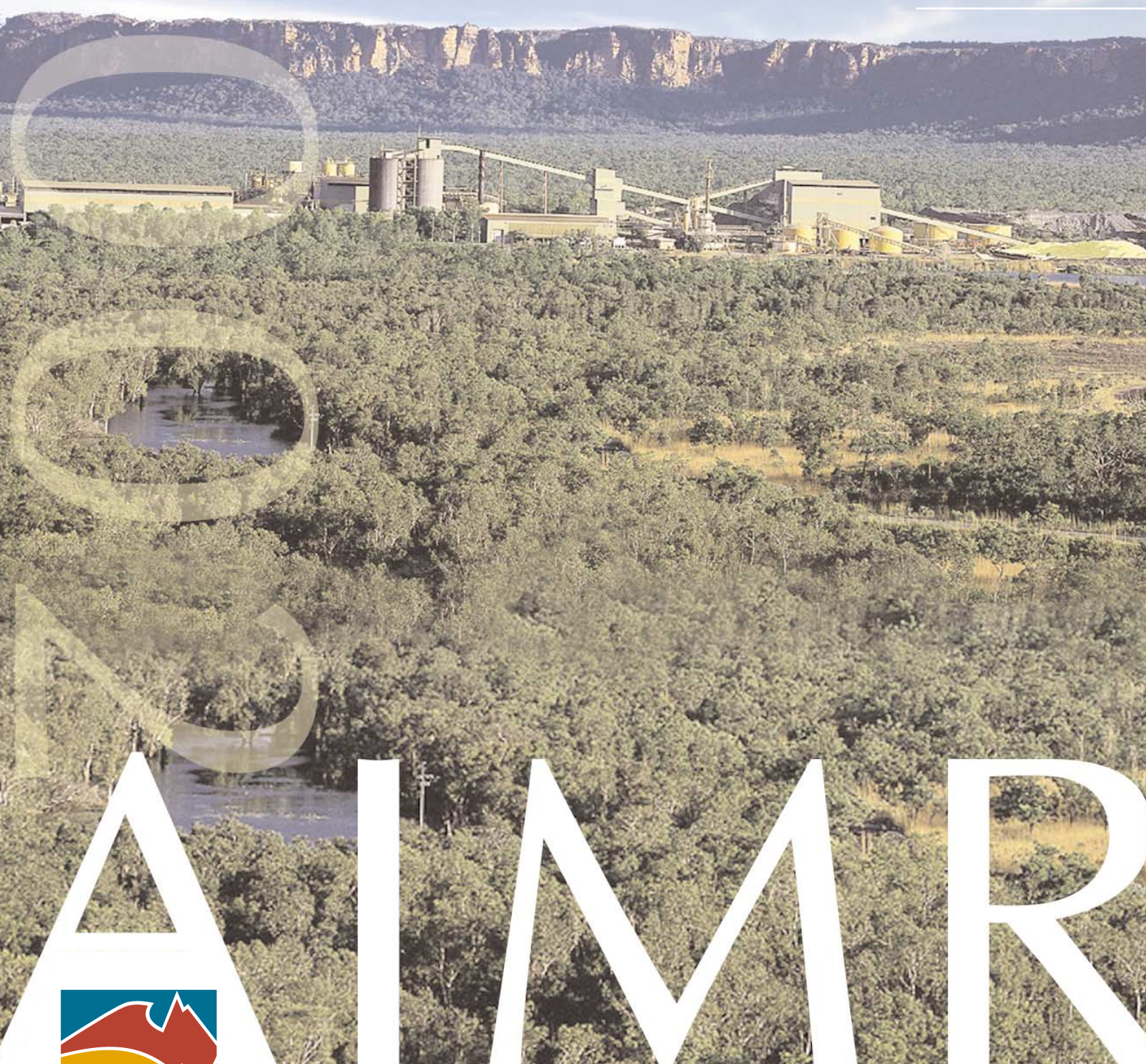


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GEOSCIENCE
AUSTRALIA

2002

A U S T R A L I A ' S I D E N T I F I E D M I N E R A L R E S O U R C E S

Geoscience Australia

Industry, Tourism & Resources Portfolio

Minister for Industry, Tourism & Resources: The Hon. Ian Macfarlane, MP.

Parliamentary Secretary: The Hon. Warren Entsch, MP

Geoscience Australia*

Chief Executive Officer: Dr Neil Williams

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ISSN 1327-1466

Bibliographic reference, Geoscience Australia 2002. Australia's identified mineral resources 2002. Geoscience Australia, Canberra.

Front cover	Ranger uranium processing plant, Alligator Rivers region, Kakadu National Park, Northern Territory (Energy Resources of Australia)
Design & layout	Karin Weiss, Geospatial Applications & Visualisation (GAV), Geoscience Australia

- * 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 information agency. Further information is available at www.ga.gov.au.



FOREWORD

—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 the States and Northern Territory.

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. National assessments of this type are also assuming greater global significance, as issues concerning cost-effective cleaner mining and product stewardship receive closer attention.

By late 2003, most of AIMR's resources data will be incorporated into a virtual atlas of Australia's Mineral Resources, Mines and Processing Centres, the core elements of which are under development by Geoscience Australia in collaboration with the Minerals Council of Australia and Department of Industry, Tourism and Resources. The atlas will have a web-based geographic information system (GIS) format and show the location of mineral and energy resources, mines and production/processing centres, existing and planned. It will also contain links to commodity and environmental data, jurisdictional legislation, and provide information on mining and processing in terms of regional development, employment and decentralisation.

Neil Williams

Chief Executive Officer
Geoscience Australia



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AIMR



COMMODITY REVIEW



SUMMARY

Summary

In 2001, Australia's economic demonstrated resources (EDR) of bauxite, copper, gold, lead, magnesite, ilmenite, zircon, nickel, phosphate, PGM, tantalum, silver, vanadium and zinc increased, while those of black coal, diamonds, iron ore, lithium, manganese ore and uranium decreased. EDR of brown coal was maintained at levels similar to those reported in 2000. The reductions in EDR were due mainly to ongoing high levels of production; with low commodity prices a subsidiary factor.

EDR of gold, nickel and mineral sands reached record levels. Gold EDR rose by 4% and was over 80% of total demonstrated resources, this increase in resources continuing the established long-term growth trend for gold. In recent years that trend has continued despite falling exploration expenditure reflecting an increasing trend to concentrate exploration efforts in brownfields regions in response to the sustained period of depressed gold price.

Australia, continues to rank as one of the world's leading mineral resource nations. It has the world's largest EDR of lead, mineral sands, nickel, silver, tantalum, uranium and zinc. In addition, its EDR is in the top six worldwide for bauxite, black coal, brown coal, cobalt, copper, gold, iron ore, lithium, manganese ore, rare earth oxides and gem/near gem diamond.

Mineral exploration expenditure rose by 1% to \$683.3 million in 2000-01, which was the first increase in annual exploration spending since 1996-97. However spending for calendar year 2001, based on the sum of ABS four-quarter figures, was down by \$12 million to \$664.4 million.

Production of many mineral commodities again reached record levels in 2000-01, and overall mine production is projected by ABARE to rise in the five years to 2006-07 with the exception of gold which they forecast will fall by 6%. ABARE have projected a very high growth of some 60% for mine production of nickel in this period. Increases are also forecast for mine production of coal (+17%), copper (4%), lead (3%), zinc (12%), bauxite (17%) and iron ore (19%).



INTRODUCTION

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 sustainable development of mineral resources. The report examines trends in 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 2000-01 and previous years. The current level of expenditure is put into perspective by comparing it in real terms to expenditure over the preceding 31 years.

Estimates of Australia's identified resources of all major and several minor mineral commodities are reported for 2001 ([Table 1](#)). The estimates are based on published and unpublished data available to Geoscience Australia up to the end of December 2001. Data on petroleum resources were provided by Geoscience Australia's Petroleum Engineering and Identified Resources Project. World data have been obtained or calculated from data in various sources, but mainly in publications of the United States Geological Survey (USGS).

The mineral resource classification system used in this report reflects both the geological certainty of existence of the mineral resource and the economic feasibility of its extraction (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 because the term 'reserve' has specific meanings for individual mineral deposits under the criteria of the Joint Ore Reserves Committee (JORC) Code used by industry for reporting reserves and resources. EDR also provide a basis for meaningful international comparisons of the economic resources of other nations. Ore is generally mined from resources in the EDR category. EDR are therefore depleted by mining and increased by discovery of new resources in known or newly discovered deposits and by technical and economic changes that can allow formerly subeconomic deposits to be reclassified as economic.

In case of uranium, Geoscience Australia has also prepared 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 2001). A correlation of the national and OECD/NEA schemes is given in the review of uranium resources.

Long-term trends in EDR for bauxite, black coal, iron ore, gold, copper, lead, zinc, nickel, and mineral sands are shown in [Figure 1](#). EDR for these commodities have generally increased or at least been maintained since 1975 despite substantial levels of production. Much of the success in maintaining EDR can be attributed to the sustained exploration activity that Australia has enjoyed over the period and to the highly prospective nature of the continent. The cyclical trend in mineral exploration expenditure continues, however, and the depth of the current recession in expenditure (being the lowest since 1978-79) is reason for concern.



