3

Australia's uranium resources, production and exploration

> *… world stockpiles of uranium are diminishing. An increase in reliance on mine production for uranium supplies by nuclear power plant operators should have the effect of increasing the significance of Australia's uranium reserves. Factors such as the size and quality of those reserves, and Australia's record as a stable and low-cost supplier, should ensure that Australia is well placed to continue to supply traditional customers and to achieve significant market penetration in Asia, which is the most rapidly growing area for use of nuclear power.*[1]

> *Without doubt Australia's known resources could be increased significantly … but there needs to be a significant change in how uranium is viewed and a clear level of support shown at both the Federal and State level. A change in political will and direction is required to give the clear message to companies that it is worthwhile exploring for uranium. Australia already plays an important role in supplying low cost uranium to support the generation of clean nuclear energy … and if properly funded and supported … the unfortunate trend of the past ten plus years can be reversed and Australia could take its rightful place as the world's most important exporter.*[2]

1 Australian Nuclear Science and Technology Organisation (ANSTO), *Submission no. 29*, p. 5.
2 Cameco Corporation, *Submission no. 43*, p. 6.

Key messages —

- **Australia possesses 38 per cent of the world's total Identified Resources of uranium recoverable at low cost (less than US$40 per kilogram).**
- **According to company reports, Australia's known uranium deposits currently contain a total of over 2 million tonnes of uranium oxide in in-ground resources. The in-situ value of this resource at spot market prices prevailing in June 2006 is over A$270 billion.**
- **Olympic Dam in South Australia contains 26 per cent of the world's low cost uranium resources and is the world's largest uranium deposit. Olympic Dam is estimated to contain more than 1.46 million tonnes of uranium oxide in overall resources.**
- **Some 75 per cent of Australia's total Identified Resources of uranium are located in South Australia, but significant deposits are also located in the Northern Territory, Western Australia and Queensland.**
- **Seven of the world's 20 largest uranium deposits are in Australia—Olympic Dam (SA), Jabiluka (NT), Ranger (NT), Yeelirrie (WA), Valhalla (Queensland), Kintyre (WA) and Beverley (SA).**
- **Australia has the greatest diversity of economically important uranium deposit types of any country in the world, with resources of economic significance in many uranium deposit types.**
- **Despite the extent of its resources, over 10 per cent of Australia's low cost uranium resources are inaccessible, due in part to state government policies prohibiting uranium mining.**
- **In 2005, Australia achieved record national production of 11 222 tonnes of uranium oxide from three operational mines—Ranger, Olympic Dam and Beverley. Beverley is the world's largest uranium mine employing the in-situ leach (ISL) mining method.**
- **The Board of Canadian mining company sxr Uranium One has approved development of its Honeymoon deposit in SA. Honeymoon will also be an ISL operation, producing some 400 tonnes of uranium oxide per year for seven years. Production will commence from Honeymoon during 2008.**
- **A proposal to expand Olympic Dam would see uranium production from the mine treble to 15 000 tonnes of uranium oxide per year, which would make Olympic Dam and its owners, BHP Billiton Ltd, by far the world's largest producer. The expanded mine would**

account for more than 20 per cent of world uranium mine production and Australia would become the world's largest supplier of uranium with a doubling of national production.

- **Australia exported a record 12 360 tonnes of uranium oxide in 2005. This quantity of uranium was sufficient for the annual fuel requirements of more than 50 reactors (each of 1 000 megawatt electrical capacity), producing some 380 terawatt-hours of electricity in total—some one and a half times Australia's total electricity production. The value of uranium exports reached a record high of $573 million in 2005. The outlook for further increases in production and export earnings is positive.**
- **Over 80 per cent of Australia's uranium is currently supplied to customers in four countries—USA, Japan, France and the Republic of Korea.**
- **The increase in uranium price and the anticipated decline in secondary supplies have stimulated a resurgence in exploration activity and expenditure in Australia. In 2005, total exploration expenditure for uranium was $41.09 million, which was almost a three-fold increase on 2004 expenditure of $13.96 million.**
- **While there has been a trend of increasing exploration expenditure since early 2003, there has been relatively little exploration for uranium over the past two decades and Australia's known uranium resources generally reflect exploration efforts that took place 30 years ago. The size of Australia's known uranium resources significantly understates the potential resource base and there is great potential for new and significant discoveries.**
- **To assist in the discovery of new world-class uranium deposits, particularly those located at considerable depth, and to assist the junior companies which are now conducting a significant share of exploration activities, the Committee repeats key recommendations made in its last report that:**
  - ⇒ **a flow-through share scheme for companies conducting eligible minerals exploration activities in Australia be introduced; and**
  - ⇒ **Geoscience Australia be granted additional funding to develop and deploy techniques to provide precompetitive geoscience of prospective areas, in order to assist in the discovery of new world-class uranium and other mineral deposits located under cover and at depth.**

Introduction

3.1 This chapter, which is divided into three sections, provides a detailed overview of Australia's uranium resources, uranium mine production and exploration for uranium.

3.2 The Committee first considers Australia's uranium resources in world context, the distribution of uranium resources across the country, and the major uranium deposit types and their economic significance in Australia.

3.3 In the second section, the Committee summarises Australia's uranium mine production and exports performance, and provides an overview of the three currently operational mines—Ranger, Olympic Dam and Beverley. This section also describes recent developments at these mines, including the pre-feasibility study currently being undertaken for a proposed expansion of Olympic Dam. The likely development of the Honeymoon deposit in South Australia and the issue of recovering uranium from brannerite are also considered.

3.4 Finally, the Committee examines Australia's uranium exploration performance, recent exploration activity and the potential for new discoveries. The Committee concludes with a discussion of the important role now played by junior exploration companies and the importance of precompetitive geoscientific data for the discovery of new world class uranium deposits located at depth.

Resources

Resource classification schemes

3.5 Estimates of uranium resources at national and international levels are prepared in accordance with a resource classification scheme developed by the Uranium Group—a joint initiative of the OECD Nuclear Energy Agency (OECD-NEA) and the International Atomic Energy Agency (IAEA)—which collects and reports on data relating to uranium resources, production and demand. These estimates are published biennially in the OECD-NEA and IAEA publication *Uranium Resources, Production and Demand,* commonly known as the 'Red Book'. The classification scheme has been adopted internationally. Resource estimates for Australia are prepared by Geoscience Australia. Uranium resources at the level of individual deposits in Australia are reported by mining companies according to the categories of the *Australasian Code for Reporting of*

Exploration Results, Mineral Resources and Ore Reserves.[3] An explanation of these two resource classification schemes follows.

3.6 The OECD-NEA and IAEA classification scheme divides uranium resource estimates into categories that reflect the level of confidence in the quantities of recoverable uranium against the cost of production. Uranium resources are broadly classified as either conventional or unconventional. Conventional resources are those that have an established history of production where uranium is a primary product, co-product or an important by-product (e.g. from the mining of copper and gold). Very low-grade resources, or those from which uranium is only recoverable as a minor by-product, are considered unconventional resources (e.g. uranium in phosphate deposits, black shale and seawater).[4]

3.7 Conventional resources are further divided, according to the level of confidence in the occurrence of the resources, into four categories:

- Reasonably Assured Resources (RAR) refers to uranium that occurs in known mineral deposits of delineated size, grade and configuration such that the quantities which could be recovered can be specified.
- Inferred Resources refers to uranium, in addition to RAR, that is inferred to occur based on direct geological evidence, in extensions of well-explored deposits, or in deposits in which geological continuity has been established but where specific data are considered to be inadequate to classify the resources as RAR. Less reliance can be placed on the estimates in this category than in RAR.
- Prognosticated Resources refers to uranium, in addition to Inferred Resources, that is expected to occur in deposits for which the evidence is mainly indirect and which are believed to exist in well-defined geological trends or areas of mineralisation with known deposits.
- Speculative Resources refers to uranium, in addition to Prognosticated Resources, that is thought to exist, mostly on the basis of indirect evidence and geological extrapolations, in deposits discoverable with existing exploration techniques. As the name implies, the existence and size of such resources are speculative.

3.8 In this classification scheme, RAR and Inferred Resources combined are referred to as Identified Resources, while Prognosticated and Speculative Resources are referred to as Undiscovered Resources. Identified Resources are normally expressed in terms of tonnes of recoverable uranium (tU), rather than quantities contained in mineable ore (quantities in situ). That

3 Geoscience Australia, *Submission no. 42*, pp. 1, 15.

4 See: IAEA and OECD-NEA, *Uranium 2005: Resources, Production and Demand,* OECD, Paris, 2005, pp. 361–363.

is, the estimates include allowances for expected mining and ore processing losses.

3.9 Identified Resources are further separated into categories based on the cost of production, which are expressed in US dollars per kilogram of uranium (comparable cost categories in US dollars per pound of uranium oxide, U_3O_8, are included in brackets) as follows:

- less than US$40/kg U (less than US$15/lb U_3O_8);
- US$40-80/kg U (US$15-30/lb U_3O_8); and
- US$80-130/kg U (US$30-50/lb U_3O_8).[5]

3.10 The *Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves* (the 'JORC Code') has been developed by the Joint Ore Reserves Committee of the Australasian Institute of Mining and Metallurgy, Australian Institute of Geoscientists and the Minerals Council of Australia. The Code sets out minimum standards, recommendations and guidelines for public reporting in Australasia of exploration results, mineral resources and ore reserves. The Code has been adopted by and included in the listing rules of the Australian Stock Exchange.[6]

3.11 The JORC Code defines a Mineral Resource as a concentration or occurrence of material of intrinsic economic interest in or on the Earth's crust in such form, quality and quantity that there are reasonable prospects for eventual economic extraction. The location, quantity, grade, geological characteristics and continuity of a Mineral Resource are known, estimated or interpreted from specific geological evidence and knowledge. Mineral Resources are sub-divided, in order of increasing geological confidence, into Inferred, Indicated and Measured categories.[7]

3.12 The Code defines an Ore Reserve as the economically mineable part of a Measured and/or Indicated Mineral Resource. It includes diluting materials and allowances for losses, which may occur when the material is mined. Appropriate assessments and studies have been carried out, and include consideration of and modification by realistically assumed mining, metallurgical, economic, marketing, legal, environmental, social and governmental factors. These assessments demonstrate at the time of reporting that extraction could reasonably be justified. Ore Reserves are

5 *ibid.*, p. 363; Geoscience Australia, *Exhibit no. 61, Australia's uranium resources and exploration*, p. 2.

6 Joint Ore Reserves Committee of the Australasian Institute of Mining and Metallurgy, Australian Institute of Geoscientists and Minerals Council of Australia (JORC), *Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves*, JORC, 2004, p. 2.

7 *ibid.*, p. 7.

sub-divided in order of increasing confidence into Probable Ore Reserves and Proved Ore Reserves.[8]

3.13 Ore Reserves are further defined in the JORC Code as those portions of Mineral Resources which, after the application of all mining factors, result in an estimated tonnage and grade which, in the opinion of the person competent to make the estimates, can be the basis of a viable project, after taking account of all relevant modifying factors listed above.

3.14 Proved and Probable Ore Reserves plus Measured and Indicated Mineral Resources in the JORC Code are equivalent to RAR in the OECD-NEA and IAEA classification scheme. Inferred Resources in the JORC Code are equivalent to Inferred Resources in the OECD-NEA and IAEA scheme.[9]

Australia's uranium resources in world context

3.15 As at January 2005, Australia's total Identified Resources recoverable at less than US$40/kg U (i.e. recoverable at 'low-cost') amounted to 1 044 000 tU (1 230 758 t U_3O_8). This represented 38 per cent of the world's total Identified Resources in this cost category. Combined across all production cost categories, Australia's Identified Resources amounted to 1 143 000 tU.[10] Australian and world totals of Identified Resources for each cost category are listed in table 3.1.

3.16 The data in table 3.1 shows that of Australia's total Identified Resources, over 90 per cent is recoverable at low cost.[11] Furthermore, more than 67 per cent of Australia's Identified Resources recoverable at low cost are classified as RAR.

8 *ibid.*, p. 10.

9 Geoscience Australia, *Submission no. 42*, p. 15.

10 IAEA and OECD-NEA, *op. cit.*, pp. 15, 94.

11 See also: Minerals Council of Australia (MCA), *Submission no. 36*, p. 4.

Table 3.1 Australian and World Identified Resources as at January 2005

Categories of Identified Resources	**Production cost ranges**		
	Tonnes U recoverable at <US$40/kg U	Tonnes U recoverable at <US$80/kg U	Tonnes U recoverable at <US$130/kg U
Reasonably Assured Resources	701 000	714 000	747 000
Inferred Resources	343 000	360 000	396 000
Australia's total Identified Resources	1 044 000	1 074 000	1 143 000
World total Identified Resources	*2 746 380*	*2 804 381*	*4 742 853*
Australia's share of world total Identified Resources	38%	38%	24%

Source IAEA and OECD-NEA, *Uranium 2005: Resources, Production and Demand*, pp. 15–16, 102–103.

3.17 Geoscience Australia (GA) submitted that as at December 2005 Australia's RAR recoverable at low cost amounted to 716 000 tU (844 340 t U_3O_8). This represents 36 per cent of the world's uranium resources in this category.[12]

3.18 As shown in table 3.1, Australia possesses 343 000 tU in Inferred Resources recoverable at low cost, which is by far the world's largest resources in this category—43 per cent of the world total. The majority of these resources are located in the south-eastern part of the Olympic Dam deposit, where exploration drilling has defined large tonnages of additional resources.[13]

3.19 Other countries that have large quantities of RAR recoverable at low cost include Canada (15 per cent of the world total), Kazakhstan (14 per cent), Niger (9 per cent), Brazil (7 per cent), South Africa (5 per cent), Uzbekistan (4 per cent), Namibia (3 per cent) and the Russian Federation (3 per cent).[14] Table 3.2 and figure 3.1 show the distribution of RAR among countries with major resources.

12 Information provided by Mr Aden McKay (GA), 21 June 2006. This figure includes resource estimates contained in Summit Resources' submission to the Committee's inquiry, that the company's Mount Isa uranium project contains a resource of over 34 500 t U_3O_8 recoverable at low cost. See: Summit Resources Ltd, *Submission no. 15*, p. 12; Mr Alan Eggers (Summit Resources Ltd), *Transcript of Evidence*, 3 November 2005, pp. 4, 5.

13 GA, *Exhibit no. 61, op. cit.*, p. 5.

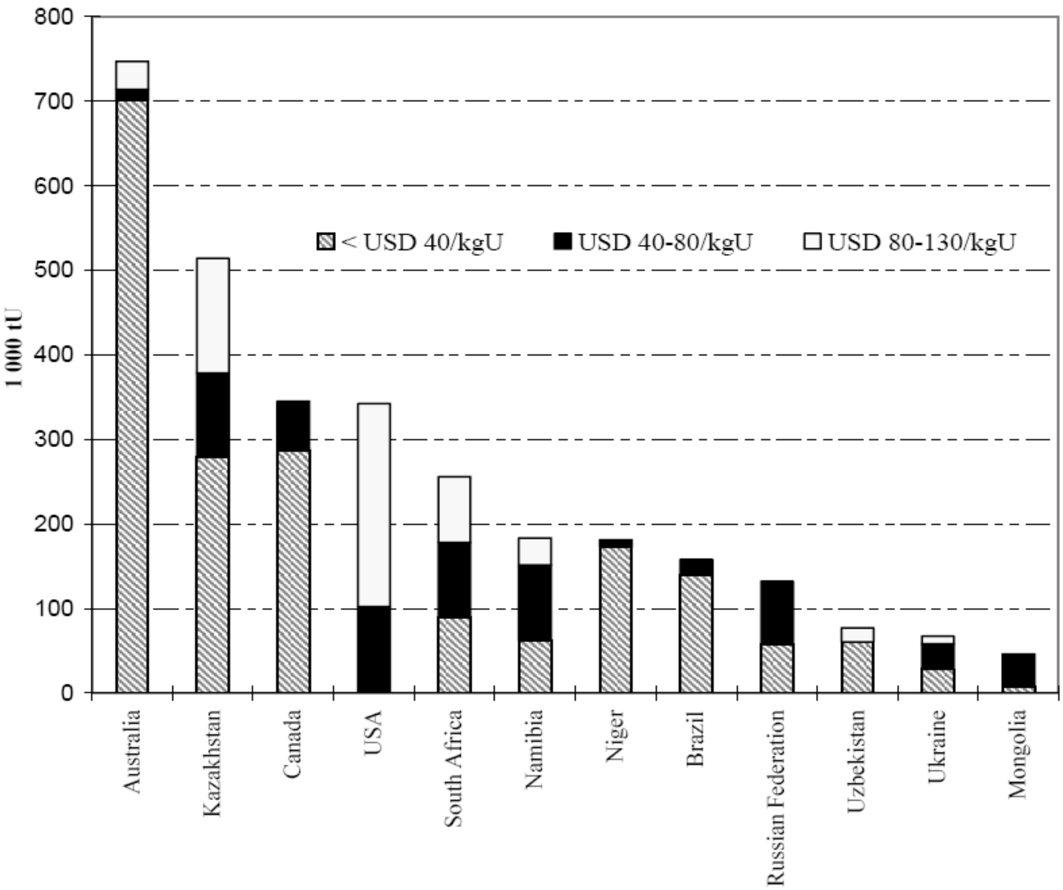
14 IAEA and OECD-NEA, *op. cit.*, p. 15; Areva, *Submission no. 39*, p. 13.

Table 3.2 Reasonably Assured Resources (tU) as at January 2005

Country	Production cost ranges		
	<US$40/kg U	US$40–80/kg U	US$80–130/kg U
Australia	701 000	13 000	33 000
Brazil	139 900	17 800	0
Canada	287 200	58 000	0
Kazakhstan	278 840	99 450	135 607
Mongolia	7 950	38 250	0
Namibia	62 186	89 135	31 235
Niger	172 866	7 580	0
Russian Federation	57 530	74 220	0
South Africa	88 548	88 599	78 446
Ukraine	28 005	30 493	8 208
United States	NA	102 000	240 000
Uzbekistan	59 743	0	17 193
Others	*63 615*	*77 433*	*209 657*
World total	1 947 383	695 960	653 346

Source IAEA and OECD-NEA, *Uranium 2005: Resources, Production and Demand*, p. 15.

Figure 3.1 Distribution of Reasonably Assured Resources among countries with major resources



Source IAEA and OECD-NEA, *Uranium 2005: Resources, Production and Demand*, p. 18.

