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GEOSCIENCE AUSTRALIA

# AIMR03



AUSTRALIA'S IDENTIFIED MINERAL RESOURCES 2003



Greenbushes tantalite concentrates (WA) are exported to America and Germany. Tantalite is used to make capacitors for mobile phones, computers and other electronic devices. Other uses include hi-tech alloys for aerospace and medical applications (Geoscience Australia, Bill McKay).



Greenbushes lithium minerals (WA) are used in flat glass, container glass, ceramics, television tubes, glazes, fibre glass, computer monitors and batteries (Geoscience Australia, Bill McKay)

## AUSTRALIA'S IDENTIFIED MINERAL RESOURCES 2003

**FRONT COVER:** The Cornwall Pit at Sons of Gwalia Ltd's Greenbushes operations, Western Australia (Geoscience Australia, Bill McKay). Tantalum, lithium and tin minerals are recovered from pegmatite (white frame) in two distinct areas – tantalum/tin from the Cornwall Pit and lithium from the adjacent Spodumene Pit (see Lithium section).

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ISSN 1327-1466

Bibliographic reference, Geoscience Australia 2003. Australia's identified mineral resources 2003. Geoscience Australia, Canberra.

\*Geoscience Australia grew out of the Bureau of Mineral Resources (BMR) and the Division of National Mapping, both of which were founded soon after World War 2. BMR became the Australian Geological Survey Organisation (AGSO) in 1992, several years after the Division of National Mapping had become the Australian Surveying and Land Information Group (AUSLIG). AGSO and AUSLIG merged to become Geoscience Australia in 2001, the nation's geoscience research and spatial information agency. Further information is available at [www.ga.gov.au](http://www.ga.gov.au).



## Foreword

Geoscience Australia provides information on the nation's future capacity to produce mineral resources. Australia's Identified Mineral Resources (AIMR) is an annual nation-wide assessment of Australia's ore reserves and mineral resources. All major and a number of minor mineral commodities mined in Australia are assessed. It includes international rankings, summaries of significant exploration results, brief reviews of mining industry developments, and an analysis of mineral exploration expenditure across Australia. Comparable information on petroleum resources is published in another Geoscience Australia publication: *Oil and Gas Resources of Australia*.

AIMR provides governments, industry, the investment sector and general community with an informed understanding of Australia's known mineral endowment and level of exploration activity. An important objective is to monitor whether resources are being discovered and developed for production at rates sufficient to maintain Australia's position as a major supplier of mineral commodities to international markets. For this reason, resource estimates in the national inventory take a long term view of what is potentially economic. Summary data on resource estimates by companies, which are based on more immediate commercial considerations, are included for comparison.

National assessments of this type are assuming greater significance given international trends in the minerals industry that are changing the resources of interest. Consolidation in the industry has led to a decrease in the number of large companies. These are willing to explore or acquire wherever in the world they see opportunities for very large and high grade deposits that can be mined cost-effectively with low impacts and low risks. There has also been a major decline in the junior and medium sized companies, which have traditionally been very active and successful in Australia.

In 2003, most of AIMR's resources data were incorporated into an online atlas of Australia's Mineral Resources, Mines and Processing Centres, developed by Geoscience Australia with support from the Minerals Council of Australia and Department of Industry, Tourism and Resources. This atlas, which can be found at [www.australianminesatlas.gov.au](http://www.australianminesatlas.gov.au), has a web-based GIS (geographic information system) format and shows the location of mineral and energy resources, mines and production/processing centres. It also contains links to commodity and environmental data, jurisdictional legislation, and provides information on mining and processing in terms of regional development, employment and decentralisation.

I thank all who contributed to this edition of AIMR (Appendix 3) during a year in which there has been ongoing high demand for their advice and services.

**NEIL WILLIAMS**

Chief Executive Officer  
Geoscience Australia

## Contents

Foreword . . . . .	2
Summary . . . . .	6
Introduction . . . . .	7

### Commodity Reviews

Bauxite . . . . .	12
Black coal . . . . .	14
Brown coal . . . . .	18
Copper . . . . .	20
Diamond . . . . .	22
Gold . . . . .	24
Iron ore . . . . .	28
Lithium . . . . .	31
Magnesite . . . . .	33
Manganese ore . . . . .	35
Mineral sands . . . . .	37
Nickel . . . . .	41
Niobium . . . . .	46
Phosphate . . . . .	46
Shale oil . . . . .	48
Tantalum . . . . .	49
Tin . . . . .	51
Uranium . . . . .	51
Vanadium . . . . .	55
Zinc, lead, silver . . . . .	55
Production and resource capability . . . . .	58

### Exploration

Expenditure . . . . .	61
Exploration drilling . . . . .	63
Cost of access to land for exploration . . . . .	63
World exploration . . . . .	65
Government programs assisting exploration . . . . .	65
Outlook for exploration . . . . .	66
Offshore mineral exploration in Commonwealth waters . . . . .	67

### Appendices

Appendix 1: Abbreviations and acronyms	
Appendix 2: National classification system for identified mineral resources	
Appendix 3: Staff – Mineral Resources & Advice and Minerals Promotion Units	

## Tables

**TABLE 1:** Australia's resources of major minerals and world figures for 2002

**TABLE 2:** Australian gold production 1998 to 2002

**TABLE 3:** Correlation of resource classification schemes for uranium

**TABLE 4:** Australian production and exports of selected mineral products 2002-03

**TABLE 5:** Australian mineral exploration expenditure by commodity, 2000-01 and 2001-02

**TABLE 6:** Australian mineral exploration expenditure by State, 2000-01 and 2001-02

## Figures

**FIGURE 1:** Trends in economic demonstrated resources (EDR) for major commodities since 1975

**FIGURE 2:** Australian mineral exploration expenditure by commodity since 1992-93 (Source ABS)

**FIGURE 3:** Australian mineral exploration expenditure by State since 1992-93 (Source ABS)

**FIGURE 4:** Australian mineral exploration expenditure since 1969-70 (2001-02 dollars)

**FIGURE 5:** Australian mineral exploration expenditure 2001-02 on non-production leases spent on gaining land access (Source ABS)

**FIGURE 6:** Proportion of Australian mineral exploration expenditure 2000-01 on non-production leases spent on gaining land access (Based on ABS data)

**FIGURE 7:** Distribution of world exploration budgets 2002 (Source Metals Economics Group, Canada)

## Photos

**FRONT COVER:** Cornwall Pit at Greenbushes mine (WA) showing the main pegmatite orebody (tantalum/tin). View to the north. Pegmatite dips west with strike length of 3.5 km (Geoscience Australia, Bill McKay)

**PHOTO 2:** Greenbushes tantalite concentrates (WA) are exported to America and Germany. Tantalite is used to make capacitors for mobile phones, computers and other electronic devices. Other uses include hi-tech alloys for aerospace and medical applications (Geoscience Australia, Bill McKay)

**PHOTO 3:** Greenbushes lithium minerals (WA) are used in flat and container glass, ceramics, television tubes, glazes, fibre glass, computer monitors and batteries (Geoscience Australia, Bill McKay)

**COMMODITY REVIEWS COVER:** Fly-in/fly-out accommodation at the West Angelas iron ore mine, Western Australia (Robe River Iron Associates)

**PHOTO 5:** Griffin Coal's Muja mine near Collie (WA). Bulldozer cleaning-off seam prior to drilling and blasting (Geoscience Australia, Bill McKay).

**PHOTO 6:** Longwall mining operation at the Newstan Colliery near Newcastle, New South Wales (Centennial Coal Co Ltd)

**PHOTO 7:** Copper processing plant, Mount Gordon mine, Queensland (Western Metals Ltd)

**PHOTO 8:** Stockpile area and train load-out at the West Angelas iron ore mine, Western Australia (Robe River Iron Associates)

**PHOTO 9:** Spodumene Pit at the Greenbushes mine (WA), immediately south of the Cornwall Pit (front cover). Fresh unweathered pegmatite is mined for spodumene ore, which is processed to four final lithium mineral products – fine, concentrate, glass grade and universal (Geoscience Australia, Bill McKay)

**PHOTO 10:** Greenbushes spodumene (1 tonne bulk bags) palletised for export through the ports of Fremantle and Bunbury, Western Australia (Geoscience Australia, Bill McKay)

**PHOTO 11:** Tantalum ore stockpile (30 kt capacity) at the Greenbushes mine, Western Australia (Geoscience Australia, Bill McKay)

**PHOTO 12:** Uranium mining operations, Ranger mine No. 3 orebody, Northern Territory (Geoscience Australia, Aden McKay)

**PHOTO 13:** Radiometric discriminators used to measure the average uranium grade of ore in haul truck, Ranger mine, Northern Territory (Geoscience Australia, Aden McKay).

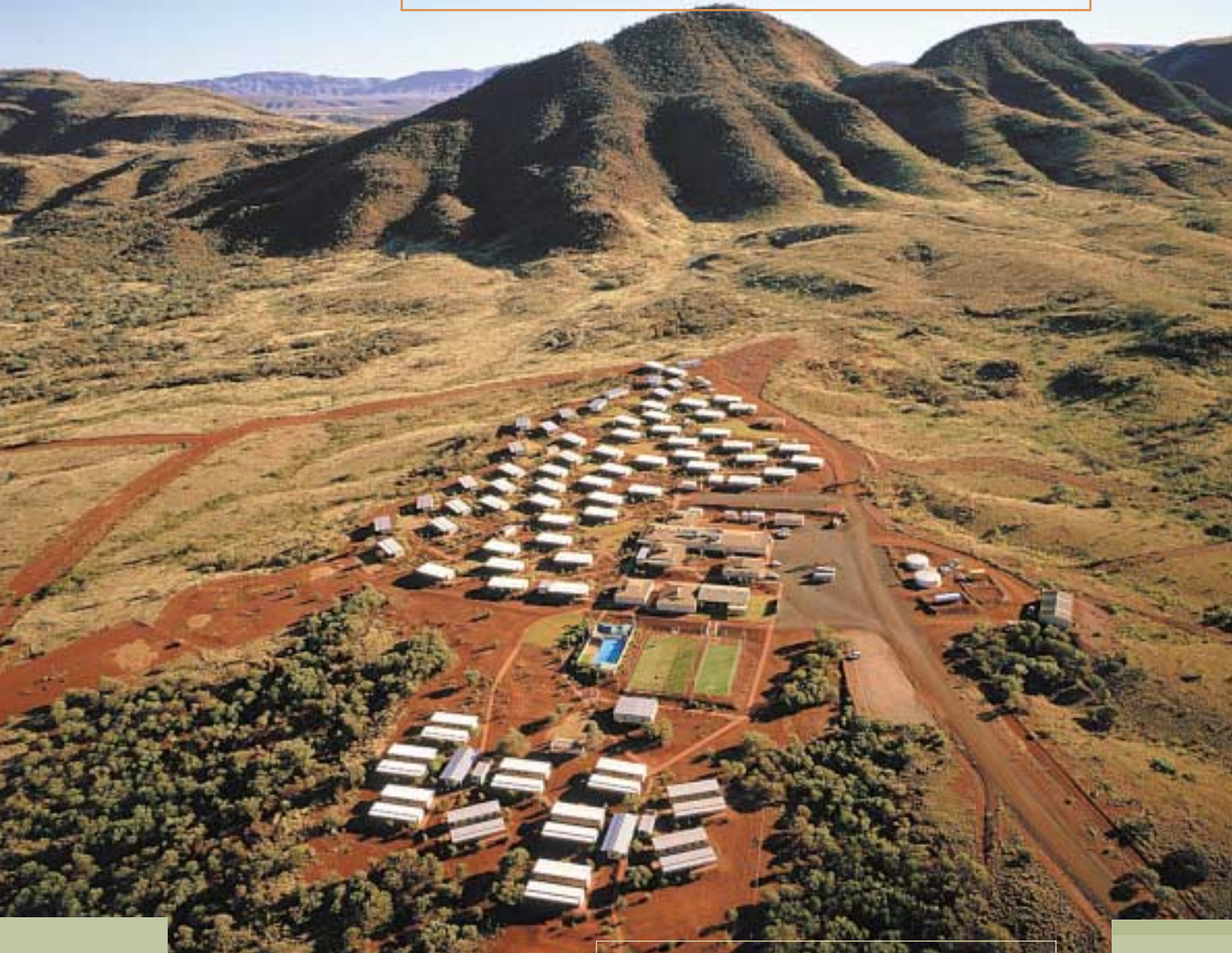
**PHOTO 14:** Open cut mining operations, Century mine, Queensland (Geoscience Australia, Aden McKay)

**EXPLORATION COVER:** Exploration drilling at the Honeymoon uranium project, South Australia (Thompson Drilling Company)

**BACK COVER:** Century open cut, Queensland. View to the north-west. Disposal of waste rock into the open cut shown on the left (Geoscience Australia, Aden McKay)



# Commodity Reviews



AIMR03

Fly-in/fly-out accommodation at the West Angelas iron ore mine, Western Australia (Robe River Iron Associates)

## Summary

In 2002, Australia's economic demonstrated resources (EDR) of bauxite, diamond, gold, iron and manganese ore, lithium, tin, tungsten and uranium increased, while those of black coal, ilmenite, tantalum, cadmium, zinc and vanadium decreased. EDR of brown coal, cobalt, lead, magnesite, rutile, zircon, nickel, niobium, phosphate, shale oil and silver remained at levels similar to those reported in 2002. The reductions in EDR were due mainly to production, with low commodity prices a subsidiary factor.

Australia's EDR of base metals (zinc, lead, silver) nickel, mineral sands and uranium remain the world's largest, while bauxite, black coal, brown coal, cobalt, copper, gold, iron ore, lithium, manganese ore, rare earth oxides and gem/near gem diamond rank in the top six worldwide.

Strong growth in gold prices in 2002 contributed to an increase in its EDR. The duration of gold's EDR (20 years at current production rates), however, signals the need for ongoing successful exploration in the short and medium term for this commodity, which is currently Australia's third largest export commodity. Similarly, there is a need for significant new discoveries of base metals to produce these commodities at current output levels beyond the next 20 to 25 years.

Australian mineral exploration expenditure fell by 6% to \$640.5 million in 2001-02, the lowest financial year current dollar amount since 1992-93. Spending for the calendar year, however, rose by \$13.8 million (2%) to \$678.2 million. A world survey of exploration budgets for 2002 by the Metals Economics Group saw Australia displaced by Canada as the world's leading exploration destination. In response to the low levels of exploration expenditure, industry and governments initiated studies to examine the economic implications of the downturn and ways at building industry recovery, including policy measures that may facilitate future mineral exploration activity in Australia.



## Introduction

This report continues a series of national mineral resource assessments that have been published by the Australian Government since 1975.

The assessment is undertaken as input into Government policy decisions relating to the minerals sector and sustainable development of mineral resources. It reports resources of all major and some minor mineral commodities, and comments on Australia's world ranking as a resource nation. In addition, it comments on exploration expenditure in 2001–02 and previous years, and puts this in perspective by comparing it in real terms to expenditure over the preceding 32 years.

Estimates of Australia's identified mineral resources of all major and several minor mineral commodities are reported for 2002 (Table 1). The estimates are based on published and unpublished data available to Geoscience Australia up to the end of December 2002. These are compared with national totals of ore reserves for major commodities that are collated by Geoscience Australia. Exploration activity is reported where available. Production data reported are based on ABARE estimates. World ranking data have been obtained or calculated mainly from information in publications of the United States Geological Survey (USGS). A summary of significant industry developments is presented.

The mineral resource classification system used for Australia's national inventory reflects both the geological certainty of existence of the mineral resource and the economic feasibility of its extraction over the long term (see 'National classification system for identified mineral resources' at the end of this report). The classification category, economic demonstrated resources (EDR), is used instead of 'reserves' for national totals of economic resources. This is because the term 'reserves' has a specific meaning for individual mineral deposits under the criteria of the Joint Ore Reserves Committee (JORC) code used by industry for reporting reserves and resources. EDR provide a basis for meaningful international comparisons of the economic resources of other nations. Ore is generally mined from resources in the EDR category.

In 2003, Geoscience Australia completed a systematic review of all commodities in terms of their availability or accessibility for development at the time of assessment. Accessible EDR (AEDR) reported in Table 1 take into account the legal and/or land use factors that prevent development of mineral resources; for example, location within National/State parks, military training areas, environmental concerns and government legislation. Ore reserves (OR) have also been included in Table 1. Industry assessments of ore reserves are for mine planning and marketing purposes and, therefore, generally have a shorter term outlook than EDR.

Long-term trends in EDR for bauxite, black coal, iron ore, gold, copper, lead, zinc, nickel, mineral sands and uranium are shown in Figure 1. EDR for these commodities have generally increased or at least been maintained since 1975. This reflects the highly prospective nature of the continent and the successful exploration activity that has led to discovery of new mineral deposits and extensions to known deposits. The substantial decreases resulting from high levels of production have been further offset by technological advances that have led to upgrading of previously subeconomic resources.

EDR/production, AEDR/production and OR/production ratios provide information on the 'longevity' of Australia's resources for different scenarios, based on production rates at the time of assessment. Each of these has deficiencies as an indicator of resource life: OR/production is a more conservative (and for some commodities very much more conservative) indicator than EDR/production. They can change quite rapidly, for example as a result of major changes in production or other factors such as commodity prices.

Geoscience Australia prepares estimates of Australia's uranium resources within categories defined by the OECD Nuclear Energy Agency (OECD/NEA) and the International Atomic Energy Agency (IAEA; OECD/NEA & IAEA 1999). These estimates are published by the OECD/NEA in their biennial publication on Uranium Resources, Production and Demand, commonly known as the 'Red Book'. In AIMR the estimates are reported under the corresponding resource categories of the national classification scheme. A correlation of the national and OECD/NEA schemes is given in the review of uranium resources.

The downturn in mineral exploration expenditure continued in 2002. This is the result of global economic factors, exacerbated by fundamental changes in the international minerals industry. It is of concern that the level of expenditure on exploration in 2002 was the lowest since 1978-79, particularly because declining exploration has been accompanied by lower interest in greenfield regions and by decreasing rates of discovery of major deposits. Unless exploration increases and is effective in locating major new deposits, most of which are likely to be buried, Australia's EDR of a number of important commodities can be expected to decrease significantly in the short to medium term, with gold, zinc and diamonds leading the way.

### Notes for Table 1 (table on following page)

**ABBREVIATIONS:** t = tonne;

m<sup>3</sup> = cubic metre; L = litre; kt = 10<sup>3</sup>t;

Mc = 10<sup>6</sup> carat; Mt = 10<sup>6</sup>t; Gt = 10<sup>9</sup>t;

GL = 10<sup>9</sup>L; na = not available.

(a) Quarantined EDR is EDR that is deemed inaccessible at present due to conservation/environmental or other reasons. The Quarantined % is the ratio of inaccessible EDR relative to total EDR

(b) Total inferred resources in economic, sub-economic and undifferentiated categories

(c) Accessible EDR (AEDR) is the portion of total EDR that is accessible (ie, not quarantined) at present

(d) Joint Ore Reserves Committee (JORC) proven and probable ore

reserves from public reporting by ASX listed mining companies and other sources

(e) Source: Australian Bureau of Agricultural and Resource Economics (ABARE) excluding Uranium (GA data) for the calendar year

(f) Based on Geoscience Australia, USGS and other sources

(g) World mine production for 2002, mostly USGS estimates

(h) Includes chrysotile production

(i) Black and Brown Coal reserves include both JORC reserves and Geoscience Australia estimated reserves for operating mines that aren't JORC compliant

(j) Raw coal

(k) Geoscience Australia estimate

(l) Saleable coal

(m) Excludes Morocco and USA

(n) Excludes USA

(o) Li<sub>2</sub>O

(p) Platinum and palladium only

(q) WEC Survey of Energy Resources for 1999

(r) Ta<sub>2</sub>O<sub>5</sub>

(s) Source: OECD/NEA & IAEA (2001). Compiled from the most recent data for resources recoverable at <US\$40/kg U. Data for USA is not available for this category

(t) Source: NUKEM Market Report, data feature 05/2003. Nukem website [www.nukemonline.com](http://www.nukemonline.com)

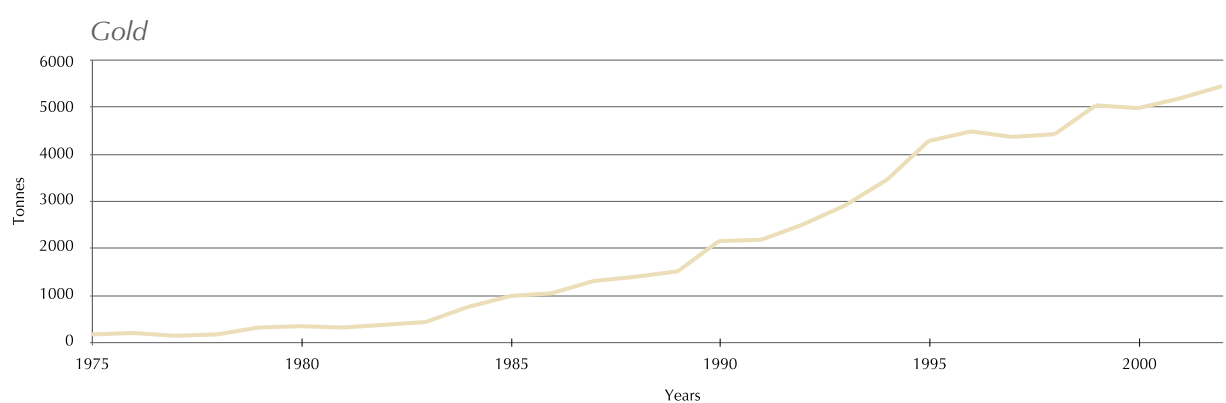
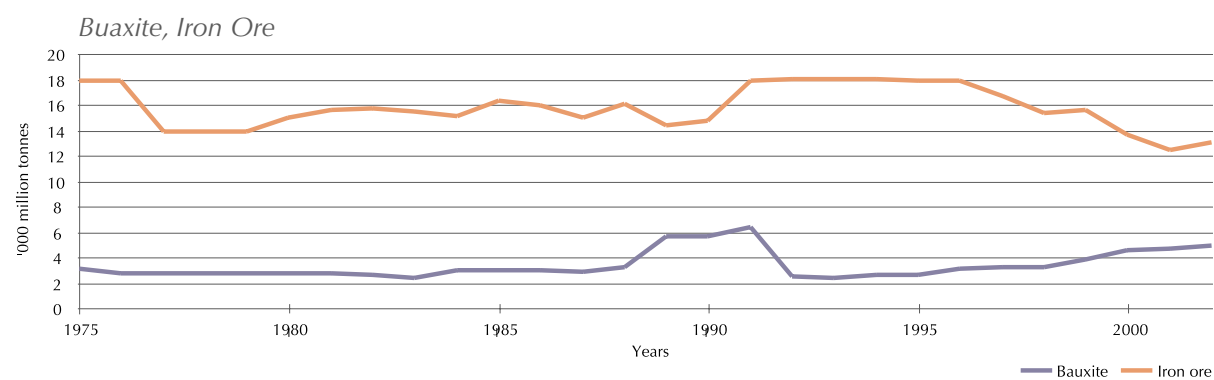
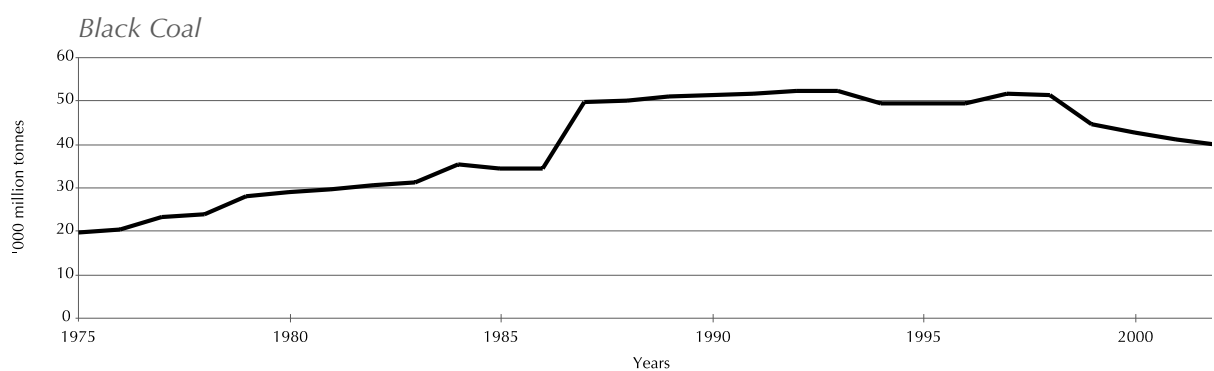
(u) Refer to text for comparison of resource categories in the national scheme with those of the international scheme for classifying uranium resources.

