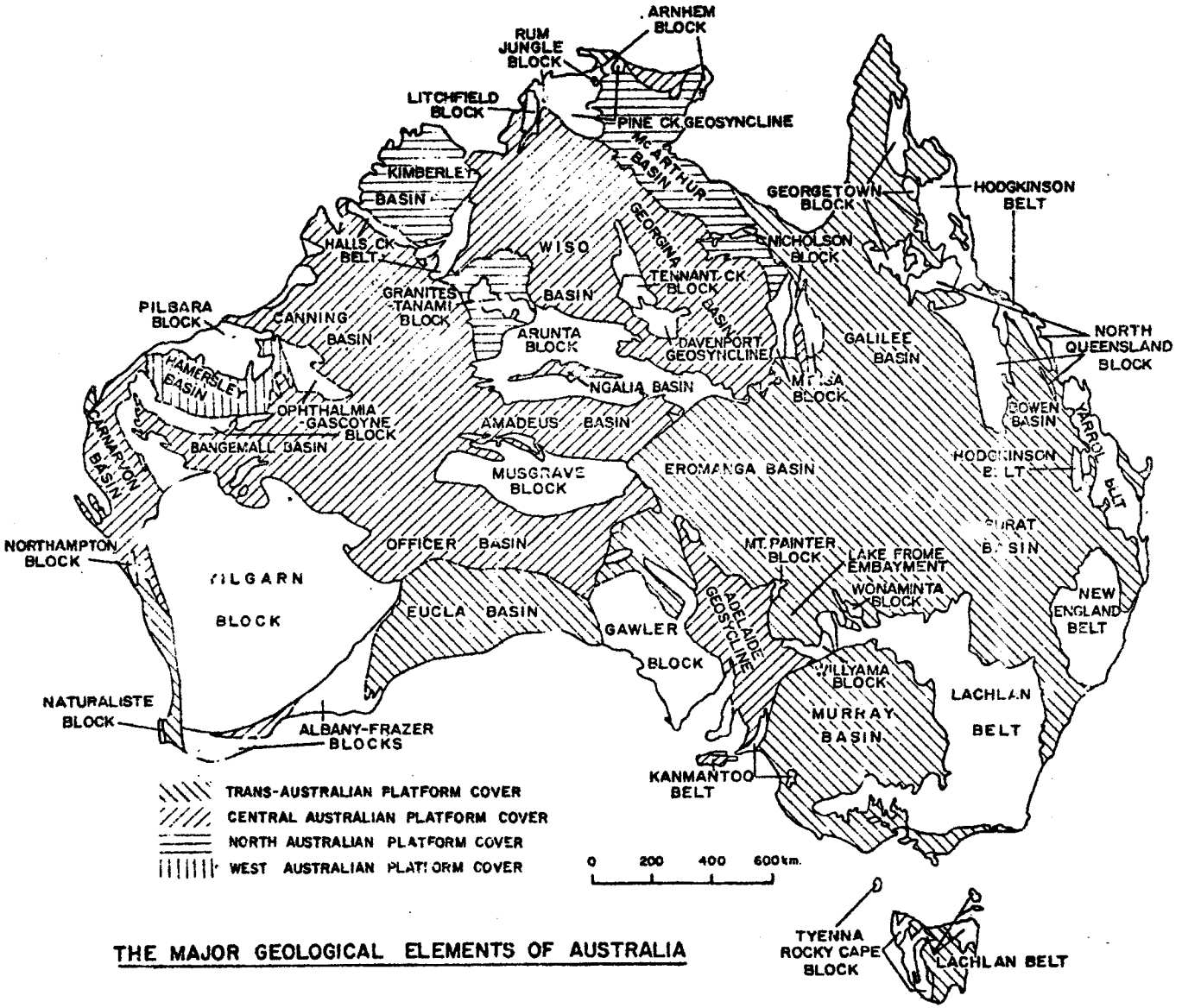
URANIUM DEPOSITS AND PROSPECTS OF AUSTRALIA



THE MAJOR GEOLOGICAL ELEMENTS OF AUSTRALIA