URANIUM DEVELOPMENTS IN AUSTRALIA

LAMBERT, I.B. and MCKAY, A.D. Australian Geological Survey Organisation, Canberra, Australia

Summary

Uranium exploration expenditure in Australia increased significantly from 1994 to 1997 as a result of improved demand for uranium and the abolition of a 'three mines' policy. During 1998, uranium exploration expenditure was A$19.4 million – 18% below 1997 levels. This decrease reflected the general decline in mineral exploration in Australia and elsewhere.

Uranium production in Australia is set to increase with three proposed new mines.

Jabiluka is one of the world's largest unconformity-related uranium deposits. It occurs in the wet-dry tropics of the Kakadu region, Northern Territory, some 20 km north of the existing Ranger mine. Mining has been approved conditional on meeting stringent conditions relating to protection of the environment, World Heritage values, fauna, flora and cultural heritage (including significant Aboriginal sites), communication with Aboriginal people, and rehabilitation of the site. Commercial mining at Jabiluka will not commence until production at Ranger mine is scaled down, so that the two mines will not be in full production simultaneously.

Beverley and Honeymoon are sandstone-type uranium deposits in the arid Frome Embayment of eastern South Australia. Beverley is Australia's first in situ leach uranium mine. The major issue in the environment impact assessment processes for these deposits was disposal of liquid wastes by re-injection into parts of the aquifers already mined out by in-situ leaching. Existing groundwaters in the mineralised aquifers have variably high salt and natural radioactivity contents.

In addition, there has been a major expansion of production at the breccia-hosted Olympic Dam copper-uranium-gold-silver mine, in the dry centre of South Australia. Water supply and tailings containment were important issues in the environmental impact assessment process.

Introduction

Australia has the world's largest low-cost uranium resources, but uranium mining has always attracted considerable debate in the Australian community. In 1983, the Labor Government introduced what became known as the 'three mines' policy. Under this policy, exports of uranium were permitted only from the Nabarlek (which closed in 1988), Ranger and Olympic Dam mines.

Following the overturning of this policy with the change of Government in 1996, formal proposals have been made for four new mines, at Jabiluka, Beverley, Honeymoon and Kintyre
(Fig. 1). The remote, unconformity-related Kintyre deposit is not being developed due to low uranium prices. The remaining projects have received a great deal of attention, and the issues arising are illustrative of the high levels of public scrutiny that can be expected at new uranium mines in Australia and elsewhere.

This paper commences with a summary of trends in exploration for uranium in Australia. It moves on to discuss the proposed new uranium mines and the major expansion of the Olympic Dam mine. After summaries of the geological features of these deposits, the environmental and social factors that have arisen in their approval processes are outlined.

Uranium exploration

Following the uranium exploration boom in Australia during the late 1970s exploration expenditure declined sharply from the peak level of A$89.8 million[#] in 1980 to A$26.7 million[#] in 1983, mirroring the sharp decline worldwide during this period.

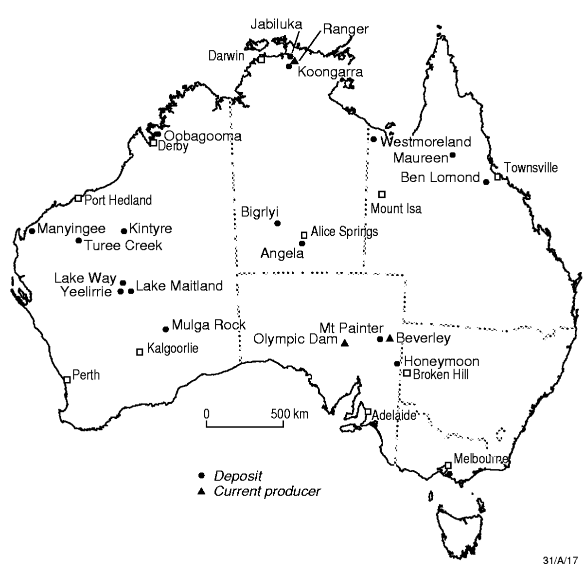

Figure 1. Uranium deposits and prospects in Australia

[#] expenditures in constant 1998 A$

Despite the dampening effect of the ‘three mines’ policy on uranium exploration, the discovery of the Kintyre deposit in the Paterson Province, Western Australia (WA) in 1985 led to an increase in exploration expenditure from 1985 to 1988. This increased exploration was aimed at locating similar deposits elsewhere in the Paterson Province. Exploration subsequently declined from 1989 onwards to an historic low of A$7.3 million[#] in 1994. This decline was due to the fall in spot market prices from 1976 onwards, excess uranium inventories in Western world countries, and the sales of uranium from the former USSR countries.