TABLE 1: Australia's resources of major minerals and world figures for 2002

Commodity	Units	Australia							World	
		Demonstrated Resources			Inferred resources <sup>(b)</sup>	Accessible EDR <sup>(c)</sup> (AEDR)	JORC reserves <sup>(d)</sup> (% of AEDR)	Mine Prod'n <sup>(e)</sup> (MP) 2002	Economic Demonstrated Resources <sup>(f)</sup>	Mine Prod'n <sup>(g)</sup> 2002
		Economic EDR (% Quarantined <sup>(a)</sup> )	Sub-economic							
			Para-marginal	Sub-marginal						
Antimony	kt Sb	90 0%	34	50	58	90.0	58.1 65%	–	1800	141
Asbestos										
Chrysotile ore	Mt	–	4.6	–	75	–	–	–	large	
Crocidolite fibre	Mt	–	0.4	–	2	–	–	–	large	2.0 <sup>(h)</sup>
Bauxite	Gt	4.8 7%	2.3	1.7	1.4	4.5	1.7 38%	0.054	22	0.14 <sup>(i)</sup>
Black coal in situ recoverable	Gt Gt	57.5 39.7 0.2%	3.9 3.2	18.5 10.7	84.7 52.8	39.6	17.4 <sup>(j)</sup> 44%	0.348 <sup>(j)</sup>	784 <sup>(k)</sup>	3.9 <sup>(k)(l)</sup>
Brown coal in situ recoverable	Gt Gt	41.8 37.6 13%	43.4 39.0	18.1 16.3	114.4 102.9	32.6	2.2 <sup>(i)</sup> 7%	0.067	187(k)	0.9 <sup>(k)</sup>
Cadmium	kt Cd	95.7 0%	10.5	24.8	24.3	95.7	78 82%	na	585	18.7
Cobalt	kt Co	1442 0%	135	148	1150	1443.8	634.1 44%	4.854	6800	36.9
Copper	Mt Cu	32.8 0%	9.6	1.2	21.8	32.8	20.4 62%	0.883	480	13.6
Diamond gem and near gem	Mc	67.3 0%	218	0.2	30.9	67.3	66.3 99%	16.5	–	–
industrial	Mc	70.1 0%	227	0.3	32.2	70.1	69 99%	17.1	580	55.2
Fluorine	Mt F	–	0.2	22.2	29	–	–	–	112 <sup>(m)</sup>	2.2 <sup>(n)</sup>
Gold	t Au	5415 0.2%	1157	112	2823	5403	3573.9 66%	266	42 500	2530
Iron ore	Gt	13 0.2%	1.1	1.8	15.5	13	4.1 31%	0.187	145.0	1.09
Lead	Mt Pb	17.2 0%	3.1	9.3	20.9	17.2	10.4 61%	0.69	70	2.9
Lithium	kt Li	171 0%	53	25	7	171.0	150 88%	4.5 <sup>(o)</sup>	4110	15.1 <sup>(n)</sup>
Magnesite	Mt MgCO <sub>3</sub>	362.9 0%	22	35	989	362.9	65.2 18%	0.484	7380	10.3
Manganese ore	Mt	126.8 0%	23	167	198	126.8	85.7 68%	2.2	1678	19.1
Mineral sands										
Ilmenite	Mt	198.2 18%	51	0.1	107	161.7	25.1 16%	1.9	616	8.36
Rutile	Mt	23.5 24%	12	0.1	26	17.8	3.4 19%	0.22	51	0.41 <sup>(n)</sup>
Zircon	Mt	29 28%	19	0.2	28	20.8	5.3 25%	0.4	72	0.92
Molybdenum	kt Mo	0.4 0%	6.3	3.7	400	0.4	0 –	–	8600	128
Nickel	Mt Ni	22.2 0%	2.7	1.6	16.5	22.2	9.3 42%	0.21	61.2	1.35
Niobium	kt Nb	29 0%	143	0	1961	29.0	10 34%	–	4400	25.7
Phosphate rock	Mt	91 0%	981	–	1126	91.0	91 100%	2	17 000	133
PGM (Pt,Pd,Os,Ir,Ru,Rh)	t metal	36.7 12%	21.0	6.1	62.3	32.4	0 –	0.9	71 000	264 <sup>(p)</sup>
Rare earths (REO and Y <sub>2</sub> O <sub>3</sub> )	Mt	0.3 67%	2.8	11.2	7	0.1	0 –	–	88	0.09
Shale oil	GL	4.6 0%	202	3719	41 425	4.6	4.6 100%	0.051	95 885 <sup>(q)</sup>	0.43 <sup>(q)</sup>
Silver	kt Ag	40.2 0%	10.2	12	25.6	40.2	28.9 72%	2.0	310	18.8
Tantalum	kt Ta	39.2 0%	30.2	0.23	66.21	39.2	35.1 90%	0.85 <sup>(r)</sup>	42	1.53
Tin	kt Sn	103.3 0%	102.9	135.4	317	103.3	84.65 82%	6.27	6100	231 <sup>(n)</sup>
Tungsten	kt W	8.6 0%	31.8	28.2	56.2	8.6	1.7 20%	–	2900	46.6 <sup>(n)</sup>
Uranium <sup>(s)</sup>	kt U	689 11%	13	33	323	614.4	332.5 54%	6.85	1569 <sup>(s)</sup>	36.2 <sup>(t)</sup>
Vanadium	kt V	0 –	794	1797	2463	0.0	0 –	3.14	13 000	67.0 <sup>(n)</sup>
Zinc	Mt Zn	33.2 0%	8.7	16.2	21.1	33.2	23.8 72%	1.47	200	8.9

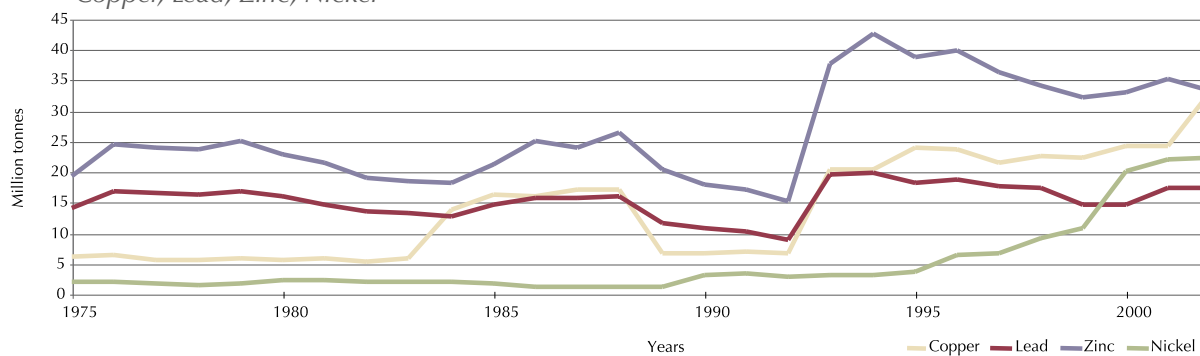


**FIGURE 1: Trends in Economic Demonstrated Resources (EDR) for major commodities since 1975**

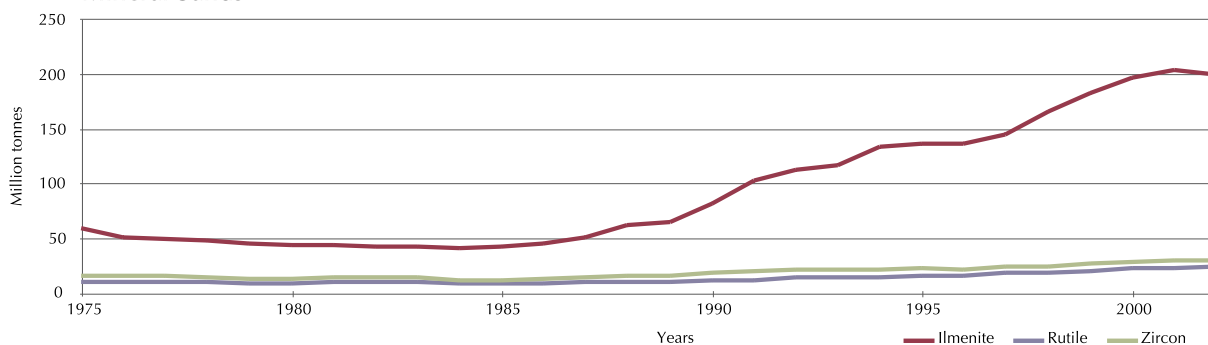


**FIGURE 1: Trends in Economic Demonstrated Resources (EDR) for major commodities since 1975 (continued)**

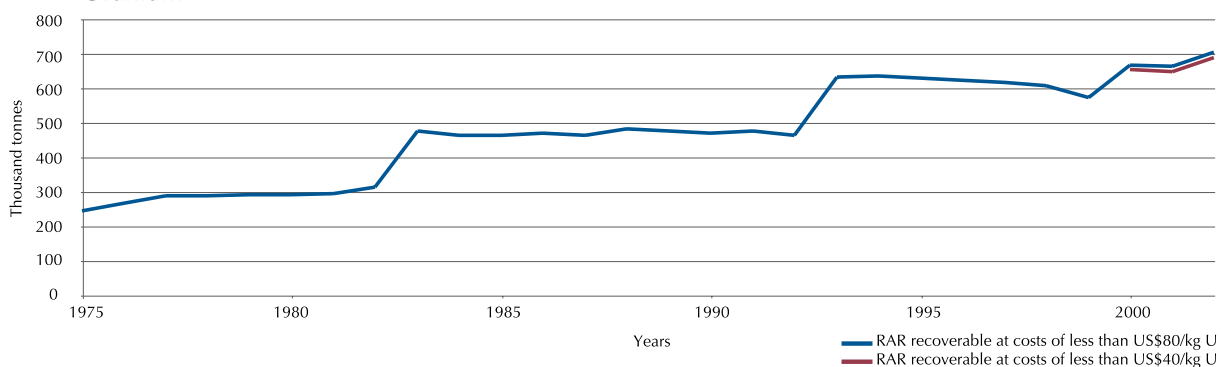
*Copper, Lead, Zinc, Nickel*



*Mineral Sands*



*Uranium*



## Bauxite

### Preamble

Bauxite is a heterogeneous naturally occurring material from which alumina ( $\text{Al}_2\text{O}_3$ ) and aluminium are produced. The principal minerals in bauxite are gibbsite ( $\text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$ ), boehmite ( $\text{Al}_2\text{O}_3 \cdot \text{H}_2\text{O}$ ) and diaspore, which has the same composition as boehmite but is denser and harder.

Over 85% of the bauxite mined globally is converted to alumina for the production of aluminium metal, an additional 10% goes to nonmetal uses in various forms of specialty alumina, and the remainder is for nonmetallurgical bauxite applications. In nearly all commercial operations, alumina is extracted (refined) from bauxite by a wet chemical caustic leach process known as the Bayer process. Alumina is smelted using the Hall-Heroult process to produce aluminium metal by electrolytic reduction in a molten bath of natural or synthetic cryolite ( $\text{NaAlF}_6$ ).

The Australian aluminium industry consists of five bauxite mines, six alumina refineries, six primary aluminium smelters, twelve extrusion mills and four rolled product (sheet, plate and foil) mills. The industry directly employs over 16 000 people and indirectly many more. It is particularly important in regions such as North Queensland, the Hunter Valley, Southwest Victoria, Southwest Western Australia, the Northern Territory and North Tasmania.

### Resources

Vast resources of bauxite in the Weipa and Gove regions adjacent to the Gulf of Carpentaria and in the Darling Ranges south of Perth, underpin the long-term future of Australia's world class alumina and aluminum industries. Deposits in these regions rank among the world's largest identified resources in terms of extractable alumina content. Bauxite deposits at Mitchell Plateau and Cape Bougainville in the north of Western Australia are uneconomic to develop but are a significant potentially viable future resource.

EDR increased by just over 4% in 2002 compared to the previous year. On-going successful exploration programs at and nearing existing mines resulted in resource upgrades from the subeconomic and inferred categories. Subeconomic demonstrated resources decreased by around 200 Mt (8%) following reclassification of some resources to EDR. Inferred resources of 1.4 Gt remain unchanged from 2000.

### Accessible EDR

Less than 10% of bauxite EDR is inaccessible for mining. This involves small areas of the Darling range (WA), within mining leases, where for environmental reasons bauxite is not available for extraction.

Australia's demonstrated bauxite resources are sufficient to last over 80 years at current rates of extraction and the potential of unexplored regions, particularly in northern Australia, is likely to extend resource life well beyond this.

### JORC Reserves

Over 35% of AEDR comprises JORC Code reserves. The remaining represents resources assessed by Geoscience Australia as being economically recoverable from industry's measured and indicated categories of mineral resources, as defined under the Code and other classification systems used by non-listed ASX companies.

### Exploration

Data relating to exploration for bauxite specifically are not available nationally.

### Production

Preliminary data released by ABARE (March quarter 2003) show that in 2002, Australia produced 54.0 Mt of bauxite, 16.4 Mt of alumina and 1.8 Mt of primary aluminium.



### World Ranking

Australia's demonstrated bauxite resources of 8.8 Gt rank first in the world followed by those of Guinea, Brazil, Jamaica, China and India. It is also the largest producer and exporter of bauxite and alumina (36% and 30% of world bauxite and alumina respectively in 2002).

When exports of bauxite, alumina and aluminium are taken into account, the aluminium industry is Australia's second largest commodity exporter behind coal, with export earnings of over \$8.2 billion in 2001–02.

### Industry Developments

Rio Tinto's Aluminium group encompasses its wholly-owned integrated aluminium subsidiary, Comalco, which is a major Australian-based supplier of bauxite, alumina and primary aluminium to world markets. Approximately 90% of the bauxite from Comalco's Weipa mine is shipped to alumina refineries in Gladstone (Qld) and Sardinia (Italy). In 2002, Rio Tinto reported bauxite shipments of 11.1 Mt from Weipa, a slight increase on 2001 due to higher production at the Queensland Alumina Refinery and higher sales to independent customers.

In January 2002, Comalco commenced construction of the first stage of its US\$750 million alumina refinery at Gladstone. Designed to produce 1.4 Mt of alumina annually, initial shipments from the refinery are expected in the first quarter of 2005 and full capacity by the end of 2006. With capacity for expansion in stages, ultimate total alumina production could increase to 6 Mtpa.

In the period under review, Alcan Gove Pty Limited produced 1.4 Mt of bauxite and 1.9 Mt of alumina from its mine and refinery near the town of Nhulunbuy on the Gove Peninsula in the Northern Territory. Alcan has commenced a detailed feasibility into a proposed expansion of the refinery, which would increase its capacity by 1.5 Mt to around 3.5 Mtpa. The study is scheduled for completion by mid-2004.

Following the demerger of WMC Limited on 11 December 2002, Alumina Limited was created comprising all of WMC's previous 40% interest in Alcoa World Alumina and Chemicals (AWAC). Alumina Limited's partnership with Alcoa (remaining 60% of AWAC) continues the business of mining (Huntly and Willowdale operations) and refining bauxite (Kwinana, Pinjarra and Wagerup) in the Darling Range region south of Perth (WA).

In Victoria, Alcoa owns the Point Henry smelter and is the operator of the Portland smelter, in which it has a 55% interest. The combined capacity of these two smelters is about 530 000 tonnes a year, with most of the aluminium ingot being exported.

Worsley Alumina Limited is a joint venture between BHP Billiton (86%), Japan Alumina Associates (Australia) Ltd (10%) and Nissho Iwai Alumina Pty Ltd (4%). Bauxite is mined and crushed at Worsley Alumina's mine site at Boddington, 123 km southeast of Perth. Crushed ore is transported 51 km by overland conveyor to the refinery. A feasibility study into expansion of the Worsley operations to 3.5 Mtpa is expected to be completed in 2004.



Griffin Coal's Muja mine near Collie (WA). Bulldozer cleaning-off seam prior to drilling and blasting (Geoscience Australia, Bill McKay).

## Black Coal

Black coal occurs in all Australian States and the Northern Territory. Most is of Permian age (about 250 million years old), but lower-rank, younger deposits of Triassic, Jurassic and Cretaceous ages are also important. Black coal from New South Wales and Queensland is exported in large quantities and also used in Australian power stations. The sub-bituminous coals at Collie (Western Australia) and Leigh Creek (South Australia) are mainly used in power stations. In Tasmania the main use of coal mined in the Fingal Valley is in cement manufacturing at Railton. Black coal is also used to make coke for the iron and steel industry and as a heat source in food manufacturing.

### Resources

In-situ EDR for 2002 was 57.5 Gt and recoverable EDR was 39.7 Gt. Both figures are lower than for 2001, mainly as a result of production and reclassification of some resources. Queensland (62.0%) and New South Wales (34.2%) had the largest share of recoverable EDR in Australia.

Significant decreases in recoverable EDR (>100 Mt) occurred at Mt Arthur (now includes Bayswater No.3), Liddell, United, Tower, Cook, Rolleston, South Blackwater and Togara South. Also, the Bellambi West, Tower (now part of Appin), Moonee and Wyee collieries closed during 2002. Recoverable coal gains occurred at the newly reported sites of Anvil Hill, Ashton, Dendrobium, A248 and A422, Neubecks Creek, Wolgan Road, Boulder, Belmont and Olive Downs. Also, the MIM NCA mines and Warkworth had significant increases in recoverable coal.

The in-situ Paramarginal Demonstrated Resources (PDR, 3.9 Gt) and recoverable PDR (3.2 Gt) increased significantly mainly due to the underground resources at Mt Arthur being considered uneconomic at this stage. In-situ Subeconomic Demonstrated Resources (SDR, 18.5 Gt) and recoverable SDR (10.7 Gt) both changed from 2001 due to re-classification and re-estimation of resources.

In-situ inferred resources (84.7 Gt) and recoverable inferred resources (52.8 Gt) are reported for the first time. New South Wales (61.2%) and South Australia (26.7%) had the largest share of recoverable inferred resources. In Queensland, inferred resources are low (6.8%) mainly because most deposits only have measured and indicated resources reported.

### Accessible EDR

Nearly all black coal EDR is accessible with only a relatively small tonnage at Hill River (WA) being quarantined within a State Reserve.

Accessible EDR of 39.6 Gt would last over 100 years at current rates of production.

## JORC Reserves

About 44% of AEDR, or 17.4 Gt, comprise the JORC Code reserves. However, not all operating mines have JORC reserves publicly available. In such cases Geoscience Australia has estimated reserves from published information. The resource life of accessible JORC reserves is around 50 years. In 2002, around 45% of EDR fell into the JORC reserves.

## Exploration

Data published by ABS on coal indicated that exploration expenditure for 2002 totalled \$61.2 million, which is an increase from \$49.0 million in 2001. Expenditure in Queensland was 70% of the total. In 2002 coal accounted for about 9.0% of Australia's total exploration expenditure.

## Production

In 2002 Australia produced 348.0 Mt of raw coal (333.0 Mt in 2001), which yielded 273.4 Mt of saleable coal (264.7 Mt in 2001). Exports of black coal during 2002 were 104.4 Mt of coking coal valued at \$7.7 billion and 98.5 Mt of steaming coal valued at \$5.1 billion. ABARE forecasts Australia's production will grow to 278.5 Mt in 2004. Thermal and coking coal exports are expected to increase to 104.2 Mt and 105.8 Mt respectively in 2004.

## World Ranking

Australia has 5% of the world's recoverable black coal EDR and ranks sixth behind USA (27%), Russia (18%), China (12%), India (10%) and South Africa (6%). Australia produced about 7% of the world's black coal in 2002 and ranked fourth after China (34%), USA (25%) and India (8%).

## Industry Developments

Significant developments in the New South Wales coal industry during 2002 included the following.

### *Coal and Allied Ltd*

- Propose to increase output from the Warkworth open-cut mine from the currently approved 10 Mtpa run-of-mine to a maximum of 18 Mtpa.
- Commenced preliminary work on a box cut at the Chestnut pit (southern extension of Hunter Valley mine).

### *Anglo Coal Australia*

- Commenced construction of the Kayuga mine (Dartbrook extension) with full production expected in 2004.
- Propose to develop the Saddlers Creek thermal coal reserves as a replacement for the Drayton West Pit, which is due to be completed at the end of 2003.

### *White Mining Ltd*

- \$100 million Ashton project, located 14 km north west of Singleton, was granted development consent. The project consists of an initial 2.0 Mtpa open-cut operation followed by an underground longwall mine. The mine will employ 140 full-time employees over a 21 year mine life.

### *Xstrata Coal Pty Ltd*

- Reopened the Cumnock open-cut mine in late 2002 after one of the longwall areas was abandoned due to difficult geological conditions.
- Paid US\$63 million for Coal and Allied's interests in Ravensworth-Narama, and Ravensworth East and West thermal coal mines.
- Commenced longwall mining at the United Colliery utilising mothballed equipment from the Teralba mine.
- Sought approvals to increase production by some 2.0 Mtpa at the Liddell open-cut mine.
- Continued development at the Beltana project. The mine is expected to cost \$24 million and produce 5 Mtpa of raw coal commencing in the first half of 2003.



#### *Newcastle Coal Company*

- Planning to commence a bord and pillar operation at the Tasman project during 2003. The mine is scheduled to reach an output of around 1.0 Mtpa of thermal coal in year five of the projects expected 12 year life.

#### *Centennial Coal Co Ltd*

- Paid \$331 million to purchase Powercoal Pty Ltd's (NSW Government) seven underground mines and five development projects. One such development project is the Anvil Hill open-cut thermal coal mine, 20 km west of Muswellbrook.

#### *Gloucester Coal Pty Ltd*

- Granted development consent for the Duralie project. The Duralie mine will be operated in conjunction with the Stratford mine with the first coal production planned for February 2003. The capital cost of \$18 million will allow total production from the two operations to remain at the current 1.8 Mtpa level.

#### *BHPBilliton Ltd*

- Commissioned the coal handling plant at the Mount Arthur project and commenced delivery of coal to Macquarie Generation in early January 2003. BHPBilliton has been awarded a contract to supply 3 Mtpa of thermal coal to Macquarie Generation for five years from 2003.
- Commenced construction of the Dendrobium mine in early 2002. The project is intended as a replacement for the Elouera mine which is due for closure in 2005.

#### *Glennies Creek Coal Management Pty Ltd*

- Commenced longwall production at Glennies Creek in August 2002.

#### *Whitehaven Coal Mining Ltd*

- Announced plans to develop the Belmont mine in the Gunnedah Basin. The annual output would be between 1 and 1.5 Mtpa to supplement production from the Whitehaven mine.

#### *Muswellbrook Coal Company*

- Granted a mining lease over the Sandy Creek underground mine in October 2002.



Longwall mining operation at the Newstan Colliery near Newcastle, New South Wales (Centennial Coal Co Ltd)

Developments in the Queensland coal industry during 2002 included the following.

*RAG Australia Coal*

- Plan to mine the Eaglefield open pit at North Goonyella.

*MIM (now Xstrata Coal Pty Ltd)*

- Ceased mining at the Alliance Colliery in early 2002 due to depletion of reserves.
- Commissioned new longwall equipment at Oaky No 1 in April 2002.
- Continued feasibility studies on the Rolleston thermal coal deposit at a production capacity of 6 Mtpa from 2005.
- Initiated development of a new mine at Newlands (Northern Underground), purchased a larger dragline for the Newlands open-cut and relocated one of the Newlands draglines to Collinsville.

*Xstrata Coal Pty Ltd*

- Signed a native title agreement covering the \$350 million Togara North underground thermal coal project with the Kangoulou and Ghungalu People and the Gurang Land Council.

*New Hope Coal Australia*

- Continued its expansion of the existing open cut mine at the Oakleigh operation in the Moreton Basin.
- Commenced coal mining operations at New Acland in August 2002.

*Peabody Energy Corporation*

- Returned to Australia by paying US\$21 million for the Wilkie Creek thermal coal mine in the Surat Basin.

*BHPBilliton Mitsubishi Alliance*

- Closed the Kenmare longwall mine in April 2002 because of geological constraints.
- Signed an indigenous land use agreement with the Ghungalu and Kangoulou Peoples and the Queensland Government covering land on which the Blackwater mine is located.
- Moved the two South Blackwater draglines onto the Blackwater leases which resulted in production increasing from 8 to 14 Mtpa.
- Investigated construction of one large preparation plant at Blackwater to handle all of the output at Blackwater (called Project Comet).
- Completed installation of a mobile crushing plant at Goonyella to process and distribute pre-stripped overburden via a conveyor and spreader system to spoil dumps on the low-wall side of the mine.

*BHP Mitsui Coal Pty Ltd*

- Commissioned a new \$35 million rail loop and coal loading facility at the South Walker Creek open-cut mine in June 2002.

*Idemitsu Kosan Company*

- Closed the Ebenezer open-cut mine in December 2002.

*Jellinbah Resources Pty Ltd*

- Completed construction of the first coal wash plant at the Jellinbah East mine.

*Anglo Coal Australia*

- Developed a mine plan around the new Oak Park open-cut deposit at German Creek.
- Formed a joint venture with Mitsui Coal in May 2002 which gave Anglo a 51% interest in the Moura mine and gave Mitsui a 49% interest in the Theodore, Dawson and Taroom deposits and 30% of the German Creek mine.
- Successfully extracted the first coal from the German Creek seam at the Grasstrees underground operation.

#### *Macarthur Coal Ltd*

- Commenced the Transport Relocation Corridor Project at Coppabella in late 2002. This involves relocating the Peak Downs Highway and the Goonyella-Hay Point rail line to allow mining of coal that is currently sterilised. Construction of the dragline was completed in December 2002.
- Continued feasibility studies on the Monto thermal coal mine that is planned to produce up to 1 Mtpa in Stage 1 of the project.
- Commenced site development works at the Moorvale project soon after the mining lease was granted in December 2002.

#### *Pacific Coal*

- Mining is scheduled to begin at the TiTree mine in late 2003. This will open up the western area of the Kestrel mine and increase mine life by 20 years.
- Investigating the development of the Kunioon deposit near the Meandu mine to supplement coal deliveries to the Tarong and Tarong North power stations.

The Dalrymple Bay Coal Terminal is undergoing a \$115 million Stage 6 expansion to lift throughput from 44 to 54 Mtpa by the middle of 2003. This will involve a new berthing pocket, new stacker, new northern berth and new ship loader. The Gladstone Port Authority is spending \$80 million at the RG Tanna Coal Terminal to increase capacity from 30 to 40 Mtpa. Completion is due in mid-2003 and includes increasing train unloading capacity, construction of a third berth, dredging of a berth pocket and departure channel and construction of stockpile 15. The expansion at the Kooragang Coal Terminal was officially opened in March 2002. The expansion increases Port Waratah Coal Services annual ship loading capacity from 77 to 89 Mt.

The Co-operative Research Centre for Mining and Technology Equipment has developed a new universal dig and dump dragline technology with benefits that include a 15% payload increase, a 5% decrease in cycle time and over a 25% increase in dragline productivity. The CSIRO has developed a turbine that generates electricity from a variable mix of mine methane and waste coal. A 1.2 MW plant has been successfully demonstrated at the Queensland Centre for Advanced Technologies in Brisbane. A \$12 million 10 MW mine scale demonstration plant is planned for 2003. The Ultra Clean Coal Energy Research Centre and pilot plant at Cessnock in New South Wales has sent the first bulk sample to Japan for combustion tests.

The Australian Coal Association launched a research body called Coal21 which plans to protect Australia's coal market, oversee new projects and develop various clean coal technologies. One project will be to coordinate the development of coal gasification. In late 2002 the Federal Government announced the creation of the Cooperative Research Centre for Greenhouse Gas Technologies. This CRC is proposing to develop detailed plans for a viable geo-sequestration project.

During 2002 there was increased activity in the coalbed methane sector mainly in the Bowen, Surat and Sydney Basins. Companies that are either exploring for and/or producing coalbed methane include, Origin Energy, Molopo Australia NL, Queensland Gas Company, Arrow Energy, Sunshine Gas, Sydney Gas Company, CH<sub>4</sub> Pty Ltd, Eastern Corporation Ltd and Santos.

## **Brown Coal**

Brown coal (or lignite) occurs in all Australian states and is Tertiary in age ranging from about 15 to 50 million years old. Victoria has extensive resources of brown coal particularly in the La Trobe Valley where seams up to 165 m thick occur. Smaller deposits occur, for example, in the Bacchus Marsh, Altona and Anglesea areas of Victoria, in the St Vincents and Murray Basins and at Pidinga in South Australia, in the Murray Basin in New South Wales and Victoria, at Rosevale in Tasmania, at Scaddan (or Esperance) in Western Australia and at Waterpark Creek in Queensland.

All brown coal mines are located in Victoria and the coal is being used mainly for the generation of electricity. Up to 1.2 Mtpa of briquettes can be produced by Energy Brix Australia for industrial and domestic heating. Brown coal can also be used to produce water gas, industrial carbon and used to decolourise and purify solutions.



## Resources

Recoverable EDR for 2002 was 37.6 Gt, a slight decrease on 2001 EDR due to production losses. Recoverable PDR and SDR remained unchanged at 39.0 Gt and 16.3 Gt respectively. Recoverable inferred resources also remained unchanged at 102.9 Gt. Victoria accounts for over 95% of Australia's identified resources of brown coal. All EDR is located in Victoria and about 89% of the total EDR are located in the La Trobe Valley.

## Accessible EDR

Approximately 87% of brown coal EDR is accessible. Quarantined resources include the APM Mill site that is under a 50 year mining ban, which commenced in 1980, and the Holey Plains State Park (Vic).

The resource life of the accessible EDR of 32.6 Gt is close to 500 years.

## JORC Reserves

JORC reserves are 2.2 Gt or 7% of AEDR. No brown coal resources as reported are compliant with the JORC Code. Geoscience Australia estimated reserves at the operating mines from published information. The resource life of accessible JORC reserves is over 30 years. In 2002, around 6% of EDR fell into the JORC reserves category.