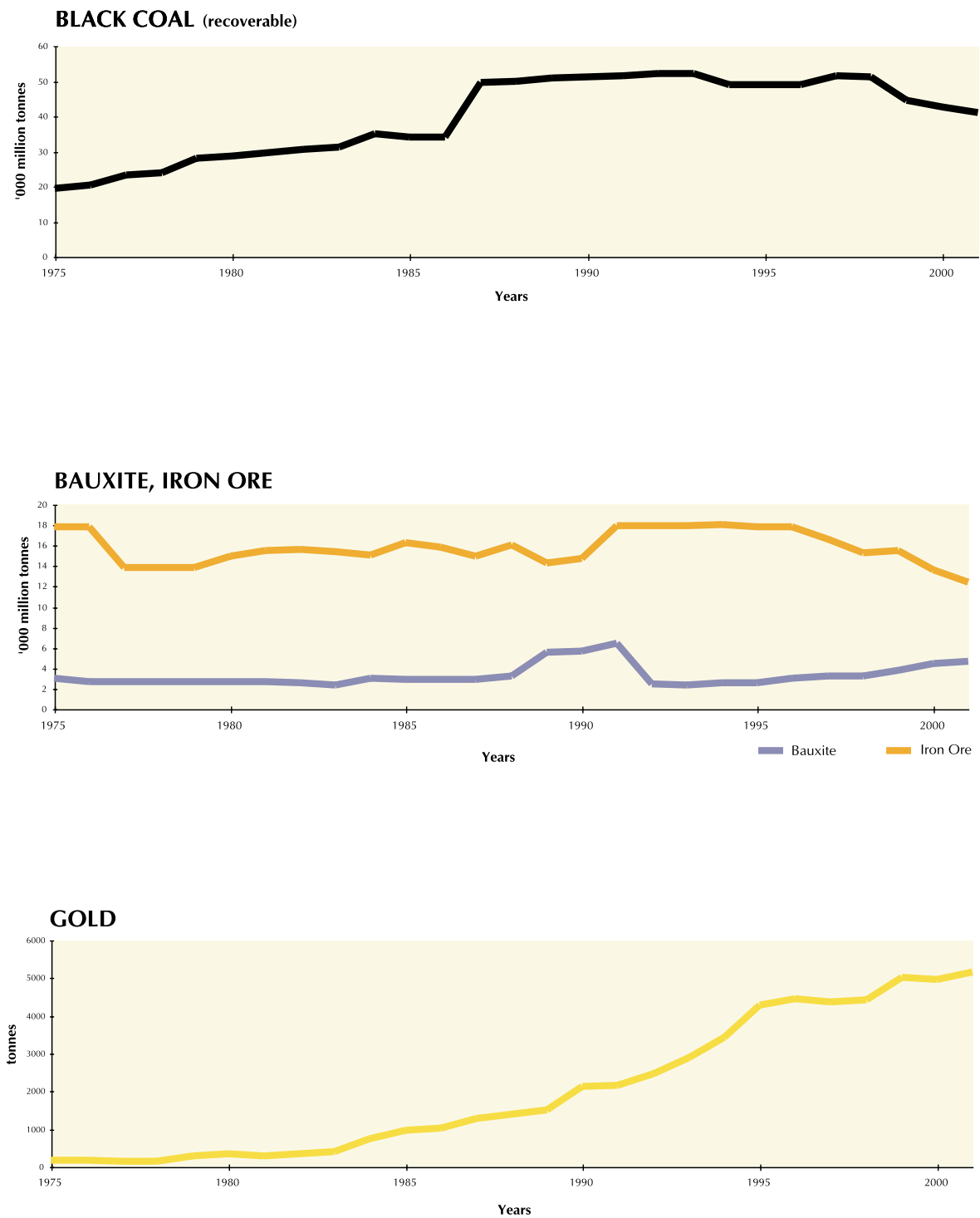


FIGURE 1.
Trends in economic demonstrated resources (EDR) for major commodities since 1975

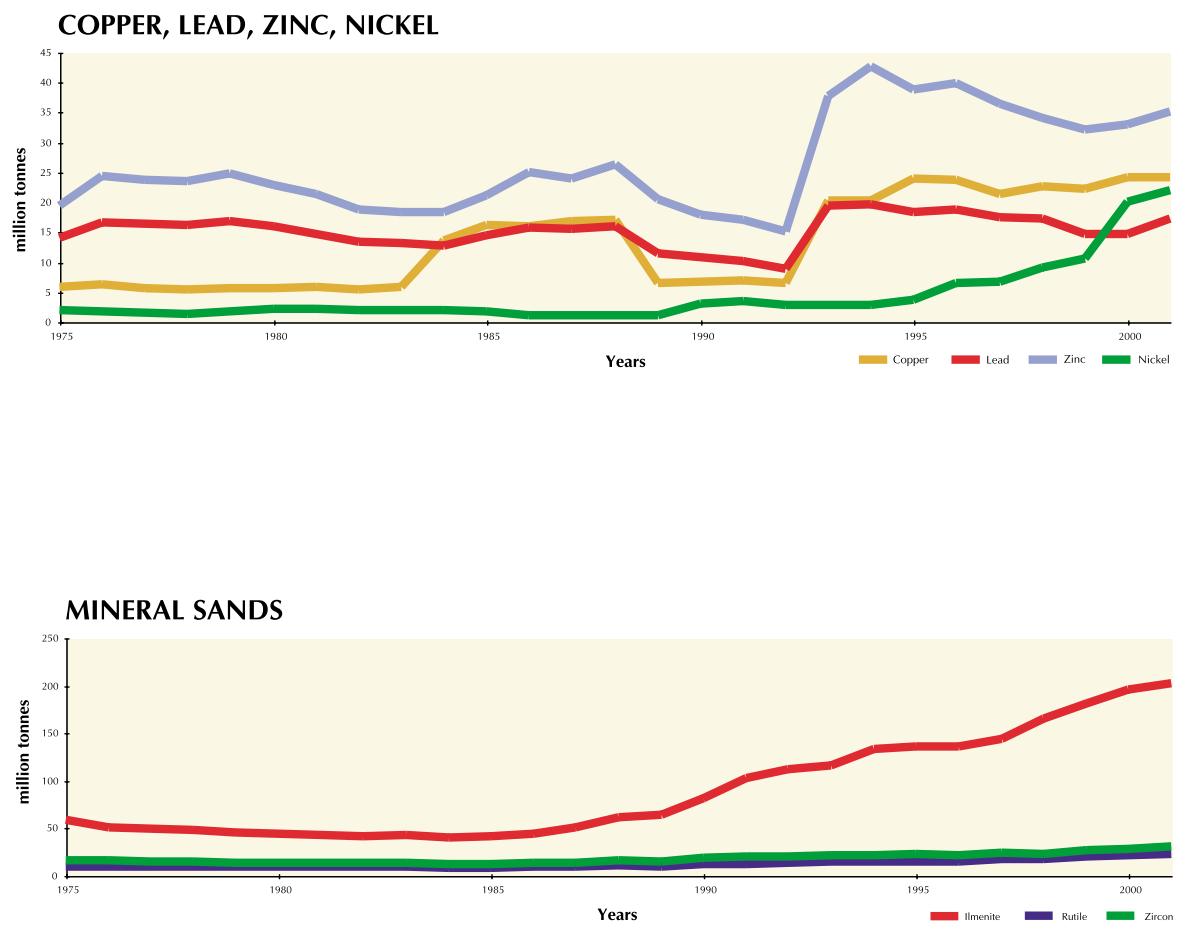


FIGURE 1 (continued).
Trends in economic demonstrated resources (EDR) for major commodities since 1975

Table 1 (following page):
Australia's resources of major minerals and fuels and world figures for 2001.