Exploration expenditure increased progressively from 1994, to A$23.6 million[#] in 1997. This was a result of improved demand for uranium, and the abolition of the ‘three mines’ policy following the election of the Liberal/National Party Coalition government in 1996. Australia was one of a few countries where uranium exploration increased in this period. During 1998, there was a decrease in expenditure to A$19.4 million, which reflected the general decline in minerals exploration during the year.

A number of significant developments in recent years have strongly influenced the focus of uranium exploration:

- the economic successes of both the Ranger mine (unconformity-related uranium deposit) and the Olympic Dam mine (breccia complex type deposit) have confirmed that these types of uranium deposits are important exploration targets,
- successful developments in the USA of in situ leach (ISL) techniques for mining sandstone-type uranium deposits have reactivated the search for this type of deposit.

The main areas where uranium exploration has been carried out since the mid-1990s are:

- Arnhem Land (Northern Territory) — exploration for unconformity-related deposits in Palaeoproterozoic metasediments below a thick cover of Kombolgie Formation. The gradual increase in exploration in Arnhem Land after a 20 year hiatus will increase the opportunities for further discoveries of uranium deposits in one of the most prospective and under-explored regions in the world.
- Paterson Province (Western Australia) — exploration for unconformity-related deposits in Palaeoproterozoic metasediments of the Rudall Metamorphic Complex which hosts the Kintyre orebody.
- Frome Embayment (South Australia) and Officer Basin (Western Australia) — exploration for sandstone-hosted uranium deposits.
- Westmoreland area (northwest Queensland) — exploration for sandstone type deposits in Proterozoic sediments of the McArthur Basin.
- Stuart Shelf (South Australia) — exploration for breccia- complex deposits similar to Olympic Dam.
- Mount Isa Inlier (northwest Queensland) — exploration at the albitite-related Valhalla deposit, where mineralisation is in a brecciated sequence of ferruginous shales, tuffaceous sediments and basalts (Proterozoic), which show hematite and sodic alteration.
- Calcrete deposits — exploration for uranium mineralisation within calcrete occurring in Tertiary drainage systems overlying granitic rocks of the Yilgarn Block (Western Australia).

Jabiluka

Geology

Jabiluka is one of the world’s largest unconformity-related uranium deposits. It occurs in the wet-dry tropics region of the Northern Territory, in the margins of (but never part of) the World Heritage-listed Kakadu National Park. It is some 20 km north of the existing Ranger mine, which is owned by the same company, Energy Resources of Australia Ltd (ERA), and where direct biological monitoring has not revealed any significant impacts on the health of ecosystems surrounding the mine lease.

Jabiluka, Ranger, and the Koongarra deposit further to the south, are in the eastern part of the Pine Creek Geosyncline. The deposits are generally stratabound, and localised within breccia zones immediately below a major unconformity surface. Hydrothermal alteration is common and chloritisation is widespread. Carbonates are common in the sequence but generally do not host mineralisation.

The basement rocks in the area are Archaean to Palaeoproterozoic granites, granitic gneiss and biotite schists of the Nanambu Complex, which forms major dome-like structures on a regional scale. The Cahill Formation unconformably overlies the Nanambu Complex and, in the Jabiluka-Ranger-Koongarra area, comprises three distinct lithological units:

1. the lower unit consists mainly of dolomite and magnesite;
2. the middle unit, which hosts most of the mineralisation, is mainly graphitic pelitic schist, semi-pelitic schist and minor carbonate; and
3. the upper unit is psammitic and consists of quartz-muscovite schist and amphibolite.