## Exploration

Data relating to exploration for brown coal specifically are not available nationally. However, exploration expenditure for brown coal in Victoria for 2001-02 was \$0.6 million (including methane gas exploration expenditure). Capital expenditure on brown coal mining development for 2001-02 was \$157.5 million.

## Production

Australian brown coal production for 2001-02 was 66.7 Mt (valued at \$533 million) and all from Victoria. The La Trobe Valley mines of Yallourn (15.7 Mt), Hazelwood (19.0 Mt) and Loy Yang (30.9 Mt) produce about 98.5% of Australia's brown coal. Locally significant brown coal operations are at Anglesea (1.1 Mt) and Maddingley.

## World Ranking

Australia has about 20% of world recoverable brown coal EDR, and is ranked second behind Germany (23%). Australia produces about 8% of the world's brown coal and is ranked third largest producer after Germany (20%) and USA (10%).

## Industry Developments

In July 2002 three companies were awarded exploration licences in the La Trobe Valley following a coal tender process by the Victorian State Government.

- Australian Power and Energy Ltd (APEL) was awarded part of the Flynn/Gormandale coalfield. Stage 1 of APEL's proposed \$3 billion Victorian Power and Liquids Project (VPLP) is planned to produce 52 000 barrels per day of low sulphur fuels (mainly diesel) and 500 MW's of electricity. At the end of 2002, APEL was undertaking a bankable feasibility evaluation of the VPLP. In January 2003, Syntroleum Corporation signed a letter of intent to participate in the VPLP.
- Loy Yang Power (LYP) was awarded that part of the Flynn/Gormandale coalfield which is adjacent to the company's existing open-cut mine. LYP is proposing to develop a 1000 MW power station that utilises new technology to meet stringent State Government greenhouse gas targets.
- HRL Ltd was awarded an area around the Driffield/Narracan coalfield and plans to construct an integrated drying gasification combined cycle plant to generate electricity.

The Yallourn Energy \$100 million Morwell River diversion will allow access to an additional five years supply of coal in the East Field mine extension and the development of the Maryvale Field. The 3.5 km river diversion is on track for completion by June 2005. Yallourn Energy also plan to replace four 1950's coal dredgers (one to be retained for overburden removal) with four CAT D11R dozers.

At the Hazelwood operation the remaining benches in the South East Field mine are scheduled to be completed over the years 2003 to 2006. As each bench is completed the dredgers will be walked to the new West Field mine where a pre-stripping program commenced in 2001. The new rectangular West Field mine will have long straight faces 1.8 to 2 km in length with a coal seam up to 130 m thick using 38 m benches. The West Field mine will secure the power station's future for the next 30 years.

Latrobe Magnesium Ltd plans to commence a bankable feasibility study on the production of magnesium metal from fly ash produced by the La Trobe Valley power stations (see Magnesium section).

In late 2002, Eastern Star Gas commenced drilling at the Oak Park brown coalbed methane pilot production project, 35 km west of Melbourne. The pilot project comprises the drilling of five wells into the Maddingley seam. The wells will then be dewatered using electric submersible pumps for an initial six month trial production period.

Carbon Minerals NL are planning to drill the first dedicated coalbed methane assessment well in the Murray Basin near Coleambally in NSW during 2003. Other brown coalbed methane projects under consideration include Sale (CBM Resources Pty Ltd), Torquay Basin (Eastern Energy Australia Pty Ltd) and Warrnambool (Purus Energy Ltd).

## Copper

Australia is a major copper producer with mining and smelting operations at Olympic Dam (SA) and Mt Isa (Qld). Other significant copper producing operations are at Northparkes and Cadia-Ridgeway (NSW), Golden Grove and Nifty (WA), Ernest Henry, Osborne and Mt Gordon (Qld) and Mt Lyell (Tas).

### Resources

Total Australian resources of copper rose by 6.9 Mt in 2002. Increases occurred in South Australia, Western Australia, Queensland and in New South Wales.

Australia's EDR rose by 8.6 Mt to just under 33 Mt, an increase of 36%. South Australia has the largest holdings of EDR with around 54% of the national total and its overall share increased by 5% in 2002. The majority of these resources are associated with the Olympic Dam deposit where EDR increased significantly through the recompilation of subeconomic demonstrated resources (SDR). This followed completion of plant expansion and process optimisation. Queensland has the second largest EDR with over 20% of the national total, followed by Western Australia (over 10%) and New South Wales (7%). The increase in EDR for Western Australia relates to recommenced operations at Telfer and a proposed restart at Boddington.

Subeconomic demonstrated resources decreased by 30% to 10.8 Mt largely reflecting the change at Olympic Dam. South Australia still dominates the paramarginal resources category, but its share fell from 90% to 84%.

Inferred resources rose by 3.4 Mt (19%) to 21.8 Mt in 2002. Increases in inferred resources were reported in South Australia, Queensland, Western Australia and in New South Wales. The largest increase occurred in South Australia where, with the release of new data on Olympic Dam, inferred resources rose by 32%.

South Australia holds over 50% of Australia's inferred resources followed by Queensland with over 20%.

### Accessible EDR

All copper EDR is accessible.

### JORC Reserves

JORC Code reserves account for approximately 60% of AEDR. The remaining AEDR comprise those measured and indicated resources (reported by mining companies) which Geoscience Australia has assessed as being EDR.

## Exploration

Exploration expenditure for copper reached a record \$42.4 million in 2002, an increase of 10% over 2001 (\$38.4 million), and represents about 6% of the total mineral exploration expenditure in Australia for 2002. ABS quarterly statistics show about half of this expenditure occurred in Queensland and a third in South Australia.

Some of the interesting exploration results in 2002 include the following:

Prominent Hill (SA) – Minotaur Resources recorded further copper intersections in 2002 with 41 m grading 6.06% copper structurally above a previous gold intersection of 57 m at 7.7 grams per tonne. Another hole nearby intersected 53 m at 3.43% copper.

Lady Annie copper project (Qld) – Buka Minerals completed a resource definition drilling program of 16 holes with results including one intersection of 20 m grading 7.27% copper from 31 m. Other intersections included 31 m at 4.48% copper from 18 m; 31 m at 4.12% copper from 34 m; and 6 m at 5.88% copper from 36 m.

Jaguar base metals deposit (WA) – Pilbara Mines and joint venture partner Inmet Mining announced resource and scoping studies had estimated a 1.4 Mt resource at 3.7% copper, 13.2% zinc, 0.9% lead, 140g/t silver and 0.18g/t gold.

Mount Oxide (Qld) – Below the old open pit mine, Perilya and joint venture partner Western Metals reported significant high-grade copper intersections. Better intersections included 16 m at 10.3% copper, 18 m at 7% copper and 7 m at 14% copper.

## Production

In 2002 Australia's mine production was 883 kt of contained copper, 1% lower than 2001 (896 kt). Queensland continued to dominate production with 475 kt, 3% less than in 2001, and accounting for 54% of Australian production, down from 55% in 2001. South Australia remained the second largest producer with 178 kt, representing 20% of Australia's production. Other production was: New South Wales (135 kt, up 6%), Western Australia (57 kt, up 21%), and Tasmania (37 kt, up 12%).

The value of Australia's exports of copper concentrates and refined copper totalled \$2.00 billion, 14% less than in 2001 (\$2.32 billion). The decline reflects lower exports, which were down 9% from 753 kt in 2001 to 684 kt in 2002. Copper prices were also lower in 2002 at an average of \$2871/t, down from an average of \$2904/t in calendar 2001.

## World Ranking

Australia has the third largest EDR of copper (10%), after Chile (45%) and USA (11%). As a producer, Australia ranks fourth (10%) in the world after Chile (51%), USA (13%) and Indonesia (13%).

## Industry Developments

Several significant copper producing operations are now owned by overseas companies. The most noteworthy are those of MIM Holdings which was taken over by Xstrata on 16 June 2003. Others include Nifty (WA), Mt Gordon (Qld), Mt Lyell (Tas), and Highway (Qld), which are owned by Indian metals corporations – the Birla Group and Sterlite Industries (India) Limited.

Noteworthy events in 2002 included the following mines and processing centres:

Olympic Dam (SA) – Copper production was curtailed by 11% in 2002 (178 kt) compared to 2001 (201 kt) as a consequence of rebuilding the solvent extraction plant, which was significantly damaged by fire in the preceding period.

Selwyn mine (Qld) – The expanded treatment plant commenced operations in early 2002 with capacity increased from 750 000 tpa to 2.0 Mtpa. However, major difficulties relating to the crushing and grinding circuits and the availability of softer ore were encountered. In December 2002 Selwyn Mines Limited went into receivership.

Copper processing plant,  
Mount Gordon mine,  
Queensland (Western  
Metals Ltd)



Mt Watson (Qld) – Matrix Metals announced in late 2002 they had identified a significant new copper oxide zone adjacent to the Mt Watson deposit which it intended to develop as part of an expansion of its Mt Cuthbert project. Mt Watson contains 1.6 Mt grading 1.1% copper. Matrix is expanding the nearby Mt Cuthbert heap leach SX-EW project from 5500 tpa to 8500-10 000 tpa capacity.

Mt Gordon (Qld) – Western Metals reported an annualised production rate of more than 52 000 t achieved in the June quarter of 2002. A stage two expansion project was ‘approved in principle’, which involves reopening the Mammoth underground, and adding additional circuitry ahead of the current plant to ensure production levels are maintained with lower grade ore. Mammoth ore reserves grade 3.2% Cu which is less than half the grade of ore processed in the June quarter of 2002.

Telfer (WA) – Work began on re-opening the mine as a large scale operation producing 30 000 tpa of copper in conjunction with 800 000 oz per annum of gold over a 20 year life.

Nifty (WA) – Straits Resources progressed plans to expand into the sulphide zone of the orebody, which would increase production to 60 000 tpa. Straits also unveiled a \$400 million development plan which would boost its total copper output from 25 000 tpa to 150 000 tpa. In January 2003 Straits sold Nifty for \$158.8 million to the Aditya Birla Group – based in India where it is the largest copper producer.

Tritton copper project (NSW) – Tritton Resources acquired this project from Straits Resources and plan to bring the area into production in the near future.

Cadia Far East (NSW) – \$2.4 million was being spent on access studies ahead of a further \$20-30 million to develop a 5-6 km long drive from Ridgeway to the deposit.

Mineral Hill (NSW) – Triako Resources discovered significant gold-copper mineralisation, described as a blind target, 400 m from its mine following re-interpretation of historical geophysical (gravity) data.

## Diamond

Diamond is composed of carbon and is the hardest known natural substance, but a sharp blow can shatter it. It also has the highest thermal conductivity of any known material at room temperature. Diamonds are thought to form 150-200 km below the Earth’s surface at high temperatures (1050-1200°C) and pressures (45-55 kilobars). They are carried to the surface by hot molten rock (magma) intruding up into the crust. These intrusions form narrow cylindrical bodies, called ‘pipes’ and only a very small proportion have significant diamond content. When pipes are eroded, liberated diamonds may accumulate in alluvial deposits. Diamonds may be found far from their source as their hardness allows them to survive multiple episodes of erosion and deposition.

The quality of diamonds is split broadly into gem, near gem and industrial categories. In rare cases, 90% of diamonds in a deposit are of gem quality but most economic deposits contain 20 to 40% gem quality diamonds. Current uses for diamond include jewellery, stone cutting and polishing, computer chip manufacture, machinery manufacture, mining and exploration, construction and transportation services. A large proportion of industrial diamond is manufactured and it is also possible to produce synthetic diamonds of gem quality.

### **Resources**

Australia's total identified resources for both gem/near gem and industrial diamond decreased by 4% in 2002. EDR for gem/near gem was 67.4 Mc and industrial 70.0 Mc, both down 15% compared to 2001. Production from the Argyle mine accounts for most of these decreases.

### **Accessible EDR**

All diamond EDR is accessible.

### **JORC Reserves**

JORC Code reserves account for almost all AEDR. The remaining AEDR comprise those measured and indicated resources (reported by mining companies), which Geoscience Australia has assessed as being EDR.

### **Exploration**

In 2002, Australia's diamond exploration expenditure was \$32.6 million, up \$1.7 million or 5% compared to 2001 expenditure. Following are some exploration highlights for 2002:

Seppelt (WA) – Striker Resources NL announced a representative 183 t bulk sample at the Seppelt 2 diamond pipe returned 412 carats of diamonds (equivalent to 2.25 carats per tonne) valued at between US\$25 and US\$52 per carat. The nearby Seppelt 1 pipe with a total area of 1 hectare contains 1.7 million tonnes of kimberlite at 0.43 carat per tonne.

Timber Creek (NT) – Bulk sampling is currently underway to confirm diamond grades and obtain valuations. Discovered by De Beers in 1991-93 and purchased by Tawana Resources in May 2002, this small outcropping diamondiferous kimberlite pipe is estimated to grade 1 carat per tonne. It is one of a cluster of five kimberlites.

Flinders Island (SA) – Tawana Resources reported recovering abundant indicator minerals and six diamonds, often with good preservation and unabraded, indicating that they occur less than 1 km from their source. Geochemical sampling and drilling were proposed to in an effort to locate source kimberlites so far undetected by geophysics.

Areas of other diamond or indicator mineral finds announced in 2002 include: Phillips Range, WA (Thunderella Exploration); the Altjarrowa Craton, NT (Elkedra Diamonds); Bingara, NSW (Rimfire Pacific Mining); King George prospect, WA (AKD Limited).

### **Production**

Australia's total diamond production in 2002 was 33.6 Mc, an increase of 7.4 Mc on the previous year. The Argyle diamond mine (at 33.5 Mc) accounts for nearly all Australian production. The Merlin mine in the Northern Territory (with 117 000 carats production in 2002) was the next highest producer.

Australia's diamond production is the largest in the world for natural industrial diamonds and second largest (after Botswana) for gem/near gem diamonds.

### **World Resources**

Australia's EDR of industrial diamond ranks third (16% of current world total EDR), after the Congo (Kinshasa) and Botswana (26% and 23% respectively). Detailed data are not available on world resources of gem/near gem diamond but Australia has one of the largest stocks for this category.



## Industry Developments

Argyle (WA) – Production from Argyle's major resource, the AK1 open pit mine, is expected to continue until 2007. A feasibility study into underground mining has commenced, with a decision on closure or ongoing production expected in 2005. An exploration decline is to be developed to assist in confirming design criteria.

Ellendale (WA) – Production commenced from pipe 9 in July 2002 following a feasibility study of mining surface enriched portions of pipes 9 and 4. Sales of Ellendale diamonds have realised prices somewhat higher than valuations used in the feasibility study. Sampling of the uppermost 3 m of pipes 4 and 9 continues to expand ore reserves. Large diameter drilling to further test ore grades of pipe 4 at depth commenced in October 2002. Preliminary results suggest that an initial 60 m deep pit could be developed on pipe 4. Bulk sampling commenced on 14 new lamproite bodies discovered by detailed airborne magnetic survey. Ellendale is expected to produce an average 300 000 carats per year until 2008.

Merlin (NT) – Australia's largest diamond at 105 carats was recovered from the Merlin deposit in May 2002. The economies of scale of this 'scattered' deposit, however, do not match those of longer-life, larger-scale mines and, following an unsuccessful effort to sell the operation, Rio Tinto announced it planned to cease mining at Merlin mid 2003.

## Gold

Strong growth in gold prices in 2002 was driven to a significant degree by the fear of war in Iraq, the threat of terrorism and a weakening American dollar. This contributed to a growth in Australia's EDR of gold and is expected to help increase the funds available for exploration in the short to medium term. While exploration continued to yield new resources most were associated with established mines or known deposits. Production fell again in 2002, continuing the downward trend established since the record year of 1997.

Gold has a range of uses but the two principal applications are as an investment instrument and in the manufacture of jewellery. Secondary uses, in terms of the amount of gold consumed, are in electronic and dental applications.

## Resources

Australia's gold resources occur and are mined in all States and the Northern Territory. At the end of 2002, total Australian gold resources were 33 t higher than at the end of 2001. After allowing for the replacement of those resources lost to production (273 t) total newly delineated resources added to the national inventory were 308 t in 2002. Inventories grew in New South Wales, Victoria, South Australia and Tasmania.

Australia's EDR rose by 259 t (8.3 Mozs) in 2002 and accounted for 81% of total demonstrated resources. In 2002, EDR increased in New South Wales, Victoria, Tasmania and Western Australia.

Western Australia continued to dominate EDR with almost 62% of the national total. In 2002 its EDR rose by just under 210 t (7%) to 3124 t. South Australia had the second largest EDR. In New South Wales EDR rose by 18% to 554 t. The Northern Territory's EDR fell by just under 39 t to 222 t. Only minor variations were recorded in the other States.

Subeconomic demonstrated resources rose by 96 t in 2002. All the growth was in the paramarginal category, which increased by 96 t to 1157 t. Western Australian paramarginal resources rose by 80 t to 821 t or 71% of total paramarginal resources slightly higher than in 2001. Increases also occurred in Queensland to 105 t, New South Wales to 63 t and the Northern Territory to 94 t. The submarginal demonstrated resources remained unchanged at 112 t.

Inferred resources fell by 323 t (10.3%) to 2823 t with the reduction being due largely to falls in Western Australia, down by 382 t, Queensland, down by 27 t and New South Wales, down by 26 t. Inferred resources in Victoria rose strongly (up by 60 t). Western Australia dominates inferred resources with 55% of the total but its share in 2002 was significantly lower than the 61% held in the previous year.

The ratio of demonstrated to inferred resources rose sharply from 2:1 in 2001 to 2.4:1 in 2002. An increase in demonstrated resources and a fall in inferred resources caused the increase. The increase in this ratio is of concern because it indicates that there are proportionally less inferred resources that future exploration might be expected to upgrade to the potentially mineable category.

### Accessible EDR

EDR for gold are essentially unencumbered (less than a fraction of 1% is in any form of restricted area). At Australia's 2002 rate of production, EDR is sufficient for an average 20 years production. If, however, resources only classified as reserves under the JORC Code are considered, they are adequate for only 13 years at the 2002 production rate. It should be remembered that these are average figures and that there are some operations that may continue after the 20 or 13 years and there are others that will be completed before those times. These figures clearly illustrate the need for ongoing successful exploration in the short and medium terms.

### JORC Reserves

EDR is the sum of the JORC Code reserves categories plus those resources from the measured and indicated resource categories assessed by Geoscience Australia as likely to be economic. In 2002 just over 66% of EDR fell into the JORC reserves category compared to 57% in 2001.

### Exploration

In the 2001-02 financial year, gold continued to dominate mineral exploration spending with \$331 million (51.7%) of total exploration in the financial year. In real terms this was a 60% fall in spending since 1996-97 and was the lowest since 1984-85.

For the calendar year 2002, based on the sum of ABS data for the four quarters of 2002, gold exploration expenditure was \$355.2 million, \$4.5 million higher than 2001. Data published by the Metals Economics Group (MEG) (a Canadian company) on company exploration budgets indicates that intended spending on gold exploration in Australia for the year was \$321 million. The higher amount reported by ABS may well have been the result of additional spending in response to the increase in gold prices that became well established during the year.

The MEG data show that 42.6% of budgets were expected to be directed at grassroots exploration, 32.7% at late stage and feasibility study stage and 24.7% on minesite exploration.

Gold exploration spending has been adversely effected by the global mergers and acquisitions activity in recent years as well as the low gold price. There are emerging signs that the worst of this impact has passed and that the 'new' companies are again embarking on significant exploration programs.

New gold mineralisation continued to be found across the continent and at depth below known deposits. A variety of styles of mineralisation also continued to be found. The Archaean greenstones of Western Australia's Yilgarn Craton remain a very favourable target, but the results that follow suggest that substantial opportunities exist in other provinces.

- Sipa Resources International report a recoverable resource of 134 000 oz of gold at the Waugh deposit, about 3 km east of the company's Mount Olympus gold mine 30 km south of Paraburdoo, WA.
- Exploration for similar deposits yielded, from the Diligence prospect, 1.5 km east of Waugh, 4 m at 20.7 g/t Au from 5 m and 2 m at 9.4 g/t Au from 7 m.
- At the Airport prospect, 95 km north of Sandstone, WA, Gateway Mining NL reported drill results of 6 m at 39.85 g/t Au (including 1 m at 173.39 g/t Au), 3 m at 14.56 g/t Au and 1 m at 20.86 g/t Au. Gateway also reported encouraging results from five other prospects in the Gidgee project area.

- Near Norseman, WA, Kinross Gold Corp. reported narrow, gold-bearing quartz veins at the Scotia North and Everlasting prospects, which had grades significantly higher than those reported at nearby Mount Henry and Selene. These results are expected to enhance the economics of mining the Mount Henry area. Kinross estimate an indicated resource of 26.9 Mt at 1.34 g/t Au for their Norseman project.
- At Big Blow, south of Coolgardie, WA, the Coolgardie Joint Venture (Mining Project Investors Pty Ltd 25%, Pittson Mineral Ventures of Australia Pty Ltd 5%, and Herald Resources Ltd 50%) reported high-grade mineralisation from a zone of intense silica-carbonate-sulphide alteration of a basalt. Intersections included 7 m at 12.69 g/t Au from 99 m, 23 m at 5.72 g/t Au from 104 m, including 9 m at 11.36 g/t Au from 115 m.
- High-grade mineralisation was discovered at the Baldock prospect, near Menzies, WA. Hamill Resources Ltd (now merged with International Goldfields Ltd) reported intersections including 4 m at 66.0 g/t Au, 3 m at 46.3 g/t Au, and 1.36 m at 74.78 g/t Au for an inferred resource of almost 67 000 oz. Encouraging intersections were also reported from the Dave North prospect (1 m at 27.69 g/t Au) and the Tim North prospect (5 m at 5.26 g/t Au).
- Central Kalgoorlie Gold Mines Ltd discovered high-grade gold at its Eureka project, 50 km north of Kalgoorlie, WA. The mineralisation is about 170 m below the surface and 45 m beneath the bottom of an existing open pit. Intersections include 2 m at 23.2 g/t Au, and 3 m at 7.07 g/t Au. Subsequent drilling on the north end of the prospect yielded 4 m at 134 g/t Au including 2 m at 255 g/t Au.
- Drilling by Greenstone Resources NL (now Red 5 Ltd) at the Indee prospect in the Pilbara region, 80 km southwest of Port Hedland, WA, has increased the potential of the prospect. Results included 6 m at 10.3 g/t Au, 2 m at 9.9 g/t Au and 24 m at 2.4 g/t Au.
- In the Kimberley region, 200 km northeast of Kununurra, WA, Striker Resources NL identified coarse gold in soil samples over 4 km<sup>2</sup> at its 88 Creek prospect, which is part of the Oombulgurri gold project. Samples have yielded 16.7 g/t Au and 10.5 g/t Au. This discovery, the first in the area, stimulated interest in gold exploration in the region.
- At its Yandal West joint venture, WA, with AuDAX Resources Ltd (49%), Newmont Mining Corp. (51%) reported encouraging intersections of 8 m at 16.2 g/t Au including 1 m at 78.8 g/t Au and 1 m at 32.7 g/t Au, and 4 m at 16.8 g/t Au.
- Tanami Gold NL and Barrick Gold Corp. reported encouraging results from the Sandpiper deposit on the WA side of the Tanami, notably 21 m at 2.6 g/t Au, including 8.6 m at 6.1 g/t Au from 366 m downhole. These results show the potential for Kookaburra-Sandpiper to have deep continuation of near-surface mineralisation.
- Deep drilling by Newmont Australia at Callie in the Tanami, NT, returned intersections including 1 m at 49.5 g/t Au, 2 m at 53.9 g/t Au, and 1 m at 93.8 g/t Au. The upper portions of previously completed drill holes targeting Kerril South/Wilson Shoot at Callie returned results including 8 m at 29.3 g/t Au, 8 m at 4 g/t Au and 2 m at 75.2 g/t Au. These are 300 m above previously known Kerril South mineralisation.
- Drilling at Harmony Gold Mining's Maud Creek project, near Pine Creek, NT, evaluated the down plunge position of the main ore zone. One hole intersected 18.6 m at 6.4 g/t Au within a mineralised zone of 55.4 m at 3.3 g/t Au. Holes testing for deeper down-plunge mineralisation intersected only thin zones of low-grade material.
- Near Wudinna, SA, Adelaide Resources Ltd reported encouraging results from its Barns prospect. These included 21 m at 1.50 g/t Au from 120 m, 12 m at 3.38 g/t Au from 67 m and 2 m at 67.6 g/t Au from 158 m (with 1 m at 128.6 g/t Au).
- At the Croydon project, 150 km northwest of Georgetown, Qld, Union Capital Limited and Newcrest Mining Ltd announced high-grade mineralisation at depth. Drilling yielded mineralisation at up to 11.3 g/t to a depth of 330 m and shallower results of 10 m at 10.9 g/t Au and 5 m at 11.6 g/t Au.
- Gympie Gold Ltd announced, in August, a three year, \$25 million exploration program at and around its existing mine at Gympie, Qld. In 2002-03, \$7 million will be spent including \$4 million on grassroots targets in the Gympie Goldfield.
- Strategic Mineral Corporation NL reported further high grade intersections from its Explorer prospect at the Woolgar project, 100 km north of Richmond, Qld. Results included 1 m from 56 m at 107 g/t Au, 5 m from 35 m at 7.35 g/t Au and 9 m from 29 m at 7.0 g/t Au. Explorer is believed to be an epithermal vein system with a high-grade core.

- Drilling by the Cracow Joint Venture, reported by Sedimentary Holdings Ltd, yielded deep intersections between the Back Creek North and Roses Pride deposits at Cracow, Qld. Results include 6.4 m at 10 g/t Au and 1.1 m at 15 g/t Au from 516.7 m and 533.9 m respectively.
- Alkane Exploration Ltd report more encouraging drill results from its Wyoming prospect, 12 km north of its Peak Hill mine, NSW. Results included 75 m at 10.43 g/t Au including 21 m at 22.71 g/t Au and 14 m at 8.32 g/t Au including 8 m at 13.70 g/t Au.
- At Bendigo, Vic, Bendigo Mining NL announced that it had commenced exploration development and bulk sampling in three gold-bearing reefs in the New Bendigo project. The D3 East Leg and Upper S3 Reefs contain coarse-grained visible gold. Initial bulk sample results have met or exceeded company expectations with grades of 4 to 16 g/t Au in the D3 East Leg Reef and 3 to 22 g/t Au in the Upper S3 Reef.
- At Fosterville, near Bendigo, Vic, Perseverance Corporation Ltd continued investigations into the sulphide resources. The Phoenix Shoot has been traced down plunge and along strike for 1.5 km and is reportedly consistent over that distance. Mineralisation is open at depth and a drill intersection of 5 m at 6.07 g/t has been reported.
- AurionGold Ltd (subsequently taken over by Placer Dome Inc) announced new resource and reserve estimates for the Henty Mine, 30 km north of Queenstown, Tas, that should enable the project to continue for at least another five years. Total reserves are 1.391 Mt grading 10.4 g/t Au (0.46 Moz) and resources are 1.928 Mt at 10.3 g/t Au (0.64 Moz).

## Production

Australian gold production in 2002 fell by 2.5% to 273 t. This was in line with the continued downward trend from the peak year of 1997 when production reached the record level of 314 t. Western Australia continued to dominate output with a production of 190 t accounting for 70% of Australia total output (Table 2).