Distribution of uranium resources in Australia

3.20 Approximately 98 per cent of Australia's Identified Resources recoverable at less than US$40/kg U are contained within the following six deposits:

- Olympic Dam in South Australia (SA);
- Ranger, Jabiluka and Koongarra in the Alligator Rivers Region Uranium Field (ARUF) of the Northern Territory (NT); and
- Kintyre and Yeelirrie in Western Australia (WA).[15]

3.21 Australia has some 85 known uranium deposits, varying in size from small to very large, scattered across the continent. Approximately 75 per cent of Australia's total Identified Resources recoverable at low cost are located in South Australia (782 798 tU or 923 111 t U_3O_8), 19 per cent is located in the Northern Territory (193 818 tU or 228 559 t U_3O_8) and 6 per cent in Western Australia (67 067 tU or 79 088 t U_3O_8).[16]

3.22 Olympic Dam is the world's largest deposit of low cost uranium. Based on ore reserves and mineral resources reported by the mine's owners as at June 2005, GA estimated that Olympic Dam contains 503 300 tU in RAR recoverable at less than US$40/kg U. This represents 26 per cent of the world's total resources and over 70 per cent of Australia's resources in this category.[17] Olympic Dam is estimated to contain in excess of 1.46 million t U_3O_8 (1.27 million tU) in total resources.[18] Moreover, of the world's 20 largest uranium deposits, seven are in Australia—Olympic Dam, Jabiluka, Ranger, Yeelirrie, Valhalla (Queensland), Kintyre and Beverley (SA).[19]

3.23 The location of Australia's uranium deposits and the relative size of ore reserves and mineral resources for each deposit are depicted in figure 3.2. Australia's major undeveloped uranium deposits, prospective mines and their main owners are listed in table 3.3.[20]

---

15 IAEA and OECD-NEA, *op. cit.*, p. 95; GA, *Submission no. 42*, p. 15; MCA, *loc. cit.*

16 GA, *Exhibit no. 61, op. cit.*, p. 3. As noted above, Summit Resources submitted that the company's Mount Isa uranium project in Queensland contains Identified Resources of 35 000 t U_3O_8 recoverable at low cost. See also: I Lambert et. al., *Why Australia has so much uranium*, GA, Canberra, 2005, viewed 4 July 2006, <http://www.ga.gov.au/image_cache/GA7518.pdf>.

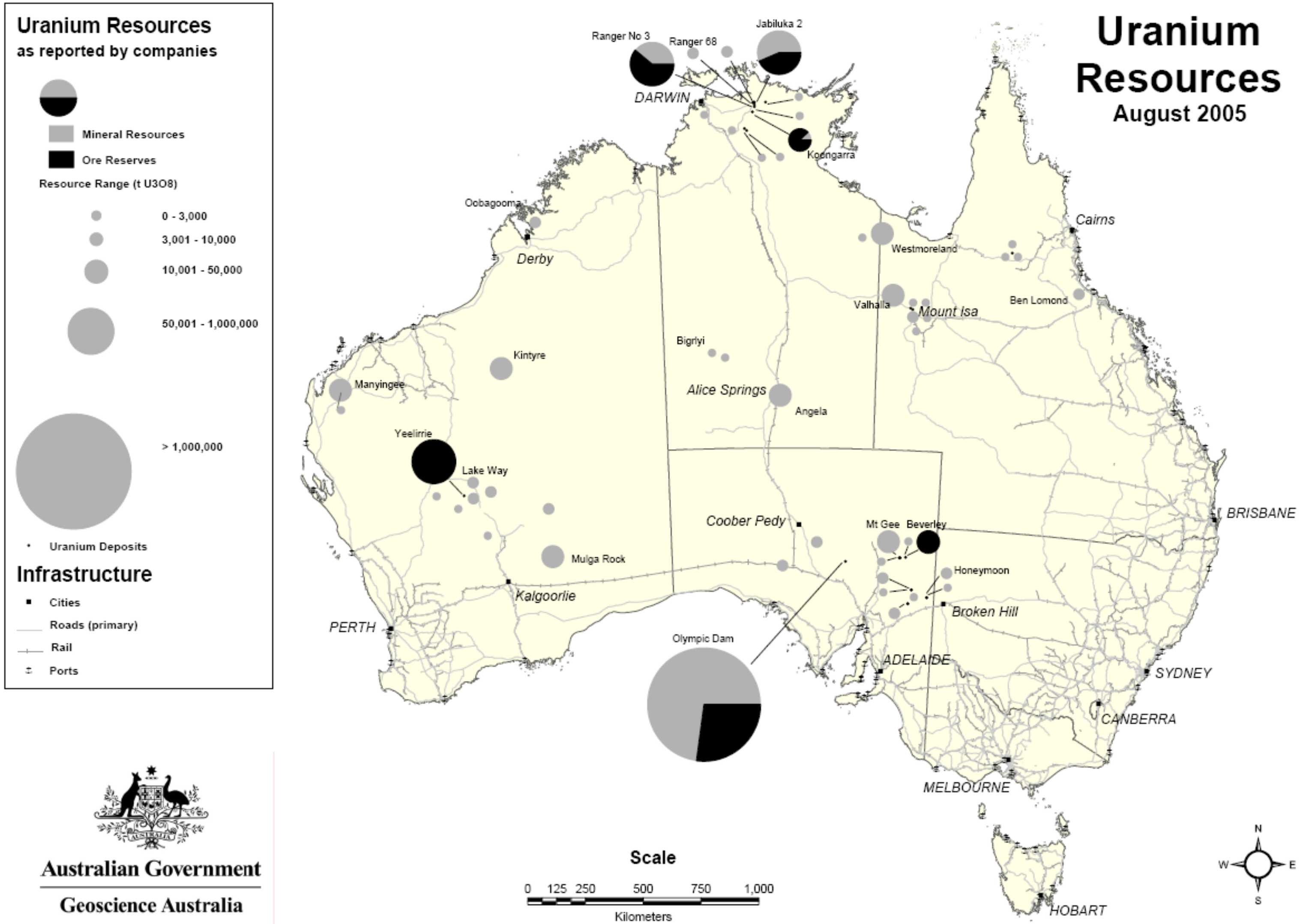
17 Information provided by Mr Aden McKay (GA), 21 June 2006.

18 Dr Roger Higgins (BHP Billiton Ltd), *Transcript of Evidence*, 2 November 2005, p. 3. See also: Uranium Information Centre (UIC), *Australia's Uranium Mines*, viewed 21 June 2006, <http://www.uic.com.au/emine.htm>.

19 Mr Stephen Mann (Areva), *Transcript of Evidence*, 23 September 2005, p. 2.

20 Detailed information including the historical background of each deposit is available online from the UIC, *Australia's Uranium Deposits and Prospective Mines*, viewed 20 June 2006, <http://www.uic.com.au/pmine.htm>.

Figure 3.2 Location of Australia's uranium deposits and the relative size of ore reserves and mineral resources for each deposit



Source Geoscience Australia, *Exhibit no. 61, Australia's uranium resources and exploration.*

Table 3.3 Australia's major undeveloped uranium deposits and prospective mines as at April 2006

State / Territory	Deposit	Main owner	Grade (per cent U_3O_8)	Contained U_3O_8 (tonnes)	Category
Northern Territory	Jabiluka	Energy Resources of Australia Ltd (Rio Tinto 68%)	0.52	67 000	reserves
			0.39	21 000	measured and indicated resources
			0.48	75 000	inferred resources
	Koongarra	Areva	0.8	14 540	reserves
	Angela	Cameco	0.1	10 250	resources
Western Australia	Kintyre	Canning Resources Pty Ltd (Rio Tinto)	0.15 – 0.4	36 000	reserves and resources
	Yeelirrie	BHP Billiton Ltd	0.15	52 500	indicated resources
	Mulga Rock	Eaglefield Holdings Pty Ltd	0.14	13 300	resources
	Manyingee	Paladin Resources Ltd	0.09	12 000	resources
	Oobagooma		not known	5 000	resources
	Lake Maitland	Redport Ltd	0.052	7 900	resources
	Lake Way	Nova Energy Ltd	not known	4 000	resources
	Centipede		0.063	4 400	resources
	Thatchers Soak	Uranex NL	0.03	4 100	resources
South Australia	Honeymoon	sxr Uranium One Inc	0.24	2 900	resources
	Goulds Dam		0.045	2 500	indicated resources
	Curnamona	Curnamona Energy Ltd	not known	Not known	-
	Prominent Hill	Oxiana Ltd	0.012	9 900	inferred resources
	Mt Gee	Marathon Resources Ltd	0.073	33 200	inferred resources
	Crocker Well	PepinNini Minerals Ltd	0.51	6 338	resources
Queensland	Westmoreland (Qld/NT)	Laramide Resources Ltd	up to 0.2	22 500	inferred resources
	Valhalla	Summit Resources Ltd	0.144	16 500	indicated resources
				25 000	inferred resources
	Skal		0.119	5 000	resources
	Andersons Lode		0.143	6 500	inferred resources
	Ben Lomond	Mega Uranium Ltd	0.25	4 760	resources
	Maureen		0.123	2 940	resources

Source UIC, *Submission no. 12*, p. 24; UIC, *Australia's Uranium Deposits and Prospective Mines*.

3.24 In addition to the currently operational mines described below, GA submitted that several uranium deposits have in previous years been subject to either a comprehensive feasibility study or an Environmental Impact Statement (EIS), or both. These projects have not proceeded to mining for a variety of reasons including state government mining restrictions or previously low uranium prices. These deposits are: Jabiluka and Koongarra in the NT; Kintyre, Yeelirrie, Manyingee and Lake Way in WA; and Ben Lomond and Valhalla in Qld.[21]

3.25 Several of the junior mining and exploration companies that submitted to the inquiry made observations about the resources contained in their uranium deposits:

- Summit Resources submitted that the company's Mount Isa uranium project (the Valhalla, Skal and Andersons Lode deposits) in Queensland (Qld) contains a total uranium resource (RAR and Inferred) of over 34 500 t U_3O_8 (29 255 tU) recoverable at low cost.[22] GA have now incorporated these resources into the estimates for Australia's RAR recoverable at low cost, provided above.
- Eaglefield Holdings, owners of the Mulga Rock deposit (MRD) in WA, noted that the MRD was evaluated by the deposit's previous owner to contain an estimated 46 000 t U_3O_8 (33 918 tU). However, the age of the resource estimation renders it non-JORC compliant. In addition to its uranium content, Eaglefield Holdings submitted that the MRD may also contain the largest known exploitable resource of scandium in the world, as well as a very large resource of oily-lignite.[23]
- Nova Energy noted that, combined, its Lake Way and Centipede/Millipede deposits in WA contain an estimated 8 860 t U_3O_8 (7 513 tU).[24]
- Compass Resources announced in July 2006 that its Mt Fitch uranium prospect in the NT contains an estimated 4 050 t U_3O_8 (3 434 tU) in indicated and inferred resources.[25]

3.26 Just over 10 per cent of Australia's RAR recoverable at less than US$40/kg U has been classified by GA as inaccessible for mining. This is

21 GA, *Exhibit no. 61, op. cit.*, p. 5.

22 Summit Resources Ltd, *op. cit.*, pp. 12, 14.

23 Eaglefield Holdings Pty Ltd, *Submission no. 18*, p. 1. It was explained that scandium is a highly sought after commodity for the manufacture of aluminium alloys in the aerospace industry. See: Mr Michael Fewster (Eaglefield Holdings Pty Ltd), *Transcript of Evidence*, 23 September 2005, pp. 24–27.

24 Nova Energy Ltd, *Submission no. 50*, p. 12.

25 Compass Resources NL, *Uranium Resources Delineated at Mt Fitch Prospect*, viewed 19 July 2006, <http://www.compassnl.com.au/news_room/_announcements/2006_CMR_Uranium_Resource_Delineated.pdf>.

due in part to prohibitions on mining in WA. WA State Government policy prohibits uranium mining on leases granted after June 2002, hence deposits in that State are classified as 'inaccessible resources'. The MCA submitted that current WA Government policy prevents Kintyre and Yeelirrie from being developed. The Qld State Government has also discouraged potential new mine developments, despite the absence of legislation that specifically prohibits uranium mining.[26]

3.27 Inaccessible resources also includes those deposits in the ARUF where mining leases are too small to accommodate the proposed mine and treatment plant facilities, such as Koongarra. These leases may not be able to be increased in size as they are surrounded by the Kakadu National Park. However, the MCA noted that the leases for both Jabiluka and Koongarra predate and were excluded from the Kakadu National Park.[27]

3.28 According to company reports, Australia's uranium deposits contain a total of over two million t U_3O_8.[28] The in-situ value of this resource at uranium spot market prices prevailing in June 2006 is over A$270 billion.[29] The uranium ore reserves and mineral resources for each of Australia's uranium deposits, as reported by the mining companies, are listed in appendix E by state and territory.

3.29 Notwithstanding the size of Australia's known uranium resources, submitters argued that these underestimate the potential uranium resource base because, until recently, there has been very little exploration activity in Australia for more than 20 years.[30] This matter is considered in the final section of this chapter.

Uranium deposit types and their economic significance in Australia

3.30 The OECD-NEA and IAEA have classified uranium deposits worldwide into fifteen deposit types on the basis of their geological setting.[31] GA explained that 98 per cent of Australia's uranium resources occur within four such deposit types:

- Hematite breccia complex deposits—deposits of this type occur in hematite-rich breccias and contain uranium in association with copper, gold, silver and rare earths.

26 GA, *Exhibit no. 62, Australia's Identified Mineral Resources*, p. 4; GA, *Submission no. 42*, pp. 17–18.

27 MCA, *op. cit.*, p. 5.

28 GA, *Exhibit no. 61, op. cit.*, p. 15.

29 Calculated on the basis of the uranium spot market price of US$45/lb U_3O_8 and 1A$ = 0.73US¢.

30 MCA, *op. cit.*, p. 4.

31 OECD-NEA and IAEA, *Uranium 2005: Resources, Production and Demand*, *op. cit.*, pp. 368–372.

Some 70 per cent of Australia's total uranium resources occur in Proterozoic hematite-rich granitic breccias at Olympic Dam, which is also the only known breccia complex that has a significant resource of uranium in the world. Broadly similar, but apparently smaller, hematite-rich breccia mineralisation is being evaluated elsewhere in the same geological province (the Gawler Craton), at Prominent Hill in South Australia. These are examples of 'iron oxide copper gold deposits' with higher uranium contents than most deposits of this type.

- Unconformity-related deposits—deposits of this type are associated with and occur immediately below and above an unconformable contact that separates a crystalline basement intensively altered from overlying clastic sediments of either Proterozoic or Phanerozoic age.

  About 18 per cent of Australia's resources are associated with Proterozoic unconformities, mainly in the ARUF of the NT (Ranger, Jabiluka, Koongarra).

- Sandstone uranium deposits—deposits of this type occur in medium to coarse-grained sandstones in a continental fluvial or marginal marine sedimentary environment.

  Some six per cent of Australia's resources are sandstone uranium deposits and are located mainly in the Frome Embayment field, SA (Beverley, Honeymoon) and the Westmoreland area, which straddles the NT and Qld.

- Surficial (calcrete) deposits—deposits of this type are broadly defined as young (Tertiary to recent) near-surface uranium concentrations in sediments and soils.

  These deposits constitute about four per cent of Australia's uranium resources, mostly in the Yeelirrie deposit (WA).[32]

3.31 Cameco noted that other deposit types are found in Australia, such as metasomatite type deposits including Valhalla in Qld, where disseminated uranium is deposited in deformed rocks. Intrusive type deposits such as Maureen and Ben Lomond are found within the Georgetown Inlier in Northwest Qld and the Westmoreland area hosts a number of vein and other sandstone deposits.[33]

3.32 The Northern Territory Minerals Council (NTMC) noted that uranium occurrences in the NT can be grouped into unconformity-related, vein-like, Westmoreland and sandstone type deposits. Almost all mined deposits and most of the currently known resources are unconformity-related and occur within Palaeoproterozoic rocks of the Pine Creek

32 GA, *Submission no. 42*, p. 17.

33 Cameco Corporation, *Submission no. 43*, p. 6.

Orogen, near the unconformity with overlying platform cover sandstone of the McArthur Basin or Birrindudu Basin. The NTMC noted that large unconformity deposits in the ARUF account for 96 per cent of past production and 95 per cent of known resources in the Territory. Smaller Westmoreland-type deposits (e.g. Eva) are present in the eastern McArthur Basin. Sandstone-hosted deposits are present in the Ngalia (e.g. Bigrlyi) and Amadeus (e.g. Angela) basins. Small vein-type deposits in the Pine Creek Orogen (e.g. Adelaide River) have been mined in the past.[34] The location of the known uranium deposits in the NT and their geological settings are depicted in appendix F.

3.33 Dr Donald Perkin submitted that 'world class' deposits are those that contain high-grade uranium ore, coupled with large tonnages and/or features which reduce the cost of mining such as convenient shape, well defined ore zones, easily treatable ore and good location. Because world class deposits are lowest cost, they are the most competitive and least vulnerable to downturns in the industry.[35]

3.34 Dr Perkin argued that 'Australia is unique in having the greatest diversity of economically important uranium deposit types of any country in the world', with resources of economic significance in many uranium deposit types.[36]

3.35 It was argued that the unconformity-related and sandstone deposit types:

> … represent potentially viable uranium mining operations and exploration target types into the future, and with their relatively high grades and large resources, these types will easily be able to withstand … erosion in real price and, in a more positive market, able to provide strong future cash flows and profits.[37]

3.36 Consequently, Dr Perkin argued that Australia along with Canada and Niger, which have a predominance of the world's relatively high-grade resources in these deposit types, are therefore 'uniquely suited to become chief suppliers of low-cost uranium to the world nuclear power industry well into the 21st century.'[38]

Thorium

3.37 In addition to uranium resources, Australia also possesses the world's largest quantity of economically recoverable thorium resources—

34 NTMC, *Submission no. 51*, p. 5.

35 Dr Donald Perkin, *Exhibit no. 3, The Significance of uranium deposits through time*, pp. 93, 108.

36 *ibid.*, p. 70.

37 *ibid.*, p. 114.

38 *ibid.*

300 000 t—more than Canada and the US combined, as shown in table 3.4. The 2005 Red Book states that current estimates put world thorium resources at 4.5 million tonnes (Mt), but this figure is considered conservative.[39]

Table 3.4 World's economically extractable thorium resources

Country	Reserves (tonnes)
Australia	300 000
India	290 000
Norway	170 000
USA	160 000
Canada	100 000
South Africa	35 000
Brazil	16 000
Other countries	95 000
World total	1 200 000

Source UIC, *Thorium*, Briefing Paper No. 67.