The Cahill Formation is unconformably overlain by the Kombolgie Formation (Mesoproterozoic) which comprises flat-lying sandstones, with minor shale and conglomerate.

There are two interbedded volcanic units each ranging up to 250 m in thickness.

The main period of regional deformation and metamorphism occurred between 1870 and 1800 million years ago. Amphibolite facies conditions were attained in the Jabiluka area.

The Jabiluka 2 orebody has mineable ore reserves of 19.5 million tonnes averaging 0.46% U_3O_8, containing 90,400 tonnes of U_3O_8 at a cut off grade of 0.2% U_3O_8.

Environmental and social issues

Proposals by ERA to mine and mill the Jabiluka orebody have been the subject of a comprehensive environmental impact assessment process, carried out over a period of three years. The company's preferred option is an underground mining operation, with the ore to be processed at the Ranger mill. The ore would be trucked for a distance of 22 km to Ranger via a haul road entirely within the lease area. The tailings would be disposed of into the open pits at Ranger. This option is referred to as the Ranger Mill Alternative. Under this proposal there would be no tailings storage on the Jabiluka site, and a policy of zero water release from the mine site would be strictly implemented.

As part of the approval for the project, ERA must comply with more than 70 stringent requirements relating to protection of the environment and cultural heritage.

The senior traditional owner of the Jabiluka Mineral Lease area has not given her consent to milling the ore at Ranger. Consequently, ERA sought environmental clearance for an alternative option, which was to mill the ore and dispose of the tailings at the Jabiluka mine site (referred to as the Jabiluka Mill Alternative).

The outcome of the assessment of the Jabiluka Mill Alternative was that the company was required to comply with an additional 17 requirements covering issues such as protection of World Heritage values, communication with Aboriginal people, rehabilitation of the site and environmental management. Based on independent scientific advice on tailings disposal, another requirement was that all of the tailings are to be disposed of underground in the mine void. A process was stipulated that ERA must follow if it wishes to pursue an alternative option for tailings disposal. A policy of zero water release applies to this option also.

While both milling options have received environmental clearances, subject to compliance with a range of conditions, the Australian Government, the Northern Territory Government and ERA consider the Ranger Mill Alternative to be the superior proposal in terms of environmental considerations, project economics and logistics. ERA sought consent of the Northern Land Council for this alternative, in accordance with directions of the traditional owners.

However, following an announcement by the Northern Land Council that it will not consider the issue of approvals for the trucking of ore from Jabiluka to the Ranger mill until at least 2005, ERA stated in October 1999 that it would now focus its strategic review and evaluation studies on developing the Jabiluka Mill Alternative.

In commitments given to the World Heritage Committee, ERA announced that full-scale commercial mining at Jabiluka will not be undertaken until 2009, following the scaling down of production at Ranger mine, so that two mines would not be in full production simultaneously. In addition, the company has agreed to implement a range of social and cultural issues relating to the wider Kakadu region.

Construction of the mine ceased in September 1999, following completion of the decline, underground level development to access the ore body, a program of underground drilling, and mine planning. The project then entered a 12 month design phase to complete further environmental and cultural studies, and to negotiate with Aboriginal groups regarding the Ranger-Jabiluka access road.

Beverley

Geology

Beverley is a sandstone-type uranium deposit in the western part of the Frome Embayment, South Australia, owned by Heathgate Resources. It is set to be the first ISL uranium mine in Australia.

Tertiary sediments in the area unconformably overlie a basement of Cambrian and Proterozoic rocks. The deposit occurs in partly consolidated, fine to medium grained sands with inter-bedded clays and silts (Upper Tertiary Beverley Sands) that were deposited in a fluvial environment of a confined palaeochannel sequence. The palaeosurface on the Alpha Mudstone (below the Beverley Sands) has three channels, which constitute the Beverley aquifer. A thick clay unit, the Beverley Clay, overlies the Beverley Sands.