**TABLE 2: Australian gold production 1998 to 2002**

	1998 (t)	1999 (t)	2000 (t)	2001(t)	2002 (t)
New South Wales	14.76	21.04	18.54	16.99	22.88
Victoria	4.89	4.63	4.22	3.48	4.00
Queensland	32.38	34.15	37.01	31.67	27.47
South Australia	1.74	1.77	2.94	4.28	3.54
Western Australia	231.98	210.92	203.30	195.24	190.07
Tasmania	4.18	4.95	6.66	6.14	5.89
Northern Territory	20.38	22.29	23.09	20.37	18.53
Australia	310.32	299.75	296.41	280.08	273.01

Source: ABARE Australian Commodity Statistics 2002 and ABARE Australian Mineral Statistics December Quarter 2002

The outlook for production is reliant on new mines coming on stream especially large operations such as the proposed Boddington, Telfer (both WA) and Cowal (NSW) mines. Smaller mines such as proposed operations at Chariot (NT) Costerfield (Vic) and Frog's Leg (WA) will play an important role in maintaining existing production levels.

## World Ranking

The USGS estimate of world gold reserves of 42 500 t was down by 15% over the estimate for 2001. The fall was largely attributable to the receipt of significant new data on South Africa. The USGS reports that South Africa still has the world's largest reserves of gold at 8000 t (18.8%). The USA ranked second with 13.2% and Australia third with 11.8%. The increased share for both Australia and the USA resulted mainly from the reduced tonnage in South Africa.

The USGS estimate world mine production of gold was 2530 t in 2002. Adjusting this estimate for the actual Australian output, the estimate is 5 t lower at 2525 t. South Africa remained the leading producer with an output 7 t lower than in 2001 at 395 t which was 15.6% of world output. It was followed by the USA which had an estimated production of 300 t (335 t in 2001), which was 11.8% of world output. Australia remained in third position with 275 t produced (10.8% of world total production). Then followed China (175 t), Russia (170 t), Indonesia (170 t) and Canada (140 t).

## Iron Ore

Iron (Fe) is one of the most abundant rock-forming elements, constituting about 5% of the Earth's crust. It is the fourth most abundant element after oxygen, silicon and aluminium, and after aluminium, the most abundant and widely distributed metal. Iron ore is almost always an oxide (for example  $\text{Fe}_3\text{O}_4$  and  $\text{Fe}_2\text{O}_3$ ), which produces metallic iron when heated with a reductant. Almost all (98%) iron ore is used in iron and steel making with small tonnages used, for example, in pigment manufacture, coal washeries and cement manufacture.

Iron ore forms the basis of a major Australian export industry centred on the Pilbara region of Western Australia. Western Australia has nearly 90% of the identified resources, but iron ore resources occur in all Australian States, the Australian Capital Territory and the Northern Territory.

There are 13 operating mines in the Pilbara region, six of which are operated by Hamersley Iron, two by Robe River and five by BHPBilliton Iron. Elsewhere in Australia there are locally significant operating mines at Koolyanobbing and Cockatoo Island (WA), Middleback Ranges (SA) and Savage River (Tas).

Pig iron is produced in blast furnaces at Port Kembla and Whyalla. Steel is produced at Port Kembla (NSW), Whyalla (SA), Rooty Hill (NSW), Mayfield (NSW) and Laverton North (Vic). Direct reduced iron (DRI) is produced by BHPBilliton from its hot briquetted iron (HBI) plant near Port Hedland (WA).

### Resources

In 2002 EDR increased by 5.3% to 13.0 Gt mainly due to increases at Mining Area C, Hope Downs and HIYandi, and East Angelas being included in the demonstrated grouping for the first time. There were decreases due to production losses plus decreases at Deepdale and Savage River but these were less than the increases.

The large increase in PDR to 1.1 Gt was mainly due to a new demonstrated resource at Fortescue being assessed as PDR. SDR increased 15% to 1.8 Gt mainly due to a reassessment of the Savage River resources. Inferred resources increased by 26% to 15.5 Gt mainly due to Hamersley Iron reassessing previously unreported inferred mineral resources.

### Accessible EDR

Almost all EDR is accessible, with the exception of 30% of the Windarling resource and all of the remaining resource at Orebody 23 in the Newman district (WA). Both are quarantined for environmental reasons.

The resource life of accessible EDR of 13.0 Gt is around 70 years.

### JORC Reserves

Over 30% of AEDR, or 4.1 Gt, is JORC Code compliant. The resource life of accessible JORC reserves is 22 years. In 2002, around 30% of EDR fell into the JORC reserves category.

### Exploration Expenditure

ABS data indicate exploration expenditure for iron ore in 2002 totalled \$37 million an increase from \$20.1 million in 2001. In 2002 iron ore exploration expenditure was 5.5% of the national total. In Western Australia in 2001-02 iron ore exploration expenditure was 6.6% of the State's total.

### Production

ABARE reported that Australia's iron ore production in 2002 was 187.2 Mt (181.6 Mt in 2001) with 97% produced in Western Australia. Exports in 2002 totalled 165.8 Mt (156.7 Mt in 2001) with a value of \$5200 million. ABARE forecast Australia's iron ore production for 2003 will be 195 Mt and in 2004, 200 Mt.



Iron ore mining in the Pilbara commenced in the mid-1960s, based on the premium quality, low phosphorous, Brockman ore. This ore provided up to 70% of the national iron ore mix up until the early 1990's. During the 1990's and early 2000's Hamersley Iron and BHPBilliton Iron commenced mining more Marra Mamba and Pisolite ore types to conserve the reserves of Brockman ore. This has resulted in Brockman ore in 2002 being 38% of the national iron ore mix. Pisolites now make up the largest portion with about 41% and Marra Mamba's portion (currently 9%) will increase in the years ahead with the opening of West Angelas and Mining Area C.

### World Ranking

Australia has some 9% of world EDR of iron ore and is ranked fourth after Ukraine (21%), Russia (17%) and China (14%). In terms of contained iron, Australia has about 12% of the world's EDR and is ranked third behind Russia (21%) and Ukraine (13%).

Australia produces around 17% of the world's iron ore production and is ranked third behind China (21%) and Brazil (20%).

### Industry Developments

Robe River Associates new \$825 million West Angelas project, 110 km west of Newman, was officially opened in August 2002. The development included a new 60 km rail spur linking the mine to the Hamersley Iron railway and new and upgraded port facilities at Cape Lambert. Marra Mamba ore is scheduled to be produced at a rate of 7 Mtpa and increase to 20 Mtpa by 2006, in line with market demand. First shipments from the new mine were made in June 2002.



Stockpile area and train load-out at the West Angelas iron ore mine, Western Australia (Robe River Iron Associates)

Construction of the \$120 million Eastern Range open-pit mine between Paraburdoo and Channar began in late 2002. Iron ore production is scheduled to commence in 2004 at a rate of 10 Mtpa over a 20 year mine life. The operation will be a joint venture between Hamersley Iron (54%) and China's largest steel producer Shanghai Baosteel Group Corporation (46%).

During 2002 Rio Tinto (60%) announced that the \$400 million HIsmelt plant would be built at Kwinana in Western Australia. The direct iron smelting plant will have an annual capacity of up to 800 kt of high quality pig iron (96% iron content). Construction began in January 2003 with the plant scheduled to be commissioned in late 2004 and reaching full production in 2006. The new HIsmelt plant will allow Rio Tinto to use higher phosphorous fine ore from the Pilbara. The Commonwealth Government will provide up to \$125 million over three years under a Strategic Investment Co-ordination scheme to Rio Tinto to commercialise and develop the HIsmelt technology at Kwinana.

In April 2002 BHPBilliton announced the investment of \$1 billion to develop the Mining Area C mine (\$380 million) and expand the port and railing facility at Port Hedland (\$625 million). The mine is due to commence in late 2003 and will be capable of producing up to 15 Mtpa. The Port and Capacity Expansion (PACE) project will increase BHPBilliton's export capacity from 67 Mtpa to 81 Mtpa by 2004. As part of the development BHPBilliton entered a joint venture with POSCO, a Korean steel producer, whereby POSCO acquired a 20% interest in the C Deposit at Mining Area C.

The Yandi Lump project was commissioned in June 2002 with the completion of an additional crushing plant. Known as the Interim Crushing Plant a further 5.5 Mtpa of fines and 4 Mtpa of lump will increase overall capacity from 32 Mtpa to around 40 Mtpa. The Yandi mine has been in operation for over a decade and is now the biggest contributor to BHPBilliton's Pilbara product mix, ahead of the traditional Mount Whaleback and satellite orebodies.

Production at the BHPBilliton's Boodarie hot briquetted iron (HBI) plant at Port Hedland was suspended in March 2002 when a tube burst in a gas reheating furnace. After undergoing mechanical repairs production recommenced in July. The Boodarie plant commenced production in 1999 and is designed to produce 2.3 million tonnes of briquettes per year.

During 2002 Portman Ltd reported the following.

- Plans to increase production from the Koolyanobbing District from 3.2 Mtpa in 2001 to between 6 and 8 Mtpa by 2004-05.
- A proposal to spend \$100 million on the expansion, of which \$70 million will be spent on a 90 km railway linking Mount Jackson and Windarling to the existing Koolyanobbing treatment plant.
- Appealed a December 2002 recommendation by the Environmental Protection Authority to reject the expansion proposal for the Windarling deposit.
- Commissioning of the Stage 2 port expansion at Esperance in early 2002. This expansion included dredging of the harbour to accommodate 180 000 dwt Capesize vessels, construction of a new berth and ship loader, and additional storage facilities to increase stockpile capacity from 300 to 600 kt.
- Reaching agreement with two overlapping claimant groups, the Ballardong and Central West people, who had native title claims over the Windarling and Mt Jackson area to the north of Koolyanobbing.
- Construction of a 15m high seawall at the Cockatoo Island mine to prevent sea water flowing into the open-cut. This will allow the mining of an additional 4 Mt of high-grade iron ore and extend the life of the project by at least three years. The first shipment of this ore was loaded in late 2002.

Mount Gibson Iron Ltd (MGI) reported a number of significant developments during 2002.

- Paying \$4.6 million to the administrator of Kingstream Steel Ltd for the Tallering Peak iron ore deposit located 120 km east of Geraldton in Western Australia. Kingstream who had attempted to develop the Mid-West Iron and Steel Project over the past decade was placed in administration in late 2001.
- An agreement with Ausmelt Ltd to investigate the production of pig iron in Western Australia utilising MGI's iron ore resources, Indonesian coal and Ausmelt's AusIron technology. This technology for direct smelting of both lump and fine ore has undergone trials at a demonstration plant at Whyalla in South Australia. MGI have exclusive access to the AusIron process until December 2007 for any pig iron project based on Western Australian iron ore.
- A commitment to spend approximately \$10 million on the construction of a 1.5 Mtpa open-pit mine at Tallering Peak. The first shipment of direct shipping grade hematite is scheduled for mid-2003.
- Planning to spend another \$5 million by mid-2004 on commissioning a 1.5 Mtpa open-pit mine at the Mt Gibson iron ore deposit, 320 km south east of Geraldton.
- The Geraldton Port Authority signing a \$73 million contract to have the harbour dredged by mid-2003 to allow the loading of 55 000 tonne ore carriers.

In mid-2002 Hope Downs Management Services Pty Ltd (HDMS) announced that a feasibility study showed the Hope Downs Iron Ore Project to be 'robust' even allowing for the construction of an independent rail line. HDMS envisages a \$1.5 billion development with production commencing at 5 Mtpa rising to 25 Mtpa over a five year period. Subject to approvals construction could commence in 2003 with the first production in 2006.

During 2002 Allied Mining and Processing Ltd signed an agreement with Iron Ore Australia Pty Ltd to undertake a full feasibility study on the Mt Nicholas iron ore project located 110 km north east of Newman in Western Australia. A pre-feasibility report had indicated that a 10 Mtpa mine with a life in excess of 20 years was possible. The estimated capital cost of \$320 million is mainly required for a processing plant and a new railway extension.

Aztec Resources Ltd announced during 2002 an investigation into the possibility of re-opening the Koolan Island iron ore project that is about 70 km north of Derby in Western Australia. BHP Ltd mined 67 Mt of hematite ore averaging 67% iron between 1965 and 1993 when mining ceased. Hatch Engineering has been commissioned to undertake a pre-feasibility study.

In other iron ore developments during 2002:

- Aulron Energy Ltd announced the cessation of further development of the South Australian Steel and Energy (SASE) pig iron project. AusIron Development Corporation (100% subsidiary of Ausmelt Ltd) plan to market and commercialise the AusIron technology that was successfully tested at the SASE demonstration plant in Whyalla.
- Austeel Pty Ltd announced that the Western Australian Government had given environmental approvals to the Fortescue Project in the Pilbara region.
- At Savage River in Tasmania, ABM Mining agreed to purchase 100% of project debt and signed a five year 1 Mtpa (minimum) pellet supply contract with BHPSteel Ltd. Five fuel oil furnaces are being converted to natural gas with the final furnace scheduled for conversion late in 2003.
- OneSteel Ltd announced a 300 Mt inferred resource had been identified at the Iron Magnet Deposit adjacent to and below the Iron Duke and Iron Duchess Deposits.

Proposed iron and steel projects in Australia include:

- Compact Steel (Rockingham, WA) – a 1.4 Mtpa steel plant costing \$1.5 billion.
- Austeel (Newcastle and Pilbara) – mine and HBI plant in the Pilbara with an electric arc furnace in the Newcastle District.
- Protech Steel (Newcastle, NSW) – \$600 million steel processing mill to produce mainly coated steel products.
- Hunter Specialty Steels (Hunter Valley, NSW) – Boulder Steel Ltd to construct a steel mini-mill capable of producing up to 260 000 tpa of stainless and specialty steel products.
- Westralia Iron and Steel Corporation Ltd (WA) – construction of a 1.5 Mtpa pig iron plant at Collie.

## Lithium

Lithium is a silvery grey metal with a density about half that of water. Sons of Gwalia's Greenbushes mine in Western Australia is the world's largest producer of lithium minerals. Greenbushes products have a range of uses that include production of specialty glasses, ceramics and ceramic glazes, glass bottles. Its ore (predominantly spodumene  $\text{Li}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 4\text{SiO}_2$ ) is also a feedstock for the production of lithium carbonate in the chemical industry.

Spodumene Pit at the Greenbushes mine (WA), immediately south of the Cornwall Pit. Fresh unweathered pegmatite is mined for spodumene ore, which is processed to four final lithium mineral products – fine, concentrate, glass grade and universal (Geoscience Australia, Bill McKay)



## Resources

All of Australia's lithium resources occur in Western Australia and all EDR occurs in the Greenbushes deposit, in the southwest of the State. EDR increased by 11% in 2002 to over 171 000 t, due to a reclassification of Greenbushes resources. Submarginal and inferred resources remained steady, however, there was an adjustment for paramarginal resources due to reclassification into economic resources.

## Accessible EDR

All EDR is accessible.

## JORC Reserves

EDR is the sum of the JORC Code reserves categories plus those resources from the measured and indicated resource categories assessed by Geoscience Australia as likely to be economic. In 2002, close to 90% of EDR fell into the JORC reserves category.

## Exploration

There are no statistics available on exploration expenditure for lithium. With continuing world oversupply of lithium resource, particularly in the form of lithium-rich brines especially in Chile, it is very unlikely that there will be any substantial exploration expenditure in Australia in the near future.

## Production

Sons of Gwalia Ltd remained the world's largest producer of lithium minerals (spodumene) in 2002. Production for the year was 109 818 t, an increase of 73% over 2001, while sales of lithium minerals totalled 90 165 t. This improvement in sales reaffirmed the company's dominance in some niche markets within the larger lithium industry. However, the supply of lithium carbonate from brine operations in Chile and Argentina is continuing to have an adverse impact on the price and supply of lithium minerals on the world markets.



Greenbushes spodumene (1 tonne bulk bags) palletised for export through the ports of Fremantle and Bunbury, Western Australia (Geoscience Australia, Bill McKay).

## World Resources and Production

According to estimates published by the USGS, Chile holds approximately 88% of the world's lithium resources, followed by Canada with just over 5% and Australia with just under 5%. Resource data, however, are not available for some important producing countries including, Argentina, China and Russia. Lithium resources occur in two distinct categories – lithium minerals and lithium-rich brines. Lithium brine resources, now the dominant feedstock for lithium carbonate production, are produced dominantly by Chile. Canada and Australia have the most significant resources of lithium minerals.



World production of lithium in 2002, as estimated by Geoscience Australia and the USGS, was 15 800 t of contained lithium, a slight increase since 2001. However, information on USA production is withheld by the USGS for commercial reasons. Chile with 41% remained the world's largest producer, followed by Australia (20%), China (16%) and Russia (13%).

### Industry Developments

There were no significant developments in the Australia's lithium industry in 2002.

## Magnesite

Magnesite (magnesium carbonate) is marketed in three main forms: (1) crude magnesite, primarily for use in chemicals and agriculture, (2) dead-burned magnesia, a durable refractory for use in cement, glass, and steel and which is used in metallurgical industries; and (3) caustic calcined magnesia, for use in making oxychloride and oxysulphate cements for flooring and wallboards, mouldings and acoustic tiles, and various environmental and chemical applications.

### Resources

EDR of magnesite decreased marginally to 363.1 Mt in 2002 from 366 Mt in 2001. Production from the Kunwarara mine (Qld) accounted for the change. In South Australia, a global resource of 579 Mt of magnesite has been identified in the Willouran Ranges, northwest of Leigh Creek. About 235 Mt of this resource in the Mount Hutton and Witchelina deposits is classified as EDR, unchanged from 2001.

Queensland has the second largest magnesite EDR. The bulk of this occurs at Kunwarara (70 km northwest of Rockhampton), where Australian Magnesium Corporation Limited has an inferred global resource of 1200 Mt of magnesite-bearing material. This includes an inferred resource of 500 Mt magnesite and several high-grade magnesite zones, which are classified as EDR, totalling 78 Mt. The Kunwarara deposit contains substantial accumulations of very high-density 'bone-type' magnesite characterised by nodular and cryptocrystalline structure and low iron content.

The third largest inventory of EDR is in Tasmania where the Arthur River deposit has an indicated resource of 29 Mt of magnesite, unchanged from 2001. Magnesite in the deposit typically grades 42.8% MgO and is part of a much larger global resource of 180 Mt in the Arthur-Lyons River area, about 53 km south of Burnie.

Minor EDR occurs in the Winchester deposit (near Batchelor, NT), at Thuddungra (80 km northwest of Young, NSW), and at Bandalup (20 km east of Ravensthorpe, WA).

Subeconomic demonstrated resources, which account for around 4% of the total identified magnesite resources, remained unchanged from 2001. All of these resources occur in Queensland and Tasmania.

Inferred resources remained essentially unchanged in 2002 at 990 Mt with Queensland accounting for 53% followed by South Australia (30%) and Tasmania (15%).

### Accessible EDR

All magnesite EDR is accessible for mining.

EDR are sufficient for around 170 years at current rates of production.

### JORC Reserves

About 18% of AEDR comprise JORC Code reserves (about 30 years at current production). The remaining represents resources assessed by Geoscience Australia from the measured and indicated categories of industry reported mineral resources, as defined under the Code and other classification systems used by non-listed ASX companies.

### Exploration

Data relating to exploration expenditure for magnesite are not published by ABS on either a State or national basis.



## Production

In 2002, Australian Magnesium Corporation Limited mined 2.14 Mt (2.7 Mt in 2001) of crude magnesite ore at Kunwarara, which was beneficiated to produce 483 002 t of magnesite (594 674 t in 2001). This in turn produced 102 785 t of deadburned magnesia (117 872 t in 2001), 58 688 t of calcined magnesia (54 346 t in 2001) and 19 582 t of electrofused magnesia (21 781 t in 2001). The only other recorded production of magnesite in 2002 was about 1500 t in South Australia.

## World Resources and Production

According to Geoscience Australia and USGS data, Australia has about 5% of the world's EDR of magnesite. Russia, North Korea and China combined, account for nearly 70% of the world's EDR of magnesite. The Kunwarara deposit is the world's largest known resource of cryptocrystalline, nodular magnesite, a high quality ore.

Australia accounted for 5% of the world's production in 2002. USGS data show that China (25%) and Turkey (19%) were the world's largest producers, followed by North Korea and Russia (both 10%) and Austria (7%).

## Industry Developments

During 2002, progress with potential magnesium metal plant projects continued. In March 2002, Australian Magnesium Corporation Limited (AMC) announced that it would adopt Alcan's Ex2 technology instead of Alcan's MK 111 technology for the electrolytic cells of its Stanwell Park Project, near Rockhampton, Queensland even though its demonstration plant had operated on the latter. AMC reported that the Ex2 cells had been commercially proven, by Noranda's Magnola plant in Canada and Sumitomo Sitix's plant in Japan. The productivity of Ex2 cells is reported to be about 60% greater than for MK111 cells, thereby enabling AMC to reduce the total cells required for its 90 ktpa magnesium plant from 64 to 40.

Leighton Contractors signed a \$1 billion engineering, procurement and construction contract with AMC for the development of the Stanwell magnesium plant. Engineering work on all major aspects began in February and site clearance works began in June in preparation for major construction activity, which commenced in November.

During the year, AMC signed a three year contract to supply 15 kt of pure magnesium metal to a major European metals group commencing in 2005. The company's marketing and technical support network continued to pursue the development of new alliance programs with automotive component manufacturers and suppliers. This included an alliance with Wagon Plc to develop magnesium automotive applications. Wagon Plc is a leading European designer and supplier of lightweight automotive body structures supplying components such as body, door, window, tailgate, bumper and space-frame systems to more than 10 million cars per year across 100 different car models.

In September 2002, AMC signed a new \$6 million three year alliance with the world-recognised Cooperative Research Centre for Cast Metals manufacturing (CAST) in support of new research into magnesium alloys and casting techniques.

In early 2003, Newmont Mining Corporation increased its interest in AMC from 22.8% to 40.9% and AMC finalised a \$100 million subordinated loan and fixed interest rate hedging facility with ANZ Banking Corp supported by a guarantee from the Australia Government.

In June 2003, AMC suspended the construction of the plant following unsuccessful attempts to attract a new corporate partner for the project and to contain the escalating project costs (which had reached \$1.7 billion compared to the original estimate of \$1.4 billion).

Magnesium International Limited (formerly Pima Mining NL) has completed its Bankable Feasibility Study for the SAMAG Magnesium Project at Port Pirie, South Australia. However, the financing stage of the project has been deferred until the second quarter 2003, because the company had not secured any major strategic investor/partner for the project. The company has signed a

15 year power supply contract with NRG Flinders, which included a 170 MW nominal/190 MW peak load supply agreement with a 2% power interruptability factor at the request of NRG Flinders.

In February 2003, Magnesium International Limited announced that following a review of the project costs, it had been able to reduce its proposed cash operating costs from US\$0.59 a pound to US\$0.57 a pound. The company has also decided to construct its proposed 84 ktpa magnesium/alloy plant in modules, commencing with a first module of 41 ktpa. Subsequently, several prospective companies have expressed an interest in becoming joint venture partners in the project.

In 2002, New World Alloy Ltd (formerly Mt Grace Resources NL) abandoned its plans to build a 12 500 t magnesium smelter plant based on the Winchester magnesite deposit, 85 km south of Darwin, Northern Territory. The abandonment of the project was brought about by uncertainties in obtaining competitively priced long-term gas supplies. In December, the company signed an option agreement to purchase the thermic magnesium production plant of Northwest Alloy's (Alcoa) Addy, USA for US\$20 million. New World Alloy Ltd planned to move this plant rebuild and upgrade it in Perak State, Malaysia with the aim to begin magnesium metal production by the end of 2004. However, in April 2003, the company was unable to obtain funding to exercise its option to purchase the Alcoa plant.

Latrobe Magnesium Limited (formerly Rambora Technologies Limited) completed its pre-feasibility study on a proposed 100 ktpa magnesium metal plant, based on brown coal fly ash tailings produced by power generators in the Latrobe Valley in Victoria at 70.5 cents a pound. The company began negotiations with several power stations to acquire their fly ash resource. The project requires about 1.2 Mt of fly ash annually to produce 100 ktpa of magnesium metal. In December, Latrobe secured two \$1.4 million grants from the Australian and Victorian governments to assist financing a bankable feasibility study, which was anticipated to cost \$20 million.

## Manganese Ore

Manganese is the 12th most abundant element in the earth's crust and the fourth most used metal in terms of tonnage – after iron, aluminium and copper. Around 90% of manganese consumed worldwide is used in iron and steel production, where it desulphurises, prevents oxidation and acts as an alloying element to improve toughness and hardness. There are no satisfactory substitutes for manganese in the manufacture of steel products. Other uses of manganese include battery production, electronics, fertilisers, animal feed and as a colorant.

Australia has two operating manganese ore mines. The largest is Groote Eylandt, which is in the Gulf of Carpentaria (NT). The other is Woodie Woodie in the East Pilbara district of Western Australia, 400 km east of Port Hedland.

Manganese ore processing plants are located at Bell Bay in Tasmania where TEMCO operate the only ferroalloy plant in Australia to produce 120 000 tonnes of ferromanganese and 110 000 tonnes of silicomanganese per annum. TEMCO also produces and sells manganese sinter. At Newcastle in New South Wales, Delta plc produces about 25 000 tpa of Electrolytic Manganese Dioxide (EMD) for use in alkaline dry cell batteries. At Risdon in Tasmania, Hydromet Corporation Ltd is developing a manganese dioxide recovery process that filters manganese mud from waste at the Pasminco zinc smelter.

### Resources

Australia's EDR of manganese ore increased by 1.5% to 126.8 Mt in 2002. A decrease in EDR at Groote Eylandt due to production losses was more than offset by an increase at Woodie Woodie due largely to a successful exploration program.

Both paramarginal demonstrated resources (23.1 Mt) and submarginal demonstrated resources (167.0 Mt) remained unchanged. Inferred resources also remained unchanged at 197.5 Mt.

### Accessible EDR

All manganese ore EDR (126.8 Mt) is accessible.

The resource life is about 30 years on current rates of production of beneficiated manganese ore.

### JORC Reserves

Manganese ore JORC reserves are 85.7 Mt (68% of accessible EDR). The resource life based on JORC reserves and rate of production of beneficiated manganese ore is 20 years.

### Exploration Expenditure

Data relating to exploration expenditure for manganese are not published by ABS on either a state or national basis. However, at the Woodie Woodie project Consolidated Minerals Pty Ltd spent \$2.85 million on exploration activities (from 2002 ASX Quarterly Reports). The company has allocated a \$5 million exploration budget for 2002-03, after a successful 2001 field season, which yielded 1 tonne of resource for every \$1.65 spent on exploration.

During 2002, Consolidated Minerals undertook exploration activities on the Woodie Woodie leases, which cover an area of some 1 300 km<sup>2</sup>. Exploration techniques employed included electromagnetic, gravity and magnetic surveys, geological mapping and interpretation and reverse circulation drilling (424 holes totalling 23 660 m). Exploration resulted in the identification of an additional 3.0 Mt of resources and 19 significant discoveries including Chris D and Camp East. The company is also exploring at other sites, including:

- Balfour Downs (WA) – bulk sampling of alluvial scree.
- Balfour South (WA) – geological mapping undertaken.
- Sunday Hills (WA) – a Joint Venture with HiTec Energy Ltd, which has identified potential for manganese ore grade mineralisation over a 1.3 km strike length.
- Pearana (WA) – airborne electromagnetic survey.
- Pernatty (SA) – a letter of intent with Gunson Resource Ltd; a gravity survey was completed in June 2002.