3.38 Like uranium, thorium can be used as a nuclear fuel. Interest in utilising thorium has arisen because it is three times more abundant in the Earth's crust than uranium, and almost all of the mined thorium is potentially usable in a reactor, compared with only 0.7 per cent of natural uranium. Thus, thorium may contain some 40 times the amount of energy per unit mass than uranium, without recourse to fast breeder reactors.[40] Thorium-based fission is described further in chapter 12.

3.39 India, which has about six times more thorium than uranium, is currently building two reactors which will use thorium-based fuel and has made the utilisation of thorium for large-scale energy production a major goal in its nuclear power program. While thorium has been the subject of research for several decades, the thorium fuel cycle is not yet commercialised.[41]

3.40 Arafura Resources submitted that the company's Nolan's Bore deposit, located 135 km north of Alice Springs, contains both thorium and uranium hosted in phosphate rock. Recent drilling indicates that the deposit contains some 24 000 t of thorium, as well as 1 800 tU and 227 000 t of rare earths.[42]

39 IAEA and OECD-NEA, *op. cit.*, p. 21.

40 UIC, *Thorium*, Briefing Paper No. 67, June 2006, viewed 3 July 2006, <http://www.uic.com.au/nip67.htm>; Professor Igor Bray, *Transcript of Evidence*, 2 March 2006, p 4.

41 UIC, *Thorium, loc. cit.*; Professor Igor Bray, *loc. cit.*

42 Mr Alistair Stephens (Arafura Resources NL), *Transcript of Evidence*, 23 September 2005, p. 47.

Production and exports

Australia's uranium mine production and exports

3.41 Australia's uranium production in 2005 came from three mines: Ranger (5 910 t U_3O_8), Olympic Dam (4 335 t U_3O_8) and Beverley (977 t U_3O_8). Combined, the mines achieved record national production of 11 222 t U_3O_8, six per cent higher than in 2004. As noted in the previous chapter, Australia is the world's second largest producer of uranium, accounting for 23 per cent of world uranium mine output in 2005, after Canada (28 per cent).[43]

3.42 All of Australia's uranium mine production is exported for use in electrical power generation. Australian export tonnages have increased steadily from less than 500 t U_3O_8 in 1976, to reach a record level of 12 360 t U_3O_8 in 2005. Exports for 2005 were valued at A$573 million—a record for annual export earnings. In the five years to 2006, Australia exported 48 496 t U_3O_8 with a value of $2.2 billion. The average export value in 2005 was $46 360 per tonne of U_3O_8.[44] Table 3.5 shows Australia's uranium mine production and exports for 2000 to 2005.

3.43 The Australian Bureau of Agricultural and Resource Economics (ABARE) has forecast that Australian uranium mine production will grow by over eight per cent in financial year 2005–06 to nearly 11 900 t U_3O_8, largely due to higher output from Olympic Dam and Ranger. The value of uranium exports is forecast to reach A$712 million in 2005–06, an increase of 50 per cent on the 2004–05 export value of $475 million.[45]

3.44 Uranium produced in Australia is shipped to uranium conversion plants in France, USA, Canada and the UK. Following the other steps of the 'front end' of the fuel cycle, outlined in chapter two, Australian uranium is used to fabricate fuel elements for use in nuclear power stations.[46]

---

43 RWE NUKEM, *NUKEM Market Report*, May 2006 edition, RWE NUKEM Inc, Danbury, Connecticut, May 2006, p. 17; GA, *Exhibit no. 62, op. cit.*, p. 5; UIC, *Newsletter*, Issue No. 2, March/April 2006.

44 GA, *Submission no. 42*, p. 10; UIC, *Submission no. 12*, p. 27.

45 ABARE, *Australian Commodities*, Vol. 13, No. 1, March Quarter 2006, Commonwealth of Australia, Canberra, 2006, p. 107, viewed 23 June 2006, <http://www.abareconomics.com/publications_html/ac/ac_06/ac06_march.pdf>.

46 GA, *Submission no. 42*, p. 10.

Table 3.5 Australian uranium mine production and exports (tonnes U_3O_8), 2000–2005

	2000	2001	2002	2003	2004	2005
Ranger Percentage of world production	4 437 10%	4 203 10%	4 407 11%	5 065 12%	5138 11%	5 910 12%
Olympic Dam Percentage of world production	4 500 11%	4 335 10%	2 867 7%	3 176 7%	4 370 9%	4 335 9%
Beverley Percentage of world production	—	546 1%	746 2%	689 2%	1 084 2%	977 2%
Australian total Percentage of world production	8 937 21%	9 104 21%	8 083 20%	8 931 21%	10 592 22%	11 222 23%^
World mine production	42 466	43 656	42 502	42 184	47 955^	49 375^
Australian exports	8 757	9 239	7 637	9 612	9 648	12 360
Value of Australian exports* (A$ million)	426	463	363	398	411	573
Average export value in A$/lb U_3O_8	22.07	22.72	21.58	18.78	19.32	21.03
Average export value in US$/lb U_3O_8	12.85	11.78	11.73	12.24	14.22	16.03

Source UIC, *Submission no. 12*, p. 27; GA, *Submission no. 42*, p. 7; UIC, *Australia's Uranium and Who Buys It*, Nuclear Issues Briefing Paper No. 1.
* Export values are free-on-board estimates.
^ Figures obtained from RWE NUKEM, *NUKEM Market Report*, May 2006, p. 14.

3.45 Australian mining companies supply uranium under long-term contract to electricity utilities in the following countries: USA, Japan, European Union (UK, France, Germany, Spain, Sweden, Belgium, Finland), South Korea, Canada and to Taiwan under safeguards agreements with the USA.[47] In 2004, Australian uranium was supplied to customers in the countries listed in table 3.6.

3.46 In April 2006, Australia and China entered into a bilateral safeguards agreement on the transfer of nuclear material, whereby sales of uranium to China will now be permitted.[48]

47 *ibid.*, p. 11; Dr Clarence Hardy (Australian Nuclear Association), *Transcript of Evidence*, 16 September 2005, p. 51.

48 Australian Safeguards and Non-Proliferation Office (ASNO), *Agreement Between the Government of Australia and The Government of the People's Republic of China on the Transfer of Nuclear Material*, viewed 26 June 2006, <http://www.dfat.gov.au/geo/china/treaties/nuclear_material.html>.

Table 3.6 Supplies of Australian uranium shown by end-user, 2004

Country	Tonnes U_3O_8	% of total
United States	3 513.89	38.4
Japan	2 292.49	25.0
France	939.06	10.3
Republic of Korea	930.00	10.1
Sweden	400.95	4.4
United Kingdom	382.84	4.2
Germany	249.48	2.7
Spain	200.00	2.2
Canada	136.08	1.5
Finland	112.03	1.2
TOTAL	**9 156.82***	**100.0**

Source Australian Safeguards and Non-Proliferation Office, *Annual Report 2004–2005*, p. 45.
* Total quantity supplied does not equal total exports (9 648 t U_3O_8) during 2004 due to timing differences in the reporting of exports and receipts.

3.47 Uranium produced from Australia's mines is largely sold under long-term contracts and thus the spot market price for uranium is not indicative of the price paid for current production. The spot market price is currently well above the long-term contract price. For example, in 2005 the average realised sale price of U_3O_8 sold by Energy Resources of Australia from its Ranger mine was US$16/lb, whereas the spot market price on 31 December 2005 was more than double this at US$36/lb U_3O_8.[49] In June 2006 the spot price reached US$45/lb U_3O_8.[50] Similarly, BHP Billiton reported that the contract price for uranium produced at Olympic Dam is currently approximately US$15/lb.[51]

3.48 In financial year 2004–05, Australia exported 11 215 t U_3O_8, in 64 shipments from the three operational mines. This quantity of uranium was sufficient for the annual fuel requirements of approximately 50 reactors (each of 1 000 MWe capacity), producing some 380 TWh of electricity in total—some one and a half times Australia's total electricity production. Effectively, Australian uranium supplied about 2 per cent of total world electricity production in 2004–05.[52]

49 Energy Resources of Australia Ltd (ERA), *Full Year Results 2005*, Media Release and Stock Exchange Announcement, issued 1 February 2006, viewed 21 April 2006, <http://www.energyres.com.au/showpdf.php3?id=212>.

50 Spot price for uranium oxide obtained from <http://www.uxc.com/>.

51 Dr Roger Higgins (BHP Billiton Ltd), *Transcript of Evidence*, 2 November 2005, p.5.

52 ASNO, *Annual Report 2004–2005*, Commonwealth of Australia, Canberra, 2005, p. 23.

3.49 As noted above, Australia currently has three operational uranium mines—Ranger in the NT, and Olympic Dam and Beverley in SA. The locations of these mines are shown in figure 3.2.

3.50 In 2005, the Ranger and Olympic Dam mines were respectively the world's second largest (12 per cent of world uranium mine production) and third largest (9 per cent of world mine production) uranium producers (see table 2.4 of chapter two). Beverley was the tenth largest producer in 2005.[53] In addition to the operational mines, a fourth—Honeymoon in SA—has government approvals in place to commence construction and in August 2006 the deposit's owners approved development of the project.[54] Following a brief overview of the history of uranium mining in Australia, the Committee describes the three currently operational mines.

Australia's uranium mining history

3.51 Uranium was first identified in Australia in 1894 at Carcoar (NSW). The earliest uranium deposits mined in Australia were at Radium Hill and Mount Painter (SA). These deposits were worked from 1910 to 1931 for radium, a radioactive daughter product of uranium, which was used mainly for medical purposes.

3.52 Exploration for uranium in Australia began in 1944 at the request of the British and US Governments. The Commonwealth Government offered financial rewards for the discovery of uranium orebodies and in 1949 the Rum Jungle deposit (NT) was discovered. Subsequently, the Mary Kathleen deposit (Qld) and a number of smaller deposits in the South Alligator Valley (NT) were discovered.[55]

3.53 There have been two phases of uranium mining in Australia:

- from 1954 until 1971; and
- from 1976 to the present.[56]

3.54 Between 1954 and 1971 the following deposits were mined: Rum Jungle (1954 to 1971), Radium Hill (1954 to 1962), Mary Kathleen (1958 to 1963) and South Alligator Valley (1959 to 1964). During this phase, Australia produced some 9 118 t U_3O_8 (7 732 tU) and sales were to the USA and UK

---

53 *ibid.*

54 MCA, *op. cit.*, p. 5.

55 See: UIC, *Australia's Uranium and Who Buys It*, viewed 27 June 2006, <http://www.uic.com.au/nip01.htm>.

56 The historical overview is extracted from: AD McKay and Y Miezitis, *Australia's Uranium: Resources, Geology and Development of Deposits*, GA, Canberra, 2001, pp. 10–18. See also: UIC, *Submission no. 12*, p. 23.

for use in weapons programs. The first phase of uranium production in Australia ceased after the closure of the Rum Jungle plant in 1971.

3.55 Uranium exploration declined during the late 1950s but increased again in the late 1960s, stimulated by the easing of a Commonwealth Government export embargo and predictions of increased world demand for uranium in the early 1970s for generating nuclear power.

3.56 Important deposits were discovered between 1969 and 1973 at Nabarlek, Ranger, Koongarra and Jabiluka in the Alligator Rivers area, at Beverley and Honeymoon in the Lake Frome area (SA), and at Yeelirrie and Lake Way (WA). The Olympic Dam and Kintyre deposits were discovered in 1975 and 1985 respectively.

3.57 Mary Kathleen began recommissioning its mine and mill in 1974. Consideration by the Commonwealth Government of additional sales contracts was deferred pending the findings of the Ranger Uranium Environmental Inquiry which commenced in 1975. In 1977 the Commonwealth announced that new uranium mining could proceed, commencing with the Ranger project in the Northern Territory. The Ranger mine opened in 1981.

3.58 Australia's second phase of uranium mining commenced in 1976, with the resumption of mining at Mary Kathleen, and continues to the present. In addition to Mary Kathleen, mining has been from the Nabarlek, Ranger, Olympic Dam and Beverley operations.

3.59 Mary Kathleen ceased production in 1982 and 4 802 t U_3O_8 (4 072 tU) was produced from the mine during its second period of operation. The Nabarlek deposit was mined and stockpiled in 1979. The stockpiled ore was then processed from 1980 to mid-1988 for a total output of 10 858 U_3O_8 (9 208 tU), which was sold to Japan, Finland and France.

3.60 Since the start of Australia's second phase of uranium mining in 1976, cumulative uranium production to the end of 2005 has been 146 315 t U_3O_8 (124 068 t U). This includes production from Mary Kathleen, Nabarlek, Ranger (1981 to the present), Olympic Dam (1988 to the present), and from Beverley (2001 to the present).

3.61 Having won Government in 1983, the Australian Labor Party's 1984 National Conference amended the Party's Platform to what has become known as the 'three mines policy', nominating Ranger, Nabarlek and Olympic Dam as the only projects from which exports would be permitted. Provisional approvals for marketing from other prospective uranium mines were cancelled. This policy prevailed until the election of the Coalition Government in 1996.

3.62 The following section of this chapter describes Australia's three currently operational uranium mines and associated recent developments.

Ranger

3.63 The Ranger uranium deposit, which is located 230 km east of Darwin in the Alligator Rivers region (see figure 3.2 and appendix F), was discovered in 1969 by a joint venture of Peko Wallsend and The Electrolytic Zinc Company of Australia. Development of the Ranger mine was the subject of the Ranger Uranium Environmental Inquiry, a major Commonwealth Government inquiry under Justice RW Fox between 1975 and 1977. The findings of the inquiry allowed the development of both the Ranger and Nabarlek mines. In 1978 the Commonwealth Government and the Northern Land Council, acting on behalf of the Traditional Aboriginal land Owners, reached agreement to proceed with mining, which commenced in 1979.[57]

3.64 The Ranger Project Area and the adjoining Jabiluka Mineral Lease are surrounded by, but not part of, the Kakadu National Park. Both areas are located on Aboriginal land, under title granted to the Traditional Owners, the Mirrar Gundjeihmi people, under the *Aboriginal Land Rights Act (NT) 1976*.[58] Ranger is served by the township of Jabiru, which was constructed largely for the purpose.

3.65 Ranger is a large unconformity-related deposit and the ore is mined by open cut methods. As depicted in figure 3.3, within the Ranger Project Area there are two orebodies—Ranger No. 1 (now mined out) and Ranger No. 3 which is currently being mined. Open cut mining at the Ranger No. 1 orebody began in August 1981 and was completed by December 1994. Production from the processing plant continued from stockpiled ore until open cut mining commenced at Ranger No. 3 orebody in October 1996.

3.66 The Ranger mill has a nominal production capacity of 5 000 t U_3O_8 per year (4 240 tU), however production has exceeded this in recent years. Approximately 2.1 Mt of ore are milled annually (a record 2.3 Mt in 2005). Uranium recovery from the processed ore is about 91.5 per cent and ranges up to 93 per cent.[59] The mill uses a sulphuric acid leach process to dissolve uranium from the ore. Uranium is recovered from the leachate by solvent extraction and is precipitated as ammonium diuranate (yellowcake). This is then calcined (heated to more than 200°C to remove volatile components) to produce concentrates of uranium oxide (grey-green coloured powder) assaying 99.2 per cent U_3O_8.[60]

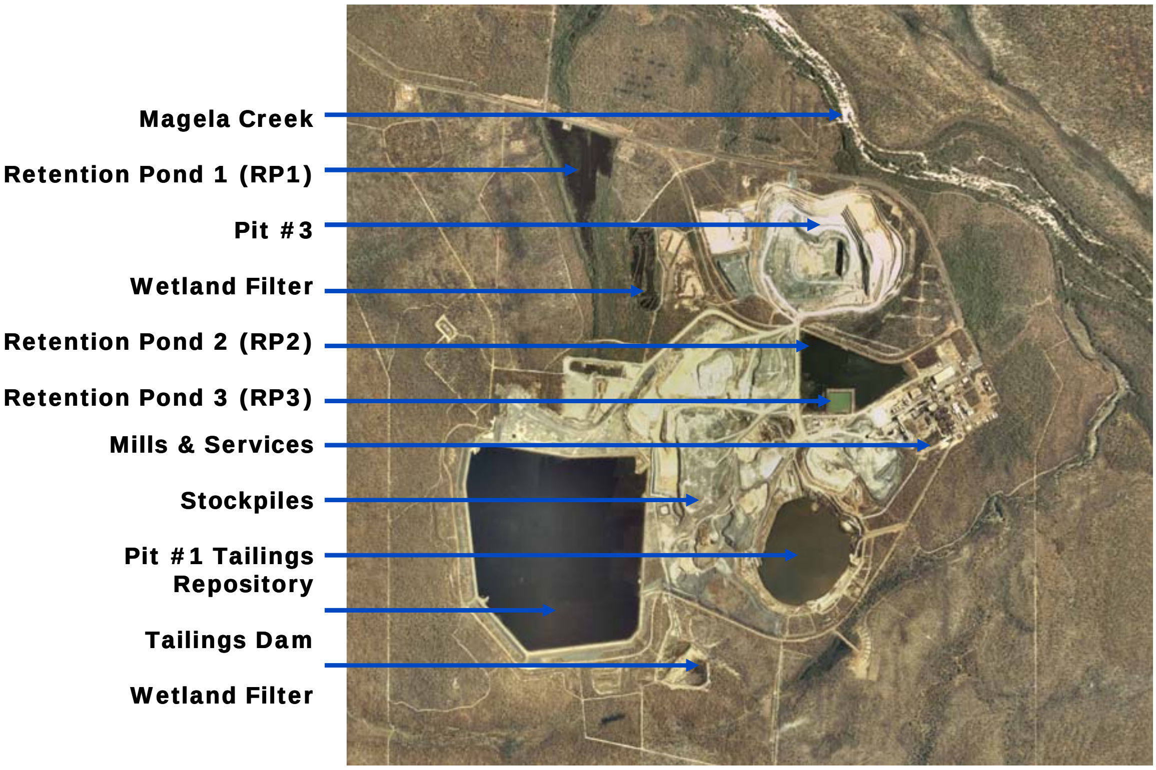
57 UIC, *Australia's Uranium Mines, loc. cit.*; ERA, *Exhibit no. 76, What is it really like to operate a large uranium mine in Australia?*, pp. 2-4; McKay and Miezitis, *op. cit.*, p. 13.

58 GA, *Submission no. 42*, p. 8.

59 UIC, *Australia's Uranium Mines, loc. cit.*

60 GA, *Submission no. 42*, p. 9.

Figure 3.3 Ranger mine site



Source Energy Resources of Australia.