COMMODITY	UNITS	AUSTRALIA							WORLD	
		Demonstrated			Inferred			Mine production(a)	Economic Demonstrated Resources (b)	Mine Production (c)
		Economic	Sub-economic Para- marginal	Sub- marginal	Eco- nomic	Sub- economic	Undiff- erentiated			
Antimony	kt Sb	95	36	50	8	25	28	1.7	2,100	115
Asbestos										
Chrysotile ore	Mt	-	46	-	-	-	75	-	large	
Crocidolite fibre	Mt	-	0.4	-	-	-	2	-	large	1.9(d)
Bauxite	Gt	4.6	2.5	1.7	-	-	1.4	0.05	24	0.1(b)
Black coal										
in situ	Gt	60.0	3.1	16.8	-	-	very large			
recoverable	Gt	40.8	1.6	11.0	-	-	very large	0.333(e)	788(f)	3.6(f)(g)
Brown coal										
in situ	Gt	41.9	43.4	18.1	-	-	114.4			
recoverable	Gt	37.7	39.0	16.3	-	-	102.9	0.066	188(f)	0.8(f)
Cadmium	kt Cd	109.0	7.1	23.6	5.5	16.8	2.9	na	600	18.7
Cobalt	kt Co	1466	121	155	-	-	1,471	4.265	3,366	36.9
Copper	Mt Cu	24.2	14.7	1.2	0.9	2.1	15.4	0.87	355	13.2
Diamond										
gem & near gem	Mc	79.2	222	0.1	2.8	19.9	1.1	26.2	-	-
industrial	Mc	82.4	230	0.3	0.1	35.1	-	-	580	58.6
Fluorine	Mt F	-	0.2	22.1	-	-	29.4	-	112(h)	2.2
Gold	t Au	5,156	1,061	112	-	-	3,146	280	50,156	2,530
Iron ore	Gt	12.4	0.2	1.6	-	-	12.3	0.182	133.6	1.02
Lead	Mt Pb	17.3	3.4	9.1	2.7	16.8	1.3	0.7	64	2.97
Lithium	kt Li	152	78	26	-	-	7	63.4 (p)	3,403	14.6(i)
Magnesite	Mt MgCO ₃	366	22	35	-	-	986	0.599	6,611	10.8
Manganese ore	Mt	125	23	167	-	-	198	2.1	1878	20.7
Mineral sands										
Ilmenite	Mt	202	51	0.1	-	-	98	2.0	639	7.29(i)
Rutile	Mt	22	12	0.1	-	-	24	0.2	49.8	0.38(i)
Zircon	Mt	30	19	0.2	-	-	26	0.4	71	1.07(i)
Molybdenum	kt Mo	0.4	6.3	3.7	-	-	415	-	5,600	133
Nickel	Mt Ni	21.9	3.3	1.3	-	-	18.8	0.21	59.9	1.24
Niobium	kt Nb	29	29	132	-	-	1,996	-	4,600	32.6
Petroleum (recoverable)(j)										
Crude oil	GL	227	-	37	-	-	-	22.5		
Natural (sales) gas	10 ⁹ m ³	2,219	-	1,027	-	-	-	32.5		
Condensate	GL	282	-	62	-	-	-	5.4		
LPG naturally occur.	GL	262	-	88	-	-	-	4.3		
Phosphate rock	Mt	91	981	-	-	-	1,151	2.3	12,000	128
PGM (Pt,Pd,Os,Ir,Ru,Rh)	t metal	37.9	21.8	6.4	11.9	22.4	29.4	1	72,000	340(k)
Rare earths (REO & Y ₂ O ₃)	Mt	0.3	2.4	10.9	-	-	6.2	-	100	0.09
Shale oil	GL	4.6	202	3,719	-	-	41,425	0.037	95,885(o)	0.43(o)
Silver	kt Ag	41.4	9.7	10.9	8.1	12.6	4.6	2.0	280	18.3
Tantalum	kt Ta	40.8	29.8	0.23	-	-	61.2	0.8(q)	43.8	0.63
Tin	kt Sn	95.1	102.7	151.6	1.8	264.3	43.4	9.8	6,900	242
Tungsten	kt W	2.8	31.8	28.2	3.7	52.5	-	-	1,900	44.6
Uranium (I)	kt U	648	13	30	201	49	-	7.72	1564(m)	36.9(n)
Vanadium	kt V	267	1,736	587	0	2,463	-	2.49	10,000	43.0(i)
Zinc	Mt Zn	35.1	8.4	16.0	3.2	16.1	2.0	1.52	190	8.9

Abbreviations: t = tonne; m³ = cubic metre; L = litre; kt = 10³t; Mc = 10⁶ carat; Mt = 10⁶t; Gt = 10⁹t; GL = 10⁹L; na = not available.

(a) Source: Australian Bureau of Agricultural and Resource Economics (ABARE)

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

(c) World mine production for 2001, mostly USGS estimates

(d) Includes chrysotile production

(e) Raw coal

(f) Geoscience Australia estimate

(g) Saleable coal

(h) Excludes Morocco and USA

(i) Excludes USA

(j) Source: Petroleum Resources Branch, Geoscience Australia (as at 1 January 2000)"

(k) Platinum and palladium only

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

(m) Source: OECD/NEA & IAEA (2000). Compiled from the most recent data for resources recoverable at <US\$40/kg U. Data for USA and France not available for this category

(n) Source: NUKEM Market Report, data feature 04/2002. Nukem website www.nukemonline.com

(o) WEC Survey of Energy Resources for 1999

(p) Li₂O

(q) Ta₂O₅

BAUXITE

Bauxite is a heterogeneous naturally occurring material from which alumina (Al_2O_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 diasporite, 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 non-metal uses in various forms of specialty alumina, and the remainder is for non-metallurgical 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 (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. It directly employs over 16,000 people and indirectly many more and 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, located 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 3% in 2001 compared to the previous year. On-going successful exploration programs at and near existing mines resulted in resource upgrades from the subeconomic and inferred categories. About 30% of EDR comprises JORC Code ore reserves. The remainder represents resources assessed by Geoscience Australia from the measured and indicated categories of mineral resources, as defined under the Code and other classification categories used by overseas companies.

Subeconomic demonstrated resources decreased by just over 70 Mt (3%) following reclassification of some resources to EDR.

Inferred resources of 1.4 Gt remain unchanged from 2000.

Exploration

ABS does not publish data relating to exploration for bauxite specifically, either nationally or at a State level.

Production

Preliminary data released by ABARE (March quarter 2002) show that in 2001, Australia produced 53.8 Mt of bauxite, 16.3 Mt of alumina and 1.8 Mt of primary aluminium.

World ranking

Australia's economic demonstrated bauxite resources of 8.7 Gt rank first in the world followed by those of Guinea, Brazil, Jamaica, China and India.

Australia is the world's largest producer and exporter of bauxite and alumina (39% and 33% of world bauxite and alumina, respectively, in 2001)



Industry Developments

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 approaching \$8.7 billion in 2000-01.

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, (Queensland) and Sardinia (Italy). In 2001, Rio Tinto reported bauxite shipments of 11.0 Mt from Weipa.

In January 2002, Comalco commenced construction of the first stage of its alumina refinery at Gladstone, Queensland. 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.

In the period under review, Alcan Aluminium Ltd announced that it had completed acquisition of the Gove alumina refinery and related bauxite mine (Northern Territory), which have a total annual capacity of 1.8 Mt of low-cost alumina. Effective 1 July 2002, Nabalco Pty Limited (manager of the former Gove bauxite/alumina joint venture) officially changed their name to Alcan Gove Pty Limited.

Alcoa is a major Australian producer of bauxite from mines at Huntly and Willowdale in the Darling Range south of Perth. These mines supply three company-owned alumina refineries at Kwinana, Pinjarra and Wagerup with a combined capacity of 7.3 Mtpa, equivalent to some 15% of world demand. Alumina is exported world-wide from shipping terminals at Kwinana and Bunbury. 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.

Following the merger between BHP Limited and Billiton Plc in late June 2001, BHP Billiton is in a position, through resulting joint venture arrangements, to closely link the Worsley mine and refinery operations with the new Mozal smelter (on Africa's east coast), which is shaping as one of the lowest-cost aluminium producers in the world. These facilities are on a direct shipping route and in effect are a perfect complement of world class assets, that would be underpinned by the bauxite reserves near Boddington, which at 3.1 Mtpa production, have a minimum 40-year mine life.

BLACK COAL

Black coal occurs in all Australian states and the Northern Territory. Most deposits are Permian in age (about 250 million years old), however, younger deposits of Triassic, Jurassic and Cretaceous ages also occur. There are significant resources of high quality black coal in New South Wales and Queensland. Small but locally significant resources also occur in Western Australia, South Australia and Tasmania. The major use of black coal in Australia is for the generation of electricity. Other uses include coke making for the iron and steel industry and as a source of heat in cement and food manufacturing. The value of black coal exports in 2001 totalled \$12.5 billion.

Resources

In-situ EDR for 2001 was 60 Gt and recoverable EDR was 40.8 Gt. Both decreased from 2000 by 4.2% due mainly to production losses and reductions due to JORC Code compliant reporting. The in-situ paramarginal demonstrated resources increased by over 120% to 3.1 Gt and recoverable paramarginal demonstrated resources increased by 60% to 1.6 Gt. The in-situ and recoverable submarginal demonstrated resources increased 34% to 16.8 Gt and 33% to 11 Gt respectively. The main reason for increases in paramarginal demonstrated resources and submarginal demonstrated resources is reassessment of resources by companies to ensure compliance with the JORC Code.

Queensland (63.4%) and New South Wales (32.9%) had the largest share of recoverable EDR in Australia. Geoscience Australia estimates that just under 50% of recoverable EDR is mineable by open-cut methods. In relation to recoverable EDR, about 36% is of coking quality and just over 40% of it occurs in current or committed mining operations.

Additional resources of black coal in Queensland and New South Wales are very large but unquantified. South Australia and Western Australia have inferred resources totalling 22 Mt.

Exploration

Data published by ABS on coal indicated that exploration expenditure for 2001 totalled \$49 million, an increase from \$35.1 million in 2000. Expenditure in Queensland was 59% of the total.