Quantum Resources Ltd has agreed to sell its interest in 644 km<sup>2</sup> of ground along strike from the Woodie Woodie mine to Consolidated Minerals, while retaining a production royalty on any future manganese production.

The Groote Eylandt Mining Company (GEMCO) is exploring to the east of the mine in the general area of the Eastern deposit in an effort to increase the mine life. GEMCO is also exploring at other sites, including:

- At Bootu Creek, 130 km north of Tennant Creek in the Northern Territory, GEMCO has already drilled out a 10.5 Mt inferred resource giving a potential 10 year mine life. To earn a 25% interest GEMCO plans to spend a further \$2.3 million exploring the Bootu Creek resources in a bid to develop a new manganese mine. Oriental Mineral Holdings have a controlling stake in the project through a 60% owned subsidiary known as Bootu Creek Resources.
- In late 2002 GEMCO spent \$0.7 million on a drilling program at the Renner Springs tenements north west of Bootu Creek. The program consisted of 208 holes totalling 10 419 m.

Elkedra Diamonds NL has identified potential for manganese at its diamond project located 300 km north east of Alice Springs in the Northern Territory, where drilling results at Lucy Creek have given encouragement to the regional manganese potential in the Altjavarra Craton.

### Production

In 2002, production of manganese ore at Groote Eylandt was 1.65 Mt and at Woodie Woodie 0.54 Mt. ABARE reported that Australia produced 2.2 Mt of manganese ore with a manganese content of 1.0 Mt. Exports for 2002 totalled 1.8 Mt, valued at \$290 million.

## World Ranking

Australia has 7% of the world EDR of manganese ore and is ranked fourth behind South Africa (46%), Ukraine (24%) and China (12%). In terms of contained manganese Australia has 9% of the world EDR and is ranked third behind South Africa (53%) and Ukraine (21%).

Australia produces 11% of the world's manganese ore and is ranked fifth behind Brazil (17%), South Africa (15%), Ukraine (14%) and China (13%).

## Industry Developments

The Groote Elylandt mine covers an area of 84 km<sup>2</sup> on the western side of the island. The operation uses excavators and 145 t dump trucks for overburden removal and ore mining (ore is also uncovered by dozer pre-stripping). Run-of-mine ore is concentrated to produce lump and fine products that are trucked to Milner Port Bay for shipment.

In October 2002 Consolidated Minerals announced an updated resource at Woodie Woodie that should provide a mine life of 10 years. In 2002 the company also spent \$3 million on improvements including upgraded crushing, wet screening and power facilities and ore analysis using XRF commenced. In another development, campaign mining was introduced between Woodie Woodie and Coobina (a wholly-owned chromite mine near Newman, WA). This mining is generally limited to about 55 m depending on water flows and blending from several pits ensures a consistent product. Crushed ore is beneficiated through a heavy media drum and cyclone plant. The product is trucked 400 km by 90 t road trains to Port Hedland for shipping to overseas customers.

HiTec Energy Ltd (HiTec) are planning to build a \$136 million 25 000 tpa EMD plant using a sulphur dioxide leach process located at either Geraldton or Port Hedland. Product testing with alkaline battery manufacturers continued during 2002. In collaboration with Curtin University, Murdoch University and the AJ Parker Centre, HiTec gained a three year grant from the Australian Government to improve the control of crystal formation during the electroplating process. This should enhance the electrical performance of EMD when used in batteries.

## Mineral Sands

The principal components of mineral sands are the titanium-bearing minerals rutile, ilmenite and zircon. Rutile and ilmenite are mainly used in the production of titanium dioxide pigment. A small portion, less than 4% of total titanium mineral production (typically rutile), is used in making titanium sponge metal. Zircon is consumed as an opacifier for glazes on ceramic tiles, in refractories and for the foundry industry.

### Resources

EDR of ilmenite decreased in 2002, from 201.6 Mt in 2001 to 198.2 Mt, a decrease of 1.7%. Despite the overall decrease in resources, ilmenite resources increased in Victoria by 50% and in New South Wales by 29%, a consequence of successful exploration in the Murray Basin by Iluka Resources Limited and BeMax Resources NL. New South Wales and Victoria each have about 5% of the total ilmenite EDR.

Western Australia has Australia's largest ilmenite EDR (63%), which decreased by 6% as a result of production during the review period. In Queensland, which has the second largest EDR (26%), ilmenite resources decreased slightly due to mining loss.

Successful ongoing exploration in the South Australian portion of the Murray Basin resulted in a 36% increase in their ilmenite EDR.

EDR of rutile (which includes leucoxene in WA) increased by 4.7% from 22.5 Mt in 2001 to 23.5 Mt in 2002. The bulk of the increase occurred in the Murray Basin of Victoria (up by 60%), South Australia (up by 30%) and New South Wales (up by 16%). Queensland and Western Australia, which together hold over 70% of Australia's EDR of rutile, had slight decreases in 2002, all due to production.

EDR of zircon decreased marginally from 29.6 Mt in 2001 to 29.5 Mt in 2002, with production outstripping increases in resources. Increase in EDR of zircon occurred in the Murray Basin particularly in Victoria and South Australia (both increased by 33%). In New South Wales, EDR of zircon increased by 4%. Western Australia and Queensland, which together have just over 80% of Australia's EDR of zircon (down from 84% in 2001), had slight decreases in 2002, due to production.

Australia's subeconomic demonstrated resources of ilmenite, rutile and zircon remained unchanged in 2002 at 51 Mt, 12.12 Mt, and 18.95 Mt, respectively. Over 97% of these resources are recorded in the paramarginal category, and are associated with the WIM deposits in the Murray Basin in Victoria. The WIM deposits also contain 14.38 Mt of leucoxene, which was included with rutile resources in 1999.

Inferred resources of ilmenite rose by 8.7% to 107 Mt in 2002. Increases of 26% and 7% in New South Wales' and South Australia's ilmenite resources respectively followed successful ongoing exploration in the Murray Basin. In Western Australia, an increase of 16% in ilmenite resources was the outcome of increased exploration on the Northern Swan Coastal Plain, north of Perth. These increases in resources offset the decreases in Victoria (down by 1.4%) brought about by the upgrading of that State's ilmenite resources to EDR. Victoria is the main holder of the inferred ilmenite resources with 37% of the Australian total. New South Wales (26%) has the second largest holdings of inferred resources followed by Western Australia (18%). Inferred ilmenite resources in Queensland, with 11% of Australia's total, remained essentially unchanged in 2002.

Inferred resources of rutile rose by 8% with increases occurring in all States except Tasmania. Victoria is the main holder of inferred rutile resources with 50% of the Australian total, followed by New South Wales (36%) and Western Australia (8%).

Inferred resources of zircon increased by 7% with the bulk of the increases occurring in New South Wales, South Australia and Western Australia. Although its inferred zircon resources remained unchanged from the previous year, Victoria is the main holder of zircon inferred resources with 53% of the Australian total, followed by New South Wales (24%), South Australia (9%) and Western Australia (8%).

### Accessible EDR

Some 18%, 24% and 28% (compared with 18%, 25% and 27% in 2001) of Australia's total EDR of ilmenite, rutile and zircon, respectively, are unavailable for mining. These resources are in areas that are quarantined from mining and now largely incorporated into national parks. They include Moreton Island, Bribie Island and Fraser Island; Cooloola sand mass north of Noosa; Byfield sand mass and Shoalwater Bay area in Queensland; and Yuraygir, Bundjalung, Hat Head and Myall Lakes National Parks in New South Wales. At Australia's 2002 rate of mining, its AEDR of ilmenite, rutile and zircon are sufficient for over 80, 90 and 50 years of production respectively.

### JORC Reserves

Over 15% of ilmenite, 19% rutile and about 25% zircon of AEDR comprise JORC Code reserve. The remaining represents resources assessed by Geoscience Australia from the measured and indicated categories of industry reported mineral resources, as defined under the Code and other classification systems used by non-listed ASX companies. Reserve lives are 13 (ilmenite), 16 (rutile), and 13 (zircon) years, at current production.

### Exploration

According to quarterly ABS figures, expenditure on exploration for mineral sands in 2002 was estimated at \$30.7 million. This represents an increase of about 5% over the previous year. Comprehensive State-by-State data are not published by ABS, however, it is likely that most of the expenditure was in the Murray Basin, which has an extensive coverage of exploration leases.



## Production

In 2002, Australia produced 1.92 Mt of ilmenite, 218 000 t of rutile, 39 000 t of leucoxene and 408 000 t of zircon (compared with 2.02 Mt of ilmenite, 206 000 t of rutile, 30 000 t of leucoxene and 394 000 t of zircon in 2001). The bulk of Australia's rutile and zircon production is exported, compared with about 51% for ilmenite. The remaining ilmenite is upgraded to synthetic rutile, which contains about 92-94% TiO<sub>2</sub>.

## World Ranking

According to Geoscience Australia and USGS data, Australia has the world's largest EDR of ilmenite, rutile and zircon with 32%, 47%, and 41%, respectively. Other major country rankings include South Africa (15%) and Norway (10%) for ilmenite; South Africa (16%) and India (13%) for rutile; and South Africa (30%) and Ukraine (8%) for zircon.

In 2002, world production of ilmenite decreased by 3% to 8.38 Mt, while rutile increased by about 0.5% to 407 kt and zircon increased by 2.7% to 918 kt. Australia accounts for about 23%, 54% and 44% of world production of ilmenite, rutile and zircon, respectively. Australia is the world's leading producer of all three minerals as well as the largest exporter. South Africa (from dune sands) and Canada (from hard rock) mine similar quantities of ilmenite to Australia, however, both countries upgrade the ilmenite to titanium slag, which contains between 75 and 94% TiO<sub>2</sub>, prior to export.

## Industry Developments

The coarse-grained strandlines in the Murray Basin in New South Wales, Victoria and South Australia continued to be the centre of exploration activity. Global resources of the basin have increased to about 100 Mt of heavy minerals as new strandlines are discovered.

Southern Titanium NL has expanded the scope of its definitive feasibility studies on the Mindarie project, 120 km north of Adelaide (SA), to incorporate the major Derrick strandline near Loxton. The project's ore reserves total 44.71 Mt grading 4.15% heavy minerals (HM) for a contained 1.86 Mt HM. The project is scheduled to commence in late 2004 at a potential annual production of 17 600 t of rutile, 43 700 t of zircon, 14 800 t of leucoxene and 76 600 t of ilmenite. The company has signed an off-take agreement with DCM DECOMetal International Trading GmbH (DCM) for the sale and purchase of 100% of planned output. DCM will also have responsibility for all logistics including transportation to ports, warehousing, and ship-loading of the mineral products, conveyance, as well as marketing.

In New South Wales, in a bid to encourage the development of the mineral sands industry in the Murray Basin, the State Government has indirectly reduced royalties to 3% by allowing mineral sands operators to take into account expenses incurred in concentrating and separating heavy minerals.

BeMax Resources NL (BeMax) has completed its definitive feasibility study and received all approvals from the New South Wales Government for the development of the Ginkgo deposit, near Pooncarie. Subject to project financing, construction is scheduled to start in late 2003, with the first product to market planned for late 2004. The operation is expected to produce 450 000 t a year of HM concentrates over a 25-year mine life with mineral separation taking place at Broken Hill. In late 2002, Sons of Gwalia Ltd sold its 25% interest in the Pooncarie project, containing the Ginkgo and Snapper deposits, resulting in BeMax taking full control of the project.

BeMax has signed an off-take agreement with E. du Pont de Nemours & Co (DuPont) covering the bulk of the secondary ilmenite and leucoxene products from Ginkgo project, as well as granting the company the sole rights for the purchase and resale of Ginkgo's premium-grade zircon product.

In November 2002, BeMax concluded an off-take contract, and a \$30 million debt funding and The contract covered the sale of a significant proportion of the annual rutile production from the Pooncarie project to Cristal.

The resources at BeMax's Snapper deposit, 10 km southwest of the Ginkgo deposit, has been upgraded to a measured resource of 99.5 Mt at an average grade of 5.4% HM (at a cut-off grade of 1.0% HM). The mineral suite is estimated at rutile (14%), zircon (7%), leucoxene (46%) and various ilmenite types (14%). The company is carrying out a pre-feasibility study on the deposit. Elsewhere in New South Wales, Mineral Deposits Limited has applied for a new exploration licence covering an area of 11.1 km<sup>2</sup> at Maguires Crossing near Kempsey, where a combined measured and an inferred resource estimate of 26 Mt grading 0.53% HM has been identified. Mining of the deposit at Fullerton near Stockton, north of Newcastle is expected to cease at the end of calendar year 2003. At Viney Creek near Hawks Nest, the company has identified a measured and an inferred resource of 8.1 Mt grading 0.19% HM in the Central Extension orebody, and a measured and inferred resource of 27.3 Mt grading 0.24% HM in the Northern Extension orebody.

In Victoria, Murray Basin Titanium, a joint venture between Sons of Gwalia Ltd and RZM Pty Ltd is considering expanding its Wemen operation to include the Ouyen project (Vic) and the Prungle project, (NSW).

Elsewhere in the Murray Basin, Iluka Resources Limited has discovered three new deposits, the Boulka deposit in the Ouyen area (Vic), Snapper deposit 120 km north of Mildura, and the Dispersion deposit about 70 km east of Mildura (NSW). The company's resources of heavy minerals in the Murray Basin have increased from 10.9 Mt to 14 Mt. Following further exploration, BeMax Resources NL announced that the resources at its Goliath prospect near the New South Wales/Victoria border total 65.5 Mt grading 3.0% HM.

In Western Australia, Doral Mineral Sands Pty Ltd has commenced mining at Dardanup, 15 km east of Bunbury, at an annual rate of 120 kt of titanium minerals and 10 kt of zircon. The project which is expected to have a nine-year mine life was purchased from ISK Minerals Ltd.

Magnetic Minerals Ltd has increased its resources at the Dongara project, 35 km north of the Eneabba mine (WA) to 133 Mt grading 4.8% HM. Drilling has confirmed the Hebe strandline has a combined zircon and rutile content of about 35% in the heavy mineral suite whereas in the Hebe South strandline the combined zircon and rutile content averages more than 40%.

Ticor Limited has made an off-market takeover bid for all the shares and options in Magnetic Minerals Limited based on the Dongara project. The takeover offer values the Dongara project at approximately \$22.6 million.

Gunson Resources Limited commenced bulk sampling of its Amy zone in the Coburn mineral sand deposit south of Shark Bay (WA) as part of its preliminary feasibility study of this deposit. Inferred resources for the deposit total 516 Mt grading 1.4 % HM, and contain on average 23% zircon, 6% rutile and 60% ilmenite-leucoxene. Drill intersections of 18 m at 2.0% HM, 16 m at 2.2% HM, and 19 m at 1.9% HM have been recorded.

Plans by Cable Sands (WA) Pty Ltd to develop the Jangardup South deposit, 45 km east of Augusta (WA), were boosted when a Native Title agreement was signed following two years of negotiations with the Boorjarah people.

Rio Tinto Limited and Iluka Resources Limited have ended litigation, which started in 1994 relating to patent ownership of a technology used in the mineral sands industry. Under the agreement, the patent for the synthetic rutile enhancement process will be jointly owned by Iluka Resources Limited and Rio Tinto Limited, with the latter company to receive a US\$15 million payment from Iluka Resources Limited.

## Nickel

More than 80% of the world nickel production is used in alloys. When alloyed with other elements, nickel imparts toughness, strength, resistance to corrosion, and various other electrical, magnetic and heat resistant properties. About 65% of the world nickel output is consumed in the manufacture of stainless steel, which is widely used in the chemical industry, consumer products (eg, sinks, cooking utensils and cutlery), motor vehicles and construction.

### Resources

Total identified resources of nickel fell by 2.28 Mt (5%) in 2002 to 43 Mt. The bulk of the decrease occurred in Western Australia and New South Wales.

EDR increased by 1.6% in 2002 from 21.85 Mt to a record 22.2 Mt, representing 52% of total identified resources. The majority of the increase occurred in Western Australia and mainly reflected industry reassessments of resources at existing deposits. Of this amount, about 23% occurred in sulphide ores and the remaining was associated with laterites.

Western Australia remains the largest holder of nickel resources with 90% of total Australian EDR (unchanged from 2001). EDR at the operating sulphide mines of WMC Resources Ltd's Kambalda and Leinster, Titan Resources NL's Radio Hill, MPI Mines Ltd's Silver Swan, Jubilee Mines NL's Cosmos and Mincor Resources NL's Miitel decreased reflecting depletion of resources through production. Ongoing exploration in the vicinity of Mount Keith, RAV8 and Wannaway mines offset resources lost through mining, resulting in additional EDR at these sites. Successful exploration by Titan Resources NL in its North Widgiemooltha tenements near Kalgoorlie, by Sally Malay Mining Ltd at the Sally Malay deposit and by Thundelarra Exploration Ltd at the Copernicus prospect, both in the East Kimberley (WA) increased EDR overall.

New South Wales has the next largest EDR, with 7% of the total. Here, EDR fell by 22% reflecting industry reassessments of resources at Young and Syerston.

There was no change in EDR in the laterite deposits near Marlborough, west of Rockhampton (Qld). In Tasmania, EDR increased two and half fold due to successful exploration by Allegiance Mining NL at their North Avebury deposit, 7 km west of Zeehan.

Subeconomic demonstrated resources, which account for about 10% of total identified resources, decreased by 20 000 t during the review period. Paramarginal resources, which are dominated by Western Australia, decreased by 53 000 t due to a combination of production loss and the upgrading of some resources, especially sulphide resources to EDR. The submarginal resources increased by 33 000 t in 2002 following the reclassification of some laterite resources. Western Australia has over 80% of the submarginal resources.

Inferred resources, which account for 38% of the total identified resources (down from 42% in 2001), decreased by 12% to 16.5 Mt in 2001. The bulk of the decreases occurred in Western Australia and Queensland. Although industry drilling has upgraded some resources to EDR especially in Western Australia, the status of some undeveloped deposits has been downgraded, especially where initial resource estimates were considered very preliminary. However, despite the decrease in Western Australia, that State maintained its dominant share of Australia's inferred resources at 88% followed by Queensland with 9%.

### Accessible EDR

Currently, all nickel EDR is accessible for mining.

At Australia's 2002 rate of production, AEDR of nickel are sufficient for an average of 105 years.

## JORC Reserves

About 42% of AEDR comprise JORC Code reserves. Of this, about 64% is in nickel sulphide deposits and the remaining in nickeliferous laterite deposits. The remaining 58% of EDR represents resources assessed by Geoscience Australia from the measured and indicated categories of industry reported mineral resources, as defined under the Code and other classification systems used by non-listed ASX companies.

JORC Code reserves are adequate for 44 years at current production levels, nickel sulphide deposits (19 years) and nickeliferous laterite deposits (176 years).

## Exploration

Spending on nickel (including cobalt) exploration for 2002 totalled \$54.7 million, \$5.5 million less than in 2001. The decrease is reflected in the rate of growth in nickel resource inventory, which has slowed considerably compared with rapid growth in the latter part of the 1990s. Over 80% of exploration expenditure occurred in Western Australia. The decrease in expenditure is on par with the decline in exploration expenditure worldwide.

The ratio of inferred resources to EDR decreased from 1: 0.9 in 2001 to 1: 0.7 in 2002.

Throughout 2002, nickel exploration continued to focus on the mafic-ultramafic Giles Complex in Western Australia and South Australia and komatiite-hosted nickel sulphide deposits in the Yilgarn Craton, Western Australia. The East Kimberley region in northern Western Australia also attracted much interest. Some of the more interesting exploration results in 2002 include the following.

- Acclaim Exploration NL has increased the nickel oxide resource at its Wingellina project, near the Western Australia-South Australia-Northern Territory border, to 227 Mt grading 1% Ni at a cut-off grade of 0.5% Ni. Significant drill intersections include 61 m grading 1.6% Ni, 18 m grading 1.5% Ni, and 108 m grading 1.1% Ni. Widespread disseminated nickel sulphide mineralisation, as pentlandite associated with chalcopyrite and pyrrhotite, has been intersected at depth at Wingellina.
- LionOre Mining International Limited and Dalrymple Resources NL discovered a high-grade nickel sulphide deposit at Waterloo, 6 km from Thunderbox (WA). Significant drill intersections include 10.68 m at 4.83% Ni and 0.4% Cu, 19.05 m at 5.09% Ni, and 5.82 m at 7.68% Ni and 0.81% Cu, 7.35 m at 10.07% Ni, 2.57 m at 8.6% Ni, and 2.83 m at 7% Ni. Significant platinum group metals (PGMs) have also been identified including 19.05 m at 2.12 g/t PGMs, 10.68 m at 1.70 g/t PGMs, and 13 m at 1.91 g/t PGMs.
- The Wildara Joint Venture (Dalrymple Resources NL and LionOre Mining International Limited) delineated massive and stringer nickel sulphides over 250 m in strike length and at a depth of 90-100 vertical metres from surface at the Amorac deposit, 1 km south of the Waterloo deposit (WA). Significant intersections include 6 m at 3.03% Ni, 5 m at 3.4% Ni and 0.1% Cu, and 6.32 m at 3.54% Ni and 0.08% Cu (including 2.7 m at 6.6% Ni and 0.1% Cu). PGMs were recorded in most holes drilled on the deposit.
- Mincor Resources NL intersected high-grade mineralisation at North Miitel near Kambalda (WA), including 1.37 m at 5.45% Ni, 15.9 m at 2.66% Ni, 4 m at 4.19% Ni, and 3.74 m at 5.99% Ni. Subsequently, Mincor intersected 9.7 m grading 3.84% Ni from 611 m down hole, and 11.25 m at 3.36% Ni from 440 m down hole, about 150 m north of the previous known extent of the mineralisation, thereby extending the strike length of mineralisation from 300 m to 450 m. Initial resource estimates, at a 2% Ni cut-off grade, for the North Miitel deposit were reported by the company as an indicated resource of 190 100 t grading 3.9% Ni and an inferred resource of 62 700 t grading 3.8% Ni.
- Deep drilling by Tectonic Resources NL below the base of the planned underground workings at its RAV 8 mine, east of Ravensthorpe (WA), intersected several high-grade intersections including 4 m at 7.7% Ni, 2 m at 4.0% Ni, and 1 m at 6.4% Ni. This is the down plunge extent of the North East Orebody, and possibly, the main RAV 8 deposit. The company has also reported that the RAV 8 resource now totals 76 576 t grading 6.58% Ni with reserves of 53 631 t grading 3.96% Ni.

- Titan Resources NL announced significant nickel intersections at its Widgiemooltha North prospect, 80 km south of Kalgoorlie (WA), including 2 m at 8.9% Ni and 9 m at 2.54 % Ni. The company also identified new mineralisation at its Carr Boyd prospect where intersections of 33.4 m at 1.82% Ni and 0.86% Cu, and 0.5 m at 2.49% Ni and 0.28% Cu were recorded.
- Titan Resources NL have reassessed the resources in the four known ore shoots within the old Carr Boyd Rocks mining area, 70 km north of Kalgoorlie. The new resources comprises a measured and indicated resource of 815 700 t grading 1.11% Ni, with some 200 000 t of this total located less than 100 m below the surface.
- Heron Resources Limited continued its pre-feasibility study of its Goongarrie nickel project, 80 km north-northwest of Kalgoorlie. Further drilling yielded significant intersections including 29 m at 1.41% Ni and 0.069% Co, 16 m at 1.52% Ni and 0.207% Co at the Goongarrie South prospect, and 18 m at 1.33% Ni and 0.032% Co at the Goongarrie Hill prospect.
- Western Areas NL intersected zones of high-grade massive nickel sulphide associated with two EM anomalies at its Daybreak deposit (formerly the Footwall Zone at the New Morning deposit), in the Forrestania greenstone belt, 150 km north of Ravensthorpe (WA). Intersections included 5.9 m at 3.6% Ni including 1 m intervals to 4.9% Ni, and 1.7 m at 4.1% Ni. Another drill hole intersected 3.6 m at 4.9% Ni, including 1.4 m at 5.5% Ni.
- Thundelarra Exploration Ltd intersected significant nickel-copper mineralisation at its Copernicus prospect in its East Kimberley project, south of Kununurra (WA); intersections include 15 m at 1.9% Ni and 1.28% Cu, and 8 m at 1.32% Ni and 0.68% Cu. Other intersections are 27 m at 1.35% Ni and 0.53% Cu, 6 m at 1.83% Ni and 0.71% Cu, and 8 m at 1.91% Ni and 0.81% Cu.
- Drilling by Allegiance Mining NL intersected a 1.3 m grading 8.15% Ni about 30 m to the north of the South Avebury North Lens zone, and 23 m at 1.6% Ni, east of the Avebury deposit, Tasmania. Other intersections include 38.8 m at 1.28% Ni including a 10 m estimated true width section at 2.05% Ni. The company is investigating the option of constructing a decline down to the orebody against further drilling from the surface to determine the extent of the resource.
- Allegiance Mining NL intersected nickel in the range 1.1-1.5% as well as zinc in the range 0.2-0.4% at its Burbank project, 4 km west of the Avebury deposit, Tasmania.
- Further exploration at its Kalpini laterite project, 65 km north east of Kalgoorlie, by Heron Resources Limited yielded significant intersections including 13 m at 1.84% Ni and 0.14% Co, 15 m at 1.44% Ni and 0.1% Co at the Acra North prospect. At the Acra prospect, intersections at a cut-off grade of 0.5% Ni include 21 m at 0.53% Ni, 18 m at 0.63% Ni, and 0.27 m at 4.36% Ni were recorded.
- Jubilee Mines NL has formed a joint venture agreement with the Randles Find syndicate to undertake nickel exploration on its tenement, 100 km south of Jubilee's Cosmos mine. Results from previous diamond drilling have included 0.75 m at 5.65% Ni and 0.45% Cu with 0.65 m at 3.8g/t combined platinum and palladium.
- Drilling by Valdera Resources Limited at its Bow River nickel-copper prospect in Western Australia's East Kimberley region confirmed the presence of large-scale but low-grade mineralisation. Sulphide zones composed of disseminated, stringer and massive mineralisation were predominantly pyrrhotite and chalcopyrite. Intersections reported were 12 m at 0.45% Cu and 0.12% Ni, and 8 m at 0.52% Cu and 0.37% Ni. Earlier exploration reported 3.12 m at 1.45% Ni and 0.41% Cu, and 16 m at 0.3% Ni and 0.69% Cu.
- Independence Gold NL drilling at Gibb South deposit near Kambalda (WA) have reported intersections of 7.1 m at 12.1% Ni, and 4.7 m at 9.3% Ni.

### Production

Preliminary data from ABARE indicates that Australia's nickel production increased in 2002 by 2.4% to 211 kt, all from Western Australia.



## World Ranking

Based on figures published by the USGS and modified to incorporate the Australian resources reported here, world EDR of nickel increased by 2% to 61.2 Mt in 2002 (59.9 Mt in 2001). Australia's share of world EDR decreased slightly to 36.3% (36.5% in 2001), and it remained the largest holder of EDR followed by Russia (11%), Canada and Cuba (each 9%).

Australia produced about 15.6% of estimated world nickel output of 1.35 Mt. Russia was again the largest producer with 328 kt (24%), followed by Australia with 211 kt (15.6%) and Canada with 188 kt (14%). The fourth largest producer was Indonesia with an output of 105 kt (8%).