Uranium mineralisation occurs in three lenticular zones, designated North, Central and South ore lenses. The North and Central ore lenses are within the central channel while the South ore lens is situated in the south channel. Mineralisation occurs at an average depth below surface of 107 m, with depths ranging from 83 m at the North ore lens to 145 m at the South ore lens. The host sands are dominated by quartz, and contain various clays, minor felspar and traces of gypsum. Organic carbon commonly ranges from $<0.05\%$ to 0.5% in these sands, but there are local higher values. Pyrite and marcasite occur in trace amounts.

Uranium is present mainly as coffinite coatings on sand grains, and there is some uraninite. Total resources recoverable by ISL mining are estimated to be at least 10 600 tonnes U_3O_8.

Environmental issues

Liquid wastes from the Beverley ISL operations will be generated from several sources: a mining solution bleed at the plant, spent solutions from the uranium precipitation process, washdown water and filter cleaning water. These liquids will be collected in the plant holding ponds. On the basis of environmental and economic considerations, the company proposed to re-inject these wastes into the Beverley aquifer in areas already mined out.

Groundwaters in the Beverley aquifer are variably saline, with total dissolved solids ranging from 3000 to 12 000 mg/l, and contain naturally occurring uranium and radium well in excess of drinking water limits. It is unsuitable as potable water, and unsuitable for agriculture or stock watering. For approval to dispose of liquid waste into the Beverley aquifer, the company was required to show that there are no hydraulic connections between this aquifer and other aquifers in the area. The Beverley aquifer, which is separated stratigraphically from the Great Artesian Basin aquifer by approximately 100m of dense plastic clays of the Alpha Mudstone, has been confirmed as a bounded, confined aquifer, which contains semi-stagnant groundwater.

Heathgate Resources received approval for the Beverley project to proceed in April 1999. Production is scheduled to commence in mid-2000 at an annual rate of 1000 t U_3O_8.

Honeymoon

Geology

Honeymoon is a sandstone-type uranium deposit in the eastern Frome Embayment. The deposit is within coarse-grained sands of Tertiary age (Eyre Formation) and is between 100 m and 120 m below surface. It has a roll-front shape and occurs at an oxidation-reduction interface along the lateral margins of a bend in the Yarramba Palaeochannel.

Uranium occurs mainly in coffinite. Quartz and kaolinite are the main gangue minerals. Pyrite content of the ore is high averaging 7%, and total organic carbon averages 0.3%

The resources recoverable by ISL methods from Honeymoon (including Honeymoon extension) are estimated to be 3,700 tonnes U_3O_8 at a grade of 0.156% U_3O_8. There are nearby deposits also owned by the same company: East Kalkaroo has an indicated resource of 900 tonnes U_3O_8 at a grade of 0.14% U_3O_8; and Goulds Dam has an inferred resource of 18,000 tonnes U_3O_8 at a grade of 0.098% U_3O_8.

Within the Honeymoon palaeochannel, the sand, silt and clay units of the Eyre Formation form an aquifer system. While the palaeoachannel is considered to form a single aquifer on a regional scale, the sediments form a series of sub-aquifers and confining layers at a local scale. The Basal Sand, Middle Sand, Upper Sand and Top Sand are separated by clay layers which are generally continuous, but lens out in places. Pumping tests have confirmed that there are hydraulic connections between these sub-aquifers. Uranium mineralisation is in the Basal Sand aquifer.

During 1998 and 1999, Southern Cross Resources carried out field leach trials. Sulphuric acid and various oxidants (oxygen gas, hydrogen peroxide and ferric sulphate) were trialed for mobilising the uranium.

Both solvent extraction and ion exchange (resin) techniques were investigated for uranium recovery at the plant. A solvent extraction and precipitation circuit gave far superior results, as the high chloride content (high salinity) of the groundwaters prevented the ion exchange process from working effectively.

Environmental issues

These trials were approved to determine the engineering and economic feasibility of Honeymoon for commercial ISL mining, as well as provide essential input to the environmental impact assessment process.

Groundwaters in all the palaeochannel aquifers have high salinity levels and in the vicinity of the orebody the groundwaters contain high concentrations of radionuclides. Groundwater is pumped from the Upper Sand and purified in a reverse osmosis plant to provide water for the camp and, downstream from the orebody, groundwaters from the Upper Sand are used intermittently for stock watering.