Production

In 2001 Australia produced 333 Mt of raw coal (301.2 Mt in 2000), which yielded 264.7 Mt of saleable coal (244.6 Mt in 2000). Of the total raw coal produced 239 Mt (72%) came from underground mines. Underground production accounted for 187 Mt (70%) of saleable coal output. Queensland and New South Wales dominate coal production accounting for a total of 97% (323 Mt) of raw coal output and 96% (266 Mt) of saleable coal production. Queensland accounted for 180 Mt of raw coal and 143 Mt of saleable coal output.

Exports of black coal during 2001 were made up of 106 Mt of coking coal and 86.7 Mt of thermal coal, in total were valued at \$12.5 billion. ABARE projects Australia's thermal and coking coal exports will grow to 105.4 Mt and 119.0 Mt respectively by 2006.

World ranking

Australia has 5% of the world's recoverable black coal EDR of 788 Gt and ranks sixth behind USA (27%), Russia (19%), China (12%), India (10%) and South Africa (6%).

Australia produced about 7% of the world's black coal output in 2001 and ranked fourth after China (27%), USA (26%) and India (8%).

Industry Developments

There were a number of significant developments in the New South Wales coal industry during 2001.

- Mount Owen increased capacity by 50% to 7 Mtpa of thermal and semi-soft coking coal.
- Construction commenced at the Nardell Colliery near Singleton. The mine is planned to produce up to 1.2 Mtpa of thermal and semi-soft coking coal with potential to expand to 5 Mtpa.
- Glennies Creek was equipped with a longwall system, which is scheduled to be producing thermal and semi-soft coking coal in mid-2002.
- The \$50 million Donaldson Project near Maitland commenced construction in early 2001. An estimated 50 people will be employed at the open-cut mine producing up to 2.5 Mtpa of thermal coal.
- Ravensworth East and South Lemington Extension commenced production of thermal and thermal and semi-soft coking coal respectively.
- An exploration adit was being driven into the Lower Whybrow Seam at Beltana. This will allow development of headings for a punch longwall operation to commence in late 2002 at a rate of up to 6 Mtpa of thermal and semi-soft coking coal.



- Preparation work for underground development of the first Tahmoor North longwall panel commenced. Extraction of coal is planned for early 2004, which should double production to 3.2 Mtpa of coking and thermal coal.
- BHP Billiton approved the development of the \$540 million Mount Arthur North open-cut mine. Production of 6.3 Mtpa (saleable) thermal coal is planned for 2003 with full production of 12.1 Mtpa (saleable) in 2006.
- Development of the \$250 million Dendrobium Colliery was approved by BHP Billiton board. Construction of the 5.2 Mtpa capacity longwall mine is scheduled to begin in early 2002 and when completed should employ 170 people. Production will be coking (metallurgical) coal and Dendrobium will replace the nearby Elouera Colliery, which is planned to cease operations in 2004.

A number of developments were announced in Queensland during 2001.

- The \$425 million Hail Creek hard coking coal mine was approved by Rio Tinto. Production is planned to commence in late 2003 with full production due in 2005 at a design capacity of 5.5 Mtpa. At the Kestrel project, planning continued for the development of the new Ti Tree mine.
- Development of the Anglo Coal Grasstrees Colliery commenced with the sinking of two shafts to access the German Creek seam. The first longwall coal production is planned for early 2005 at a rate of 4 Mtpa of coking coal.
- At Newlands, the Northern mine area is due to commence in mid-2003. Longwall production is scheduled to finish in the Southern area by 2005. Mining has commenced at the Pipeline deposit south of Collinsville. MIM are continuing studies on the Suttor Creek thermal coal deposit with the aim of augmenting future production from Newlands. MIM are also undertaking a feasibility study on the Rolleston thermal coal deposit with a decision due in mid-2002.
- The Coppabella mine is expanding with an extension of the washplant by mid-2002 and introduction of a dragline.
- Macarthur Coal is to undertake a bankable feasibility study for the development of the Monto deposit in the Mulgildie Basin. The \$15 million thermal coal mine is planned to have a capacity of 0.5 to 1.0 Mtpa and could start as early as 2002-03. Macarthur is also undertaking studies on the Moortvale deposit, which could result in a 1.6 Mtpa semi-soft coking, pulverised coal injection and thermal coal mine as early as 2003.
- Mining commenced at the Curragh East coking and thermal coal mine. At Girrah exploration drilling continued with a view to establishing an open-cut coking and thermal coal mine by 2003 as a satellite to the Curragh mine.
- Stanwell Corporation plans to develop the Pisces open-cut coal mine about 35 km north of Blackwater. Thermal coal will be supplied to the Stanwell power station near Rockhampton.
- New Hope Coal Australia announced plans to commence operations from the New Acland mine near Oakey in late 2002. Thermal coal production of 2 Mtpa will be for export and domestic markets.

Several developments took place during the year at Australian coal ports including work to upgrade the RG Tanna Coal Terminal, Queensland, from 30 to 40 Mtpa at a cost of \$80 million. Completion is expected in early 2003 and will include a third berth capable of servicing 220,000 DWT vessels. The Dalrymple Bay Coal Terminal, Queensland, has been leased to Babcock and Brown for 50 years with an option to extend for a further 49 years. A \$45 million stage 5 expansion will take capacity from just over 40 to 44 Mtpa by early 2002. The stage 3 expansion of Port Waratah Coal Terminal, New South Wales, to 89 Mtpa was completed in late 2001.

The Commonwealth Government passed the Coal Industry Repeal Act (2001), which signalled its intention to withdraw from the Joint Coal Board (JCB). New South Wales passed the Coal Industry Bill, which allows for the establishment of two industry owned and operated companies to administer the functions of the JCB and the NSW Mines Rescue Board.

A major Chinese coal producer (Yankuang) has signed a formal agreement with the CSIRO and the University of NSW to progress the introduction of longwall top coal caving into Australia. The method can operate in seams up to 12m with good conditions. An Australian-American joint venture plans to introduce an underground thin seam coal auger. The auger may be used to access additional reserves from any of the numerous mature mines in Australia, which are nearing the end of their economic life.

In South Australia the Ingomar trial coal pit produced 15,000 t from the Rankin Seam. The coal is scheduled to be used in the Whyalla demonstration iron ore smelter. In New South Wales, a briquetting plant was constructed at the closed Wallerawang mine to process tailings into a product suitable for blending into feed for the Mount Piper Power Station.

The Johndilo coal bed methane (CBM) pilot project in New South Wales commenced during 2001. Initially the gas is being delivered into the distribution network at Camden. This project has been declared a State Significant Development. Queensland Gas Co is planning two CBM pilot projects in the Surat Basin (Aberdeen and Berwyndale South), which are due to commence in 2002. Arrow Energy NL intends to commence a CBM pilot project at Dundee-2 in the Surat Basin.

BROWN COAL

Australian brown coal deposits occur in Victoria, South Australia, Western Australia and Tasmania. The deposits are Tertiary in age ranging from about 15 million to 50 million years old. Brown coal is mined only in Victoria, where it is used mainly for the generation of electricity at adjacent power stations. Briquettes are also produced for industrial and domestic heating in Australia and overseas.

Resources

Australia's in situ EDR of brown coal was slightly lower than in 2000 at 41.9 Gt, but recoverable EDR was unchanged at 37.7 Gt. In situ and recoverable paramarginal demonstrated resources and submarginal demonstrated resources remained unchanged. In situ inferred resources increased marginally to 114.4 Gt as did recoverable inferred resources to 102.2 Gt. Victoria accounts for over 95% of Australia's total resources of brown coal. All EDR is located in Victoria, with about 89% of the total located in the La Trobe Valley.

Exploration

ABS does not publish data relating to exploration for brown coal specifically either nationally or at a State level.



Production

In 2001, Australian brown coal production was about 66 Mt, down slightly on 2000. About 98.5% of Australia's brown coal production comes from the La Trobe Valley, Victoria.

World Ranking

Australia has about 20% of the world's recoverable brown coal EDR of 188 Gt and was ranked second behind Germany (23%).

Australia produced 8% of the world's brown coal in 2000 and was ranked third largest producer after Germany (20%) and USA (10%). World output in 2001 was about 188 Gt.

Industry developments

In late 2001 the Victorian Government invited tenders for the exploration rights to defined brown coal resources in the La Trobe Valley. In providing access to these coal resources, the Government is encouraging the application of new and innovative technologies to produce competitive electricity and other products. Successful tenders are to be announced in mid-2002.

Australian Power and Energy announced a proposal to build a \$5 billion plant to convert the coal into gas and diesel fuel and build a 1000 MW power station in the Latrobe Valley. The company plans to reduce greenhouse gas emissions by using geosequestration technology.

Yallourn Energy is investigating a new mining method, which uses a dozer fitted with a special blade to push coal into a mobile feeder breaker located at the toe of the batter of the slope. The coal then passes onto a link transfer conveyor to feed the trunk conveyor system.

