# RECENT DEVELOPMENTS IN AUSTRALIA'S URANIUM MINING INDUSTRY

**Ian B. Lambert, Aden D. McKay**
Bureau of Resource Sciences, Australia

## ABSTRACT

Australia's economic demonstrated resources of uranium (U) at the end of 1996 amounted to 622,000 tonnes U, the largest of any country. Uranium is currently produced at two mining/milling operations in Australia — Ranger in the Alligator Rivers Region of the Northern Territory, and Olympic Dam in South Australia. Improved market conditions and recent changes to Government policies have encouraged Australian companies to commit to the expansion of existing operations and the development of new uranium mines. Australia's annual production is likely to increase from its present level of 6000 tonnes (t) $U_3O_8$ to approximately 12 000 t $U_3O_8$ by the year 2000.

## 1. INTRODUCTION

Following its election in March 1996, the Liberal/National Coalition Government removed the former Government's 'three mines' policy which restricted the development of new uranium mines in Australia. The current Government's policy is to approve new uranium mines and exports, provided they comply with strict environmental, heritage and nuclear safeguards requirements. Where Aboriginal interests are involved, the Government is committed to ensuring full consultation with the affected Aboriginal communities. Uranium export contracts remain subject to Government approval but are no longer scrutinised for pricing purposes.

In November 1996, the Treasurer announced changes in the Foreign Investment Review Board guidelines relating to foreign investment in Australian uranium mining, which mean that no special investment restrictions will apply. 'The Government has decided that the foreign investment policy in relation to the uranium sector will be the policy that currently applies to the mining sector generally. The establishment of a new mine involving investment of $10 million or more, or the acquisition of a substantial interest in an existing uranium mining business valued at $5 million or more, requires prior approval and no objections will be raised unless the proposal is considered contrary to the national interest.'

In May 1997, the Senate Inquiry into Uranium Mining and Milling in Australia reported *inter alia* on the environmental impact, health and safety, and other implications in relation to the mining, milling and export of Australian uranium. This Senate Inquiry came almost two decades after the Ranger Uranium Environmental Inquiry, published as the so-called Fox report, which preceded the agreement to mine uranium at Nabarlek and Ranger and provided the foundation for current policy on uranium mining in Australia. The Senate Inquiry report vindicated the principal findings of the Fox report.

This paper briefly reviews Australia's uranium resources, exploration, environmental and social issues, before presenting summaries of current mining operations and proposed mines.

## 2. RESOURCES

Figure 1 shows the locations of significant uranium deposits in Australia. Australia has the world's largest resources of uranium in the low cost reasonably assured resources category, with 28% of world resources in this category (BRS, 1997).


Figure 1 Uranium deposits and prospects in Australia

Approximately 95% of Australia's economic demonstrated resources of 622,000 tonnes U are within six deposits:

- Olympic Dam in South Australia (the world's largest low-cost uranium deposit);
- Ranger, Jabiluka, and Koongarra in the Alligators Rivers Region of the Northern Territory; and
- Kintyre in Western Australia.

## 3. EXPLORATION

Uranium exploration expenditure in Australia declined from the peak levels in 1980 to an historic low of $A6.67 million in 1994. This decline was due to many factors, including a progressive fall in both spot market and contract prices for uranium during this period, and the effects of the former government's "three mines" policy. Uranium exploration expenditure has increased in recent years to $A14.92 million in 1996. This increase is due to the abolition of this policy and improved demand for uranium.

The main areas where uranium exploration is currently being carried out include:

- Arnhem Land (Northern Territory) — exploration for unconformity-related deposits in Palaeoproterozoic metasediments below a thick cover of Kombolgie Sandstones,
- Paterson Province (Western Australia) — exploration for unconformity-related deposits in Palaeoproterozoic metasediments of the Rudall Metamorphic Complex which hosts the Kintyre orebody,

- Westmoreland area (northwest Queensland) — exploration for sandstone type deposits in Proterozoic sediments of the McArthur Basin,
- Olympic Dam area — exploration drilling along the southern margins of the deposit.

## 4. ENVIRONMENTAL, HEALTH AND SOCIAL

Australia has stringent and effective arrangements in place for environmental impact assessment of proposed uranium mines, which ensure comprehensive consideration of mining proposals before they are approved, with input from all interested parties. These are the basis for setting and enforcing conditions for mining so as to protect environmental, health and social values. Uranium mines are expected to have no detectable environmental impact beyond the mine-sites and they have to take full account of social issues.