Olympic Dam

Geology

The Olympic Dam deposit in central South Australia is being mined by Western Mining Corporation (WMC), who discovered it in 1975 beneath approximately 300 metres of flat-lying sedimentary rocks of the Stuart Shelf geological province. It is one of the world's largest deposits of uranium.

The mineralisation occurs in a hematite-rich granite breccia complex of Mesoproterozoic age. The central core of the complex is barren hematite-quartz breccia, with several localised diatreme structures, flanked to the east and west by zones of intermingled hematite-rich breccias and granitic breccias. These zones are approximately 1 km wide and extend almost 5 km in a northwest-southeast direction. Virtually all the economic copper-uranium mineralisation is hosted by these hematite-rich breccias. This broad zone is surrounded by granitic breccias extending up to 3 km beyond the outer limits of the hematite-rich breccias.

The deposit contains iron, copper, uranium, gold, silver, rare earth elements (mainly lanthanum and cerium) and fluorine. Only copper, uranium, gold, and silver are recovered. Olympic Dam reserves and resources were estimated in June 1998 to be:

	Million Tonnes	**Cu (%)**	**U_3O_8 (kg/t)**	**Contained U_3O_8 (tonnes)**
Reserves				
Proved	105	2.4	0.6	63 000
Probable	455	1.9	0.6	273 000
Resources*				
Indicated	1220	1.1	0.4	488 000
Inferred	430	1.3	0.4	172 000

No close analogues of the Olympic Dam deposit are known elsewhere.

Environmental issues

A major expansion of the Olympic Dam mine was completed in 1999, increasing copper production from 85 000 tonnes per annum (tpa) to 200 000 tpa. Uranium production, which is tied to copper production, is expected to increase to 4200 tonnes U_3O_8 in 2000.

A major issue considered in the environmental impact assessment for the expansion was the sustainable supply of water in the arid environment from boreholes in the Great Artesian Basin. Containment of tailings, and flora and fauna management were other significant issues addressed.

WMC is required to reduce the demand on water resources as much as possible, both at the mine and at Roxby Downs township by the use of efficient water supply and usage practices. In recent years, and particularly since the major expansion completed in 1999, application of more water efficient practices in the milling operations have achieved considerable reductions in the amount of water used per tonne of ore milled. Olympic Dam is licensed to water use of 42 mega-litres per day, and is currently using about 30 mega-litres per day.

* Resources are in addition to reserves

WMC is required to avoid adverse impact on the environmentally sensitive mound springs, and to monitor water flows at the mound springs. Should this monitoring indicate any significant variations from the predicted flows, the company must implement contingency measures to address these variations.

For the current operations, WMC proposes to continue using paddock cell methods for tailings disposal. The central thickened discharge method is being investigated as a new method for tailings disposal, with potential environmental and technical advantages. This method involves thickening the tailings slurry by removing excess liquids, and discharging the slurry from elevated outlets to form a final tailings profile resembling a series of intersecting flattened cones. It would be necessary to prevent acidic supernatant fluids from entering shallow groundwater aquifers in the underlying karstic Andamooka Limestone.

Should the company decide to use central thickened discharge methods, further environmental assessment would be necessary.

Conclusions

Exploration activity for uranium in Australia increased substantially from 1994 to 1997, but decreased by approximately 20% in 1998.

The main recent developments in the uranium mining industry in Australia have centred on proposals for three new mines. Jabiluka is an unconformity-style deposit within the Kakadu region of the Northern Territory. Beverley and Honeymoon are sandstone-hosted deposits in eastern South Australia, and the former is the first in situ leach uranium mine in Australia. In addition, a major expansion was completed in 1999 at the Olympic Dam mine, increasing copper and uranium production from this breccia-hosted deposit in central South Australia.

Jabiluka is in a wet-dry tropical region, while the other three deposits are in remote arid environments. Each project has been subjected to a comprehensive environmental impact assessment process. In the case of Jabiluka, socio-cultural issues have been particularly important.