COPPER

Australia is a major copper-producing nation with world class mining and smelting operations at Olympic Dam (South Australia) and Mt Isa (Queensland). Other significant copper producing operations are at Northparkes and Cadia Hill in New South Wales, Ernest Henry, Osborne and Mount Gordon (Queensland), and Golden Grove and Nifty in Western Australia.

Resources

Total Australian resources of copper rose by 3.78 Mt in 2001 to 58.5 Mt with increases in inventories occurring in Queensland, New South Wales, Victoria and South Australia.

Australia's EDR rose by 178 kt, an increase of just under 1% to 24.24 Mt. EDR is the sum of the JORC Code Ore reserve categories and those resources from the measured and indicated resource categories assessed by Geoscience Australia as likely to be economic at the time of classification. South Australia has the largest EDR with just under 50% of the national total, but its overall share declined by 2% in 2001. The majority of South Australia's resources are associated with WMC's Olympic Dam deposit. Queensland has the second largest EDR with 26%, followed by New South Wales and Western Australia, each with about 9%.

Subeconomic demonstrated resources increased by about 2% to 15.9 Mt, made up of 14.7 Mt in the paramarginal demonstrated resource category and 1.2 Mt in the submarginal demonstrated resource category. South Australia clearly dominated the paramarginal resources category, but its share fell from 92% to 90%. In 2001, New South Wales recorded the largest growth in paramarginal resources, a seven-fold increase. Minor increases in the submarginal category occurred in Western Australia and New South Wales.

Inferred resources rose by 3.3 Mt (22%) to 18.32 Mt in 2001. Increases in inferred resources were reported in all states, except Northern Territory and in Tasmania. The largest increase occurred in South Australia where, with the release of new data on the Olympic Dam deposit, inferred resources rose by over 40%. In Queensland, with the publication of new information by MIM Ltd, Selwyn Mines Limited and other companies, inferred resources rose by 31%. South Australia held 46% of Australia's inferred resources followed by Queensland with 23%.

Exploration

Exploration expenditure for copper reached a record \$38.4 million in 2001, an increase of 37% over 2000 (\$28.1 million). Based on ABS quarterly statistics, about 50% of this expenditure occurred in Queensland. Expenditure on copper exploration represents 6% of the total mineral exploration expenditure in Australia.

Encouraging exploration results across Australia in 2001 included the following.

- At Cadia, near Orange, New South Wales, Newcrest Mining Ltd encountered 100 m at 3.9 g/t Au and 0.32% Cu within a broader interval of 222 m at 2.3 g/t Au and 0.3% Cu at the Cadia Far East prospect. Newcrest subsequently announced an initial inferred resource of 200 Mt at grades of 1.1 g/t Au and 0.41% Cu for the prospect. Total resources for the Cadia system now stand at 18.8 Mozs Au and 2.35 Mt Cu.
- Kagara Zinc Ltd announced that exploration of the King Vol deposit, 160 km west of Cairns, Queensland, resulted in a global resource estimate of 825,000 t at 20.3% Zn, 0.9% Cu, 1.0% Pb and 38 g/t Ag. Included in this resource is an indicated resource of 730,000 t at 20.4% Zn, 0.8% Cu, 1.0% Pb and 40 g/t Ag. The deposit is reportedly open along strike and down dip. Subsequent drilling yielded additional high grade intersections including 9 m at 20.6% Zn and 3.5% Cu and 6 m at 13% Zn and 1.6% Cu.
- Successful exploration drilling (maximum hole depth of 25 m) by Matrix Metals Ltd at the Mt Watson project, 100 km northwest of Cloncurry, Queensland and 25 km from its Mt Cuthbert mine yielded an indicated oxide resource of 837,000 t at 1.3% Cu. Mapping suggests that mineralisation extends over an area 350 m further east and 700 m further west.
- Selwyn Mines Ltd announced increased reserves for its Mt Elliott and Selwyn Line mines, 150 km southeast of Mt Isa, Queensland. Reserves of 16.61 Mt at 1.27% Cu and 1.38 g/t Au, are part of a measured and indicated resource of 22.5 Mt at 1.37% Cu and 1.69 g/t Au.
- Minotaur Resources Ltd, operator of the Mt Woods Joint Venture, reported copper-gold intersections from the Prominent Hill Prospect half way between Olympic Dam and Coober Pedy, South Australia. A major intersection was 107 m at 1.94% Cu and 0.66 g/t Au, which included 35 m at 3.86% Cu and 0.63 g/t Au. Deeper in the same hole an intersection of 57 m at 1.28% Cu, 0.66 g/t Au, 2.0 g/t Ag, 0.57% rare earths (cerium+lanthanum) and 495 ppm U was recorded. Copper mineralisation occurs as chalcocite disseminations and thin veins in a haematite matrix in the upper parts of the hole, but at depth it is in chalcopyrite and bornite. This variation is similar to the copper zonation in the Olympic Dam deposit. The hole tested partially coincident gravity and magnetic anomalies. Further geophysical surveying along the 2 km gravity anomaly - interpreted to represent an iron oxide body - will support the next phase of drilling. The Mt Woods Joint Venture includes Minotaur (earning 19%), BHP Billiton (earning 51%) and Normandy Exploration Pty Ltd, Sons of Gwalia Ltd and Sabatica Pty Ltd.



- At Gossan Hill, 50 km southeast of Yalgoo, Western Australia, Normandy Mining Ltd reported high grade mineralisation in the new Amity, Catalpa and Hougoumont orebodies. Normandy defined an inferred resource of 2.4 Mt at 14.7% Zn in the Amity body and 0.96 Mt at 17.7% Zn in the upper zone of the Catalpa orebody; a drill intersection 400 m deeper yielded 5.9 m at 29.6% Zn. In the Hougoumont orebody, a zinc resource of 1.88 Mt at 19.4% Zn and 3.5 g/t Au has been delineated and there is an additional copper-rich zone with an inferred resource of 2.37 Mt at 3.1% Cu.
- The deepest hole drilled by Compass Resources NL at its Browns project, 65 km south east of Darwin, Northern Territory, intersected 68 m (true width of 45 m) of high grade mineralisation, from a depth of 387 m, grading 0.44% Cu, 11.28% Pb, 0.11% Co, 0.09% Ni and 26 g/t Ag. Included were a number of higher grade intervals of up to 43.8% Pb and up to 2.58% Cu. Compass also announced that drilling on previously untested tenements surrounding Browns had intersected base metal mineralisation.

Production

In 2001, Australia's mine production of copper was 869 kt, 5% higher than 2000 (829 kt). Queensland continued to be dominant accounting for an increase of 461 kt (3%) in production over 2000, and accounted for 53% of Australian production, down from 54% in 2000. South Australia remained the second largest producer with 201 kt, representing 23% of Australia production. Production of contained copper (in rounded figures) in other States was: New South Wales 126 kt, Western Australia 47 kt and Tasmania 33 kt.

The value of Australia's exports of copper concentrates and refined copper amounted to some \$2.3 billion, an increase of 21% over 2000 (\$1.9 billion). The increase was achieved despite a fall in copper prices over the last year, from an average of \$3475/t in the December quarter 2000 to an average of \$2773/t in the December quarter 2001.

World ranking

Australia has the third largest EDR of copper (7%), after Chile (25%) and USA (13%).

As a copper producer, Australia ranks fourth (6%) in the world after Chile (35%), USA (10%) and Indonesia (8%).

Industry developments

MIM is investigating the feasibility of extending the life of its copper operations. The new Enterprise mine accesses ore reserves at depths of up to 2000 m making it the deepest mine in Australia.

At the Ernest Henry mine, Queensland, the open-pit is currently 200 m deep, with an expected final pit depth of 570 m scheduled to be reached in 2016. Additional resources are potentially accessible by underground methods.

The Selwyn project, Queensland, treatment plant was expanded from 750 ktpa to 2.0 Mtpa in early 2002. Drilling programs are planned along the Selwyn Line and at Mt Elliott and Lady Ella with a view to extending the operational life at Selwyn.

The Osborne copper-gold orebody, Queensland, extends 900 m below ground and the mine has a minimum life to 2006. However, exploration has established copper mineralisation within three ironstone units along a continuous strike length of 1.6 km, which could extend the operation.

At Mt Watson, 100 km north of Mt Isa, Queensland, Matrix Metals has identified an oxide copper resource that has the potential to extend the life of the Mt Cuthbert operation. At Mt Gordon, re-establishment of the Mammoth underground decline commenced in preparation for an underground drilling campaign to evaluate future mining opportunities.

Mineral Commodities NL have prepared a mine plan based on mining 450 ktpa over four years at the Trekelano copper project, 110 km southeast of Mt Isa.

The Thalanga Copper Mines Pty Ltd is developing the Reward Deeps underground mine by way of a 3.3 km decline from the Highway open-cut. Exploration is being carried out at the Acquittal, Coronation and Handcuff prospects to extend mine life in the area.

WMC has announced a scoping study (to start in 2002), to evaluate increasing copper production at Olympic Dam from 200 ktpa to between 350 and 600 ktpa. The recommendations from this study would address whether a pre-feasibility study should be undertaken to produce development plans.