## 5. MINING OPERATIONS

Uranium oxide is currently produced at two mining/milling operations—Ranger and Olympic Dam. Australia's total production for the year ended 30 June 1997 was a record high of 5995 t $U_3O_8$ (5084 t U) of which Ranger produced 4237 t $U_3O_8$ and Olympic Dam produced 1758 t $U_3O_8$. Total production for this year was 17% higher than the previous year (ended 30 June 1996) as a result of increases in production at both mining operations, and improved mill recovery rates at Olympic Dam. Australia is now the world's second largest uranium producer after Canada.

### *5.1 Ranger*

Ranger is an unconformity-related deposit which occurs within the Palaeoproterozoic metasediments of the Pine Creek Geosyncline in the Alligator Rivers region, Northern Territory (Figure 1). Energy Resources of Australia Ltd (ERA) commenced operations at Ranger in 1981. Mining of the Ranger No. 1 Orebody was completed by December 1994. At 30 June 1997, approximately 4.5 million t of Ranger No. 1 ore remained on the stockpile. The pit is now used as a repository for mill tailings.

Open cut mining of Ranger No. 3 Orebody commenced in October 1996 and this increased to full-scale mining by mid 1997. For the year ended 30 June 1997, a total of 709 000 t ore averaging 0.23% $U_3O_8$ (1654 t $U_3O_8$ ) was mined. No. 3 Orebody has proven plus probable reserves of 18.8 million t ore with average grade 0.28% $U_3O_8$, containing 53 400 t $U_3O_8$. The orebody is within the Ranger Project Area and the environmental impacts of mining this deposit were addressed as part of the original Environmental Impact Statement (EIS) for the Ranger Project which was submitted in 1975.

Expansion of the Ranger mill from its previous capacity of 3500 tonnes per annum (tpa) $U_3O_8$ to 5000 tpa $U_3O_8$ was completed by August 1997 to coincide with the commencement of mining at No. 3 Orebody. The tonnages of ore processed will increase from the previous level of 1.3 million tpa to 2.0 million tpa. ERA has reported that capacity of the Ranger mill would be increased further to approximately 6000 tpa $U_3O_8$ in order to process ore from the proposed Jabiluka mining operation (refer later description of Jabiluka project).

### *5.2 Olympic Dam*

The Olympic Dam copper-uranium-gold-silver deposit is the world's largest deposit of low-cost uranium. It contains in excess of 30 million t of copper metal, almost 1 million t $U_3O_8$ and 1200 t of gold (Scott, 1995). Ore reserves and resources for the Olympic Dam deposit, as at 30 June 1997 (WMC, 1997) are:

| Reserves/Resources | Ore (Mt) | %Cu | % $U_3O_8$ | Contained $U_3O_8$ (t) |
|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| Reserves | Proved | 82 | 2.4 | 0.07 | 57 400 |
| | Probable | 484 | 2.0 | 0.06 | 290 400 |
| Resources | Measured | 0 | | | |
| | Indicated | 1220 | 1.1 | 0.04 | 488 000 |
| | Inferred | 400 | 1.3 | 0.04 | 160 000 |

Note: Resources are in addition to Reserves.

The orebody occurs within the hematite-rich Olympic Dam Breccia Complex, which is a large Mesoproterozoic hydrothermal breccia complex within the Roxby Downs Granite (Scott, 1995, Smith, 1993, Reeve, Cross, Smith & Oreskes, 1990). The deposit is unconformably overlain by approximately 300 metres of undeformed Neoproterozoic and Cambrian marine sedimentary rocks.

There is a variety of breccia types which range from granite breccias through hematite-granite breccias to hematite-rich breccias. Ore grade copper-uranium-gold-silver mineralisation forms a large number of ore zones mostly within hematite-rich breccias.

Uranium occurs in association with all copper mineralisation. The predominant uranium mineral is uraninite (pitchblende) with lesser amounts of coffinite and brannerite. Throughout the deposit there is a well developed zonal distribution of the principal copper sulphide minerals. Chalcopyrite (and pyrite) occur in the deeper and outer parts of the orebody whereas bornite and chalcocite occur in the upper and more central parts. The boundary between bornite-chalcocite mineralisation and chalcopyrite mineralisation (the bn-cp interface) is usually sharp (Reeve, Cross, Smith & Oreskes, 1990).