## Industry Developments

World demand for nickel improved by about 6.4% to slightly over 1.17 Mt in 2002 with global stainless-steel production increasing by more than 7%. Refined nickel production increased by 1.7% to 1.18 Mt leaving the global nickel market with a small surplus. The average LME (London Metal Exchange) settlement price for nickel in 2002 was US\$6772/t.

Australia has eleven nickel sulphide mines currently in operation: WMC Resources Ltd's Kambalda, Leinster and Mount Keith, MPI Mines Ltd's Silver Swan, Titan Resources NL's Radio Hill, Tectonic Resources NL's RAV8, Jubilee Mines NL's Cosmos, Mincor Resources NL's Miitel and Wannaway, LionOre International Mining Limited's Emily Ann, and the Independence Gold NL's Long-Victor. The Long-Victor mine commenced production in the December quarter of 2002. Three laterite nickel mines were in operation: Preston Resources' Bulong, OM Group's Cawse, Anaconda Nickel's Murrin Murrin. All these operating nickel mines are in Western Australia. Australia has one nickel smelter at Kalgoorlie, Western Australia, and two refineries, one at Yabulu, Queensland and the other at Kwinana, Western Australia.

During 2002, total nickel-in-concentrates production by WMC Resources Ltd increased by 1.8% over the previous year reflecting the increased output from the independent operations of the divested Kambalda nickel mines. Nickel-in-concentrates production totalled 43 192 t at Mount Keith, 9.9% lower than 2001, and 40 006 t at Leinster, 5.3% higher than in 2001. The Kambalda concentrator produced 23 225 t of nickel-in-concentrates of which 20 925 t of feed were purchased from third parties and 2300 t were sourced from mines owned and operated by WMC Resources Ltd.

In February 2002, a fire in the sulphuric acid plant at Kalgoorlie smelter destroyed one of the four banks of mist precipitators that removes fine acid-mist particles from the smelter's off-gas stream. The acid plant recommenced in March with the smelter operating at 95% capacity. The smelter returned to full production capacity in September. Production of nickel-in-matte in 2002 was 91 574 t.

Refined metal production at Kwinana nickel refinery reached a record level of 65 055 t, 6.1% higher than 2001, following the completion of its recent expansion program.

Australian Mines Limited acquired the Blair nickel mine from Blair Nickel Mine PL, a wholly owned subsidiary of McMahoys Holdings. Australian Mines Limited plans to commence mining by the end of 2003 subject to confirmation of underground mining reserves, the conclusion of an off-take agreement and receipt of statutory approvals

A feasibility study on the Sally Malay nickel sulphide deposit (105 km northeast of Halls Creek, Western Australia) was completed by Sally Malay Mining Ltd. The project will commence as an open-cut operation and proceed later to underground mining. The ore will be treated using conventional technology to produce a bulk Ni-Cu-Co concentrate, which will be exported through Wyndham to be treated at the Jinchuan Group Ltd smelter-refinery complex in China. The Sally Malay Mining Ltd expects the mine to produce 344 500 t of bulk concentrate containing 45 600 t of nickel, 21 750 t of copper, and 2250 t of cobalt over a 5.5 year mine life, with plant commissioning to commence in late 2003.

Independence Gold NL has purchased the Long and Victor nickel mine complex and the associated assets, near Kambalda, Western Australia from WMC Resources Ltd. Mining of the Long mine commenced in October with the ore toll-treated at WMC Resources Ltd's Kalgoorlie concentrator.

Fox Resources Ltd has acquired the Radio Hill nickel operation, Western Australia from Titan Resources NL, and plans to commence mining in first quarter 2003 at a production rate of about 200 ktpa of ore grading about 1.5% Ni and 1% Cu plus cobalt. Fox Resources Ltd will use a conventional heap-leaching operation to treat the remaining sulphide ores. Titan Resources NL closed the Radio Hill mine in early 2002.

LionOre Australia NL has decided to develop the Maggie Hays nickel deposit, 110 km west of Norseman, Western Australia. The existing concentrator at its Emily Ann mine, 3 km north of Maggie Hay, will be expanded from 250 ktpa to 500 ktpa throughput capacity. Nickel concentrates from Maggie Hays will be sold to Inco Limited of Canada under the life-of-mine off-take agreement negotiated for Emily Ann concentrates. The integrated development of Maggie Hays and Emily Ann will substantially increase nickel production to between 10 000 and 12 000 t of payable nickel per year in the short to medium term.

In mid 2002, a consortium comprising MPI Mines Pty Ltd (80%) and the OM Group (20%) acquired the Black Swan (45 km northeast of Kalgoorlie) and Honeymoon Well (37 km southeast of Wiluna) nickel sulphides projects from the Finnish company Outokumpu Oy.

BHP Billiton completed a feasibility study on the Ravensthorpe nickel laterite project, 16 km east of Ravensthorpe, Western Australia. The company was waiting confirmation on a new low-pressure leach technology that could economically extract nickel and cobalt from the laterite.

Western Areas NL is to make a final decision on the development of a 250-300 ktpa mining and processing operation producing 7000 t annually of contained nickel-in-concentrate by mid-2003 after a scoping study has been completed. The proposed operation will be based on the Daybreak/New Morning North shoot and the former Digger South mine.

Jubilee Mines NL will commence production from its Cosmos Deep orebody via the Ilias decline in mid-2003. Production will be at an annual throughput of 150 ktpa of ore producing 50 000 t of nickel-in-concentrate containing 10 000 t of nickel for a mine life of three and half years.

Allegiance Mining NL is planning to develop its Avebury project via a 800 m long underground decline accessing the relatively shallow higher grade portion of the Viking deposit (formerly called South Avebury). Production from this mine will be at annual throughput of 300 ktpa over an initial period of two-to-three years, to produce about 5000 t annually of nickel-in-concentrate. The company is investigating the option of toll-treating the ore at Western Metals Ltd's Hellyer plant, 90 km away.

Australia's three laterite facilities (Bulong, Murrin Murrin and Cawse) continued to experience mixed success throughout 2002, and all were operating well below their production capacity. The Murrin Murrin project produced 30 000 t of nickel in 2002 representing on average 67% of its plant capacity (45 ktpa of nickel). The capacity of the Murrin Murrin's nickel operation was expected to exceed 80% by the end of 2003.

Anaconda Nickel NL has completed preliminary designs for a 30 000 t trial pit and metallurgical test work on Heron Resources Limited's nickel laterite deposit at Goongarrie South.

Construction of the Syerston nickel – cobalt – platinum plant, 400 km north-west of Sydney, NSW, by Black Range Minerals Ltd was placed on hold until there was a marked improvement in the operational performances of the current high pressure acid leach producers in Western Australia. However, in late March 2003, the company was experiencing financial difficulties and had appointed administrators to oversee their operations.

## Niobium

Niobium is known for its ductile and superconductive properties. It is used mostly as an alloying element in steels and in superalloys for jet engine components, rocket subassemblies, and heat-resisting and combustion equipment. Niobium-titanium alloy wire is now the leading commercial superconductor wire for Magnetic Resonance Imaging.

### Resources

Resources occur in association with tantalum in New South Wales and Western Australia.

Australia's EDR of niobium remained steady in 2002 at 29 090 t Nb with a minor decrease at Greenbushes being offset with a minor increase at Mt Deans (WA).

Subeconomic demonstrated resources remained unchanged from last year. Inferred resources also remained stable despite a minor decrease at Greenbushes.

### Exploration

Data relating to exploration for niobium are not available.

### Production

An estimated 300 t of niobium (as published by the USGS), was produced in Australia in 2002 (cf 230 t in 2001). This production is bi-product niobium, which is shipped from the Greenbushes deposit in Western Australia in tantalum products.

### World Resources and Production

The USGS report world EDR as being 4.4 Mt of which Brazil has 4.3 Mt. Canada has the second largest EDR with 0.087 Mt followed by Australia with 0.029 Mt.

World production in 2002, based on USGS estimates, is 25 700 t Nb of which 22 000 t came from Brazil. Canada produced an estimated 3 200 t.

### Industry Developments

No developments for 2002.

## Phosphate

Australia's commercial resources of phosphate are in Queensland (Phosphate Hill, 150 km south of Mt Isa) and on the Indian Ocean Territory of Christmas Island. Phosphate Hill is a world-class rock phosphate resource that is close to surface and easy to access and mine. The rock is ideal for the manufacture of high analysis fertilisers for domestic and international use. The first di-ammonium phosphate (DAP) fertiliser utilising Phosphate Hill ore was produced in late 1999.

Christmas Island is a source of quality rock phosphate, which is exported to the Asia-Pacific and southeast Asian region. Christmas Island rock phosphate products are used widely in the palm oil sector of this region, and sales of higher-grade rock phosphate are made to Australian manufacturers of mono-ammonium phosphate (MAP) fertiliser.

DAP and MAP have different ratios of phosphorous and nitrogen, and have slightly different applications. Both products are generally produced as granules with a diameter of between 2-4 mm. DAP (20% P and 18% N) is used on broad-acre crops such as cereal, legume, fodder, horticultural and row crops, and dairy and newly-established pastures. MAP (22% P and 10% N) assists with early crop growth and enhances phosphorous uptake in broad-acre crops.

## Resources

EDR of phosphate rock remained unchanged in 2002 compared to the previous year. All EDR is sedimentary phosphate rock (phosphorites), with an average grade of about 23-24% P<sub>2</sub>O<sub>5</sub> at Phosphate Hill. There is no publicly available information on Christmas Island's phosphate resources. Geoscience Australia, however, has reasonably detailed knowledge of this deposit and known resources remaining within the existing mining lease on the island.

Most of Australia's demonstrated resources of phosphate occur in the Georgina Basin and are classified as paramarginal. Two deposits, Swan and Emu, occur within carbonatite at Mount Weld, 26 km southeast of Laverton (WA), where a phosphate-rich zone has formed by the solution and weathering of a primary carbonatite.

The bulk of Australia's inferred phosphate resources are in phosphorites in the Georgina Basin, and these are distributed between Queensland, Western Australia and the Northern Territory.

## Accessible EDR

Currently, all phosphate classified as EDR is accessible for mining. Significant resources exist outside the mining lease on Christmas Island but are mostly within the National Park.

## JORC Reserves

JORC Code reserves make up all EDR.

At the end of 2001, WMC announced that its Queensland Fertiliser operations had achieved design capacity. Operating at this level, ore reserves at Phosphate Hill will support production for at least 35 years.

## Exploration

Data relating to exploration for phosphate are not available.

## Production

Australia's total production of fertiliser in 2002 was 821 kt (718.3 kt DAP and 102.7 kt MAP), which came from rock phosphate ore treated at WMC Resources' Queensland fertiliser operations at Phosphate Hill.

## World Ranking

Australia's EDR of phosphate rock comprises less than 1% of the world's total EDR of 17 Gt, which occurs principally as sedimentary marine phosphorites.

## Industry Developments

During 2002, WMC Resources commenced production and sales of MAP. Growth opportunities in 2003 may include expanding fertiliser production to include sulphur-enriched DAP or MAP to meet new market opportunities.

Phosphate Resources Limited (PRL) mined a total of 631 256 dry metric tonnes of phosphate rock and exported 516 570 t of bulk and bagged phosphate during 2001/02. In its Annual Report for 2002, PRL advised of the need for an accelerated mining program. This is necessary in order to be able to surrender areas to allow for the development of new projects on the island. These projects include the airport extension, Nui Nui Port and Linkwater Road upgrade by the Australian Government. The company is negotiating with the Government in regard to phosphate resources surrendered following resumption of land in 2002 for a permanent Immigration and Reception and Processing Centre on the island.

## Shale Oil

Organic-rich shale that yields substantial quantities of oil by heating and distillation is commonly referred to as oil shale. One tonne of oil shale can contain over 200 litres of oil. The organic material in oil shale is kerogen, which can be a precursor to conventional petroleum given appropriate conditions in sedimentary basins.

Australian oil shale deposits of commercial interest are predominantly in a series of narrow and deep extensional-basins near Gladstone and Mackay in central Queensland. These are thick Tertiary lacustrine (lake-formed) deposits that are relatively easy to mine. They contrast with generally harder carbonate-rich oil shales (marls) found elsewhere in the world, which are more difficult to mine and process.

### Resources

All ten of the central Queensland oil shale deposits are held by Southern Pacific Petroleum (SPP), either solely or with joint venture partners. In 2000 SPP systematically reviewed the in-situ mineralisation for these ten oil shale deposits to accord with the JORC Code. The 2002 reserve and resource estimates reported by SPP remain little changed from those reported in 2000.

Australia's shale oil EDR is 4.6 GL (29 million barrels). However, this could increase significantly if the research and development demonstration-scale processing of shale oil advances to a proposed commercial plant at SPP's Stuart deposit near Gladstone. Paramarginal and submarginal demonstrated resources are 202.1 GL (1.3 billion barrels) and 3719 GL (23.4 billion barrels), respectively. The shale tonnage processed to date is insignificant in comparison to the overall resource.

The potentially extractable oil in these oil shales is many times greater than Australia's remaining conventional oil reserves.

### Accessible EDR

All resources are currently accessible.

### JORC Reserves

EDR is the sum of the JORC Code reserves categories and those resources from the measured and indicated categories assessed by Geoscience Australia as likely to be economic. All of the shale oil EDR fell into JORC reserves category in 2002.

### Production

Almost one million barrels of shale oil have now been produced from the Stuart deposit. Oil production at the Stuart demonstration plant for the 2002 calendar year was up 39% to 51.5 million litres (324 000 barrels). By mid-2003, total production since the start of operations had reached 153.4 million litres (965 000 barrels) of oil from 1.556 Mt of oil shale. A new monthly production record of 85 000 barrels was set in June 2003 as part of the longest continuous production run of 96 days.

The Stage 1 design ore grade is 172 litres per tonne at zero moisture (LT0M). The retorting has now been tested with a range of input grades from 152 LT0M in July and August 2002, to 189 LT0M more recently. Recovery rates have been improved from 70% to a current recovery of 87%.

The oil products are Ultra Low Sulphur Naphtha (ULSN) 55-60% and Light Fuel Oil (LFO) 40-45%. ULSN, which can be used to make petrol, diesel and jet fuel, has a sulphur content of less than 1 ppm. To put this into perspective, petrol in Australia currently contains up to 500 ppm sulphur. Regulatory guidelines are in place to reduce sulphur to 150 ppm in petrol by 2005, and to 50 ppm in diesel by 2006.

In July 2002, SPP secured a long term sales contract with Mobil Oil Australia Pty Ltd for all naphtha produced at its Stuart Project, through 2005.



### World Resources and Production

The 2001 survey of energy resources by the World Energy Council reported that Jordan, Australia and Morocco have the largest estimated resources of 'proved oil shale in place'. The same survey also reported that production of oil from shale for 1999 was recorded in Brazil (239 million litres), Estonia (185 million litres) and Australia (6 million litres).

### Industry Developments

Production has progressively increased at the \$350 million Stuart demonstration plant (Stage 1) since trials commenced in August 1999. Production for Calendar 2003 is expected to attain 600 000 bbl (95 million litres), an increase of 85% over 2002 production.

Results from research and development at the Stage 1 plant are being incorporated into the design for a 4:1 commercial scale-up (Stage 2). If Stage 2 proceeds it is expected to cost \$600 million and SPP are actively seeking joint venture partners.

SPP has committed to restricting net greenhouse gas emissions lower than that produced by conventional oil extraction methods over the full cycle of production and end use. SPP's long-term goal is to achieve, through progressive plant expansion, production of 200 000 barrels per day. This would be greater than Bass Strait's current oil production (now in decline) and would deliver a balance of payments benefit to Australia of about \$4 billion annually at current oil prices. Federal Industry Minister, Ian Macfarlane stated 1 July 2002 "This method of extracting oil has the potential to significantly boost Australia's ability to remain self-sufficient for liquid fuels. The Queensland deposits hold about 20 billion barrels of oil equivalent resources while Australia's total known liquid petroleum reserves are less than 4 billion barrels."

## Tantalum

Tantalum is known for its resistance to corrosion and as a good conductor of heat and electricity. The major use for tantalum is in the production of electronic components, mainly tantalum capacitors, for use in automotive electronics, pagers, personal computers, and mobile telephones. Tantalum is also used in surgical instruments and implants because it does not react with body fluids.

After slowing in 2001, demand for tantalum increased in 2002. Australia, through the operations of Sons of Gwalia Ltd, is the world's largest producer of tantalum in the form of tantalum concentrates. The company also has the world's largest stock of tantalum resources, principally in its holdings at Greenbushes and Wodgina (WA).

Tantalum ore stockpile (30 kt capacity) at the Greenbushes mine, Western Australia (Geoscience Australia, Bill McKay)



## Resources

Despite increased production of tantalum pentoxide ( $\text{Ta}_2\text{O}_5$ ), EDR remained steady in 2002 at 39 983 t Ta with a decrease at Greenbushes being offset by increases at Wodgina and Bald Hill. Small levels of resources in the EDR category occur elsewhere in Western Australia and the Northern Territory.

Subeconomic resources remained unchanged from last year with only a slight adjustment in the reassessment of the Greenbushes deposit. Inferred resources also remained stable on last year's estimates.

## Accessible EDR

All resources are currently accessible.

## JORC Reserves

EDR is the sum of the JORC Code reserves categories and those resources from the measured and indicated categories assessed by Geoscience Australia as likely to be economic. All of the EDR fell into JORC reserves category in 2002.

## Exploration

Data relating to exploration for tantalum are not available.

## Production

In 2002 Sons of Gwalia produced 1 232 012 lbs (559 t) of  $\text{Ta}_2\text{O}_5$  from the Greenbushes operation and a further 1 305 615 lbs (592 t) from its Wodgina mine. Haddington International Resources produced 153 294 lbs (70 t) of  $\text{Ta}_2\text{O}_5$  at its Bald Hill deposit while Tantalum Australia completed its first full year of production at Dalgara with 38 263 lbs (17 t)  $\text{Ta}_2\text{O}_5$ .

## World Resources and Production

Based on world estimates published by the USGS and modified by Geoscience Australia to take account of recent discoveries, Australia has over 90% of the world's EDR of tantalum. Canada has the second largest resource base.

World production in 2002, based on USGS estimates modified to account for later Australian data, amounted to 1643 t Ta. Production was dominated by Australia, with 1013 t won in 2002 (about 62% of world output). According to the USGS, other producers of tantalum metal were Brazil (which increased its production to 340 t), Rwanda (90 t), Canada (80 t), Congo (60 t) and Ethiopia (40 t).

## Industry Developments

Sons of Gwalia restructured its tantalum production base with increased output from Wodgina and a reduction from the Greenbushes mine following the deferment of underground development to access high grade ore via a decline. The decline will be reopened when increases in demand for tantalum are sufficient to offset costs of underground production.

Tantalum Australia Ltd, through Boston University, has exclusive world rights to the Solid ion Oxygen Membrane (SOM) process in the fields of tantalum, niobium, tungsten, gallium, yttrium and germanium. To date tantalum has been produced from tantalum oxide feedstock. The next stage will be to test the process with tantalum concentrates.

Increased demand for semiconductors in Europe, Japan and US enabled Australasian Gold Mines NL to make its first delivery of tantalum concentrate to an overseas customer in 2002.

Australasian Gold Mines NL confirmed a major tantalum resource at the Mt Deans Project near Norseman in Western Australia. A feasibility study has been undertaken into establishing an initial 500 000 tonnes per annum operation. This operation will source ore from open pits at Binneringie and Mt Deans utilising the Company's existing milling infrastructure at Norseman.

## Tin

Three tin mines maintained operations during the review period: Ardlethan (NSW), Greenbushes (WA) and Renison Bell (TAS). Renison Bell ceased production in May 2003 as a result of problematic ground conditions with the extraction of high-grade ore and has been placed on care-and-maintenance.

Mining of alluvial tin at Ardlethan increased with the rate of production increasing from around 20 tpa in 2001 to 175 tpa in 2002. Marlborough Resources upgraded their tin reserves and resources, which accounted for a 9% increase in EDR. Greenbushes no longer report reserves and resources of tin, classifying it as a by-product of their tantalum production.

## Uranium

### Resources

Geoscience Australia prepares estimates of Australia's uranium resources within categories defined by the OECD Nuclear Energy Agency (OECD/NEA) and the International Atomic Energy Agency (IAEA) (OECD/NEA & IAEA, 2002). In Table 1, these estimates are reported under corresponding resource categories of the national classification scheme. The resource categories of both schemes are correlated in Table 3.

**TABLE 3: Correlation of resource classification schemes for uranium**

National Scheme	OECD/NEA & IAEA Scheme
Economic Demonstrated Resources	Reasonably Assured Resources (RAR) recoverable at less than US\$40/kg U
Paramarginal Demonstrated Resources	RAR recoverable at US\$40-80/kg U
Submarginal Demonstrated Resources	RAR recoverable at US\$80-130/kg U
Economic Inferred Resources	Estimated Additional Resources Category 1 (EAR-1) recoverable at less than US\$40/kg U
Subeconomic Inferred Resources	EAR-1 recoverable at US\$40-130/kg U

Australia's RAR recoverable at <US\$40/kg U were estimated to be 689 000 t U, an increase of 41 000 t compared to the previous year. This was due to increases during 2002 of ore reserves and mineral resources for the Olympic Dam deposit. Australia's RAR recoverable at <US\$80/kg U were estimated to be 702 000 t U.

Approximately 97% of Australia's total uranium resources in RAR recoverable at <US\$40/kg U are within the following six deposits:

- Olympic Dam (SA), which is the world's largest uranium deposit,
- Ranger, Jabiluka, Koongarra in the Alligator Rivers region (NT),
- Kintyre and Yeelirrie (WA).

### Accessible EDR

Approximately 11% of uranium EDR is inaccessible for mining. Inaccessible resources include those deposits in the Alligator Rivers region where the mining leases are too small to accommodate the proposed mine and water retention ponds. These lease areas cannot be increased because they are surrounded by the Kakadu National Park. It also includes some deposits in Western Australia which are affected by uranium mining policies of the State Government. At Australia's 2002 rate of production, Accessible EDR for uranium is sufficient for approximately 90 years of production.

### JORC Reserves

JORC Code reserves account for approximately 50% of Accessible EDR. The remaining Accessible EDR comprise those measured and indicated resources (reported by mining companies) which Geoscience Australia has assessed as being EDR.

## World Ranking

Australia has the world's largest resources of uranium in RAR recoverable at <US\$40/kg U (equates to EDR), with 44% of world resources in this category (OECD/NEA & IAEA, 2002). Other countries with large resources include Kazakhstan (20%), Canada (18%) and South Africa (8%).

## Exploration

Uranium exploration expenditure in Australia for 2002 was A\$5.34 million, compared with A\$4.80 million in 2001. Expenditure for 2001 was an historic low for uranium exploration in Australia. Exploration was undertaken only in the Northern Territory (NT) and South Australia (SA), the main areas and deposit types targeted being:

- Arnhem Land (NT) – exploration for unconformity-related deposits in Palaeoproterozoic metasediments below a thick cover of Kombolgie Sandstone,
- Frome Embayment (SA) – exploration for sandstone type deposits in Tertiary sediments,
- Stuart Shelf area (SA) – exploration for hematite breccia complex type copper-uranium-gold deposits in hematite-rich breccias.

Uranium exploration expenditure for 2002 includes 10% of total expenditure at the Prominent Hill prospect (SA), the remainder being on copper and gold. In November 2001, Minotaur Resources Ltd announced the discovery of copper-gold mineralisation, which contains uranium and rare-earths in generally low concentrations, in hematite breccias at Prominent Hill. The geological setting, coincident gravity and magnetic anomalies, and style of mineralisation appear broadly similar to the Olympic Dam deposit, approximately 150 km to the southeast.

Exploration drilling continued during 2002, with most holes intersecting significant zones of copper and gold mineralisation. The major intersections also contained between 200 and 300 ppm uranium. Some smaller intersections recorded higher uranium grades.

During 2002, a program of 23 reverse circulation drill holes was completed to test a broad envelope of rocks enclosing the known mineralisation at Prominent Hill. This intersected zones of gold mineralisation, with only minor copper and uranium.

BHP Billiton, the major partner in the Prominent Hill joint venture, announced that it intends to sell its 51% equity in the project. Minotaur Resources is of the opinion that the project has potential to be economic and is examining the feasibility of increasing its equity.

## Production

In 2002, Australia's uranium production was 8083 t U<sub>3</sub>O<sub>8</sub> (6854 t U), the lowest it has been over the last three years, because of production problems at Olympic Dam. Uranium production at Olympic Dam decreased nearly 34% to 2867 t of U<sub>3</sub>O<sub>8</sub> in 2002. Ranger increased production by 6% to 4470 t of U<sub>3</sub>O<sub>8</sub>. Beverley increased production by 37% to 746 t of U<sub>3</sub>O<sub>8</sub>.



Uranium mining operations, Ranger mine No. 3 orebody, Northern Territory (Geoscience Australia, Aden McKay)

## Industry Developments

### *Olympic Dam*

In October 2001, a fire destroyed the solvent extraction plant at Olympic Dam. Rebuilding the new plant is expected to be completed by mid 2003 and it is anticipated that production for 2003 will be about 3600 t  $U_3O_8$ .

An optimisation program to increase nominal production capacity for copper from 200 000 to 235 000 tpa should be completed by the end of 2003. Following the rebuild of the solvent extraction circuit and completion of an optimisation program, it is anticipated that the plant will operate at full capacity of 235 000 t copper and 4500 t  $U_3O_8$  by 2004.

WMC Resources is continuing studies into long-term expansion options for Olympic Dam to produce between 350 000 and 600 000 tpa copper with a commensurate increase in uranium production.

Diamond drilling during 2001 and 2002 intersected ore grade mineralisation outside the currently exploited ore zones. These intersections are adjacent to mining areas in the northern ore zones and also adjacent to unmined resources in the southern part of the orebody. The mineralisation was intersected over a strike length of more than 1 km. The mineralised zone is from 50 to 100 m outside the active mining zones. Intersections range from 60 m averaging greater than 3% Cu, to 12 m averaging greater than 6% Cu. More drilling is required to establish the vertical and strike continuity of the zone, however, the company considers that the intersections are part of an ore zone parallel to the known mineralisation.

### *Ranger*

The higher production from Ranger in 2002 follows commissioning of the second mill circuit in the latter part of the year in order to meet higher sales commitments. Further increases in production are anticipated in 2003.



Radiometric discriminators used to measure the average uranium grade of ore in haul truck, Ranger mine, Northern Territory (Geoscience Australia, Aden McKay)

### *Beverley*

Beverley is Australia's first in-situ leach (ISL) uranium mine. The higher production attained in 2002 reflects the company's objective to ramp up production closer to the project's nominal capacity of 1000 tonnes per annum of  $U_3O_8$ .

During 2002, Heathgate Resources carried out an airborne electromagnetic survey and a program of exploration drilling. Exploration targets were identified after reassessing results from drilling conducted in the region during the late 1960s together with data from the airborne survey. The 2002 drilling was in an area a few kilometres south of the mine.