At Cadia Far East, New South Wales, Newcrest Mining Ltd is conducting deep drilling to investigate the potential for a bulk underground mineable resource based upon the wide intervals of continuous grade gold-copper mineralisation, which was first identified by drilling in 1996.

The \$20 million expansion of the Nifty operation in Western Australia was completed in mid-2001 increasing production to 25 ktpa. Straits Resources are investigating the possible development of an integrated copper facility at Nifty, capable of fully exploiting the oxide and sulphide resources. Straits are also studying the development of Whim Creek deposit, which would involve relocating the processing plant from its Girilambone operation.

In Tasmania, Mt Lyell overcame stope development problems and increased production to 2.8 Mtpa. The aim is to achieve a 3.5 Mtpa underground operation, which will have a mine life of 7 years on current reserves.

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 Earth's 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 downstream 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 drill bits, 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 had a net decrease of 5% in 2001. The EDR for gem/near gem diamond was 79.2 Mc and industrial 82.4 Mc, both down 14% compared to 2000. Production from the Argyle mine accounts for most of this change.



Exploration

In 2001, Australia's diamond exploration expenditure was \$30.9 million, up \$1.5 million compared to 2000 expenditure.

Production

Australia's total diamond production in 2001 was 26.2 Mc, a decrease of 0.4 Mc on the previous year. The Argyle diamond mine (at 26.1 Mc) accounts for most Australian production. The Merlin mine in the Northern Territory (with 55,000 carats production in 2001) 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 (14% 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

Further development of the open pit at Argyle (AK1 pipe) continued in 2001. Rio Tinto reported that results from an order of magnitude study on underground mining of the AK1 pipe (the main resource at Argyle) were encouraging.

Kimberley Diamond Company formally acquired the Ellendale mining area leases previously held by Argyle Diamond Mines. Bulk sampling results from Ellendale pipes 4 and 9 revealed higher grades near surface. The company reported an initial resource for Ellendale 4 of more than 2 Mc to a depth of 140 m (23 Mt at 8.8 carats/100t), including a higher grade zone of 444,000 t at 26.1 carats/100t to a depth of 3 m, and the discovery of 11 new lamproite pipes in the Ellendale area.

Striker Resources NL announced the commencement of drilling on the Seppelt 1 pipe, with the intention of establishing an inferred resource. The company also reported the recovery of 162 diamonds from stream sampling approximately two kilometres from Seppelt 1, which according to the company, are unlikely to be from the Seppelt 1 pipe and suggest the presence of an additional diamond source.

Tawana Resources NL reported that a detailed gravity survey over its Flinders Island prospect in South Australia identified a gravity low coincident with an area of abundant anomalous kimberlitic indicator minerals. The company recovered three diamonds from loam sampling on the island.

Elkedra Diamonds has taken out extensive tenement coverage over the Altjawarra Craton, some 200km northeast of Alice Springs in the Northern Territory. They reported the identification of 31 drilling targets from aeromagnetic data, and the recovery of 11 diamonds (including 1 macrodiamond) from a 40 kg ant mound sample taken over a high priority magnetic anomaly located northeast of the Mt Ultim target area.

GOLD

Gold prices were depressed throughout the year and despite a small rally in September and October, when the average price was around US\$283 per ounce, it finished the year in the mid-US\$270s per ounce. Australian gold exploration spending continued to fall with a reduction of 5.6% registered in 2001. Despite this, resources increased in both the demonstrated and inferred categories, reflecting a concentration of exploration at or close to known deposits. Although production was still at a historically high level it was substantially lower than in 2000. Australia maintained its world standing in terms of both production and resources.



POURING GOLD AT MINE-SITE OPERATIONS (AurionGold Ltd)

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 in and are mined in all States and the Northern Territory. Total Australian resources rose by 661 t (21.3 Mozs) in 2001. After allowing for replacement of resources lost to production, total newly delineated resources added to the national inventory in 2001 was 942 t (30.3 Mozs). An increase in inventories occurred in New South Wales, Victoria, Western Australia and the Northern Territory.

Australia's EDR rose by 197 t (6.3 Mozs), an increase of 4% to 5156 t. EDR is the sum of the JORC Code reserves categories and those resources from the measured and indicated resource categories assessed by Geoscience Australia as likely to be economic. Some 57% of the EDR fell into the JORC reserves category in 2001, an increase on the 55% recorded in 2000.

Western Australia continued to dominate EDR with almost 61% of the national total. In 2001 its EDR recovered from a reduction in 2000 to increase by 165 t (6%) to 3124 t. South Australia had the second largest and with Western Australia account for almost 79% of Australia's EDR. EDR in New South Wales was unchanged at 470 t. Queensland became the state with the fourth largest EDR, as an increase of 31 t brought its EDR to 261.3 t. The Northern Territory's EDR rose by just under 4 t to 260.8 t. After a small fall in 2000, Victoria's EDR rose by 9 t in 2001 to 75 t but Tasmanian EDR fell by almost 7 t to 33 t.

EDR accounted for just over 80% of demonstrated resources, a similar level to 2001.



Subeconomic demonstrated resources increased by 35 t (3%) to 1173 t. The increase was due to a 40 t growth in paramarginal resources more than offsetting a decline of 5 t in the submarginal category. Western Australia clearly dominated paramarginal resources with 741 t. This was an increase of 105 t and caused its share of Australia's paramarginal resources to rise from 62% to 70%. Paramarginal resources fell in all other states but rose by 22 t in the Northern Territory to just over 89 t. Queensland recorded the largest fall with a drop of 58 t to 86 t. Other reductions recorded were: New South Wales down by 26 t, and Victoria 3 t. Tasmanian and South Australian paramarginal resources were unchanged in 2001.

Once again only minor movements occurred in the submarginal demonstrated resource category, where there was an overall reduction of 5 t. In Western Australia, an increase of 10 t occurred but this was insufficient to offset reductions of 8.5 t in the Northern Territory, 5 t in Queensland, 1 t in Victoria and 0.2 t in New South Wales.

Inferred resources rose by 429 t (16%) to 3146 t in 2001. Increased inferred resources were recorded in all states except Queensland, where there was a reduction of 43 t (17%). Western Australia's inferred resources rose by 280 t (17%) and New South Wales' by 74% to 415 t. The growth in New South Wales is largely attributable to the release of the first resource estimates for the Cadia Far East deposit. Changes in the other regions were relatively small with the Northern Territory adding 14 t to its inferred resources, Victoria added 0.5 t, Tasmania 1 t and South Australia 0.1 t. Western Australia maintained its dominant share of Australia's inferred resources at 61%.

The ratio of demonstrated to inferred resources fell from 2.2:1 to 2.0:1

Exploration

At Australia's 2001 rate of production, EDR is sufficient for an average 18 years production. If, however, only resources classified as reserves under the JORC Code are considered, they are adequate for only 10 years at the 2001 production rate. It should be remembered that these are average figures and that there are some operations that may continue after the 18 or 10 years and there are others that will be completed earlier. These figures clearly illustrate the need for ongoing successful exploration in the short and medium terms.

Australia's total mineral exploration expenditure for calendar year 2001 was \$664.5 million based on the sum of ABS quarterly statistics for the year, \$11.9 million lower than in 2000. The gold component of this total was \$350.7 million, \$21 million less than in 2000.

The 2000-2001 spending on gold exploration was \$370.2 million, \$4.6 million less than in 1999-00 and was the lowest recorded since 1992-93. The sharp downturn in exploration spending in recent years shown in [Figure 2](#) reflects the world situation.

Despite this fall in exploration spending, exploration has been successful with substantial tonnages added to the nation's resource base ([Figure 3](#)). An analysis of Australia's gold resources since 1976 shows that in the 1980s resource additions were at deposits discovered in that decade, while in the 1990s only one-third of the new resources defined were in newly discovered deposits. First years of the current decade are similar to the 1990s. In other words, the additions in the 1990s and 2000 and 2001 were largely the result of brownfields exploration.

Australia's ability to contract to brownfields exploration, particularly in the latter 1990s, ensured that its industry as a whole could survive that sustained period of low gold prices. However, this was achieved at the cost of a much-reduced effort in greenfields regions, which have high potential for discoveries. If the industry is going to have a long-term future, exploration and discovery in greenfields areas will need to increase substantially.