The orebody is mined by long-hole open stoping methods. The processing plant comprises a milling circuit, concentrator, hydrometallurgical circuits, concentrate smelting, copper, gold and silver refining (including copper electro-refining and electrowinning), and uranium precipitation.

The Olympic Dam operation currently has an annual production rate of 85 000 t copper, 1700 t $U_3O_8$ and associated gold and silver. WMC Limited (WMC) proposes to undertake a two-phase expansion of production at the Olympic Dam operations. The first phase of the expansion, to be completed by the end of 1999, will increase production to a nominal rate of 200 000 tpa copper, and approximately 4600 tpa $U_3O_8$, 2050 kg per annum gold and 23,000 kg per annum silver. For the processing plant to achieve a sustained production rate of 200 000 tpa copper, the mine would need to supply 8.7 - 9.2 million t ore per annum, depending on the grade of ore processed (Kinhill, 1997). At least thirty stopes would need to be operated in any one year for this rate of production.

The second phase of the expansion, which is subject to WMC Board approval, would further increase production to 350 000 tpa copper, 7700 tpa $U_3O_8$ , and associated gold and silver. The final EIS for the project to expand to 350 000 tpa copper is currently being assessed jointly by both Commonwealth and South Australian Government authorities. The major issues raised by this expansion relate to (Kinhill, 1997):

- the sustainable supply of water for the mining and processing operations, and the township,
- containment of tailings,
- management of radiation exposures.

Exploration drilling over the last three years has discovered significant tonnages of copper mineralisation along the southern margin of the deposit (Scott, 1995). Drilling intersections included one of 84 metres averaging 2.1% copper and 0.04% $U_3O_8$ .

## 6. PROPOSED NEW MINING OPERATIONS

Since the removal of the 'three mines' policy in March 1996, the Commonwealth Government has received formal proposals to develop four new uranium mining operations:

- Jabiluka deposit, Northern Territory (ERA Ltd)
- Kintyre deposit, Western Australia (Canning Resources Ltd, a subsidiary of Rio Tinto)
- Beverley deposit, South Australia (Heathgate Pty Ltd, a wholly owned subsidiary of General Atomics Inc., which is a United States company),
- Honeymoon deposit, South Australia (Southern Cross Resources Aust. Pty Ltd).

### *6.1 Jabiluka*

The Jabiluka deposit, 20 km north of Ranger, occurs within Palaeoproterozoic metasediments of the Pine Creek Geosyncline and lies immediately below the unconformity with the overlying Kombolgie Sandstone. Total proved and probable ore reserves for Jabiluka are 19.5 million tonnes ore averaging 0.46% $U_3O_8$, and containing 90 400 t $U_3O_8$. The total geological resource (which includes the ore reserves) was estimated to be 28.7 million tonnes ore averaging 0.52% $U_3O_8$ (Kinhill, 1996).

The draft EIS for the Jabiluka project which was released in October 1996, examined a number of options for the development of the Jabiluka deposit. ERA's preferred option is for an underground mining operation, with the ore to be processed at the Ranger mill. The ore would be trucked for a distance of 20 km to Ranger via a haul road entirely within the lease area.

The key aspects of ERA's proposal include:

- no tailings dam and no processing plant at Jabiluka,
- surface facilities will cover only 20 hectares,
- total disturbed land including the transport corridor is estimated at 80 hectares which is much less than other options,
- tailings will be placed in the Ranger open pits which will be rehabilitated at the end of the mine life.

The environmental impact assessment of the proposal was recently completed, and in August 1997 the Minister for the Environment advised the Minister for Resources and Energy that, on the available evidence, there does not appear to be any environmental issue which should prevent the Jabiluka proposal from proceeding. However, the Environment Minister recommended that stringent regulatory and operating conditions be applied to ensure the protection of World Heritage values, flora and fauna and cultural heritage (including Aboriginal sacred sites). Best practice environmental management will be required at all stages of the project including water management and rehabilitation.

On 8 October, 1997 the Minister for Resources and Energy, formally advised ERA Ltd of his endorsement of the recommendations of the Minister for the Environment, and cleared the way for the Jabiluka project to proceed. He required the company to undertake further relevant baseline environmental studies. The Minister noted that ERA has an excellent record on environmental management at its nearby Ranger operation. The Office of the Supervising Scientist (now Supervising Scientist Group) has monitored the environmental impact of this operation over a period of 16 years, and has consistently reported that no significant effects on the environment have been detected. No other mine in Australia has come under such strict scrutiny.