3.67 Since August 1997, the No. 1 orebody open cut (Pit 1) has been used as a repository for mill tailings. The company proposes to finally dispose of all mill tailings into the No. 1 and No. 3 orebody open cuts, on completion of mining.[61]

3.68 Production from Ranger was a record 5 910 t U_3O_8 (5 012 tU) in 2005, 15 per cent above production levels for 2004.[62] In 2005, production from Ranger amounted to 12 per cent of the world total and was the world's second largest uranium mine (in terms of annual production), behind the very high grade McArthur River mine in Saskatchewan (Canada) which produced 8 491 t U_3O_8.[63] Uranium mined from Ranger is sold to utilities in Japan, South Korea, Europe (France, Spain, Sweden and the UK) and North America.[64] In 2005, the Ranger mine employed more than 350 people, including 46 Indigenous people.[65]

3.69 Ranger is now owned by Energy Resources of Australia (ERA), a subsidiary of Rio Tinto (which owns 68 per cent of ERA). In 2005, Rio

61 *ibid*.

62 ERA, *Full Year Results 2005, loc. cit.*

63 GA, *Submission no. 42*, p. 9; RWE NUKEM, *NUKEM Market Report*, *loc. cit.*

64 Mr Harry Kenyon-Slaney (ERA), *Transcript of Evidence*, 24 October 2005, p. 46.

65 ERA, *2005 Annual Report*, pp. 12, 18, viewed 27 June 2006, <http://www.energyres.com.au/corporate/era-ar-2005.pdf>.

Tinto was the world's second largest producer of uranium after Cameco (Canada), with Areva (France) the third largest producer.[66]

3.70 At the end of 2005, Ranger contained total Proved and Probable Reserves of 44 458 t U_3O_8 and an additional 42 587 t U_3O_8 in mineral resources (total of Measured, Indicated and Inferred Resources), as listed in table 3.7.

3.71 In October 2005 ERA announced that, due to the recent increases in uranium price, it is now economic for the company to lower the cut-off grade down to which it will process uranium ore (from 0.12 per cent to 0.08 per cent U_3O_8). The consequences of the reduction in cut-off grade are that milling operations will now continue at Ranger until 2014 and reserves have been increased. ERA intends to mine at Ranger until at least 2008 and the company has recently been exploring for extensions of the No. 3 orebody.[67]

Table 3.7 Ranger uranium ore reserves and mineral resources as at 31 December 2005

Reserves/Resource classification	**Ore** (Mt)	**Grade** (% U_3O_8)	**Contained U_3O_8** (tonnes)
Ore Reserves			
Current stockpile	9.98	0.15	14 716
Proved	4.48	0.25	11 314
Probable	8.42	0.22	18 428
TOTAL RESERVES	22.78	0.20	44 458
Mineral Resources *(In addition to reserves)*			
Measured	1.42	0.15	2 115
Indicated	12.55	0.14	18 018
Inferred	16.11	0.14	22 454
TOTAL RESOURCES	30.08	0.14	42 587

Source Energy Resources of Australia, *2005 Annual Report*, p. 8.

3.72 In other developments at Ranger, in December 2005 ERA completed construction of a $28 million water treatment plant, which the Committee inspected during its visit to the ranger mine site in October 2005. The plant will ensure that process and other water reaches drinking water standard before it is released from the site to the surrounding environment. In

66 UIC, *Australia's Uranium Mines*, *loc. cit.*; RWE NUKEM, *op. cit.*, p. 19.

67 ERA, *Increase in Ranger Mine's Reserves and Resources*, Media Release and Stock Exchange Announcement, issued 27 October 2005, viewed 26 April 2006, <http://www.energyres.com.au/showpdf.php3?id=199>; GA, *Submission no. 42*, p. 21.

addition to assisting mining operations, it is intended that the plant will eventually become part of rehabilitation plans after the mine's closure.[68]

3.73 Figure 3.4 depicts several Committee members during an inspection of the Ranger mine site, standing on uranium ore stockpiles overlooking the processing plant. Figure 3.5 shows open cut mining of the Ranger No. 3 orebody.

Jabiluka

3.74 ERA holds title to the Jabiluka deposit, situated 22 km north of Ranger. The orebody was discovered in 1971, one year after Ranger, and the NT Government granted a mineral lease in 1982 following the signing of an agreement between the senior Mirarr Traditional Owner and the mining company (Pancontinental Mining). Jabiluka is a world class uranium deposit with total Proved and Probable Reserves of 67 000 t U_3O_8 and an additional 92 000 t U_3O_8 in mineral resources, as listed in table 3.8.[69]

Table 3.8 Jabiluka uranium ore reserves and mineral resources as at 31 December 2005

Reserves/Resource classification	**Ore** (Mt)	**Grade** (% U_3O_8)	**Contained U_3O_8** (tonnes)
Ore Reserves			
Proved	6.40	0.59	38 000
Probable	6.42	0.45	29 000
TOTAL RESERVES	12.82	0.52	67 000
Mineral Resources *(In addition to reserves)*			
Measured	1.80	0.41	7 000
Indicated	3.75	0.39	14 000
Inferred	15.70	0.48	75 000
TOTAL RESOURCES	21.07	0.46	96 000

Source Energy Resources of Australia, *2005 Annual Report*, p. 8.

3.75 Mining at Jabiluka was approved in 1999 subject to over 90 environmental conditions. As with Ranger, Jabiluka is surrounded by, but is not part of, Kakadu National Park. In consideration of World Heritage concerns about the impact of Jabiluka' s development on the park, ERA previously agreed that Jabiluka and the Ranger operation would not be in full operation simultaneously.[70]

68 ERA, *Social and Environmental Report 2005*, p. 12, viewed 27 June 2006, <http://www.energyres.com.au/corporate/ERA_SE_Rep05ART.pdf>; ERA, *2005 Annual Report, op. cit.*, p. 9.

69 GA, *Submission no. 42*, p. 21; ERA, *2005 Annual Report, op. cit.*, pp. 2, 7, 8.

70 GA, *loc. cit.*

Figure 3.4 Committee members standing on ore stockpiles at the Ranger uranium mine in the Northern Territory

Source Energy Resources of Australia.

Figure 3.5 Open pit mining of uranium and processing plant at the Ranger uranium mine

Source Energy Resources of Australia.

3.76 Development of the Jabiluka deposit has been opposed by the Traditional Owners and allied environmental groups. The Traditional Owners have refused to grant approval for development of the mine, with the Mirarr people arguing that they were under duress when they signed the 1982 agreement.[71] The Mirarr and their supporters appeared before the United Nation's (UN) World Heritage Committee to argue that the mine would damage heritage values in the Kakadu region. However, the UN ultimately rejected this contention.[72]

3.77 Following a dialogue with the Mirarr which commenced in 2002, ERA has announced that there will be no further development at Jabiluka without the formal support of the Traditional Owners, and subject to feasibility studies and market conditions.[73]

3.78 In February 2005, the Gundjeihmi Aboriginal Corporation (representing the Traditional Owners), ERA and the Northern Land Council signed an agreement on the long-term management of the Jabiluka lease. This agreement obliges ERA (and its successors) to secure Mirrar consent prior to any future mining development of uranium deposits at Jabiluka. The decline which had previously been sunk at the Jabiluka site has been backfilled and the project site is currently under long-term care and maintenance.[74]

3.79 Mr Harry Kenyon-Slaney, Chief Executive of ERA, explained that ERA is determined to end years of adversarial and acrimonious debate over the future of Jabiluka:

> It is my view, and I think it is also the view of the majority shareholder of ERA [Rio Tinto], that it is very important that you do not bulldoze into people's backyards and develop mining operations without their consent. Clearly, there was not implicit consent, given the adversarial nature of the debate over Jabiluka. Sometimes you have to take a step back before you can move forward. We are now in the process of discussing with the traditional owners what might happen. When the parties are ready, hopefully we will be able to move forward, but that long period of acrimony is still very recent and I think the parties need time to think about the future.[75]

71 Gundjeihmi Aboriginal Corporation, *Submission no. 44*, p. 4.

72 ERA, *Exhibit no. 76*, p. 8.

73 GA, *Submission no. 42*, p. 21.

74 Mr Harry Kenyon-Slaney, *op. cit.*, p. 48.

75 *ibid.*, p. 50.

Olympic Dam

3.80 The Olympic Dam deposit, which is located 560 km north of Adelaide, was discovered in 1975 by Western Mining Corporation (WMC) which was exploring in the area for copper. After considering geophysical data, a drill hole was sunk near a small stock water dam known as Olympic Dam, named in 1956 after the Olympic Games which took place in Melbourne that year. The speculative surface drilling struck copper and later drilling confirmed a resource of more than 2 000 million tonnes of ore containing both copper and uranium. From 1979 the deposit was developed as a joint venture between WMC and British Petroleum (BP) and production commenced in 1988. WMC, which took over BP Minerals' share in 1993, was acquired by BHP Billiton in July 2005.[76]

3.81 Olympic Dam is the largest known uranium orebody in the world, with an estimated overall resource of more than 1.46 Mt U_3O_8 contained in some 3.9 billion tonnes of ore. The grade of the uranium resource is relatively low at between 0.03 and 0.06 per cent U_3O_8. The orebody starts at a depth of 350 metres and continues down to (at least) 1 000 metres. The mineralisation occurs in a hematite-rich granite breccia complex and lies beneath flat-lying sedimentary rocks of the Stuart Shelf geological province of SA.[77] Olympic Dam's uranium ore reserves and mineral resources as at June 2005 are listed in table 3.9.

Table 3.9 Olympic Dam uranium ore reserves and mineral resources as at June 2005

Reserves/Resource classification	**Ore** (Mt)	**Grade** (% U_3O_8)	**Contained U_3O_8** (tonnes)
Ore Reserves			
Proved	119	0.06	71 000
Probable	642	0.05	321 000
Mineral Resources*			
Measured	650	0.05	325 000
Indicated	1 440	0.04	576 000
Inferred	1 880	0.03	564 000
TOTAL RESOURCES	3 970	0.04	1 465 000

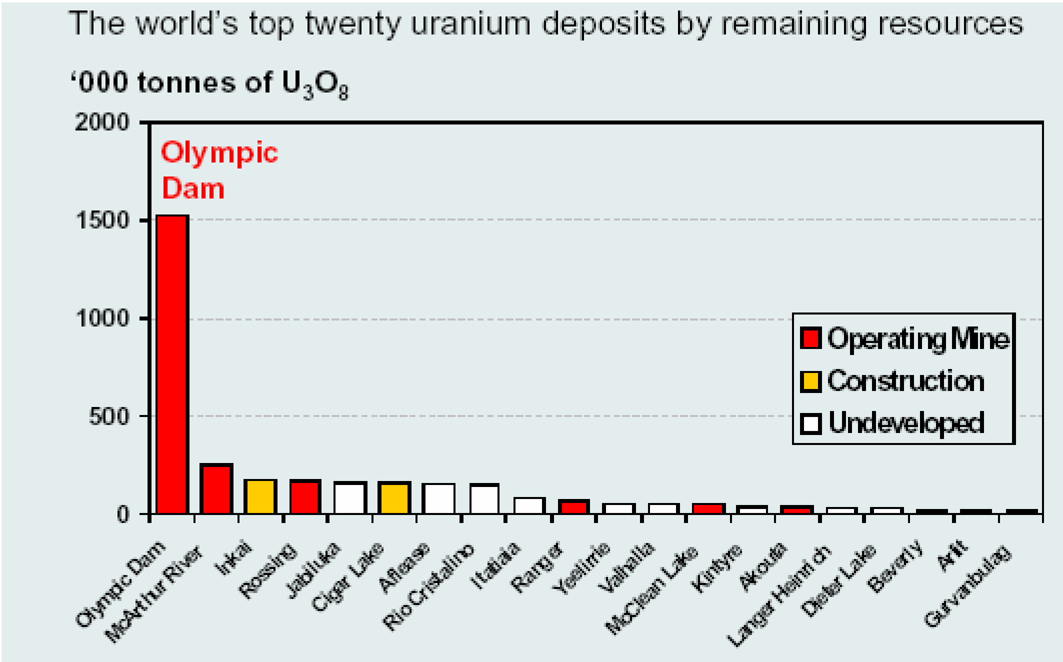
Source Geoscience Australia, *Submission no. 42*, p. 18; BHP Billiton PLC, *Annual Report 2005*, pp. 196–97.
* Measured and Indicated Resources are inclusive of those resources classified as Ore Reserves.

3.82 Despite conducting a large drilling program (a total of 2 270 km of drill core will have been completed by the end of 2007) as part of the pre-feasibility study for its proposed expansion of Olympic Dam (discussed below), BHP Billiton stated that the company has *not* yet defined the limits

76 UIC, *Australia's Uranium Mines*, *loc. cit*; RWE NUKEM, *op. cit.*, p. 5.
77 RWE NUKEM, *op. cit.*, p. 6.

of the orebody in all dimensions. In particular, the boundaries of mineralisation at Olympic Dam are still open to the south and at depth.[78] Figure 3.6 illustrates Olympic Dam's immense size and global significance, ranking it alongside the world's top 20 uranium deposits by quantity of remaining resources.

Figure 3.6 The world's twenty largest uranium deposits by quantity of remaining resources



Source WMC Resources, *Developing the World's Biggest Uranium Resource*, Presentation by Mr Michael Nossal, April 2005, p. 5.

3.83 Olympic Dam is primarily a copper mine and the relatively low average grade of uranium (0.04 per cent U_3O_8) means that Olympic Dam would not support a uranium mine in its own right. The orebody is mined principally for its copper, gold and silver, with uranium as a valuable by-product. Olympic Dam ranks as the world's fourth largest known deposit of copper and fourth largest known deposit of gold.[79] In the mix of products, uranium represents 20–25 per cent of revenue from Olympic Dam, which totalled $1.1 billion in 2004.[80]

3.84 Olympic Dam is a large-scale underground mining operation using sub-level open stoping methods. Between 1989 and 1995, the annual capacity of the processing plant was increased in two stages to 85 000 t copper and

78 BHP Billiton Ltd, *Exhibit no. 78, Presentation by Dr Roger Higgins*, p. 19.

79 RWE NUKEM, *op. cit.*, p. 5.

80 Dr Roger Higgins, *op. cit.*, pp. 3, 5; BHP Billiton Ltd, *Exhibit no. 56, Olympic Dam Development Pre-feasibility Study*, p. 2.

1 700 t U_3O_8 (1 440 tU) plus associated gold and silver from the processing of 3.0 Mt ore per year.[81]

3.85 A major expansion of the project was completed in March 1999 at a cost of $1.94 billion. Annual production capacity was increased to 200 000 t copper, 4 600 t U_3O_8 (3 900 tU), 2 050 kg gold and 23 000 kg silver. To sustain this rate of production, approximately 8.7–9.2 Mt ore are mined and processed annually. Water required for mining and processing operations and for the township of Roxby Downs is pumped from borefields within the Great Artesian Basin (GAB). The main borefield is located more than 175 km north-east of the mine.[82]

3.86 Government approval for the major expansion was granted after a comprehensive EIS was assessed jointly by the Commonwealth and SA Governments. In addition to the existing environmental regulations and controls on the project, new requirements were imposed relating to the management of the GAB water resources, future assessments of the tailings management systems, and impacts of future changes to technology and mining practices.[83]

3.87 GA noted that the metallurgical processes to recover copper, uranium, gold and silver at Olympic Dam are complex, however the processes relating to uranium recovery can be summarised as follows. After crushing and grinding, the ore is mixed with water and the slurry is pumped to the flotation plant. Copper concentrates are produced using standard flotation processes. The non-sulphide particles, which do not float (referred to as flotation tailings), contain most of the uranium minerals. Acid mixed with an oxidant is then added to leach uranium from the flotation tailings, and the slurry is heated to 60°C to improve the leach process. Uranium is recovered from the leach liquor by solvent extraction. Pulsed column technology is used to improve the recovery rate and to reduce the consumption of organic reagents. As at Ranger, the solutions containing dissolved uranium are treated with ammonia and calcined to produce uranium oxide powder.[84]

3.88 In 2005 Olympic Dam produced 4 335 t U_3O_8 (3 676 t U), which was nine per cent of the world's total mine production and the third largest uranium producer. This represented a marginal decrease on 2004 production of 4 370 t U_3O_8 (3 735 tU). However, production from Olympic Dam has continued to expand since mining commenced in August 1988—production in 1988 was 1 180 t U_3O_8, in 1991 it was 1 400 t U_3O_8, in 1993 it

81 GA, *Submission no. 42*, p. 9.

82 *ibid*.

83 *ibid*.

84 *ibid*.

was 1 900 t U_3O_8, and in 1998 it was 4 500 t U_3O_8.[85] Uranium sales are to the US, Canada, Sweden, UK, Belgium, France, Finland, South Korea and Japan.[86]

3.89 The Olympic Dam operation employs 1 670 people of which some 283 people work in the uranium production sector.[87] The scale of Olympic Dam (approximately 6–7 km in length) and the mine's processing plant, smelter and refinery are depicted in figures 3.7 and 3.8.

Proposed expansion of Olympic Dam

3.90 Prior to the acquisition by BHP Billiton, in 2004 WMC commenced a study to investigate the feasibility of a major expansion of the Olympic Dam operations. One of the proposals was an open pit mining expansion that would increase annual uranium production, from some 4 000 t U_3O_8 currently, to approximately 15 000 t U_3O_8, as well as expand copper production to 500 000 t per year and gold to 500 000 ounces per year. This would require mining 40 Mt of ore per year—a four-fold increase in the mining rate.[88] Table 3.10 compares current activity at Olympic Dam with the proposed development.

Table 3.10 Proposed Olympic Dam expansion

	Current	**Proposed (2013+)**
Mine production (per year)	Ore mined = 10 Mt Uranium = 4 000 t Copper = 220 000 t Gold = 80 000 ounces Silver = 800 000 ounces	Ore mined = ~40 Mt Uranium = ~15 000 t Copper = ~500 000 t Gold = ~500 000 ounces Silver = ~2 900 000 ounces
Roxby Downs population	4 100 (average age 27 yrs, 32 per cent under 15 yrs)	Total = 8 000–10 000
Energy (per year)	120 MW, from State grid	Total of ~420 MW, from State grid, on-site gas fired generation, or a combination
Water (per year)	12 GL (32 ML per day), from Great Artesian Basin (GAB)	Total of ~48 GL, from GAB/regional aquifers or coastal desalination (Whyalla area)
Transport In/Out (per year)	1 Mt, by road 12 000 trucks (30 per day)	Total of ~2.2 Mt, by road/rail intermodal or direct rail 26 500 trucks (70 per day)
Exports	Via Port Adelaide	Via Port Adelaide and/or Darwin

Source BHP Billiton, *Exhibit no. 78, Presentation by Dr Roger Higgins*, p. 13.