### *Jabiluka*

As with Ranger, Jabiluka is surrounded by, but is not part of, Kakadu National Park. In view of World Heritage concerns about the impact of Jabiluka's development on the park, Energy Resources of Australia Ltd (ERA) has previously agreed that Jabiluka and the nearby Ranger operation would not be in full operation simultaneously

At its 2003 Annual General Meeting, ERA announced that there would be no further development at Jabiluka without the support of Aboriginal people, and subject to feasibility studies and market conditions.

The project site remains on long-term environmental care. The company has held recent consultations with the traditional Aboriginal owners and supervising authorities on various longer-term options for making the site as benign as possible.

### *Honeymoon*

In late 2001 Southern Cross Resources received Commonwealth and State environmental clearances to develop the Honeymoon ISL uranium project in South Australia. Development, however, is currently on hold pending an improvement in market conditions.

### *Western Australia Legislation*

The Western Australian Government has prohibited the mining of uranium for nuclear purposes from any mining lease granted after June 2002. The policy is to be ratified with a Government Bill, which will amend the Mining Act so as to prohibit the mining and export of uranium for nuclear purposes. The State Development Minister said, "The decision would not interfere with existing rights under the Act, nor where the mining of uranium was incidental to the mining of other minerals and was not extracted for sale". There are no existing uranium mines in Western Australia, but large deposits occur at Kintyre and Yeelirrie. Currently there are no proposals to mine these deposits. Both Kintyre and Yeelirrie are covered by mineral claims and mining leases and it is not clear, at this stage, how this new legislation could affect these.

### *Government inquiries into uranium mining*

The Northern Territory Government commissioned an independent review of the Government's environmental regulation of uranium mining at Ranger and Jabiluka. The report, released in September 2002, concluded that:

- existing Authorisations issued by the Northern Territory Government are more than adequate to ensure the protection of the environment and the health of workers and the public, and
- monitoring and reporting systems of the company are adequate, and occur in a timely manner which achieves their primary purpose of ensuring the company's compliance with these Authorisations.

The South Australian Government commissioned an independent review of the current incident reporting procedures associated with uranium mining and related activities at Olympic Dam, and in situ leach operations at Beverley. The decision for the review followed a series of accidental spills, including uranium-bearing copper concentrate slurry at Olympic Dam in December 2001, and leach fluids at Beverley in January 2002.

The review recommended new regulations for reporting incidents, including releases of radioactive process materials or liquids leading to the accidental exposures of workers to radioactive materials. It also specified the size and nature of spills that must be reported to government.

In June 2002 the Australian Senate agreed to a Senate Committee inquiry into environmental regulation of uranium mining. The Committee is scheduled to submit its report to the Senate in October 2003.

## Vanadium

Vanadium is used in metal alloys with iron to produce high strength steel. Mine production accounts for around 20% of annual world production of vanadium, the majority of world production (approximately 80%) is a by-product from reprocessing of steel slags, oil refining, and the uranium enrichment industry.

### Resources

EDR of vanadium were reclassified during the review period following closure of the Windimurra mine and processing plant (WA), which became unviable. Ore reserves and resources for this deposit, which accounted for more than 97% of Australia's EDR, were reclassified as paramarginal resources (cf EDR 267 kt in 2001). Resources within the Yeelirrie uranium-vanadium deposit were also reassessed by Geoscience Australia to be paramarginal.

### Exploration

There was virtually no exploration for vanadium during the year because of continuing low prices and chronic oversupply in the market. No work was reported on any of the main vanadium projects in either the Yilgarn (Gabanintha) or Pilbara (Balla Balla and Don Well) regions of Western Australia.

### Production

In 2002, Australia produced 5614 t  $V_2O_5$  flake (3144 t V) valued at A\$30.929 million, all of this being from the Windimurra mine in its third year of production. Windimurra was Australia's only vanadium mining operation.

### Industry Developments

Xstrata ceased production at Windimurra in early 2003. Profitability of the operation was strongly affected by two factors: low prices for  $V_2O_5$ , and the United States/Australian dollar exchange rate. Despite increasing demand in recent years, the vanadium market has remained in a situation of oversupply with prices for vanadium pentoxide ( $V_2O_5$ ) and ferrovanadium (FeV), at very low levels for most of the review period. The company is assessing all options including permanent closure of the operations.

## Zinc, Lead, Silver

Zinc is the 23rd most abundant element in the earth's crust. The construction and appliance manufacturing industries use large amounts of zinc, mainly as coatings on steel beams, sheet steel and vehicle panels in the automotive industry. It is also used in alloy die cast products, zinc pigments, zinc salts, zinc oxide as additives to rubber and for zinc chemicals in agriculture, and for wrought or rolled zinc products.

The widespread occurrence, relatively simple extraction, and combination of desirable properties have made lead useful to humans since at least 5000 BC. In deposits mined today, lead (in the form of galena, PbS) is usually associated with zinc, silver and commonly copper, and is extracted as a co-product of these metals. More than half of the lead utilised today comes from recycling, rather than mining. The largest use is in batteries for vehicles and communications. Less important uses include cable sheathing, solder, casting alloys, chemical compounds, ammunition, glass in TV and computer screens for radiation protection, and ceramics. Its use as a petrol additive has declined significantly with the progressive introduction of lead-free petrol worldwide. New uses for lead could be in large storage batteries used for load-levelling of electrical power and in electric vehicles.

The relative scarcity, attractive appearance and malleability of silver has made it suitable for use in jewellery, ornaments and silverware since before ancient Roman times. Its extensive use in coins throughout history has declined over the last forty years. In Australia, the 1966 fifty-cent piece was the last coin in general use to contain silver (80% silver, 20% copper). Silver is mined and produced mainly as a co-product of copper, lead, zinc, and to a lesser extent, gold. Today, photographic paper

and film, followed by the electronics and jewellery/tableware industries are the most important users of silver. Demand for silver as an anti-bacterial agent is likely to double over the next few years as its use increases in water treatment (as an ioniser with copper in domestic swimming pools) and for biocide and bacteriostatic activity in plastic and textiles formulations.

### Resources

Australia's total resources of zinc, lead and silver did not change much in 2002. Total identified resources of zinc decreased slightly (1%) to 79.4 Mt of contained zinc; lead remained steady at 50.7 Mt of contained lead; and silver rose by 1% to 88.2 kt of contained silver. All three commodities experienced minor falls in EDR as a result of reclassification of major deposits. These falls were mostly offset with minor increases that occurred in all other categories.

Australian EDR for zinc fell by 5.6% to 33.3 Mt in 2002. Although Queensland remained pre-eminent, its EDR fell from 19.1 Mt to 17.8 Mt. Its share of the total EDR remained steady at 54%. The fall in EDR resulted mainly from production and the reclassification of resources at Century. These decreases were partially offset with minor increases at Cannington and Balcooma. The Northern Territory at 10.4 Mt again had the second largest EDR and its share of national EDR was 31.1% compared to 29.5% in 2001. New South Wales had the third largest EDR with 3.0 Mt (3.4 Mt in 2001). This decrease was primarily due to the reclassification of the Elura deposit after a decision to adopt a 'no fill' mining system. Western Australia's EDR fell to 1.4 Mt, (1.7 Mt in 2001), mainly due to production depleting Golden Grove and Pillara resources, while Victoria remained unchanged at 0.39 Mt. Tasmania's EDR increased to 0.26 Mt (0.17 Mt in 2001), due to an increase at Rosebery.



Paramarginal demonstrated resources of zinc rose marginally from 8.38 Mt to 8.79 Mt and submarginal demonstrated resources also rose from 16.0 Mt to 16.3 Mt over the year. These global variations are attributed to relatively small changes in most states and the Northern Territory in both categories.

Total inferred zinc resources fell by just under 1% to 21.2 Mt in 2001 following small variations in all States and the Northern Territory.

Total identified lead resources remained steady at 50.7 Mt in 2002. Australia's EDR of lead marginally decreased in 2001 (0.7%) to 17.2 Mt of contained lead and constituted 34% of total identified resources. Queensland retained the premier ranking with 9.1 Mt with 53% of total EDR (51% in 2001), again due to increased resource definition at Cannington and Mt Isa. The Northern Territory remained stable at 5.75 Mt EDR, or 33% of the national total. New South Wales recorded a small drop in EDR from 2.0 Mt in 2001 to 1.8 Mt due to the reclassification of the Elura resource. EDR in Western Australia fell by 0.1 Mt (29%) to 0.5 Mt, this was due to production depleting Pillara resources. Tasmania's EDR rose by 0.02 Mt (27%) to 0.08 Mt due to a minor increase in Rosebery resources.

Australia's paramarginal demonstrated resources of lead are 3.1 Mt, which is 6.1% of total identified resources. Submarginal demonstrated resources totalled 9.4 Mt or 18.5% of total identified resources. The aggregate sub-economic resources were 1% less than in 2001. These global variations are attributed to relatively small changes in most states and the Northern Territory in both categories.

Total inferred lead resources rose by less than 1% to 21 Mt in 2001 following small variations in the States and the Northern Territory.

EDR for silver fell by 3% to 40.2 kt in 2002. Queensland remained pre-eminent and its EDR rose from 28.7 kt to 29.1 kt and its share of the total EDR rose from 69% in 2001 to 73% in 2002, increases at Mt Isa and Cannington offsetting production depleting resources at Century and Hilton. The Northern Territory at 5.1 kt, again had the second largest EDR and its share of national EDR was up marginally to 12.6% compared to 12.2% in 2001. South Australia had the third largest EDR with 2.4 kt (3.6 Mt in 2001), due a small decrease at Olympic Dam and was followed by New South Wales at 2.2 kt (2.6 kt in 2001), due to small decreases at Broken Hill and Elura due to reclassification. Western Australia was next with 0.8 kt (0.9 kt in 2001), followed by Victoria, unchanged at 0.28 kt and Tasmania with 0.26 Mt (0.2 kt in 2001) due to minor increases at Rosebery.

Paramarginal demonstrated resources of silver increased from 9.65 kt to 10.72 kt and submarginal demonstrated resources also increased slightly from 10.9 kt to 12.1 kt over the year. These global variations are attributed to relatively small changes in most states and the Northern Territory in both categories.

Total inferred silver resources had a slight increase to 25.7 kt in 2002 following small variations in some States.

### **Accessible EDR**

All zinc, lead and silver EDR is accessible for mining. On current mine production rates, the estimated life of AEDR is around 20 to 25 years for lead and zinc and 20 years for silver.

### **JORC Reserves**

JORC Code reserves account for over 70% of AEDR for silver and zinc and over 60% of AEDR for lead. The remaining AEDR is comprised of resources assessed by Geoscience Australia from the measured and indicated categories of industry reported mineral resources, as defined under the Code and other classification systems used by non-listed ASX companies. On current mine production rates, the life of JORC reserves is around 15 years for lead and zinc and 14 years for silver.

### **Exploration**

In calendar year 2002 Australian base metal (copper, lead, zinc, silver, nickel and cobalt) exploration spending totalled \$133 million, \$17.9 million less than in 2001. Expenditure on the search for zinc, lead and silver in that period was just over 27% of total base metal expenditure and totalled \$36.1 million. The 2002 spending on zinc, lead and silver was \$10.2 million less than in 2001.

### **Production**

Mine production for zinc, lead and silver were 1.47 Mt, 0.7 Mt and 2.1 kt respectively. These figures represent a slight decrease for zinc (down 0.05 Mt), no change for lead and a slight increase for silver (up .07 kt).

### **World Ranking**

Australia has the world's largest EDR of zinc (17% of the world), lead (25%) and silver (14%).

In terms of production, Australia ranks first for lead, second for zinc after China and third for silver after Mexico and Peru. Cannington is the world's largest and lowest cost silver and lead producer.

## Industry Developments

Pilbara Mines Ltd are examining a feasibility study into the development of the Jaguar Base Metal Project at Teutonic Bore in Western Australia. Initial results confirm scope for Jaguar to develop into an underground mine with drill intersections showing areas of increased thickness of massive sulphide mineralisation (high grade copper/zinc/silver).

During the review period, MIM commenced pilot production using its proprietary Albion Process for atmospheric leaching to produce metal directly from concentrate at the McArthur River mine. The new process has potential to revolutionise MIM's lead-zinc business.

Kagara Zinc Ltd commissioned its \$43 million Mt Garnet Zinc project in early 2003, trucking zinc concentrate to the Sun Metals Refinery in Townsville, 500 km to the southeast. The first stage of the project will initially treat ore from the Mt Garnet pit. From July 2003 ore will be sourced from the high-grade Surveyor deposit (635 000 t at 15.1% zinc), located 120 km south of Mt Garnet.

Consolidated Broken Hill commenced a \$9.5 million mine improvement plan after completing the acquisition of the Elura mine from Pasminco. The plan is designed to increase mine output and operating efficiency with an expectation of doubling mine life to at least 9 years.

Kanowna Lights Ltd, after releasing an amended inferred minerals resource calculation on the Mt Carrington Gold/Silver project in New South Wales, has resolved to withdraw from the project.

Macmin Silver Ltd's reserve/resource assessment of the Twin Hills Silver Project in the Texas District in Queensland, based on the 2002 drilling campaign and previous drill results, has resulted in a significant upgrade of reserves and resources. The reserves for the Phase 1 and 2 Pit of the proposed Twin Hills mine development now total 16.3 Mozs of silver equivalent.

Phelps Dodge entered into a joint venture with Goldsearch to explore for base metals in South Australia's Gawler Craton. The company will spend \$4 million to earn up to 70% equity in an area, which covers 324 km<sup>2</sup> and is located 100 km northwest of Coober Pedy.

Kagara Zinc Ltd acquired the Red Dome tenement package from Niugini Mining. The tenements adjoin Kagara's Walsh River tenements in the Chillagoe region of Northern Queensland.

## Production and Resource Capability

Australia's production of selected mineral resources, concentrates and metals for 2002-03 are presented in Table 4. ABARE forecast that the value of total minerals and energy exports is to rise to \$56.2 billion during this period.

To sustain such benefit to the nation and maintain a position as one of the world's leading minerals producers, resources need to be discovered and developed for production at rates sufficient to meet demand. To facilitate assessment of the future supply capability of identified resources, Geoscience Australia is now providing data on the accessibility of EDR and longevity (duration) based on current rates of mine production.

Figure 1 shows that trends in EDR of major commodities generally increased until the mid or late 1990's. Thereafter black coal and iron ore declined and the rate of increase of gold, copper, lead and zinc decreased or plateaued. While known resource inventories for black coal and iron ore are adequate to support current production rates for over 100 and around 70 years respectively, the future for gold (20 years), lead and zinc (20 to 25 years) is an issue that needs to be monitored.

As reported under Gold, new mineralisation and a variety of styles encouragingly continue to be found across the continent and at depth below known deposits. Over the next few years, however, the extent to which this mineralisation (and/or new discoveries) can translate into new ore deposits or extension to existing mines will be critical to the longer term sustainability of the gold industry.



For lead and zinc, new discoveries are being complemented by the success of fine grinding technology, which has allowed the efficient extraction of metals from the Century and McArthur River mines in Northern Australia. However, the need to discover and develop a high quality, metallurgically attractive lead-zinc resource(s) akin to Broken Hill remains a desirable outcome.

**TABLE 4: Australian production and exports of selected mineral products 2002-03**

Commodity	Production	Exports	Export value \$ million
<b>Aluminium</b>			
Bauxite (Mt)	54.472		186
Alumina (Mt)	16.408	13.187	3664
Aluminium (Mt)	1.850	1.552	3696
<b>Coal</b>			
Black raw (Mt)	351.50		
Black saleable (Mt)	274.72	207.71	11 902
Brown	64.56		
<b>Copper</b>			
Ores and concentrates (kt)	2555	1198	1048
Refined primary (kt)	532	359	956
<b>Diamond (kc)</b>	32 006	32 274	649
<b>Gold</b>			
Mine production (t)	277.19		
Refined (t) (a)	386.14	281.78	5133
<b>Iron and Steel</b>			
Ore and Pellets (Mt)	198.87	181.684	5328
Iron and steel (Mt)	9.399	3.599	1853
<b>Lead</b>			
Ores and concentrates (kt)	970	366	289
Refined (kt)	267	269	203
Bullion (kt)	181	150	169
<b>Manganese</b>			
Ores and concentrates (kt)	2457	1999	316
<b>Mineral sands</b>			
Ilmenite concentrates (kt)	1986	1020	135
Rutile concentrates (kt)	206	193	148
Synthetic rutile (kt)	673	453	292
Titanium dioxide pigment (kt)	194	147	428
Zircon concentrates (kt)	454	445	281
<b>Nickel</b>			
Concentrate (kt Ni)	210		
Refined (kt)	231 <sup>(b)</sup>	209	2327 <sup>(c)</sup>
<b>Uranium (t U<sub>3</sub>O<sub>8</sub>)</b>	9 222	9593	427
<b>Zinc</b>			
Ores and concentrates (kt)	2806	1911	666
Refined (kt)	570	486	757

Source: Australian Mineral Statistics, ABARE, June quarter 2003

**ABBREVIATIONS:** t = tonnes; kt = 10<sup>3</sup>t; Mt = 10<sup>6</sup>t; kc = 10<sup>3</sup> carats

(a) Includes primary and secondary gold of Australian and overseas origin

(b) Sum of products in the Intermediate nickel, <99.8% Ni and >99% Ni categories

(c) Sum of all nickel product export values

# Exploration



AIMR03

Exploration drilling at the Honeymoon uranium project,  
South Australia (Thompson Drilling Company)

## Expenditure

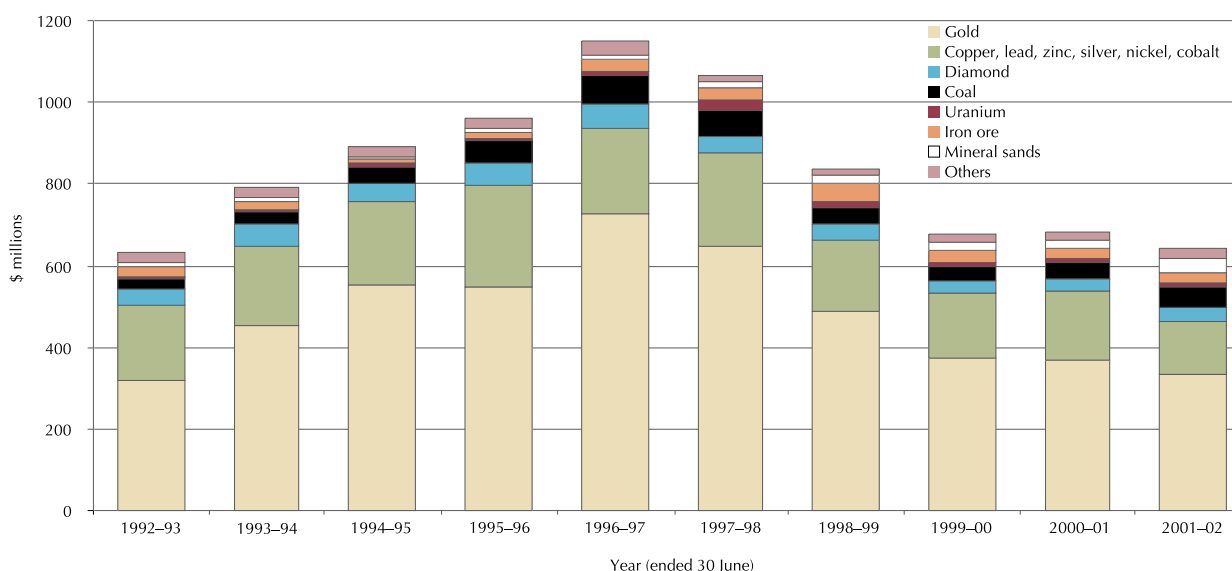
Mineral exploration expenditure for a range of commodities is collected quarterly by ABS. The following discussion is based on the survey data for 2001-02 (year ended 30 June 2002) and the first two quarters of 2002-03. Differentiation of exploration spending into commodity groups prior to 1980 is based largely on a breakdown of ABS totals by Geoscience Australia.

Australian mineral exploration expenditure fell by 6% to \$640.5 million in 2001-02 according to the ABS, the lowest financial year current dollar amount since 1992-93.

Spending for calendar year 2002, based on the sum of the ABS four quarterly figures, rose by \$13.8 million to \$678.2 million.

Gold was again the principal commodity sought although its share of total exploration fell from 54.2% in 2000-01 to 51.7% in 2001-02. Despite retaining its dominant position, exploration expenditure on gold fell by \$38.9 million to \$331.3 million its lowest level since 1992-93 (Fig. 2). Western Australia accounted for 72% (\$238.1 million) of gold exploration spending and was followed by the Northern Territory with 7.7% (\$25.4 million), Victoria 7.3% (\$24.2 million), Queensland 6.6% (\$21.7 million) and New South Wales 4.7% (\$15.7 million).

**FIGURE 2: Australian exploration expenditure by commodity since 1992-93**



Source: ABS

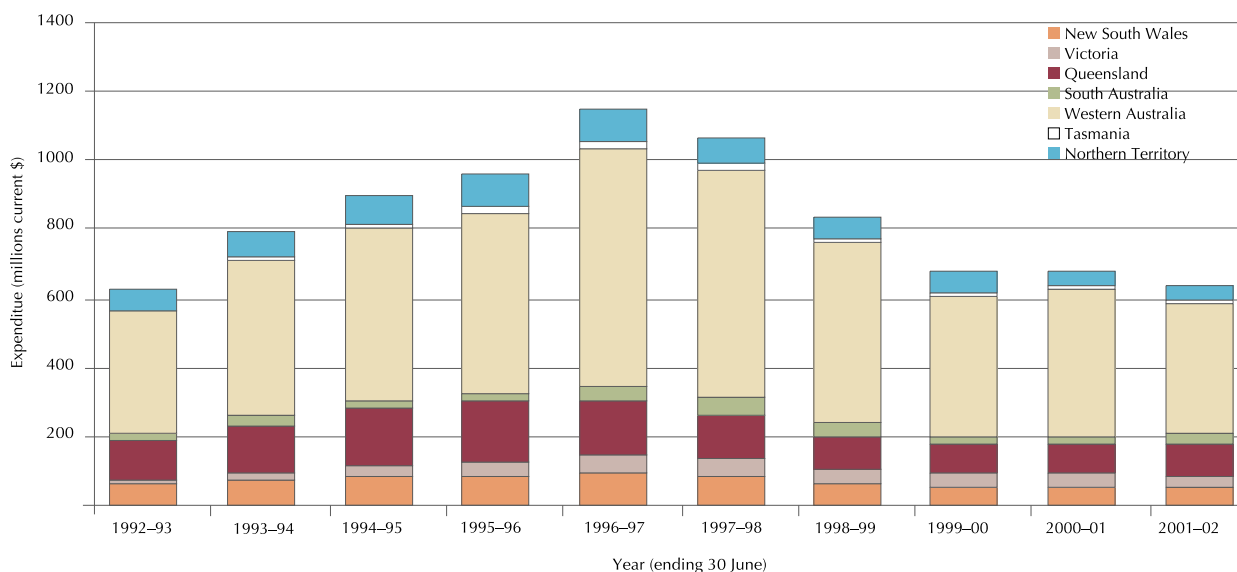
The combined spending on base metal (copper, lead, zinc, silver, nickel, cobalt) exploration fell by 19.6% to \$132.9 million. ABS data for base metals exploration show that spending on copper exploration rose by \$8.8 million to \$41.6 million in 2001-02. However, this growth was more than offset by substantial falls in spending on zinc-lead-silver and nickel-cobalt, which fell by \$22.2 million and \$19.2 million respectively. Actual zinc-lead-silver spending was \$37.6 million and nickel-cobalt was \$53.7 million. Queensland with 44.5% (\$18.5 million) and South Australia with 32.7% (\$13.6 million) dominated exploration for copper. ABS publishes little state-by-state data on zinc-lead-silver exploration spending but do show Western Australia received 27.9% (\$10.5 million) of spending, New South Wales 7.2% (\$2.7 million) and the Northern Territory 6.9% (\$2.6 million). In relation to nickel-cobalt exploration, Western Australia was clearly dominant with 87.7% (\$47.1 million) of total spending.

All other major commodities groups had increased spending in 2001-02 (Table 5) including mineral sands, which rose by \$9.6 million (40.7%) to \$33.2 million, a record. Other significant movements in spending compared to the previous year were in coal, which rose by \$9 million (21.8%) to \$50.3 million, diamond which rose by \$3.6 million (11.3%) to \$35.4 million and iron ore which rose by \$1.8 million (7.7%) to \$25.2 million. Gold and base metals combined accounted for over 72% of total exploration spending a sharp reduction from the 78% held in 2000-01.

**TABLE 5: Australian mineral exploration expenditure by commodity, 2000-01 and 2001-02**

Commodity	Exploration Spending (\$ million)		Change (\$ million)	Proportion of Australian Total Exploration Spending		Change % points
	2000-01	2001-02		2000-01	2001-02	
Gold	370.2	331.3	-38.9	54.2	51.7	-2.5
Base Metals	165.4	132.9	-32.5	24.2	20.7	-3.5
Diamond	31.8	35.4	3.6	4.7	5.5	0.8
Coal	41.3	50.3	9.0	6.0	7.9	1.9
Iron Ore	23.4	25.2	1.8	3.4	3.9	0.5
Mineral Sands	23.6	33.2	9.6	3.5	5.2	1.7
Uranium	8.4	8.8	0.4	1.2	1.4	0.2
Others	19.3	23.4	4.1	2.8	3.7	0.9

Exploration spending rose in Victoria, Queensland, South Australia and the Northern Territory in 2001-02 (Fig. 3 and Table 6). Western Australia was again the principal destination for exploration with \$381.1 million spent (10.1% reduction), 59.5% of total Australian spending. Queensland again had the second highest expenditure, attracting \$92.7 million (11.6% of total Australian spending), which was \$9.6 million higher than in 2000-01. The Northern territory recorded a 1.9% increase to \$48.4 million spent in 2001-02 while New South Wales had a 15.6% reduction to \$48.3 million. In Victoria, spending rose by \$1.2 million to \$33.9 million, its highest level since 1998-99. South Australian spending continued the recovery started last year as it rose by 8.4% to \$32.1 million. Tasmanian spending fell by over 56% to \$4 million and its share of national spending was halved to 0.6%.