ERA is negotiating with the Traditional Aboriginal Owners for consent to develop Jabiluka according to the company's preferred option. Aboriginal approval already exists for Pancontinental's original concept of a stand alone mill, underground mine and tailings dam on the Jabiluka lease. It is estimated that the Aboriginal community will receive approximately $210 million (1996 dollars) in royalties over the life of the mine, in addition to royalties already being received from the Ranger Project.

ERA plans to develop Jabiluka by 1999, and initially 300 000 t of Jabiluka ore will be processed annually to produce approximately 1800 tpa of $U_3O_8$. Capacity of the operation will expand to 900 000 t ore annually to produce approximately 4000 tpa of $U_3O_8$ in the 14th year.

## 6.2 Kintyre

The Kintyre deposit is located on the western edge of the Great Sandy Desert in the Eastern Pilbara Region of Western Australia, approximately 1200 km north-northeast of Perth. The project area is located immediately north of the Rudall River National Park. Probable resources were estimated to be 24 500 t $U_3O_8$, with an additional 11 500 t $U_3O_8$ of inferred resources (Gauci & Cunningham, 1992).

Kintyre is a Proterozoic unconformity-related deposit which occurs in metasediments of the Rudall Complex and lies immediately below the unconformity with the overlying Neoproterozoic sandstones. Host rocks are mainly chlorite-garnet-quartz schists, chlorite-carbonate-garnet-quartz schist, garnetiferous quartzite (metachert) and metamorphosed carbonate rocks. Mineralisation occurs as narrow veins of high grade pitchblende within barren host rock. Multiple sets of closely spaced mineralised veins form ore zones (Jackson & Andrew, 1990).

Accurate definition of the resource using drilling data is difficult because of the vein type mineralisation, and the fact that the primary mineralisation does not outcrop. To obtain more detailed information on the mineralisation a small shaft was sunk during 1996, and a drive and a cross cut were mined through the orebody. The purpose of this was to:

- see the mineralisation and assess its nature and continuity,
- establish the structural controls on the vein system,
- compare grade estimates from drillholes with grades from bulk sampling,
- compare radiometric measurements with chemical assays,
- provide a bulk sample for metallurgical purposes.

The results from detailed underground mapping, channel sampling, and horizontal drilling from the underground openings have provided a more accurate picture of the mineralisation and resulted in a reinterpretation of the geological model. This has defined new targets for exploration and has highlighted that extra data is required to more accurately plan an efficient mining operation (Larson, 1997).

In 1996, Canning Resources advised the Commonwealth and Western Australian Governments of its intention to develop the Kintyre deposit, and work commenced on the environmental impact assessment of the proposed mining operation. However, the company recently decided to delay the decision on developing the deposit in view of current low uranium prices. Initially the operation was to produce 1200 tpa $U_3O_8$, from four separate open pits, with the potential to increase production up to 2000 tpa $U_3O_8$ over a twenty year period.

## 6.3 Beverley

The Beverley deposit is located near Lake Frome, 530 km NNE of Adelaide, South Australia. Mineralisation occurs at depths of 110 to 140 m within partly consolidated and uncemented sands and

clays of the Tertiary Namba Formation. Uranium is present as coffinite which coats sand grains and also occurs within the interbedded clay horizons (Heathgate Resources Pty Ltd, 1997). Beverley has an overall resource of 16 200 t $U_3O_8$ at an average grade of 0.27% $U_3O_8$, of which approximately 11 600 t $U_3O_8$ could be recovered by in situ leach mining (Heathgate Resources Pty Ltd, 1997).

Uranium mineralisation is within a semi-isolated aquifer zone that resembles a concealed fluvial stream. This aquifer appears to be isolated from other groundwater aquifers in the area. Impermeable plastic clays and silts, over 100m thick, separate the Beverley aquifer from the underlying Great Artesian Basin aquifers. The uppermost part of the Namba Formation is a sequence of clays which cap the mineralised sands and on-lap the channel margins (Gauci & Cunningham, 1992, Heathgate Resources Pty Ltd, 1997). This clay sequence acts as a hydrological barrier separating the mineralised sands from the aquifers in the overlying sediments (Willawortina Formation).