85 BHP Billiton Ltd, *Exhibit no. 78, op. cit.*, p. 9.

86 UIC, *Submission no. 12*, p. 24.

87 GA, *Submission no. 42*, p. 9. BHP Billiton stated that there are currently 1 750 permanent full-time employees at Olympic Dam. BHP Billiton Ltd, *Exhibit no. 56*, *op. cit.*, p. 18.

88 Dr Roger Higgins, *op. cit.*, p. 6.

Figure 3.7 Processing facilities at Olympic Dam in South Australia

Source BHP Billiton.

Figure 3.8 Aerial view of Olympic Dam

Source BHP Billiton.

3.91 The study for the proposed expansion has included:

- a major drilling program (90 drill holes) to better define the resources in the southern part of the deposit;
- assessing the alternative mining, treatment and recovery methods for the southern part of the deposit;
- identifying and evaluating water and energy supply options; and
- logistics planning that may include linking Olympic Dam to the national rail network.[89]

3.92 Recent drilling has identified significant additional resources in the south-eastern portion of the deposit. The resources as at March 2005 were almost a 35 per cent increase over the resources at December 2003.[90] WMC considered that these resources were 'of sufficient size to support an expanded world-class operation for many decades.'[91]

3.93 Evaluation of the various mining methods and the scale of operations were completed in March 2005. Two mining options were evaluated: underground (sub-level caving or block caving) and open pit. From the results of the study, WMC selected open pit as the preferred method because it provided 'clear economic benefits over the alternatives based upon commercially proven technology.'[92]

3.94 The mine's current owners, BHP Billiton, are now undertaking an extensive pre-feasibility study (PFS) for the proposed expansion, with the study expected to be completed by October 2007. Under the company's capital investment procedures, the PFS is the predominant decision making activity, with only a brief feasibility study, of perhaps one year's duration, to follow. BHP Billiton will expend approximately $300 million on the PFS and a further $100 million on the feasibility study.[93] The objectives of the study are to:

- identify the mine's total resource base;
- select a single preferred, sustainable life of mine plan;
- identify financing needs;
- identify implementation requirements; and
- assess strategic implications of the preferred development option.[94]

89 BHP Billiton Ltd, *Exhibit no. 78, op. cit.*, p. 12.

90 GA, *Exhibit no. 61*, *op. cit.*, p. 9.

91 Cited in GA, *Submission no. 42*, p. 19.

92 *ibid*; BHP Billiton Ltd, *Exhibit no. 78, op. cit.*, p. 18.

93 Dr Roger Higgins, *op. cit.*, p. 7. Total expenditure on feasibility studies will amount to approximately 10 per cent of the project's total costs.

94 BHP Billiton Ltd, *Exhibit no. 56, op. cit.*, p. 14.

3.95 It is expected that by late 2007, or early 2008, BHP Billiton will have decided on the size and shape of the expansion project. An Environmental Impact Study will be completed by the end of 2007. The feasibility study phase is expected to be completed by early 2009, with construction (the execution phase) commencing in that year and continuing for four years until 2013. The expanded facilities are expected to become operational in 2013.[95]

3.96 As the mineralisation at Olympic Dam commences at about 300 metres below surface, the execution phase will require the removal of a substantial overburden, amounting to one billion tonnes of rock that will need to be pre-stripped. During this phase, it is likely that production will continue from underground, but begin to diminish as the open pit starts up. It is expected that the underground and open pit operations will run in parallel for up to eight years.[96] The dimensions of the completed pit will be approximately three kilometres across and one kilometre deep.[97]

3.97 The proposed expansion would more than treble uranium production from the mine and, in doing so, double Australia's current national production.[98] Olympic Dam would become the world's largest uranium producer, accounting for over 20 per cent of total world production annually. Furthermore, the quantity of remaining uranium resources means that Olympic Dam could be mined at the expanded rate for over 70 years. WMC estimated that once the expansion is complete, uranium production will contribute 35–40 per cent of revenues from the mine.[99]

3.98 The majority of the mine's workforce of some 1 750 employees (with a similar number of permanent contractors) live at Roxby Downs, located 15 kilometres to the south of the mine. The town, which was developed by the mine, currently has a population of 4 000. The expanded mine would double the workforce, requiring an expansion of the town and its facilities.

3.99 As listed in table 3.9, BHP Billiton is studying options to provide water (including possible construction of a desalination plant located near Whyalla and piping the water inland, a distance of 300 km), power (including gas piped from Moomba) and transport (including the

95 BHP Billiton Ltd, *Exhibit no. 78, op. cit.*, p. 15; Dr Roger Higgins, *op. cit.*, p. 8.

96 Dr Roger Higgins, *op. cit.*, p. 9.

97 BHP Billiton Ltd, *Exhibit no. 78, op. cit.*, p. 18.

98 Mr Aden McKay, *op. cit.*, p. 3.

99 BHP Billiton Ltd, *Exhibit no. 78, op. cit.*, p. 3; Dr Roger Higgins, *op. cit.*, p. 3; WMC Resources Ltd, *Developing the World's Biggest Uranium Resource*, Presentation by Mr Michael Nossal, April 2005, p. 9.

construction of a rail link between Pimba and Olympic Dam of 90 km) for the expanded mine.[100]

3.100 The proposed expansion would involve an investment of up to US$5 billion. The four-year execution phase would employ an average of some 5 000 construction workers, with a peak of up to twice this number.[101] Chapter nine discusses Olympic Dam's economic significance and the benefits that may flow from the proposed expansion of the mine. Some submitters were critical of the proposed expansion, primarily on the grounds of the possible environmental impacts, and these concerns are summarised in chapter ten.

3.101 In relation to its other uranium asset in Australia, the Yeelirrie deposit in WA (Australia's third largest uranium deposit), BHP Billiton stated that 'at the moment, opening Yeelirrie is not an option.'[102]

Beverley

3.102 The Beverley uranium deposit, which is located 520 km north of Adelaide and adjacent to the northern Flinders Ranges on the plains north-west of Lake Frome, is a relatively young sandstone deposit with uranium mineralisation leached from the Mount Painter region. The deposit was discovered in 1969 and purchased by its current owners, Heathgate Resources (a wholly-owned subsidiary of General Atomics of the US), in 1990. The deposit consists of three mineralised zones (north, central and south) in a buried palaeochannel (the Beverley aquifer) at a depth of between 100 and 130 metres below surface, and 10 to 20 metres thick. The aquifer is isolated from other groundwater, most notably the GAB, which is about 150 metres below it, and small aquifers above it which are used for stock watering.[103]

3.103 The Beverley project is Australia's first commercial in situ leach (ISL) uranium mining operation. At Beverley, uranium occurs in porous sandstones saturated with groundwater. GA and the UIC explained the ISL technology as follows. Uranium is leached in situ using sulphuric acid and an oxidant (hydrogen peroxide) which is introduced into the sandstones via injection wells. The leach solutions containing dissolved uranium are then pumped to the surface via production (extraction) wells and into the processing plant. Thus, the Beverley mine consists of wellfields which are progressively established over the orebody as uranium is depleted from sections of the orebody immediately

100 Dr Roger Higgins, *op. cit.*, pp. 6–7.

101 *ibid.*, p. 16.

102 Dr Roger Higgins, *op. cit.*, p. 21.

103 UIC, *Australia's Uranium Mines, loc. cit.*

underneath. Wellfield design is on a grid with alternating extraction and injection wells, each identical to typical water bores. The spacing between injection wells is about 30 metres with each pattern of four having a central extraction well. Monitor wells are situated to detect any leakage of mining fluids into other aquifers.[104] Figure 3.9 shows Committee members inspecting one of the extraction wells at the Beverley uranium mine.

3.104 Uranium is recovered in the processing plant using ion-exchange technology. The final product is hydrated uranium oxide ($UO_4.2H_2O$) which is a yellow powder, also referred to as 'yellowcake'. This is heated in a low temperature zero-emissions dryer to remove moisture and residual chemical reagents.[105] Figure 3.10 shows Committee members with drums of yellowcake at Beverley being prepared for shipping.

3.105 Production from the northern zone at Beverley commenced in 2000. In 2005 the mine produced 977 t U_3O_8, which was marginally less than 2004 production of 1 084 t U_3O_8.[106] Heathgate Resources aims to increase the mine's capacity to 1 500 t U_3O_8 per year and plans to achieve this level of production in 2009.[107]

3.106 Beverley is the world's largest single ISL uranium mine. In 2004, production from Beverley was greater than total US production, which was from a number of ISL operations in Wyoming, Nebraska and Texas. In 2005 Beverley accounted for two per cent of world mine output. Beverley has sales contracts with utilities in the US, Japan, South Korea and Europe and the mine employs some 180 people.[108]

3.107 Mr Mark Chalmers, the former Senior Vice President and General Manager of Heathgate Resources, argued that:

> … whilst small in comparison to Olympic Dam and Ranger, [Beverley] is important in terms of setting a standard for the small and medium sized producers of the future. Our mine is the most technologically advanced ISL uranium mine in the world. It is equipped with the latest instrumentation and controls. Our method of extraction minimises environmental impact and health and safety impacts to our employees and to the public.[109]

104 GA, *Submission no. 42*, p. 10; UIC, *Australia's Uranium Mines, loc. cit.*

105 *ibid.*

106 UIC, *Australia's Uranium Mines, loc. cit.*

107 Heathgate Resources Pty Ltd, *Exhibit no. 57, General Information Document*, p. 1.

108 GA, *Submission no. 42*, p. 10; UIC, *Submission no. 12*, p. 24.

109 Mr Mark Chalmers (Heathgate Resources Pty Ltd), *Transcript of Evidence*, 19 August 2005, p. 96.

Figure 3.9 Committee members inspecting an extraction well at the Beverley in-situ leach uranium mine in South Australia

Figure 3.10 Committee members with drums of yellowcake (hydrated uranium peroxide) in a container being prepared for shipping at the Beverley uranium mine

3.108 As at April 2005, the Beverley deposit contained 5 897 t U_3O_8 in Proved and Probable Reserves. The deposit contains an overall resource of 21 600 t U_3O_8 at a grade of 0.18 per cent.[110]

3.109 During 2003, ISL mining at Beverley progressed from the deposit's north orebody into the much larger central orebody. Installation of the main pipelines (trunklines) connecting the plant to the central orebody was completed and, by early 2004, production reached an annualised rate of 1 000 t U_3O_8, the licensed capacity of the plant at that time.

3.110 Commonwealth and SA Government agencies have recently considered a proposal from Heathgate Resources to optimise the Beverley operations to produce up to 1 500 t U_3O_8 per year. Geoscience Australia and the Bureau of Rural Sciences (BRS), which provided technical advice on this proposal to the Australian Government Departments of Industry (DITR) and the Environment and Heritage (DEH), advised that the company should be required to undertake groundwater studies to determine the hydrological impacts on the Beverley aquifer which could result from increased rates of disposal of liquid wastes from the ISL operations.

3.111 GA informed the Committee that in 2004, after considering this technical advice together with further reports from the company, the Minister for Industry, Tourism and Resources approved the extension and granted Heathgate Resources a new uranium export permit. As part of the export permit, the Minister imposed a number of conditions including, inter alia, that the Beverley operations are to be carried out on the basis of a neutral water balance; that is, the total volume of fluid injected into the aquifer from all sources must equal the total volume pumped out.[111]

3.112 In 2004 Heathgate Resources announced the discovery of a new zone of uranium mineralisation approximately three km south of the Beverley deposit. This ore zone, referred to as the Deep South zone, was discovered using a range of geophysical surveys followed up by an extensive drilling program comprising more than 120 holes totalling 23 745 metres. The Deep South ore zone is within sands similar to the main Beverley deposit. Resource estimates for this zone have not been reported to date.

3.113 The company has also recently reported other discoveries in and around the Beverley mine area in addition to the Deep South zone. These more recent discoveries are new and require additional follow-up, however, the

---

110 Heathgate Resources Pty Ltd, *Exhibit no. 57, op. cit.*, p. 2; UIC, *Australia's Uranium Mines, loc. cit*; P Abbot, 'Uranium in South Australia', *Earth Resources Information Sheet*, Primary Industries of SA, Adelaide, March 2006, p. 1, viewed 30 June 2006, <http://www.pir.sa.gov.au/byteserve/minerals/references/info_sheets/m50_web.pdf>.

111 GA, *Submission no. 42*, p. 20.

success of on-going exploration is expected to increase the life of the project.[112]

3.114 ISL mining has numerous advantages over traditional excavation techniques, including: minimal disturbance to the land surface; no excavation of large volumes of overburden or mine wastes; a simple processing plant with no crushing or grinding required; no large volumes of tailings or tailings dams; no exposure of the orebody to the atmosphere; reduced radiation exposure to workers and the public; and relatively simple rehabilitation requirements.[113] However, for the ISL mining method to be applicable requires unique geological and hydrological conditions. In general, the deposits need to be located in sedimentary permeable zones. Heathgate Resources estimated that ISL would be applicable to some 15 to 20 per cent of uranium deposits worldwide. In addition to Beverley, other in situ leachable uranium deposits in Australia include Honeymoon and Goulds Dam in SA, and Oobagooma and Manyingee in WA.[114]

3.115 The Committee received some evidence that was critical of the environmental impacts of ISL mining and these are considered in chapter ten.

Other industry developments

3.116 In addition to the industry developments described above, evidence to the inquiry mentioned the likely development of the Honeymoon deposit in SA and the problematic issue of recovering uranium from brannerite ores, such as those at Olympic Dam and the Valhalla deposit in Qld.

Honeymoon Project

3.117 The Honeymoon deposit, located 75 km north west of Broken Hill in South Australia (see figure 3.2), was discovered in 1972 and is contained within unconsolidated sands at a depth of 100 metres in the Yarramba palaeochannel. The deposit extends over 150 hectares. Honeymoon, along with the adjacent East Kalkaroo deposit and the Goulds Dam–Billaroo West deposits (located 80 km north west of Honeymoon–East Kalkaroo), were acquired by Canadian company Southern Cross Resources in 1997. In 2005, Southern Cross Resources merged with South African companies Aflease Gold and Uranium Resources to form sxr Uranium One, which

112 *ibid.*, p. 21.

113 I Dobrzinski, *Beverley and Honeymoon uranium projects*, MESA Journal, April 1997, p. 11.

114 Mr Mark Chalmers, *op. cit.*, p. 98.

has a primary listing on the Toronto stock exchange. Uranium One also owns uranium and gold projects in South Africa.[115]

3.118 Honeymoon and East Kalkaroo contain 4 200 t U_3O_8.[116] Table 3.11 summarises the resource estimates for both the Honeymoon and Goulds Dam deposits.

3.119 Southern Cross Resources submitted an initial EIS to develop the Honeymoon deposit in June 2000. Following the approval of the EIS, the company was granted an export license by the Commonwealth Government in November 2001.[117] Following the conclusion and signing of a Native Title Agreement with the Adnyamathanha people (a similar agreement with the Kuyani people was concluded in 1998), the State Government granted Southern Cross Resources a mining lease to develop Honeymoon as an ISL project in February 2002.[118] The current State Government reportedly considers that the project is an existing mine, because the mining lease was granted by the previous State Government, and will therefore allow the mine to proceed.[119]

Table 3.11 Mineral resources for Honeymoon, East Kalkaroo, Goulds Dam and Billeroo

Deposit	**Resource category**	**Million tonnes**	**Average grade** (% U_3O_8)	**Contained U_3O_8** (tonnes)
Honeymoon*	Indicated	1.2	0.24	2 900
East Kalkaroo	Indicated	1.2	0.074	910
Goulds Dam	Indicated	5.6	0.045	2 500
Billeroo	Inferred	12.0	0.03	3 600
Total Resources				**10 310**

Source Southern Cross Resources, *2004 Annual Report*, p. 6
* Resource figures for Honeymoon from sxr Uranium One, *sxr Uranium One Announces Honeymoon Feasibility Study and Approves Honeymoon Project*, News Release, 29 August 2006.

3.120 In 2004 Southern Cross Resources commissioned a cost and engineering study for a plant at Honeymoon with a design capacity of 400 t U_3O_8 per

115 UIC, *Australia's Uranium Deposits and Prospective Mines, loc. cit.*; SXR Uranium One Inc, company information, viewed 3 July 2006, <http://www.uranium1.com/index.php?section=company&page=0>.

116 Southern Cross Resources Inc, *2004 Annual Report*, p. 5, viewed 3 July 2006, <http://www.uranium1.com/uploads/report/AR2004.pdf>.

117 The export permission authorises exports of uranium from Honeymoon for five years commencing 1 January 2002.

118 GA, *Submission no. 42*, p. 22; sxr Uranium One Inc., *sxr Uranium One Inc. submits application to commercially mine and mill radioactive ore at Honeymoon*, News Release, 25 May 2006, viewed 3 July 2006, <http://www.uranium1.com/uploads/articles/Application%20To%20Mine%20and%20Mill_25.PDF>.

119 See: C England, 'Uranium mine "to proceed"', *Adelaide Advertiser*, 2 May 2006, p. 31; M Wiese Bockmann, 'Nuclear minefield', *The Australian*, 31 August 2006, p. 12.

year and a mine life of six to eight years. However, the company decided to defer production pending higher uranium prices.[120]

3.121 In May 2006 Uranium One submitted an application for a license to commercially mine uranium at the Honeymoon site to the SA Environment Protection Authority (EPA). The license application relates to mine design, radiation and waste management, and rehabilitation.[121] In June 2006 the company completed feasibility studies and additional drilling to better define the Honeymoon and East Kalkaroo deposits. Subject to State Government approval of the subsidiary plans, the Board of Uranium One was expected to decide on whether to proceed with production in mid 2006. Plant construction is expected to take less than 18 months with production commencing in the first quarter of 2008.[122]

3.122 In August 2006 the Board of Uranium One announced that it had approved the development of the deposit.[123] The Honeymoon project, which will be an acid ISL operation similar to the Beverley uranium mine, is expected to produce a total of 2 400 t U_3O_8 over a period of seven years. The project will employ approximately 50 people.[124]

Recovery of uranium from brannerite ores

3.123 At Olympic Dam, Ranger and many other uranium mines worldwide, sulphuric acid is used to dissolve uranium minerals from uraninite ores using conventional acid leach plants. However, brannerite, which is another important uranium mineral, is not dissolved in these sulphuric acid plants. The consequence is that less uranium is recovered after processing these ores and the brannerite is sent to tailings dams for disposal. This was confirmed by the Australian Atomic Energy Commission during the 1960s, after research on bulk metallurgical samples from brannerite-rich mineralisation at the Valhalla deposit in Qld.[125]

---

120 Southern Cross Resources Inc, *loc. cit.*

121 sxr Uranium One Inc., *sxr Uranium One Inc submits application to commercially mine and mill radioactive ore at Honeymoon, loc. cit.* The Honeymoon project application, along with the company's EIS and proposed radiation management and radioactive waste management plans are available online at the EPA web site, viewed 3 July 2006, <http://www.epa.sa.gov.au/honeymoon.html>.