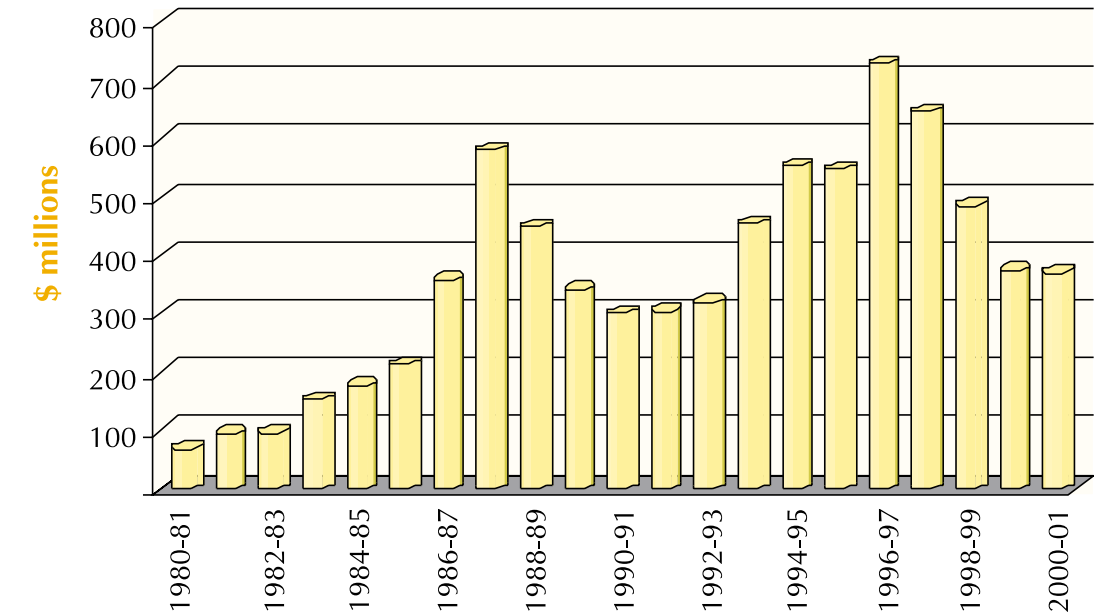


Figure 2: Australian gold exploration expenditure from 1980-81 to 2000-01 (Source: ABS).

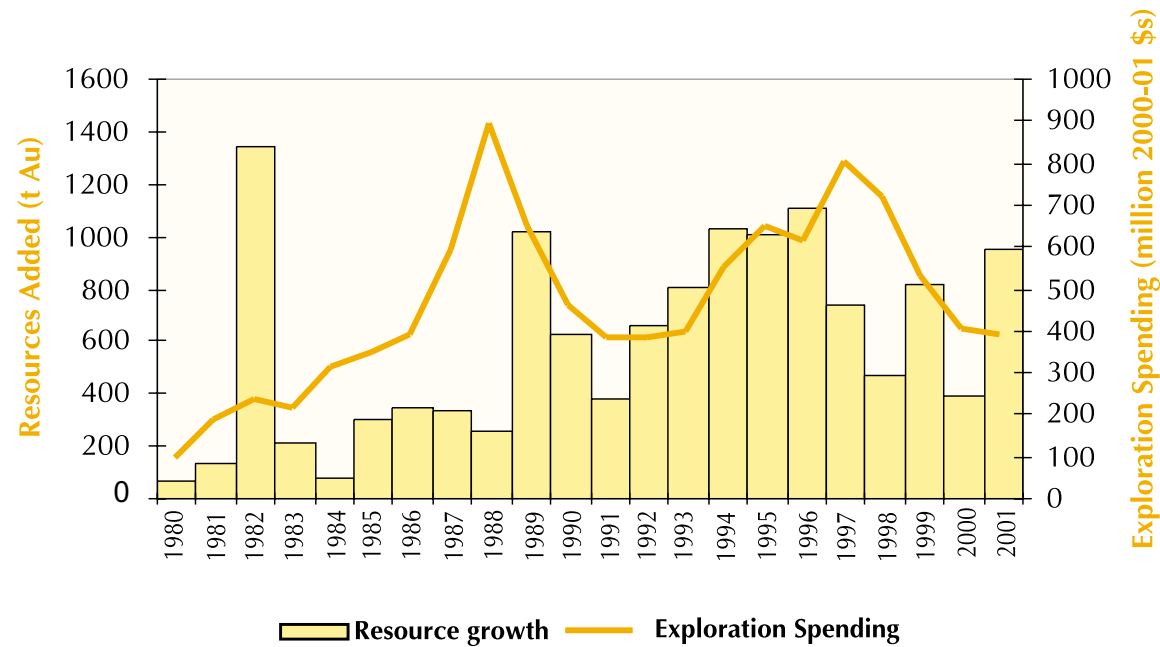


Figure 3: Annual additions to Australia's resource inventory and exploration spending since 1980. (Sources: Resources data from Geoscience Australia; exploration spending is based on published ABS data deflated by a CPI time series provided by ABARE).



Three features of gold exploration in 2001 stand out: - the wide geographical spread of discoveries of new mineralisation across the continent; the continuing success in finding deep mineralisation beneath known mineralised bodies; and the variety of mineralisation styles encountered. These features highlight the continued attractiveness of Australia as a prime target for gold exploration. Although the Archaean greenstones of the Eastern Goldfields of Western Australia continue to attract most attention, there is clearly considerable opportunity for success in other proven and greenfields provinces.

- Minotaur Resources Ltd, operator of the Mt Woods Joint Venture, reported copper-gold intersections from the Prominent Hill Prospect half way between Olympic Dam and Coober Pedy, South Australia. A major intersection was 107 m at 1.94% Cu and 0.66 g/t Au that included 35 m at 3.86% Cu and 0.63 g/t Au. Deeper in the same hole an intersection of 57 m at 1.28% Cu, 0.66 g/t Au, 2.0 g/t Ag, 0.57% rare earths (cerium+lanthanum) and 495 ppm U was recorded. Copper mineralisation occurs as chalcocite disseminations and thin veins in a haematite matrix in the upper parts of the hole but at depth it is in chalcopyrite and bornite. This variation is similar to the copper zonation in the Olympic Dam deposit. The hole tested partially coincident gravity and magnetic anomalies. Further geophysical surveying along the 2 km gravity anomaly - interpreted to represent an iron oxide body - will support the next phase of drilling. The Mt Woods Joint Venture includes Minotaur (earning 19%), BHP Billiton (earning 51%) and Normandy Exploration Pty Ltd, Sons of Gwalia Ltd and Sabatica Pty Ltd.
- At Cadia, near Orange, New South Wales, Newcrest Mining Ltd encountered 100 m at 3.9 g/t Au and 0.32% Cu within a broader interval of 222 m at 2.3 g/t Au and 0.3% Cu at the Cadia Far East prospect. Newcrest subsequently announced an initial inferred resource of 200 Mt at grades of 1.1 g/t Au and 0.41% Cu for the prospect. Total resources for the Cadia system now stand at 18.8 Mozs Au and 2.35 Mt Cu.
- Sipa Resources International NL reported high grade intersections at depths of less than 30 m at the Waugh prospect, 3 km northeast of the Mount Olympus gold mine and 30 km south east of Paraburdoo, Western Australia. Significant intersections include 3 m at 16.5 g/t Au from 1 m and 12 m at 44.0 g/t Au from 20 m including 3 m at 123 g/t Au. Subsequent drilling gave 15 m at 57.2 g/t Au from 21 m, including 3 m at 233 g/t Au from 22 m, and 16 m at 74.8 g/t Au from 41 m including 6 m at 186 g/t Au from 41 m.
- Ongoing work at Dioro Exploration NL's Frog's Leg deposit at the Mungari East Joint Venture near Kalgoorlie, Western Australia, has more than doubled resources to 5.07 Mt at 4.6 g/t Au (0.75 Mozs). Further work showed that mineralisation extends a further 400 m north of its previously known northern limit, including intersections of 3 m at 15.32 g/t Au and 12 m at 7.10 g/t Au. Preliminary assays from one diamond drill hole at Frog's Leg gave 6 m at 40.58 g/t Au.
- WMC Resources Ltd reported further quality intersections from the Belleisle prospect at Kambalda, Western Australia, particularly 42 m at 16 g/t Au. WMC also reported that drilling 10 km to the northwest on the same structure yielded intersections including 29 m at 11 g/t Au and 24 m at 15 g/t Au close to the surface at the Temeraire Prospect. These properties have been sold to Gold Fields Ltd.
- Although mining has started on part of the Raleigh deposit near Kalgoorlie, Western Australia, the East Kundana Joint Venture (Goldfields Ltd 51%, Tribune Resources NL 36.75% and Rand Mining NL 12.25%) reported further high grade drilling intercepts. This drilling was to test the extension of the orebody to a depth of 500 m and to obtain geotechnical data for an underground mining feasibility study. Intersections included 0.28 m at 4.74 g/t Au, 0.5 m at 39.5 g/t Au and 1.6 m at 75.09 g/t Au.