**FIGURE 3: Australian mineral exploration expenditure by state since 1992-93**

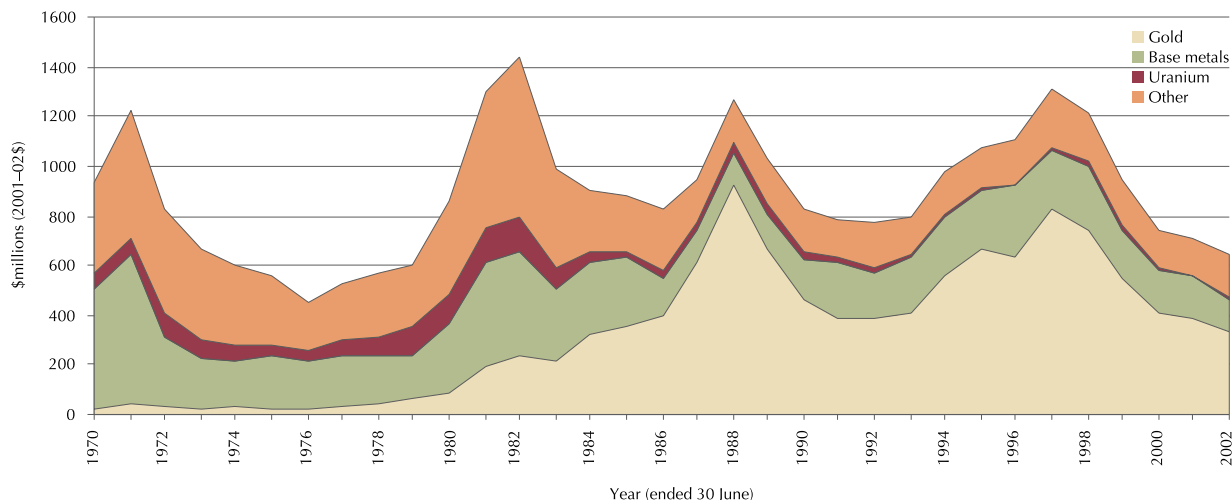
Source: ABS

**TABLE 6: Australian mineral exploration expenditure by State, 2000-01 and 2001-02**

Commodity	Exploration Spending (\$ million)		Change (\$ million)	Proportion of Australian Total Exploration Spending		Change % points
	2000-01	2001-02		2000-01	2001-02	
Western Australia	424.1	381.1	-43.0	62.1	59.5	-2.6
Queensland	83.1	92.7	9.6	12.2	14.5	2.3
Northern Territory	47.5	48.4	0.9	7.0	7.6	0.6
New South Wales	57.2	48.3	-8.9	8.4	7.5	-0.9
Victoria	32.7	33.9	1.2	4.8	5.3	0.5
South Australia	29.6	32.1	2.5	4.3	5.0	0.7
Tasmania	9.2	4.0	-5.2	1.3	0.6	-0.7

The depth of the exploration recession is highlighted in constant 2001-02 dollar terms (Fig. 4) with the 2001-02 spending of \$640.6 million the lowest since 1978-79 and 4.6% lower than 2000-01.

**FIGURE 4: Australian mineral exploration expenditure since 1969-70 (2001-02 dollars)**



*Footnote: In 2002-03 Australian current dollar exploration spending rose by 14% to \$732.8 million. In 2002-03, constant dollar spending rose by 11%.*

ABS exploration expenditure figures for the combined September and December quarters 2002 were up by \$37.6 million to \$375.1 million, compared to the equivalent period in 2001. This expenditure was \$73 million higher than in the first half of 2002. In Western Australia, spending in the last six months of calendar 2002 was \$14.4 million higher than in the last half of 2001. Increases in last half calendar year spending were recorded in all other States, except Tasmania where it remained unchanged at \$2.1 million, and the Northern Territory. Queensland rose by \$8.5 million to \$55.1 million, Northern Territory by \$0.7 million to \$29 million, New South Wales by \$4 million to \$29.1 million, South Australia by \$4.8 million to \$19.7 million and Victoria by \$5.3 million to \$19.6 million when compared to the last half of calendar year 2001.

## Exploration Drilling

In 2001-02, 4.83 million metres of exploration drilling was completed in Australia, a reduction of 17% over the previous year according to ABS. Of the total metres drilled, 29% was in Production Areas, almost the same proportion as in 2000-01.

## Cost of Access to Land for Exploration

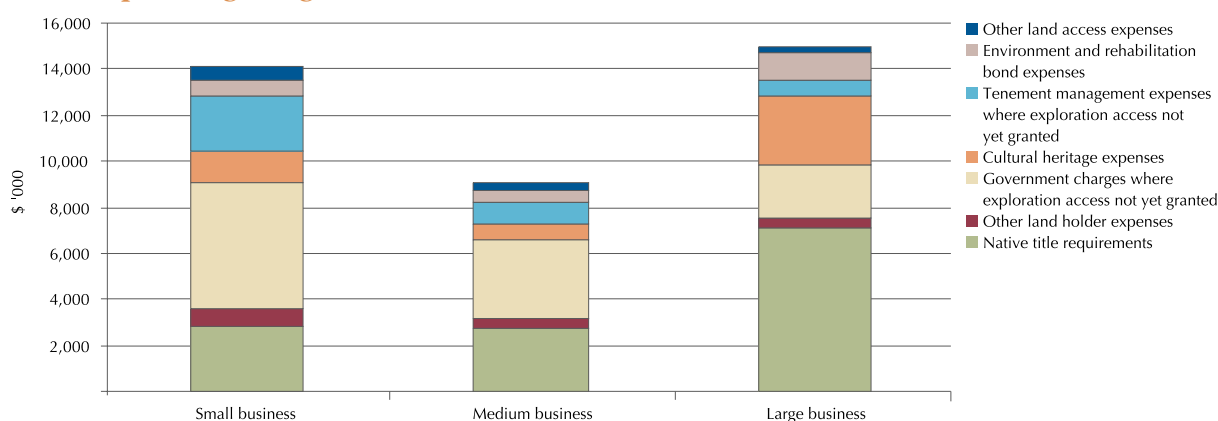
In 2002, ABS was commissioned by the Ministerial Council on Mineral and Petroleum Resources to undertake a survey to collect data on the cost of gaining access to land for mineral exploration. ABS published the results of the survey, which covered 2001-02, in their publication 'Mineral and Petroleum Exploration Australia March Quarter 2003' Catalogue Number 8412.0.

Of the total mineral exploration for the year 2001-02 on non-production leases of \$509.1 million, 7.5% (\$38.1 million) was spent on gaining land access.

Explorers spent \$12.6 million of the total on matters related to native title and \$11.2 million on government charges, such as application fees for tenements where access to explore was being negotiated (Fig. 5).



**FIGURE 5: Australian mineral exploration expenditure 2001-02 on non-production leases spent on gaining land access**



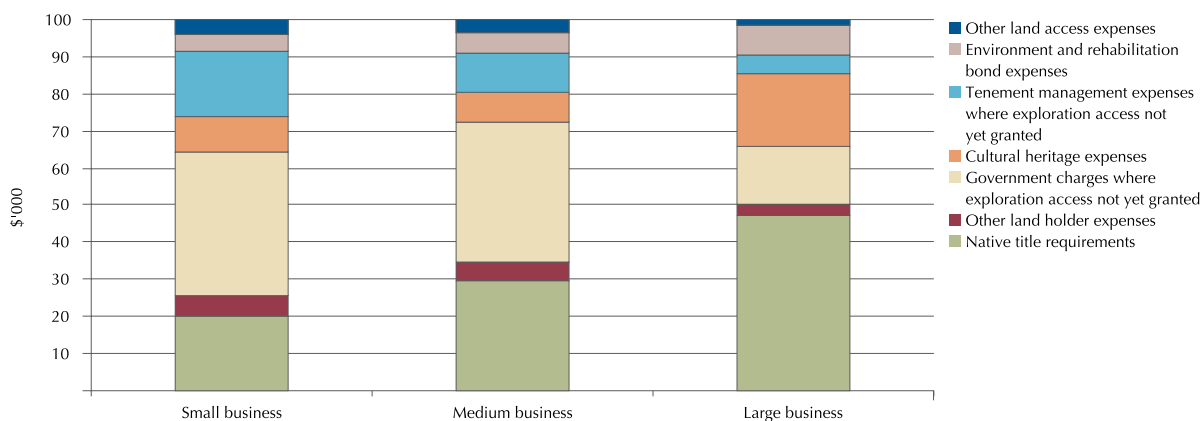
Source: ABS

ABS reported results according to companies exploration spending in 2001-02. The categories were: small businesses (exploration spending of less than \$1 million), medium businesses (exploration spending of \$1-5 million) and large businesses (exploration spending over \$5 million).

Small and large businesses incurred the highest land access costs at \$14.1 million and \$14.9 million respectively (Fig. 5). Medium sized businesses incurred costs totalling \$9.0 million.

Although small and large businesses had fairly similar total costs the composition of the expenses was markedly different (Fig. 6). Small businesses committed 20% of land access expenditure to native title issues while large businesses used 47% of their land access spending on it. In contrast, government charges relating to tenements, where access had not yet been granted, accounted for 38.5% of small business access spending but only 16% for large businesses. Cultural and heritage expenses accounted for 9.8% of small business expenses but for large businesses it doubled to 19.7%.

**FIGURE 6: Proportion of Australian mineral exploration expenditure 2001-02 on non-production leases spent on gaining land access**



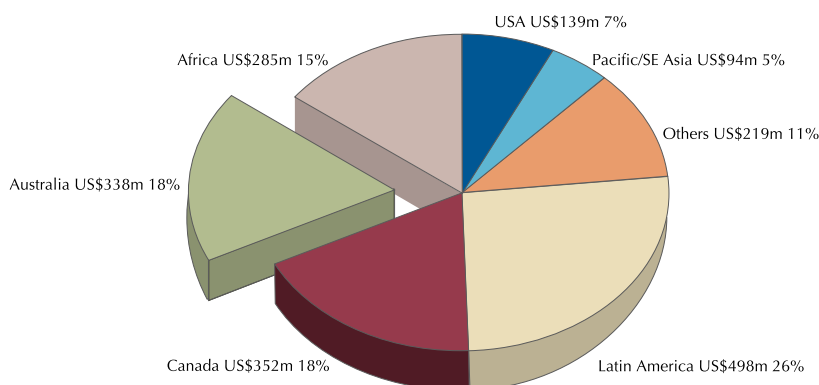
Based on ABS data

While the published ABS data does not allow firm conclusions to be drawn, the concentration of small business spending on government tenement matters and that of large businesses on issues that come to the fore after a tenement has been granted may simply be a reflection of the roles played by the both entities in exploration joint ventures.

## World Exploration

The Metals Economics Group's (MEG) world survey of exploration budgets for 2002 saw Australia displaced by Canada as the world's leading exploration destination (Fig. 7). Canadian exploration spending was boosted by: ongoing diamond exploration boom; the return of junior companies to domestic rather than foreign exploration; new high quality precompetitive geoscientific data provided by federal and provincial governments; and the impact of the 'super flow through shares' scheme, which is estimated to have raised C\$160 million in 2001. Total world exploration budgets for 2002 amounted to US\$1.9 billion, a 14% reduction on the 2001 budget.

**FIGURE 7: Distribution of world exploration budgets 2002**



*Source: Metals Economics Group, Canada*

An analysis of MEG data shows that 72% of 2002 budgets for exploration in Australia is sourced from Australian based companies, down slightly on previous years. Australian grassroots exploration budgets are dominated by the search for gold (55% of total budgets). The MEG survey includes 221 companies with exploration budgets of more than US\$100 000 were exploring in Australia. Of the 221, only five had Australian exploration budgets of US\$10 million or more (30% of total), a further nine had budgets of US\$5-10 million (22% of total), 22 had budgets of US\$2-5 million (21% of total), 28 had budgets of US\$1-2 million (12%), and the remaining 157 companies (71%) had exploration budgets of less than US\$1 million (15% of total budgets).

## Government Programs Assisting Exploration

The Australian Federal Government initiated two inquiries into the state of mineral exploration in Australia: the House of Representatives Standing Committee on Resources inquiry into resources exploration impediments and the Minerals Action Agenda. Both will report in 2003.

Geoscience Australia, together with the State and Northern Territory geological surveys under the National Geoscience Agreement, continued major multi-disciplinary geoscience programs in the Yilgarn, Tanami-Arunta, and Gawler provinces, as well as other regional and national-scale studies. Highlights were major deep crustal seismic reflection surveys in the NE Goldfields and the Batten Trough, NT, near the giant McArthur River Zn-Pb-Ag deposit. The new spatial data policy that provides geoscientific spatial data either free online or at the cost of transfer resulted in a substantial increase in the uptake of geophysical and other data especially by junior explorers.

The NSW Government continued to support exploration investment in the State through its \$30 million Exploration NSW initiative. This initiative produced a range of outstanding new geoscience products during the year including a major hyperspectral survey over the Broken Hill region and extensive airborne geophysical programs in the New England and southwest of the State. A Falcon™ airborne gravity gradiometry survey was acquired over the Broken Hill area.

The Geological Survey of Western Australia continued geological programs in the Yilgarn and Pilbara Cratons, and adjacent Proterozoic basins. Airborne magnetic and radiometric data were acquired over the west Tanami and west Musgrave regions of WA, and new regional mineral resource and exploration potential assessments released. A new information management system provides on-line access to data and information on WA mines and mineral deposits.

During 2002, the final full year of its four year \$16 million Exploration Initiative, the Northern Territory acquired 175 000 line kilometres of high-resolution airborne magnetic and radiometric data over the Wiso and Georgina basins. It also completed multidisciplinary geoscientific studies of the western Arunta Region and southern Georgina Basin, and compilation of exploration geochemical data over 325 000 km<sup>2</sup> of the Arunta region.

Victoria continued its Victorian Initiative for Minerals and Petroleum (VIMP) that runs until 2005. Data release highlights for 2002-03 include regolith and geological maps over Ballarat – Bendigo region, the Honeysuckle Creek AEM survey, and the Latrobe Valley digital coal resources model.

Mineral Resources Tasmania will complete its TIGER geoscience information project in 2003, providing web delivery of all Tasmania's geoscientific databases and information, including company exploration reports. Its Western Tasmanian Regional Minerals Program has provided new aeromagnetic and radiometric data for the entire belt, and AEM data for selected areas.

The new Queensland Digital Exploration reports system (QDEX) allows explorers to lodge, search and retrieve company exploration reports over the Internet. Spatial exploration data can also be accessed through upgraded interactive maps on-line. A new pricing policy for basic, digital geoscience data has been adopted, with such data supplied at cost of transfer.

SARIG II provides online access to South Australia's latest geological and geophysical data. The Mineral Tenement Management System currently under development will allow management of mineral tenements from initial exploration to the completion of rehabilitation at the end of mine life. Future developments will include online licence application and lodgement of mining returns. Airborne magnetics, radiometric and terrain elevation data is now available for the entire South Australian portion of the Musgrave Block and a complete tectonic map of the Gawler Craton is available for the first time.

## Outlook for Exploration

Australian mineral exports are at near record levels with the Australian Bureau of Agricultural and Resource Economics (ABARE) predicting export earnings from Australia's mineral resources to rise by 1.3% to \$56.2 billion in 2002-03. ABARE expects metals and other minerals (excluding energy minerals) to rise by approximately 3.9% on the back of increased production and expected higher prices for most metals in 2003.

Global and domestic mineral exploration levels continue to decline both in terms of overall expenditure and in the average and median exploration budgets reported in the MEG surveys. This year has seen a reduced number of mergers and acquisition of mining companies compared with the extraordinary level seen in 2001. The rise in metal prices – especially gold – if sustained should result in an increase in minerals exploration spending in 2003 given the 12-18 month lag between increased gold prices and exploration levels. Several global gold majors, notably Barrick Gold and Newmont Corporation, have indicated that exploration budgets are likely to rise in 2003 to redress under-investment in grassroots gold exploration in recent years. AME Mineral Economics expect nickel prices to rise sharply in response to increasing demand in an environment of constrained supply caused by a lack of new projects.

Overall, the outlook for exploration, although still remaining difficult, is the best in the past five years.

## Offshore Mineral Exploration in Commonwealth Waters

The Commonwealth Offshore Minerals Act 1994 provides the statutory framework for the exploration and production of minerals, other than petroleum, on Australia's continental shelf three nautical miles beyond the territorial baseline of the states and territories. The administration is shared between the Commonwealth and the States and the Northern Territory. The Joint Authority consists of the relevant Commonwealth minister and State/NT minister and is responsible for major decisions relating to titles, such as grants, refusals, etc. The State/NT minister is called the Designated Authority and is responsible for the normal day-to-day administration of the Commonwealth legislation.

Applications for a mineral exploration licence (MEL) are made to the Designated Authority with an application fee of \$3000. The application must be made in the approved manner and specify details such as:

- block numbers (maximum 500 per application),
- proposed exploration program,
- amount of money allocated to each part of the program,
- technical qualifications of the applicant and employees, and
- financial resources.

The initial term of a MEL is four years and it may be renewed for three two-year periods subject to satisfactory performance of licence conditions. There is a mandatory reduction of 50% of the licence area on renewal of an offshore MEL. However, it is possible to apply for an extension of term if activities have been significantly interrupted or stopped by circumstances beyond the control of the licence holder.

As at August 2003, a total of 66 offshore MEL applications had been received since February 1990. Currently there is one active licence, T-2-MEL, in Ringarooma Bay in northeast Tasmania, where previous exploration has identified an inferred tin resource. During the 1990's there was exploration for alluvial diamonds in offshore palaeochannels and tidal shoals in the Joseph Bonaparte Gulf region of northwest Australia. No diamonds were discovered in Commonwealth waters. However, gem quality diamonds were discovered in State waters.

## Appendix 1

### Abbreviations and Acronyms

**ABARE** Australian Bureau of Agricultural and Resource Economics

**ABS** Australian Bureau of Statistics

**AEDR** accessible economic demonstrated resources

**AIMR** Australia's Identified Mineral Resources  
**BRS** Bureau of Resource Sciences

**c** carat

**CSIRO** Commonwealth Scientific and Industrial Research Organisation

**EAR-1** estimated additional resources – category 1

**EDR** economic demonstrated resources

**GIS** geographical information system

**g** grams

**g/t** grams per tonne

**GL** gigalitre

**Gt** gigatonne

**IAEA** International Atomic Energy Agency

**JCB** Joint Coal Board

**JORC** Joint Ore Reserve Committee

**kg** kilogram

**km** kilometre

**kt** kilotonne (thousand tonnes)

**ktpa** kilotonne per annum

**L** litre

**lbs** pounds

**m** metre

**m<sup>3</sup>** cubic metre

**Mc** million carats

**MEL** mineral exploration licence

**ML** million litres

**Mlbs** million pounds

**mm** millimetre

**Mozs** million ounces

**Mt** million tonnes

**Mtpa** million tonnes per annum

**MW** megawatt

**na** not available

**NSW** New South Wales

**NT** Northern Territory

**OECD/NEA** Organisation for Economic Cooperation and Development/Nuclear Energy Agency

**PGM** platinum-group metals

**ppm** parts per million

**Qld** Queensland

**RAB** rotary air blast

**RAR** reasonably assured resources

**RC** reverse circulation

**\$** dollar

**SA** South Australia

**SDR** Subeconomic demonstrated resources

**t** tonne

**Tas** Tasmania

**tpa** tonnes per annum

**U** uranium

**U<sub>3</sub>O<sub>8</sub>** uranium oxide

**USA** United States of America

**USGS** United States Geological Survey

**US\$** United States of America dollar

**Vic** Victoria

**WA** Western Australia



## Appendix 2

### National Classification System for Identified Mineral Resources

#### *Introduction*

Australia's mineral resources are an important component of its wealth, and knowledge of the location, quantity and quality of such resources – including estimates of resources yet to be discovered – is an essential prerequisite of formulating sound policies on their use and conservation. Results of resource assessment can be used also to set priorities for mineral exploration and research to indicate mineral potential where alternative land uses are being considered.

In 1975, the then Bureau of Mineral Resources, Geology and Geophysics (BMR) adopted, with minor changes (BMR 1976), the McKelvey resource classification system used by the US Bureau of Mines and USGS (USBM/USGS 1980). Subsequently informal guidelines for using the system's definitions were developed and used by BMR for several years, until the whole system and its application was reviewed in the light of accumulated experience. The results of that review were published (BMR 1984) as the refined BMR mineral resource classification system for national resource assessment.

The principles of the McKelvey system, were retained, as were most of the definitions used by BMR in its original system, although minor changes were made to some. Guidelines on applying the system were established, and adopted. It was decided that the term 'reserves' would not be used for regional or national aggregates of resources, so as to avoid the confusion arising from its use with different meanings in other contexts.

The Bureau of Resource Sciences (BRS) was formed in 1992 by combining the Mineral and Petroleum Resource Assessment Branches of the BMR with the Bureau of Rural Resources. BRS used the modified McKelvey system in preparing its annual national assessments of Australia's identified mineral resources from 1992 to 1998. Following administrative changes in the Australian Government in late 1998, the Mineral and Petroleum Resource Assessment Branches of BRS were incorporated into AGSO within the newly created Commonwealth Department of Industry, Science & Resources. AGSO was later renamed to Geoscience Australia and estimates prepared by BRS, AGSO and Geoscience Australia are therefore consistent with earlier estimates prepared by BMR, which means any analysis of trends is based on consistent datasets.

Several editions of an industry code for reporting resources in individual deposits have been published, the most recent being the 1999 edition entitled 'Australasian Code for Reporting Mineral Resources and Ore Reserves', commonly referred to as the JORC Code. This is a report by a Joint Committee of the Australasian Institute of Mining and Metallurgy, the Australian Institute of Geoscientists, and the Minerals Council of Australia.

The modified McKelvey system and JORC Code are compatible, and data reported for individual deposits by mining companies are used by Geoscience Australia in the preparation of its assessments of Australia's mineral resources.

#### *Classification principles*

Geoscience Australia classifies known (identified) mineral resources according to two parameters: degree of assurance of occurrence (degree of geological assurance) and degree of economic feasibility of exploitation. The former takes account of information on quantity (tonnage) and chemical composition (grade); the latter takes account of changing economic factors such as commodity prices, operating costs, capital costs, and discount rates.

Resources are classified in accordance with circumstances at the time of classification. Resources which are not available for development at the time of classification because of legal and/or land-use factors are classified without regard to such factors; however, the amount of resource thus affected will, wherever possible, be stated for each classification category.

The classification framework is designed to accommodate all naturally occurring metals, non-metals, and fossil fuels, and to provide a means of comparing data on different resources, which may have a similar end use (eg, petroleum, coal, and uranium as energy sources).

The modified McKelvey system for classifying identified mineral resources is illustrated below.

			Decreasing degree of geological assurance →		
			IDENTIFIED		
			DEMONSTRATED		INFERRED
			MEASURED	INDICATED	
Decreasing degree of economic feasibility ↓	ECONOMIC				
	SUB-ECONOMIC	PARAMARGINAL			
	SUB MARGINAL				

## Terminology and Definitions

### *Resource*

A concentration of naturally occurring solid, liquid, or gaseous materials in or on the Earth's crust and in such form that its economic extraction is presently or potentially (within a 20–25 year timeframe) feasible (see guideline i).

## Categories of Resources Based on Degree of Assurance of Occurrence

### *Identified (Mineral) Resource*

Specific bodies of mineral-bearing material whose location, quantity, and quality are known from specific measurements or estimates from geological evidence. Identified resources include economic and subeconomic components. To reflect degrees of geological assurance, identified resources can be divided into the following categories:

#### *Measured*

Resources for which tonnage is computed from dimensions revealed in outcrops, trenches, workings, and drillholes, and for which the grade is computed from the results of detailed sampling. The sites for inspection, sampling, and measurement are spaced so closely, and the geological character is so well defined, that size, shape, and mineral content are well established.

#### *Indicated*

Resources for which tonnage and grade are computed from information similar to that used for measured resources, but the sites for inspection, sampling, and measurement are farther apart or are otherwise less adequately spaced. The degree of assurance, although lower than for resources in the measured category, is high enough to assume continuity between points of observation.

#### *Demonstrated*

A collective term for the sum of measured and indicated resources.

#### *Inferred*

Resources for which quantitative estimates are based largely on broad knowledge of the geological character of the deposit and for which there are few, if any, samples or measurements. The estimates are based on an assumed continuity or repetition for which there is geological

evidence. This evidence may include comparison with deposits of similar type. Bodies that are completely concealed may be included if there is specific geological evidence of their presence. Estimates of inferred resources should be stated separately and not combined in a single total with measured or indicated resources (see guideline ii).

### **Categories of Resources Based on Economic Considerations**

#### *Economic*

This term implies that, at the time of determination, profitable extraction or production under defined investment assumptions has been established, analytically demonstrated, or assumed with reasonable certainty (see guideline iii).

#### *Subeconomic*

This term refers to those resources which do not meet the criteria of economic; subeconomic resources include paramarginal and submarginal categories.

#### *Paramarginal*

That part of subeconomic resources which, at the time of determination, almost satisfies the criteria for economic. The main characteristics of this category are economic uncertainty and/or failure (albeit just) to meet the criteria which define economic. Included are resources which would be producible given postulated changes in economic or technologic factors.

#### *Submarginal*

That part of subeconomic resources that would require a substantially higher commodity price or some major cost-reducing advance in technology, to render them economic.

### **Geoscience Australia Guidelines for Classifying Mineral Resources**

- (i) Use of the term 'resources' is restricted to material, the extraction of which is generally judged to be potentially economically viable in an arbitrary time frame of about 20 to 25 years. The term includes, where appropriate, material such as tailings and slags. The definition does not intend to imply that exploitation of any such material will take place in that time span, but only that its possibility might reasonably be considered. This guideline attempts to establish a lower limit to what is worth assessing. It should be applied on a commodity by commodity basis to take account of prevailing and prospective technologies. Material falling outside the category of resource should be referred to as 'occurrences'. Unless otherwise stated, the classification system refers to in-situ resources. However, it is possible and in fact desirable to also show recoverable quantities of resources in each category.
- (ii) By definition, inferred resources are classified as such for want of adequate knowledge and therefore it may not be feasible to differentiate between economic and subeconomic inferred resources. Where inferred resources are shown as 'undifferentiated', the amount known or judged to be economic may be indicated. Such judgements must take careful account of the commodity being assessed and its mode of occurrence as these factors will have a bearing on the reliability of estimates made. Specifically, grade estimates can be more reliably made for concordant sedimentary and biological deposits than for discordant epigenetic deposits (King et al. 1982, p. 8).
- (iii) The definition of 'economic' is based on the important assumption that markets exist for the commodity concerned. All deposits which are judged to be exploitable economically at the time of assessment, whether or not exploitation is commercially practical, are included in the economic resources category. It is also assumed that producers or potential producers will receive the 'going market price' for their production. The classification is therefore based on the concept of what is judged to be economic rather than what is considered to be commercial at any particular time.

The information required to make detailed assessments of economic viability of a particular deposit is commercially sensitive (eg, a company's costs and required internal rate of return), and these data may not be available to Geoscience Australia. Furthermore, as corporate strategies are likely to be different, individual companies will have different criteria for what is considered to be 'economic'. Thus to standardise the approach for national or regional resource assessments, the following mineral deposits/situations are accepted by Geoscience Australia, as a general guide, to be economic:

- (a) the resources (published or unpublished) of operating enterprises, whether or not such operations are sustained by long- or short-term, direct or indirect, government subsidies;
- (b) resources in a deposit which is being developed for production (ie, where there is a corporate commitment to production);
- (c) undeveloped resources which are judged to be economic on the basis of a financial analysis using actual, estimated, or assumed variables – viz, the tax rate, capital and operating costs, discount rate (such as reflects the long-term bond rate), commodity prices, and depreciation schedules; the values for the economic variables used in an assessment must be realistic for the circumstances prevailing at the time of the assessment;
- (d) resources at mines on care-and-maintenance meeting the criteria outlines in (c) above.
- (iv) The term 'recoverable' is considered to make allowance for mining as well as processing losses. Where a finer distinction needs to be made, mineable is used to take account of mining losses and metallurgically recoverable (saleable for coal) is used to take account of processing losses.
- (v) Some minerals derive their economic viability from their co-product or by-product relationships with other minerals. Such relationships and assumptions must be clearly explained in footnotes or in accompanying text.
- (vi) National aggregates of resource estimates should be rounded to the appropriate last significant digit, so as not to create false impressions of accuracy.

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## Appendix 3

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Century open cut, Queensland. View looking north-west. Disposal of waste rock into the open cut shown on the left (Geoscience Australia, Aden McKay)