122 Personal communication with Mr Greg Cochran, Executive Vice President, Australia and Asia, sxr Uranium One Inc., 3 July 2006.

123 sxr Uranium One Inc., *sxr Uranium One Announces Honeymoon Feasibility Study and Approves Honeymoon Project*, News Release, 29 August 2006, viewed 31 August 2006, <http://www.uranium1.com/uploads/articles/HoneymoonFeasibility_29Aug06.pdf>.

124 sxr Uranium One Inc., *Honeymoon Project Application License to Mine or Mill Radioactive Ore*, p. 4, viewed 3 July 2006, <http://www.epa.sa.gov.au/pdfs/honeymoon_application.pdf>.

125 GA, *Submission no. 42*, p. 22.

3.124 GA argued that this is a key issue for the Australian uranium industry because cost effective processes to recover uranium from brannerite would result in a significant increase in Australia's recoverable low cost resources of uranium. As noted above, under the IAEA and OECD-NEA resource classification scheme, Identified Resources are quantified as *recoverable* uranium—that is, after mining and processing losses have been deducted. This issue is of particular importance for Australia because much of the uranium at Olympic Dam (approximately 30 per cent) is contained in brannerite and only about 70 per cent of the uranium is recovered.[126] Hence, if uranium recoveries from Olympic Dam could be increased it would mean much greater production of uranium from the same quantity of ore, and therefore have a dramatic effect on the quantity of Australia's overall recoverable uranium resources.

3.125 GA noted that the mine's former owners, WMC Resources, commenced a major research program to improve uranium recoveries, including testing various new recovery techniques such as elevating the temperature of the leach tailings.[127] During 2004 the company implemented a first phase of these metallurgical improvements and reported recoveries as high as 77 per cent. GA argued that:

> The implications of these results are far reaching because, if they can improve recoveries up to 85% (as proposed), this will have a marked improvement in production and revenues. In the lower grade ores at Olympic Dam, the ratio of brannerite:uraninite increases with decreasing ore grade. It is very important for future expansions of the operations into the southern section of the orebody (lower grade) that this brannerite problem be solved.[128]

3.126 Summit Resources stated that its metallurgical test work indicates a potential overall recovery of around 75 per cent of the uranium at the Valhalla deposit in Mount Isa.[129]

3.127 Before turning to a discussion of exploration and the potential for further discoveries of uranium in Australia, the Committee notes again a conclusion of the previous chapter—that there is great potential for Australia to expand production and become the world's premier supplier of uranium.

3.128 The UIC submitted that 'Australia is a preferred supplier to the world' and GA argued that 'Australian uranium mining companies have gained a

126 *ibid*. See also: See also: Dr Gavin Mudd, *Transcript of Evidence*, 19 August 2005, p. 50; Dr Gavin Mudd, *Submission no. 27*, p. 9.

127 Mr Aden McKay (GA), *Transcript of Evidence*, 5 September 2005, p. 6.

128 GA, *Submission no. 42*, p. 23.

129 Summit Resources Ltd, *op. cit.*, p. 14; Mr Aden McKay (GA), *op. cit.*, p. 7.

reputation as reliable suppliers to customer countries and utilities.'[130] Similarly, ASNO argued that:

> As a stable, secure low-cost uranium producer Australia is likely to occupy a key position in world uranium supply. Not only does Australia hold the largest uranium reasonably assured recoverable resources, it also holds a significant share of the market in areas where nuclear power is expanding; principally, North Asia.[131]

3.129 Likewise, the Australian Nuclear Association (ANA) submitted that:

> Australia is a preferred uranium supplier in many markets, not only due its low cost high-quality product, but also because it is seen to have high economic and political stability.[132]

3.130 Moreover, Nova Energy argued that, unlike some other supplier countries, the Australian minerals industry can properly claim to be a 'mature, high technology and heavily regulated industry', where stringent safety and environmental regulations are imposed.[133]

Exploration

3.131 The Australian Bureau of Statistics (ABS), which produces official exploration data for Australia, records that uranium exploration expenditure amounted to $20.7 million during financial year 2004–05. This figure was almost double the 2003–04 total of $10.5 million, which in turn was an increase on the 2002–03 figure of $6.9 million. In the first half of 2005–06, exploration expenditure totalled $27.7 million, already exceeding expenditure of the entire previous year.[134]

3.132 GA also undertakes an annual survey of uranium exploration in Australia, reporting expenditures on a calendar year basis. As with the ABS findings, GA has reported a significant increase in uranium exploration since early 2003. In 2005, total expenditure on uranium exploration was $41.09 million, which was the highest since 1988 (in constant 2005A$) and almost a three-fold increase on 2004 expenditure of $13.96 million. Exploration

---

130 UIC, *Submission no. 12*, p. 27; GA, *Submission no. 42*, p. 11. See also: Deep Yellow Ltd, *Submission no. 16*, p. 2.

131 ASNO, *Submission no. 33*, p. 6.

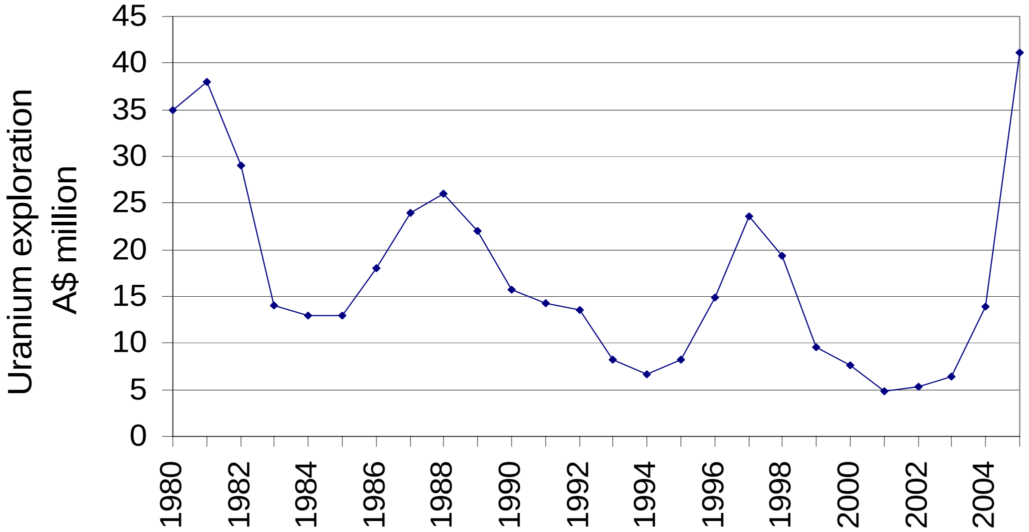
132 ANA, *Submission no. 19*, p. 2.

133 Nova Energy Ltd, *op. cit.*, p. 9.

134 ABS, *Mineral and Petroleum Exploration*, cat. no. 8412.0, ABS, Canberra, 2005, p. 12, viewed 23 June 2006, <http://www.abs.gov.au>.

expenditure in 2003 was $6.38 million.[135] Figure 3.11 shows uranium exploration expenditure in Australia since 1980.

Figure 3.11 Uranium exploration expenditure in Australia 1980–2005



Source Geoscience Australia
Annual expenditures are nominal, dollar of the day, figures and have not been adjusted for inflation.

3.133 GA argued that exploration expenditure has risen for three principal reasons: the rise is uranium spot market price, which has increased four-fold from US$10/lb U_3O_8 in early 2003 to more than $45/lb U_3O_8 in June 2006; the rise in crude oil prices; and the perception in the market that secondary supplies of uranium are being exhausted. These factors were discussed in chapter two.[136]

3.134 GA observed that, historically, uranium exploration in Australia has been highly successful. The majority of Australia's uranium deposits were discovered between 1969 and 1975—approximately 50 deposits were discovered during this short period, including several world-class deposits such as Ranger, Jabiluka, Nabarlek and Koongarra in the Alligator Rivers region (NT); Olympic Dam and Beverley (SA); and Yeelirrie in Western Australia (WA). From 1975 to 2003, only another four deposits were discovered and of these only one deposit (Kintyre in the

135 GA, *Exhibit no. 62*, *op. cit.*, p. 4. Exploration expenditure for 2005 provided by Mr Aden McKay (GA), 26 June 2006.

136 Mr Aden Mackay (GA), personal communication, 3 February 2006.

Paterson Province of WA) has RAR recoverable at less than US$40/kg U.[137]

3.135 Despite steady growth in mining and exports, expenditures on uranium exploration in Australia fell progressively for 20 years, from a peak level of $35 million ($105 million in constant 2003A$) in 1980 to a historic low of $4.8 million in 2001 ($5.34 million in constant 2005A$).[138] The increase in expenditure that culminated in the 1980 peak was in large part due to the oil shocks of 1973 and 1979, which GA noted strongly resembles the current situation of high crude oil prices.[139]

3.136 During the late 1970s and early 1980s, up to 60 companies were actively exploring for uranium in Australia. Exploration was carried out in 'greenfields' areas, as well as the known uranium provinces. Subsequently, expenditures declined to 2001, when only five companies were actively exploring for uranium in areas adjacent to known deposits, mainly in western Arnhem Land (NT), the Frome Embayment and the Gawler Craton-Stuart Shelf (SA). This long decline was interrupted by two brief periods of increasing expenditures following the discovery of the Kintyre deposit in 1985, and the abolition of the 'Three mines' policy by the Commonwealth Government in 1996.[140] The decline in exploration expenditure resulted from several factors:

- falling uranium prices over two decades—prices fell from an average of US$42.57/lb U_3O_8 in 1979 to an average of $8.30/lb U_3O_8 in 2002;
- restrictions in some jurisdictions on uranium exploration and production;
- increasing availability of supplies from secondary sources (mainly highly enriched uranium stocks); and
- decreasing costs of production resulting from large-scale, low-cost mining in Canada and Australia.[141]

Figure 3.12 plots uranium exploration expenditure in Australia and the spot price for uranium from 1967 to 2003.

137 GA, *Exhibit no. 61, op. cit.*, p. 5.

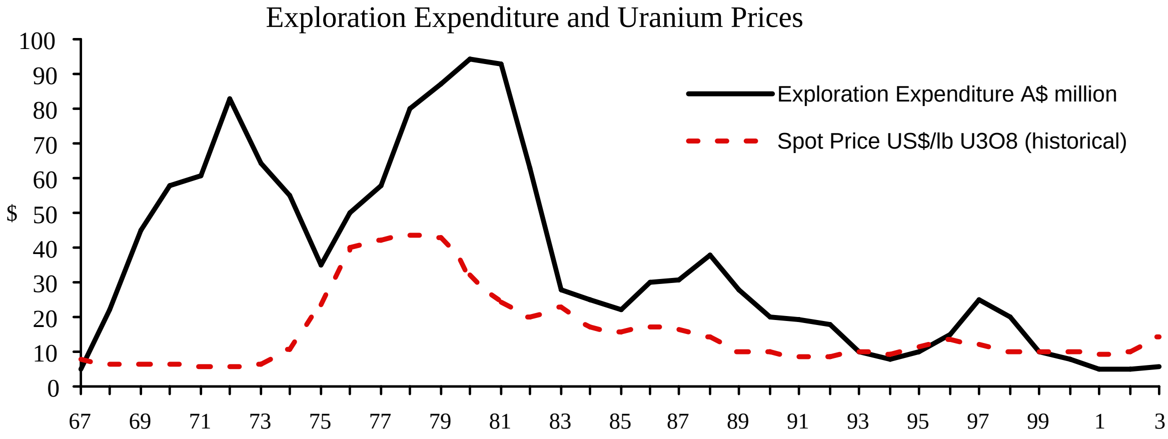
138 *ibid.*; GA, *Australia's Identified Mineral Resources 2002*, GA, Canberra, 2002, p. 51, viewed 4 July 2006, < http://www.ga.gov.au/image_cache/GA3309.pdf>.

139 McKay and Miezitis, *op. cit.*, p. 8; I Lambert, et. al., *op. cit.*, p. 2.

140 GA, *Submission no. 42*, p. 23.

141 *ibid*. For a detailed history of uranium exploration in Australia see McKay and Miezitis, *op. cit.*, pp. 5–9.

Figure 3.12 Exploration expenditure and uranium prices (1967–2003)



Source UIC, *Submission no. 12*, p. 13.

3.137 Cameco noted that the decline in exploration expenditure resulted in activity being focussed in relatively few areas, including the Frome Embayment in SA, the ARUF in the NT and, in the early 1980s, the Rudall Province of WA. However, apart from limited activity in these areas, 'exploration has effectively stopped in the rest of Australia for the past twenty years.'[142]

3.138 Despite the paucity of discoveries since 1985, Australia's low-cost resources have continued to increase as a result of the delineation of additional resources at known deposits, mostly at Olympic Dam.[143] Figure 3.13 illustrates exploration expenditure, discovery of deposits and the increase in low-cost resources over the period 1967 to 2004. While there has been a trend of increasing exploration expenditure since early 2003, there has been relatively little exploration for uranium over the past two decades and Australia's known uranium resources generally reflect exploration efforts that took place 30 years ago. As the UIC argued:

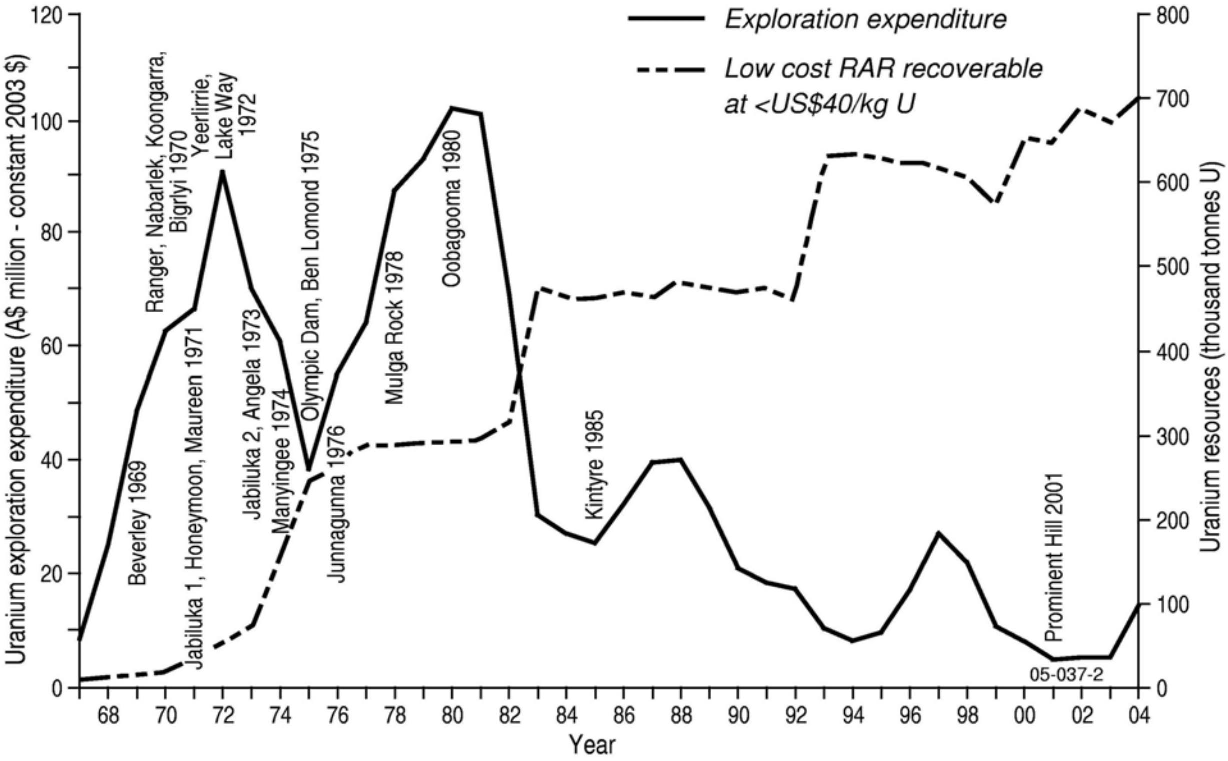
> It can thus be seen that Australia's known uranium resources largely reflect exploration efforts more than 25 years ago. Very little exploration for uranium has been carried out since. There is now significant potential for increasing exploration in the light of higher uranium prices, but state government policies need to be positive.[144]

142 Cameco Corporation, *op. cit.*, p. 4.

143 GA, *Submission no. 42*, p. 23.

144 UIC, *Submission no. 12*, p. 25.

Figure 3.13 Trends in uranium exploration expenditures, discovery of deposits and the increase in Australia's low cost resources



Source Geoscience Australia, *Exhibit no. 60, Australia's uranium resources, production and exploration*, p. 9.