Heathgate Resources Pty Ltd proposes to recover the uranium using in situ leach (ISL) methods. The deposit is particularly suited to in situ leaching because of its shape, grade and leachability. As part of its evaluation of the project, the company recently commenced a continuous field leach trial (FLT) using modern ISL methods. The FLT is intended to test a variety of options for the ISL mining operation. Initially it is planned to use a sulphate leach, with pre-treatment of the ore zone. Sulphate leach was chosen because (Brunt, 1997, Heathgate Resources Pty Ltd 1996):

- past laboratory testing of core from Beverley showed that sulphate leach gave faster and more complete extraction of uranium,
- Beverley ore has a low level of trace elements and heavy metals which might be mobilised during leaching,
- low carbonate levels support the use of a sulphate leach.

The proposed FLT will be able to test ion both exchange and solvent extraction methods for uranium capture from the lixiviant.

Heathgate proposes to develop an in situ leach operation capable of producing 900 tpa $U_3O_8$ with production commencing in the year 2000. The company has commenced preparation of an Environmental Impact Statement for the proposed in situ leach operation.

### *6.4 Honeymoon Project*

The Honeymoon deposit is in the Lake Frome region, 80 km NW of Broken Hill. The deposit has a roll-front shape and occurs at an oxidation-reduction interface along the lateral margins of a palaeochannel. The deposit is within Tertiary sands (Eyre Formation) and is 110 m below the surface.

During the late 1970s, testwork showed that the most efficient method of recovering uranium was sulphate leaching with sulphuric acid, ferrous sulphate and hydrogen peroxide (Brunt, 1997). This was followed by construction of a small commercial plant having a flow capacity of 25 litres/second, and mine support facilities, and finalising of flow testing of pipelines and equipment. In March 1983, the South Australian Government announced that, in accordance with the then Commonwealth Government's 'three mines' uranium policy, it would not grant a production licence for the project. Subsequently the site was placed on a care and maintenance basis.

In 1996, the project was acquired by Southern Cross Resources Inc., a Canadian-based company, which is partly-owned (35%) by an Australian company, Sedimentary Holdings NL. The resources recoverable by ISL methods for Honeymoon and nearby deposits owned by Southern Cross are (Ackland, 1997):

| Deposit or prospect | Resource category | Resources (t $U_3O_8$ ) | Grade (% $U_3O_8$ ) |
|---|---|---|---|
| Honeymoon (including Honeymoon Extension) | measured | 3700 | 0.156 |
| East Kalkaroo | indicated | 900 | 0.14 |
| Goulds Dam | inferred | 2300 | 0.14 |

Southern Cross recently announced plans to develop the Honeymoon project by refurbishing the existing ISL plant and associated facilities. The company proposes to operate the plant at a rate of 25 litres/second for a period of approximately 18 months as an initial phase of the development. A draft EIS for the project is currently being prepared. The proposed commercial operation will produce approximately 460 t $U_3O_8$ per year using a flow rate of approximately 100 litres/second. Subject to the necessary approvals being obtained, production is scheduled to commence in 1998/99.

### *6.5 Other developments*

The Koongarra deposit in the Alligator Rivers region, is owned by Cogema. The company is currently reassessing the project in order to decide whether development approvals will be sought.

Rio Tinto Exploration has completed the buy-out of its joint venture partners (Queensland Mines and Cogema) in the Westmoreland uranium deposit, NW Queensland. Exploration is continuing in the area surrounding the deposit.

The Ben Lomond deposit, 50 km west of Townsville was purchased by Anaconda Uranium Corporation. The deposit contains resources of about 6800 t $U_3O_8$ at an average grade of 0.228% $U_3O_8$ and 4578 t of molybdenum at 0.149% Mo. The company will prepare a new feasibility study on the project. Anaconda has also brought the smaller Maureen uranium-molybdenum deposit northwest of Ben Lomond. Maureen has measured and indicated resources of 3000 t $U_3O_8$ grading 0.123% and 0.07% Mo.

## *7. CONCLUSIONS*

The abolition of the ‘three mines’ policy means that several new uranium mines are likely to be developed to take advantage of market opportunities. Australia’s annual production could increase from its present level of 6000 t $U_3O_8$ to approximately 12 000 t $U_3O_8$ by the year 2000 as a result of proposed increases in production at Ranger and Olympic Dam, together with projected production from possible new mines (Jabiluka, Beverley and Honeymoon). These increases in production will depend on market conditions.

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## 9. KEY WORDS

Australian uranium resources, Ranger, Olympic Dam, Jabiluka, Kintyre, Beverley, Honeymoon, Government policy.