Recent exploration activity

3.139 The marked uranium price rise since 2003 (see figure 2.6 in chapter two) has stimulated a significant resurgence in exploration activity. In 2004 there were 14 active uranium exploration projects in Australia, while in 2005 the number of active projects had increased to 70. The number of companies actively exploring for uranium increased from five at the start of 2004 to more than 34 by late 2005.[145]

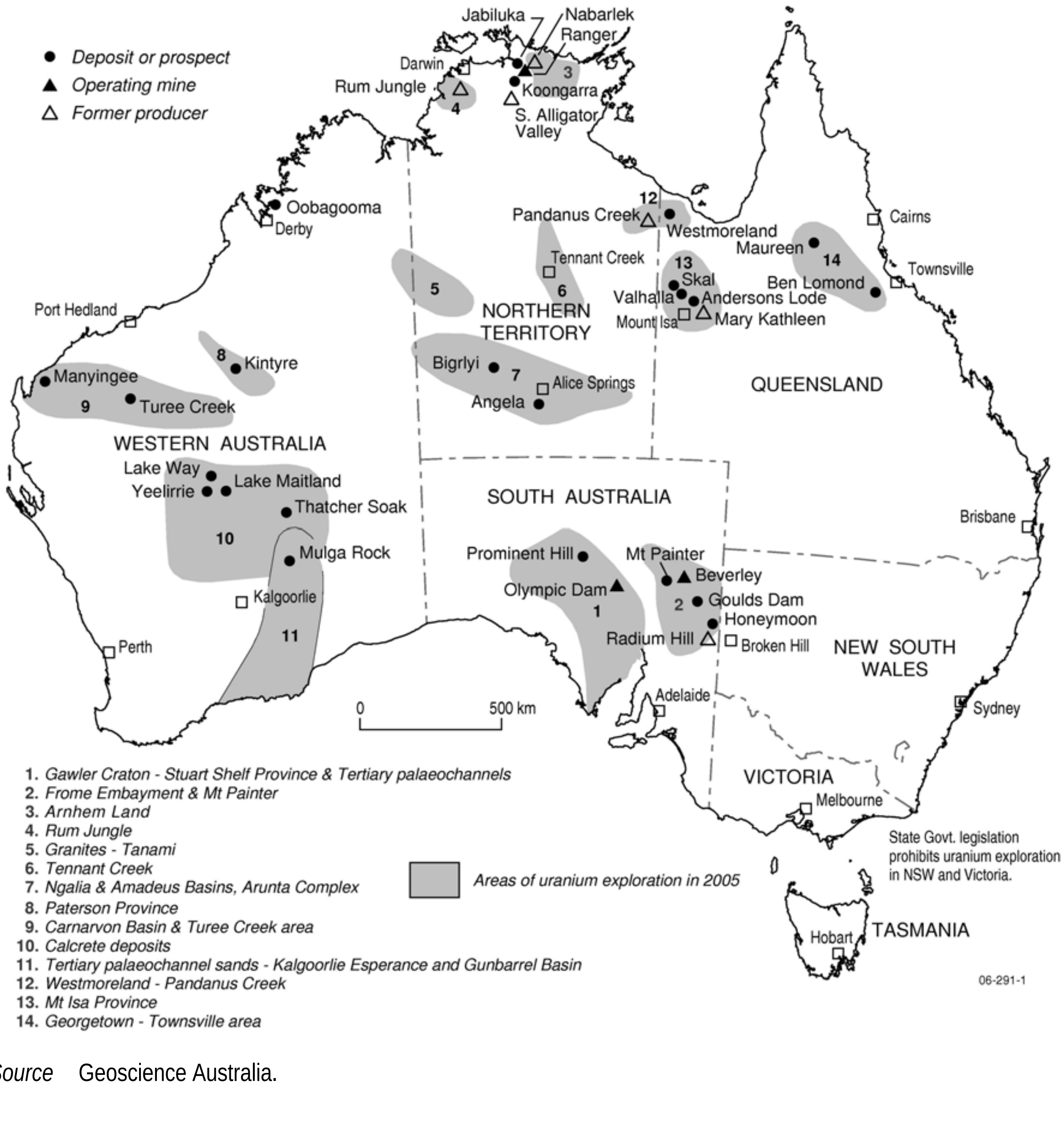
3.140 The proportions of total exploration expenditure spent in each jurisdiction in 2005 were: SA 42 per cent, NT 37 per cent, Qld 15 per cent and WA 6 per cent. The majority of expenditure was in SA and NT which together accounted for almost 80 per cent of the total. The main areas (in terms of expenditure) of exploration, which are illustrated in figure 3.14, were:

- South Australia—Gawler Craton-Stuart Shelf region; Tertiary palaeochannel sediments of the Frome Embayment; and palaeochannels overlying the Gawler Craton;

145 Information provided by Mr Aden McKay (GA), 5 July 2006, from the findings of the 2005 uranium exploration survey.

- Northern Territory—Alligator Rivers region and Western Arnhem Land, and Ngalia Basin (including Napperby project in Tertiary sediments overlying the Ngalia Basin); and
- Queensland—Mount Isa province.[146]

Figure 3.14 Areas of uranium exploration in 2005



Source Geoscience Australia.

146 *ibid*.

3.141 Important uranium exploration results in 2005 included:

- discovery of major extensions of the Olympic Dam deposit to the south-east, and the proposal to test the deeper zones of mineralisation down to depths of 2.5 km below surface (currently resources have been evaluated to a depth of 1 km below surface);
- discovery of a new deposit, Beverley 4 Mile, which is 5–10 km west of the Beverley mine, and continued discovery of further mineralisation to the south of the Beverley mine; and
- discovery of extensions to the Valhalla, Skal and Andersons deposits and significant intersections in the Bikini and Mirrioola deposits.[147]

3.142 In other developments, GA noted that in 2005 Bullion Minerals explored for sandstone-hosted uranium deposits in Tertiary sands overlying granitic basement rocks in the Kalgoorlie–Esperance region of WA. This is the first time that uranium exploration has been undertaken in this area. Exploration also re-commenced in many geological provinces in which the last exploration for uranium occurred more than 20 years previously.[148]

3.143 In 2004–05 Southern Cross Resources and Heathgate Resources conducted drilling in areas of the Frome Embayment area of SA, which had first been identified by airborne electromagnetic surveys that defined the extent of buried palaeochannels. These activities were directed at exploring for sandstone-type deposits. As noted above, Heathgate Resources announced the discovery of a new zone of uranium mineralisation 3 km south of Beverley (the Deep South zone).[149]

3.144 In 2004 Southern Cross Resources discovered a new zone of low-medium grade uranium mineralisation in the area of the Yarramba palaeochannel, approximately 1.5 km north-west of the Honeymoon deposit, known as the Brooks Dam prospect. The grade and thickness of mineralisation were measured using a 'Prompt Fission Neutron' probe technology, which gives more reliable uranium grades than probes normally used in sandstone-hosted uranium deposits. Southern Cross Resources also completed airborne electromagnetic surveys and ground gravity surveys over the Billeroo region and defined the extent of the Billeroo palaeochannel. A program of drilling was also conduced to evaluate the resources at the Goulds Dam prospect. In August 2005, Marathon Resources announced an inferred resource of 33 200 t U_3O_8 at its Mount Gee prospect in the Curnamona Province of SA.[150]

147 *ibid.*

148 *ibid.*

149 GA, *Exhibit no. 61, op. cit.*, p. 9.

150 GA, *Exhibit no. 62, op. cit.*, pp. 4–5.

3.145 The Beverley 4 Mile prospect, owned by Alliance Resources/Quasar Resources, is important because, if current interpretations prove to be correct, it represents the first known discovery of significant uranium mineralisation within Mesozoic sediments in SA. GA explained that this highlights the potential for further discoveries in the Mesozoic sediments which underlie extensive regions of the Frome Embayment.[151]

3.146 In the Gawler Craton of SA, Minotaur Resources continued exploration drilling of copper-gold-uranium mineralisation at the Prominent Hill deposit. The geological setting and style of mineralisation are similar to Olympic Dam, which is also located in the Gawler Craton 150 km to the southeast. However, uranium grades at Prominent Hill are lower than at Olympic Dam and GA noted that the company has no plans to recover uranium.[152]

3.147 The SA Government Department of Primary Industries and Resources has reported that there are currently more than 20 companies involved in uranium exploration in SA.[153] Media reports have stated that as at January 2006 some 25 Australian and international companies have been granted a total of 86 uranium exploration licenses in SA, an increase of 100 per cent in three years.[154]

3.148 The NTMC also explained that there has recently been considerable interest in uranium exploration in the Territory, with exploration licences granted to 17 companies in the five months to October 2005 alone. There are now some 25 companies currently active in the Territory, with most of these being Australian companies, three Canadian, one UK-linked and one French company, either exploring or planning to explore for uranium.[155] The recent interest in exploration was attributed to the uranium price rise and to the Commonwealth Government's decision to assume responsibility for uranium mine approvals, which gave certainty to the junior companies in the industry. The NTMC estimated that exploration expenditures varied from a couple of hundred thousand dollars by juniors, up to $5–6 million per year by Cameco, which is the largest explorer in the Territory.[156]

3.149 In terms of exploration activity and expenditure by individual companies, the Committee received the following evidence:

---

151 *ibid.*, p. 4.

152 GA, *Exhibit no. 61, loc. cit.*

153 P Abbot, *op. cit.*, p. 1.

154 C Pippos, 'Uranium mines: the rush is on', *Sunday Mail*, 15 January 2006, p. 11.

155 NTMC, *Exhibit no. 75, List of uranium exploration and mining companies working in the Northern Territory as at September 2005.*

156 Ms Kezia Purick (NTMC), *Transcript of Evidence*, 24 October 2005, p. 36.

- Cameco noted that it has been exploring for uranium in Australia for ten years prior to the present price upturn, spending some $50 million in the ARUF of the NT and $4–5 million in the Rudall area of WA to August 2005.[157]
- Heathgate Resources, operators of the Beverley mine, noted that despite the company's small size it is one of the largest explorers for uranium in Australia, with exploration expenditure approximately equal to that of Cameco. Heathgate indicated that it may spend close to $6 million in uranium exploration in 2006.[158]
- Since commencing exploration in Australia, Areva has spent some $150 million with the company focussing on SA but with some exploration also in the NT. Areva argued that there has been negligible uranium exploration over the past twenty years and 'there appears to be a much greater potential for discovery of further uranium resources in Australia.'[159]

3.150 ERA reported that in 2005 the company conducted exploration drilling on the eastern vicinity of the Ranger Pit 3 for the purpose of determining the ultimate size of the orebody. Some 9 232 metres were drilled at a cost of $2.26 million. ERA also conducted airborne geophysical surveys which highlighted further opportunities and exploration drilling may be conducted in 2006.[160]

3.151 RWE NUKEM reported that BHP Billiton plans to spend US$130 million on surface and underground drilling over the next two years to better define the Olympic Dam orebody, as part of its pre-feasibility study for the possible mine expansion. A further US$25 million is budgeted for a new underground tunnel into the southern orebody for detailed resource drilling/technical evaluation.[161]

3.152 In terms of uranium exploration and mine development abroad, Australian mid-tier mining company, Paladin Resources, which owns uranium deposits in WA (Manyingee and Oobagooma), is currently developing a new uranium mine and mill at its Langer Heinrich project in Namibia. Paladin decided to develop the deposit in May 2005. The company is also completing a feasibility study on its Kayelekera Project in Malawi, with the intention of bringing that project into production in 2008 or 2009.[162]

---

157 Dr Ron Matthews (Cameco Australia Pty Ltd), *Transcript of Evidence*, 11 August 2005, p. 3.

158 Mr Mark Chalmers, *op. cit.*, p. 97; P Abbot, *loc. cit.*

159 Mr Stephen Mann, *op. cit.*, p. 3.

160 ERA, *2005 Annual Report, op. cit.*, p. 6.

161 RWE NUKEM, *op. cit.*, p. 9.

162 Paladin Resources Ltd, *Submission no. 47*, p. 2; IAEA and OECD-NEA, *op. cit.*, p. 94.

Potential for new discoveries

3.153 The UIC, GA and other submitters argued that:

> The potential for new discoveries is great. Not only have many prospective areas not been explored at all thoroughly, but also geological knowledge evolves and exploration technology improves, so that there is increased sophistication and effectiveness of the exploration effort going into the future. A significant example of this is that in the mid 1970s when the main uranium discoveries were made in Canada's Athabasca Basin, airborne electromagnetic surveys there were effective only to 100 metres depth below the surface, today they yield useful data down to one kilometre. This is particularly relevant to uranium exploration in NT, much of which targets similar geological formations.[163]

3.154 The NTMC concurred with this observation, noting that in the Territory:

> [t]he potential for undiscovered [resources] is high. Only 20 per cent to 25 per cent of the prospective rock units has been effectively explored because superficial cover has masked any potential airborne anomalies.[164]

3.155 In addition to the known undeveloped uranium deposits in the NT (including Jabiluka and Koongarra in West Arnhem Land, and Angela near Alice Springs), there is said to be good uranium mineralisation in the following areas:

> … the Batchelor-Rum Jungle-Coomalie area … 100 kilometres south of Darwin; West Arnhem Land; the Napperby-Tanami-Arunta region, which is about 150 kilometres north-west of Alice Springs; and the Ngalia Basin, 250 kilometres north-west of Alice Springs.[165]

3.156 The NTMC observed that the Alligator Rivers Region is recognised a world class mineral province and unconformity-related uranium deposits are the main exploration target in the NT, because of the potential for large tonnage, low to medium grade resources. However, it was argued that a significant proportion of the most prospective area is included within the boundaries of the Kakadu National Park. Other areas considered prospective for unconformity-related deposits exist in the Ashburton and

---

163 UIC, *Submission no. 12*, p. 25.

164 NTMC, *Submission no. 51*, p. 6.

165 Ms Kezia Purick, *op. cit.*, p. 33.

Davenport Provinces, Tanami Region and on the margins of the Murphy Inlier.[166] These geological provinces are shown in appendix F.

3.157 Cameco argued that: 'Significant potential remains throughout Australia in a variety of geological provinces and settings', and that the exploration activity 'to date has only relatively scratched the surface.'[167] Cameco mentioned prospective regions that may contain deposits of the following types:

- unconformity-related deposits may be found in the Pine Creek Inlier, particularly the ARUF in West Arnhem Land, in the NT. Other prospective areas for unconformity type mineralisation include the Ashburton and Bresnahan Basins in WA, the Birrindudu Basin in the NT and the Eyre Peninsula of SA.
- Sandstone hosted deposits, which are amenable to ISL mining, may be found in younger basins including the Gunbarrel, Carnarvon and Canning Basins of WA, and the Amadeus and Ngalia Basins of the NT.
- Near surface uranium deposits in very young sediments, which are often hosted in calcrete, may be found in the northern portion of the Yilgarn Craton of WA.[168]

3.158 Southern Gold, which holds exploration tenements in the Gawler Craton of SA, argued that the Gawler contains highly prospective and under-explored geological terrain (relative to the Curnamona/Frome Craton which hosts the Beverley and Honeymoon deposits). It was argued that the Gawler Craton, which hosts the Olympic Dam and Prominent Hill deposits, offers excellent opportunities to discover new shallow resources such as calcrete-hosted deposits amenable to ISL technology.[169]

3.159 GA argued that there is significant potential for additional uranium deposits to be found in Australia, including:

- unconformity-related deposits, including high-grade deposits at and immediately above the unconformity, particularly in Arnhem Land in the NT but also in the Granites–Tanami region (NT–WA), the Paterson Province (WA) and the Gawler Craton (SA);
- hematite breccia deposits, particularly in the Gawler Craton and Curnamona Province of SA, and the Georgetown and Mount Isa Inliers of Qld;
- sandstone-hosted deposits in sedimentary strata in various regions adjacent to uranium-enriched basement; and

166 NTMC, *ibid.*, pp. 5, 6.

167 Cameco Corporation, *loc. cit.*

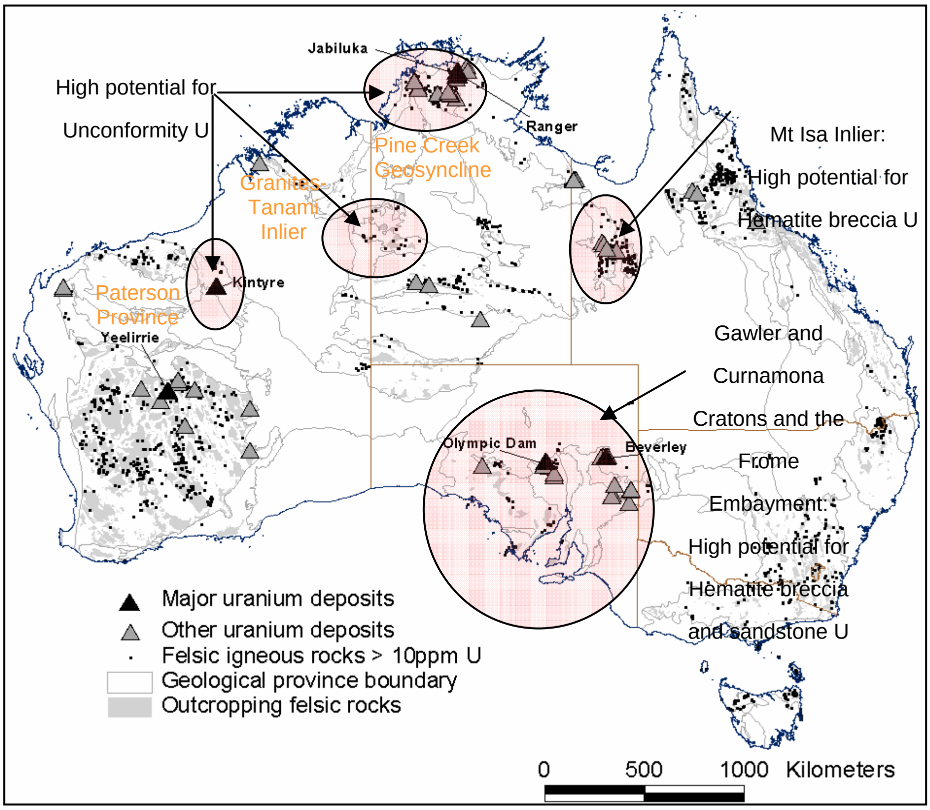
168 *ibid.*, pp. 5–6.

169 Southern Gold Ltd, *Submission no. 54*, pp. 7, 11, 12.

- carbonatite-related rare earth–uranium deposits in Archaean cratons and Proterozoic orogens.[170]

3.160 GA have identified regions of Australia having a high potential for further discoveries of uranium deposits. These regions are depicted in figure 3.15. GA observed that exploration is currently under way in all these areas, although there has not been much exploration in the Paterson Province in WA to date.[171]

Figure 3.15 Regions of Australia with high potential for uranium



Source Geoscience Australia, *Exhibit no. 60, Australia's uranium resources, production and exploration*, p. 10.

3.161 Cameco and Areva urged that Australia's policy in relation to uranium exploration and mining be clarified. Dr Ron Matthews of Cameco stated that:

> From our perspective, we are here for the long term, but we would like to see clarity on uranium and for Australia's future to be clearly identified. We feel that Australia has significant potential, and that should be harnessed. With the present interest in nuclear

170 I Lambert et. al., *loc. cit.*

171 Mr Aden McKay (GA), *Transcript of Evidence*, *op. cit.*, p. 3.

> energy worldwide, Australia's uranium is a resource that should clearly be developed. We would like to see that moved forward.[172]

3.162 It was submitted that state government opposition to the development of uranium deposits is impeding uranium exploration in those states. Areva observed that:

> Cogema [Areva] believes there is significant potential for uranium discoveries in other states of Australia, but at the moment it prefers to explore in those states that are not opposed to the concept of uranium exploration or mining.[173]

3.163 Likewise, Cameco submitted that 'Cameco Australia's exploration efforts are effectively on hold in WA because of the State government's policy with respect to uranium mining.'[174] It was noted that while a large number of junior companies have recently applied for licenses over prospective ground in WA, 'realistically the level of exploration expenditure will be limited until this policy is changed.'[175]

3.164 Cameco argued that 'without doubt Australia's known resources could be increased', but:

> … there needs to be a significant change in how uranium is viewed and a clear level of support shown at both the Federal and State level. A change in political will and direction is required to give the clear message to companies that it is worthwhile exploring for uranium.[176]

3.165 To this end, the Association of Mining and Exploration Companies (AMEC) recommended that Australia adopt an active exploration program to identify further uranium mineralisation.[177]

The role of junior exploration companies

3.166 During 2004 and 2005, a number of small uranium-focussed exploration companies listed on the Australian Stock Exchange.[178] In 2005, 25 junior exploration companies were exploring for uranium nationwide.[179] While a

172 Dr Ron Matthew, *loc. cit.*

173 Mr Stephen Mann, *loc. cit.*

174 Cameco Corporation, *op. cit.*, p. 5.

175 *ibid.*

176 *ibid.*, p. 6.

177 Mr Alan Layton (AMEC), *Transcript of Evidence*, 23 September 2005, p. 13.

178 GA, *Submission no. 42*, p. 24.

179 Information provided by Mr Aden McKay (GA), 7 July 2006. By July 2006, there were reports of consolidation in the industry, with takeover bids announced for some juniors (particularly from mid-tier Canadian companies). See: J Clarke, 'Uranium players seek out solid ground', *Australian Financial Review*, 8 July 2006, p. 10.

substantial part of the increase in total exploration expenditure in 2005 was due to exploration in the south-east of Olympic Dam, junior companies now account for a significant proportion of total exploration expenditure.[180]

3.167 Several junior companies that submitted to the inquiry mentioned their exploration expenditures:

- Summit Resources, which owns the Valhalla, Skal and Andersons Lode deposits in Qld, reported that it spends between $2.5 and $3 million a year on exploration.[181]
- Compass Resources, which holds tenements at Batchelor (the Rum Jungle uranium field) in the NT, stated that it spent between $20 and $30 million over the past five years exploring for minerals, including uranium.[182]
- Southern Gold, which holds tenements in the Gawler Craton of SA (including the Southern Gawler Arc and Yarlbrinda projects), stated that it aimed to spend $500 000 in 2005 and $1 million per year over the next five years.[183]

3.168 Geoscience Australia observed that a comparison between the exploration expenditures of major mining companies in the early 1990s with those of today reveals that 'what they are spending now is an order of magnitude decrease in general.'[184] Instead, the major companies now:

> … prefer to have good small companies working for them. They can have a loose or somewhat tighter relationship with small companies—maybe seed funding—and then cherry pick the results. That seems to be a model that has emerged.[185]

3.169 Deep Yellow supported this view and argued that:

> The trend over the last 10 years has been for the bigger companies to let the smaller companies do that exploration work, let them take the risk at that early stage and then come in when they have found something. It is a similar case with uranium. It is a risky venture to spend a lot of money on exploration.[186]

180 Information provided by Mr Aden McKay (GA), 3 February 2006; Areva, *op. cit.*, p. 13.
181 Mr Alan Eggers, *op. cit.*, p. 5.
182 Dr Malcolm Humphreys (Compass Resources NL), *Transcript of Evidence*, 16 September 2005, p. 66.
183 Mr Cedric Horn (Southern Gold Ltd), *Transcript of Evidence*, 19 August 2005, pp. 18–19.
184 Dr Ian Lambert (GA), *Transcript of Evidence*, 5 September 2005, p. 5.
185 *ibid*.
186 Mr James Pratt (Deep Yellow Ltd), *Transcript of Evidence*, 23 September 2005, p. 88.

3.170 Southern Gold emphasised the key role played by juniors following the rationalisation of the mining industry and the retreat of large companies from exploration activity. It was argued that because juniors are now 'carrying a greater burden for defining and developing Australia's uranium resources but with limited funding', these smaller companies merit support from government:

> The junior exploration sector warrants expanded financial and regulatory support from State and Federal governments in facilitating exploration for the country's future development, competitiveness and prosperity.[187]

3.171 Among other recommendations, Southern Gold called for the provision of high quality geoscientific data and encouragement for industry through programs such as the PACE initiative ('Plan for Accelerating Exploration') in SA, where 'the (State) government subsidises drilling programs dollar for dollar.'[188] The company also recommended subsidies for infrastructure development in regional areas.[189]

3.172 The MCA agreed that there has been structural adjustment in the minerals industry. A consequence of the rationalisation and consolidation of the industry is that now 'much of the exploration effort is essentially outsourced to junior companies.'[190] For the MCA, the significant role of juniors in conducting much of the uranium exploration points to the importance of:

> … one of the … fundamental platforms of the exploration action agenda, which is flow-through shares and improved financing or being able to wash out the tax liabilities to investors. The juniors do not have income to offset these tax liabilities, so there is a market failure in terms of tax asymmetry.[191]

3.173 The Committee notes that its previous report, *Exploring: Australia's Future*, recommended that the Australian Government examine the introduction of a flow-through share scheme for companies conducting eligible minerals and petroleum exploration activities in Australia.[192] The Committee also notes that the 2005 progress report on the implementation

---

187 Southern Gold Ltd, *op. cit.*, p. 2.

188 Mr Cedric Horn, *op. cit.*, p. 15. See: Primary Industries and Resources SA, *PACE – A Plan for Accelerating Exploration*, Government of SA,, viewed 6 July 2006, <http://www.pir.sa.gov.au/byteserve/minerals/initiatives/pdf/pace_brochure_web.pdf>.

189 Southern Gold Ltd, Submission no. 54.1, 5–6.

190 Mr Mitch Hooke (MCA), *Transcript of Evidence*, 5 September 2005, p. 35.

191 *ibid*.

192 House of Representatives Standing Committee on Industry and Resources (HRSCIR), *Exploring: Australia's Future*, Commonwealth of Australia, Canberra, 2003, p. 40. Available online: <http://www.aph.gov.au/house/committee/isr/resexp/chapter3.pdf>.

of recommendations from the Minerals Exploration Action Agenda (MEAA) strongly advocated the introduction of a flow-through share system to 'reinvigorate the search for the next generation of Australia's mineral deposits.'[193]

3.174 The NTMC expressed strong support for a close examination of a flow-through share scheme, 'to try and drive exploration expenditure in Australia, which has lost ground significantly compared to the rest of the world.'[194] Dr Ron Matthews of the NTMC argued that:

> I would see great benefits in that to drive greenfields exploration in particular, and also to benefit junior companies specifically, which really form the engine behind the resource industry. I think there is a move to look at that; I think we would all endorse this being looked at very seriously.[195]

3.175 In its previous report, which addressed impediments to exploration, the Committee accepted that future world-class uranium deposits are likely to be located at greater depths than those hitherto discovered. It was concluded that this will require large injections of exploration investment capital to overcome the technical challenges of locating bedrock deposits. These observations reinforce the need to ensure that juniors, which are generally efficient explorers, are appropriately assisted to discover Australia's future world-class uranium and other mineral deposits. The Committee is convinced of the merits of flow-through share schemes and repeats the recommendation contained in its previous report. The Committee makes additional observations about the challenges faced by junior companies in chapter 11.

Recommendation 1

The Committee recommends that the Australian Government introduce a flow-through share scheme for companies conducting eligible minerals and petroleum exploration activities in Australia.

---

193 MEAA Implementation Group, Notes from the Chair, *Annual Progress Report to the Minister for Industry, Tourism and Resources*, DITR, Canberra, November 2005, viewed 24 March 2006, <http://innovation.gov.au/assets/documents/itrinternet/MEAA_Implementation_Group_2005_Annual_Report20051122124132.pdf>.

194 Dr Ron Matthews (NTMC), *Transcript of Evidence*, 24 October 2005, p. 37.

195 *ibid.*

New exploration technologies and geoscientific data

3.176 The Committee's previous report observed that future exploration programs aimed at major discoveries beneath thick cover are likely to require high-cost sophisticated exploration technology.[196]

3.177 Evidence presented to the Committee's current inquiry again pointed to the need for new technologies to identify deposits located at depth. For example, GA emphasised the need for a new generation of tools and technologies to assist in the discovery of uranium deposits located down to 500 metres below surface:

> … the focus has to be on the covered areas like the Gawler Craton where you have deep weathering and sedimentary cover. The information available for those covered areas is limited … We need a new generation of information … we have to look through the cover and get down to the rocks of 100 to 400 or 500 metres below the surface. We need to bring in a new set of technologies to do that. It is important to be able to identify palaeochannels in the Frome Embayment and to be able to identify the favourable alteration minerals in the Olympic Dam domain for that style of mineralisation. That requires a new generation. That is what we hope will eventually come to GA as a result of the various inquiries we have had in the last couple of years.[197]

3.178 Cameco argued that: 'The potential for new discoveries, in both previously defined terrains and new areas, using advanced techniques and deep exploration tools is very high.'[198] Similarly, the MCA argued that:

> Australia's current Economic Demonstrated Resources, though large, underestimates the potential resource. Indeed, given that exploration technology has improved significantly in recent years, there is a reasonable expectation that significantly more uranium would be discovered if the latest technologies and models of how ore bodies form were applied in Australia.[199]

3.179 CSIRO explained that future discoveries of uranium will require more sophisticated geochemical and geophysical technologies in order to see through the regolith to discover the deeper deposits.[200]

---

196 HRSCIR, *op. cit.*, pp. 47, 61–62.

197 Dr Ian Lambert, *op. cit.*, p. 5. See also: Mr Keith Alder, *Transcript of Evidence*, 16 September 2005, p. 81.

198 Cameco Corporation, *op. cit.*, pp. 4–5. See also: UIC, *Submission no. 12*, p. 25.

199 MCA, *op. cit.*, p. 4.

200 Dr Rod Hill (CSIRO), *Transcript of Evidence*, 19 August 2005, p. 6.

3.180 In terms of particular techniques to provide the needed precompetitive geoscience, GA mentioned that regional airborne electromagnetics could be more widely deployed to identify minerals and the graphite related to uranium hundreds of metres below surface.[201]

3.181 GA also informed the Committee that the Athabasca Basin in Canada, which contains several extremely high-grade deposits (such as Macarthur River and Cigar Lake), has been exhaustively surveyed in a collaborative study involving the Geological Survey of Canada and mining companies using these techniques:

> They have pulled it apart and done everything they possibly could to it—the sorts of things that we do here in Australia, depending on our level of resources. They have done seismic studies, airborne geophysical studies and a whole lot of pulling together of existing information. That has shown a number of areas of potential in that highly prospective Athabasca Basin.[202]

3.182 The MCA supported GA's call for the deployment of more sophisticated techniques to improve the under cover exploration activity. The MCA noted that a recommendation for additional funding for precompetitive geoscientific data was one of the four elements of the MEAA.[203] It was also noted that the use of exploration techniques that are classed as 'low impact' permit expedited approvals procedures under the Native Title Act. The MCA urged the Committee to 'back the increased resourcing for precompetitive geoscientific data for Geoscience Australia.'[204] The MCA stated that it:

> … strongly supports the Minerals Exploration Action Agenda proposal of a new, national innovative geoscience program to underpin the discovery of the next generation of ore deposits in frontier areas to sustain Australia's mineral exports.[205]

3.183 The NTMC argued that the provision of geoscience data by the NT Government is 'extraordinary and it is very highly regarded by industry.'[206] Nonetheless, the NTMC also argued that the Territory and

---

201 Dr Ian Lambert, *op. cit.*, p. 9.

202 *ibid.*, p. 7.

203 The four key areas are: access to finance; the quality and availability of pre-competitive geoscience information; access to land; and access to human and intellectual capital. See: DITR, *Minerals Exploration Action Agenda*, viewed 7 July 2006, <www.industry.gov.au/minexpagenda>.

204 Mr Mitch Hooke, *op. cit.*, p. 35.

205 MCA, *op. cit.*, p. 3.

206 Ms Kezia Purick, *op. cit.*, p. 43.

Commonwealth Governments should work together to encourage the search for new deposits.[207]

3.184 Jindalee Resources and Southern Gold also spoke highly of the survey data provided by the NT Government and GA:

> It is sensational. It is great stuff. The state governments will now give you all of their geophysical surveys on disk. You can get them for just about nothing. The Northern Territory government is sensational with that. Instead of repeating the work that somebody else did five years ago you can get all of this on file now.[208]

3.185 In its previous report on the impediments to increasing Australia's exploration investment, the Committee made several recommendations pertaining to precompetitive geoscientific data, including that the Australian Government provide additional funds to enable GA to accelerate data acquisition programs.[209]

3.186 The Committee notes that in the 2005 progress report on the implementation of recommendations from the MEAA, the implementation group also recommended that:

> … a new national geoscience program should be implemented to address the deficiencies in modern coverage. A new program should specifically focus on pioneering new techniques and methods for revealing the potential of Australia's prospectivity under sedimentary cover, and at depth.[210]

3.187 The MEAA implementation group repeated the recommendation that new precompetitive geoscience information, particularly geophysical data, be provided for frontier areas.

3.188 The Committee welcomes the announcement in August 2006 of an addition $59 million for GA to pioneer the application of innovative, integrated geoscientific research designed to identify on-shore energy sources. Nonetheless, the Committee calls for additional funding for GA to develop and deploy new techniques to assist in the discovery of new world-class uranium deposits.

---

207 *ibid*., p. 33.

208 Mr Donald Kennedy (Jindalee Resources Ltd), *Transcript of Evidence*, 23 September 2005, p. 67; Mr Cedric Horn, *op. cit*., pp. 21, 22.

209 HRSCIR, *op. cit*., p. 55.

210 MEAA Implementation Group, *Annual Progress Report to the Minister for Industry, Tourism and Resources*, DITR, Canberra, November 2005, p. 15, viewed 24 March 2006, <http://innovation.gov.au/assets/documents/itrinternet/MEAA_Implementation_Group_2005_Annual_Report20051122124132.pdf>.

Recommendation 2

The Committee recommends that Geoscience Australia be granted additional funding to develop and deploy new techniques, including airborne electromagnetics, to provide precompetitive geoscience of prospective areas, in order to assist in the discovery of new world-class uranium and other mineral deposits located under cover and at depth.

Conclusions

3.189 The Committee was pleased to note record uranium production and exports for Australia in calendar year 2005. Production across the three operational mines (Ranger, Olympic Dam and Beverley) was 11 222 t U_3O_8 and exports were 12 360 t U_3O_8. Uranium exports also earned a record $573 million in 2005.

3.190 Australia is rightly regarded as a low-cost and reliable supplier of uranium. The Committee agrees that there is great potential for Australia to expand production and become the world's premier supplier of uranium. Specifically, the Committee looks forward with interest to the outcomes of BHP Billiton's PFS and feasibility studies for the possible expansion of Olympic Dam. Should the proposed expansion proceed, Olympic Dam could be producing some 20 per cent of world uranium mine output by 2013. If this were to eventuate, national production would be double the current level and Australia would become by far the world's largest uranium producer. The Committee would welcome this development.

3.191 In addition, the Committee notes that sxr Uranium One, owners of the Honeymoon deposit in SA which has already been granted a mining lease and an export license, have announced that the company expects to proceed with construction in the second half of 2006. Australia's second ISL mining operation is expected to commence production in 2008.

3.192 Although the Committee appreciates that ISL mining is applicable in very specific geological conditions, it notes that this mining method has numerous advantages over traditional excavation techniques, including minimal environmental impacts. The Committee was extremely impressed with the Beverley operation, its minimal surface disturbance and its advanced instrumentation. Committee members were convinced that once production has ceased at Beverley and the infrastructure has been removed, there will be virtually no indication that a mine ever existed at the site at all and the rehabilitation process will be relatively simple.

3.193 The Committee was also pleased to note Heathgate Resources' claim that Beverley is not only the largest but also the most technologically advanced ISL operation in the world. The Committee hopes that the Australian uranium industry will continue to lead the world in this area of expertise.

3.194 The Committee notes that Australia possesses 36 per cent of the world's RAR of uranium recoverable at low cost and 43 per cent of the world's low cost Inferred Resources. Australia has some 85 uranium deposits scattered across the country and these contain a total of over 2 Mt U_3O_8. Australia also possesses the world's largest quantity of thorium resources, which could be used as nuclear fuel.

3.195 Almost all of Australia's Identified Resources of uranium are contained in six deposits—Olympic Dam, Ranger Jabiluka, Koongarra, Kintyre and Yeelirrie. Olympic Dam, the world's largest uranium orebody, dwarfs all others and contains an estimated overall resource of 1.46 Mt of U_3O_8. Olympic Dam contains 26 per cent of the world's entire RAR recoverable at low cost.

3.196 The Committee notes that improvements in the recoveries of uranium from brannerite mineralisation, which have the potential to significantly increase Australia's recoverable resources (mainly at Olympic Dam and the Mt Isa deposits) would, in turn, have important ramifications for Australia's uranium mining industry. Given its importance for the industry as a whole, the Committee encourages an increased research and development effort to achieve improved uranium recoveries.

3.197 Notwithstanding the size of Australia's resources, the Committee notes that some 10 per cent of Australia's low cost uranium resources are deemed inaccessible to mining. Aside from those deposits in the NT that are surrounded by the Kakadu National Park, these resources include the deposits that cannot be developed in WA and Qld due to state government prohibitions on uranium mining. State government restrictions have also impeded exploration investment and activity in these states as mining companies have gone elsewhere to explore.

3.198 While there has been a trend of increasing exploration expenditures since 2003, there was relatively little exploration for uranium over the previous two decades and Australia's known uranium resources generally reflect exploration efforts that took place 30 years ago. As exploration expenditures declined from 1980 onwards, only four new uranium deposits were found and only one, Kintyre in WA, contains RAR recoverable at low cost. It follows that the size of Australia's known uranium resources significantly understates the potential resource base.

3.199 The Committee concludes that there are a number of regions that are highly prospective for uranium and there is great potential for new discoveries in various geological settings across Western Australia, South Australia, the Northern Territory and Queensland. Regrettably, there has been no exploration for uranium in Victoria and NSW since these states legislated to prohibit uranium mining in the 1980s.

3.200 Reflecting a trend which is occurring across the minerals industry, junior companies are now conducting much of the exploration activity for uranium. With the withdrawal of major mining companies, there are now calls for increased government support for juniors. The Committee repeats the recommendation contained in its previous report that a flow-through share scheme for companies conducting eligible minerals exploration activities in Australia be introduced.

3.201 The Committee is aware that there has been a significant turn-around in uranium exploration expenditure in recent years and a key obstacle to further uranium exploration is opposition to uranium mining in some states. Other impediments to juniors are discussed in chapter 11.

3.202 Submitters pointed to the need for a new national geoscience program to address current deficiencies. It was argued that future discoveries of uranium will require more sophisticated geochemical and geophysical technologies in order to see through the regolith to discover the deeper deposits. The Committee recommends that GA be funded to develop and deploy techniques to provide precompetitive geoscience of prospective areas, in order to assist in the discovery of new uranium (and other mineral) deposits located at depth.

3.203 In the following chapter, the Committee considers the potential implications for global greenhouse gas emission reductions from the further development and export of Australia's uranium resources.