- Normandy Mining Ltd reported results from its Bronzewing and Jundee properties, Western Australia, that continued a general trend for quality intersections in deep drilling. At Bronzewing, Normandy reported 5 m at 5.5 g/t Au from work on the Pathfinder Fault and northeast of the Central Shoot 1.8 m at 7.5 g/t Au from 238 m and 6.1 m at 3.6 g/t from 329 m. At Jundee results from the Digger and Gateway structures included 1 m at 38.1 g/t from 384 m, 1.7 m at 280 g/t Au from 232 m and 2 m at 13.4 g/t Au from 404 m. Also at Jundee, underground drilling on the Westside structure yielded high grade intercepts including 1.1 m at 96.3 g/t Au, 3.6 m at 46.2 g/t Au, 1.0 m at 52.8 g/t Au and 2.4 m at 26.7 g/t Au. Mineralisation is open at depth and the structure has a probable strike length of over 600 m.
- The Wildara Joint Venture (LionOre Mining and Dalrymple Resources) and PacMin Mining Corp reported encouraging intersections from the Snapper Prospect 70 km south of Leinster, Western Australia, and 7 km south of the Thunderbox deposit. Reported downhole widths and grades included: 32 m at 8.2 g/t Au, 16 m at 2.13 g/t Au, 6 m at 1.10 g/t Au and 35 m at 1.0 g/t Au.
- A deep diamond drilling program at the Whisper project, near Laverton, Western Australia, reported by Metex Resources Ltd gave good primary mineralisation grades. Intersections were 2 m at 2.75 g/t Au from 250 m, 7 m at 9.41 g/t Au from 254 m and 1 m at 3.46 g/t Au from 263 m. The mineralisation occurs in a banded carbonate rock, with up to 20% disseminated pyrite, that has been extensively intruded by felsic rocks. Delta Gold Ltd (now part of Aurion Gold) is Metex's joint venture partner.
- Selwyn Mines Ltd announced increased reserves for its Mt Elliott and Selwyn Line mines, 150 km southeast of Mt Isa, Queensland. Reserves, which total 16.61 Mt at 1.27% Cu and 1.38 g/t Au, are part of a measured and indicated resource of 22.5 Mt at 1.37% Cu and 1.69 g/t Au.
- At the Mt Rawdon mine, 70 km west southwest of Bundaberg, Queensland, Equigold NL, reported a major increase in reserves to 45.85 Mt at 1 g/t Au and 3.7 g/t Ag for 1.44 Mozs of contained gold of which pit optimisation studies suggest 1.31 Mozs will be recoverable. This growth in reserves will extend the project's life to 18 years.
- Alkane Exploration Ltd has reported encouraging exploration results from the Wyoming prospect, 12 km north of Alkane's Peak Hill mine, New South Wales. Better intersections included 14 m at 3.29 g/t Au and 34 m at 1.98 g/t Au including 7 m at 7.06 g/t Au. The mineralisation is reportedly spatially associated with an anomalous arsenic trend along the contact between pelitic sediments and a volcanic/volcaniclastic sequence.
- Drilling by AGD Mining Ltd on behalf of itself and partner Deepgreen Minerals Corporation at Costerfield, Victoria, resulted in high-grade gold-antimony intersections in six diamond drill holes over some 200 m of strike length. Included in the results were: 0.88 m at 43.1 g/t Au and 20.5% Sb, and 0.3 m at 9.2 g/t Au and 4.4% Sb. A measured and indicated resource of 242,300 t at 12.4 g/t Au and 6.4% Sb has been estimated.
- At the Woolgar project, 100 km north of Richmond, Queensland, Strategic Minerals Corporation N.L. reported several very good intersections from the Explorer epithermal system including 6 m at 34.48 g/t Au from 36 m and 5 m at 6.7 g/t Au from 54 m.
- Grenfell Resources Ltd announced the discovery of a new gold-copper mineralised zone at its Soyuz prospect 25 km northwest of Tarcoola, South Australia, where 7 m at 4.83 g/t Au with minor copper and silver was intersected in a mineralised assemblage consistent with an iron oxide copper-gold system. The prospect has strong magnetite developments close to what is believed to be granitoids of the Hiltaba Suite.



- Hill 50 Gold NL continued successful exploration adjacent to known deposits in its properties at Mount Magnet, Western Australia. They reported a new deposit, Crawfords, in sheared komatiite and granodiorite 200 m west of the O'Meara deposit. Intersections reported included 12 m at 5.9 g/t Au from 22 m and 8 m at 10.4 g/t from 51 m. The company says that the new deposit will support an open pit mine.
- Gateway Mining N.L. reported 4 m at 4.90 g/t Au from 31 m at its Nasdaq prospect near Cowra, New South Wales, in a skarn which also has minor copper. The company also reported that drilling at the Tuckerbox prospect near Cootamundra, NSW, included 7 m at 3.53 g/t Au, including 1 m at 8.47 g/t Au and 1 m at 5.83 g/t Au.
- In the Telfer district, Western Australia, Newcrest Mining Ltd recorded encouraging intersections from holes aimed at testing the down-plunge extension of the Backdoor mineralisation. Better intersections reported included 13 m at 6.6 g/t Au and 45 m at 2.8 g/t Au both of which incorporate higher grade zones.
- At Pajingo in the Drummond Basin, Queensland, results at Police Creek, where Normandy Mining Ltd tested a geophysical anomaly, included 8 m at 3.45 g/t Au from 108 m, 12 m at 1.85 g/t from 28 m and 7 m at 2.5 g/t Au from 170 m.
- Ongoing exploration in the Norseman Goldfield, Western Australia, continues to yield good results from the Daisy prospect. Central Norseman Gold Corporation Ltd reported intersections of 17 m at 13.8 g/t Au, 10 m at 3.3 g/t Au and 13 m at 7.9 g/t Au.
- Sedimentary Holdings announced that the Cracow Joint Venture had encountered significant new gold intercepts some 800 m northwest of the Royal Shoot at Cracow, Queensland. Intersections included 6 m at 5.2 g/t Au and 18.9 m at 4.3 g/t Au. Newcrest Mining Ltd and Sedimentary also announced that the combined resource estimate for the Crown and Royal shoots at the Cracow JV was 2.4 Mt of ore at 10 g/t Au (0.8 Mozs).
- A currently unlisted subsidiary of Macmin Ltd announced encouraging results from a re-evaluation of samples generated by previous work at its Southern Mt Read Volcanics project south of Macquarie Harbour, Tasmania, including a drill intersection of 3 m at 17.5 g/t Au.
- Also in Tasmania, drilling by Anglo Australian Resources NL and Silverthorn Resources Pty Ltd extended the zone of mineralisation at the East Denison prospect, 40 km north of Launceston. Intersections reported included 9 m at 1.81 g/t Au and 5 m at 2.17 g/t Au.

Production

Preliminary data from ABARE indicate that Australia's gold production in 2001 fell by just over 4% to 284 t. Western Australia continued to dominate production with just over 200 t, almost 2% lower than in 2000, and accounting for 70% of Australian production compared to 69% in 2000. Queensland was again the second largest producer but its output fell by over 5 t to 31.7 t. Other production (in rounded amounts) was: Northern Territory 20 t, New South Wales 18 t, Tasmania 6.1 t, Victoria 3.6 t and South Australia 4.3 t.

World ranking

Based on figures published by the USGS and modified to incorporate the Australian resources reported here, Australia has the third largest EDR after South Africa and the USA. World EDR in 2001 is estimated at 50,156 t of which South Africa accounted for 38%, a slight reduction on its share in 2000. The USA's share was steady at 11% and Australia maintained its share of world EDR at 10% for the year. Russia again followed Australia and had 6% of the total EDR.



UNDERGROUND WORKSHOPS AT THE HENTY GOLD MINE, TASMANIA
(AurionGold Ltd).

The USGS report total world gold production in 2001 at an estimated 2530 t. Production rankings remained unchanged with South Africa being the largest producer with 16% (400 t) of world output, slightly less than in 2000. It was followed by the USA (350 t), whose share was steady at 13.8%. Australia's share was down slightly to just over 11%. The USGS estimate that China's production rose to 185 t, maintaining its position ahead on Canada (160 t). Russian production, according to the USGS, rose by 23% to 155 t making it the world's sixth largest producer.

Industry developments

In the Tanami region of the Northern Territory, the Groundrush mine commenced production in November. Ore from the mine is treated at The Granites treatment plant. Mining commenced at the M1 deposit at the Minjar project in Western Australia during the year.

A number of established mines closed during 2001 including the Boddington operation in Western Australia, which ceased production in November. After a cleanup and closure phase the mine will be put on a care-and-maintenance footing in 2002. A feasibility study was completed in 2000 for the expansion of the operation, which has a reserve of nearly 11Mozs of gold, and a decision on the project is expected during 2002.

Other mines to close include Mount Charlotte, Western Australia, which was officially closed in December. At Kidston, Queensland, mining operations ceased in June and the last gold was poured in July. Mining was completed at Mount Leyshon, also in Queensland, in June and processing of remaining stockpiled ore was continuing at the end of the year.

IRON ORE

Iron ore is the raw material for the production of iron and steel and provides the basis of a major Australian export industry. Resources of iron ore occur in all Australian States and the Northern Territory. Western Australia has over 86% of the identified resources most of which are in the Pilbara region.

Resources

EDR decreased 9.2% to 12.4 Gt mainly due to a company reassessment of the Robe River deposits. Approximately 43% of EDR are in the JORC Code categories of proven and probable reserves. Paramarginal demonstrated resources decreased by 89.2% to 0.2 Gt mainly because of the downgrading of many of the Area C deposits, which are now only considered to be exploration results due to outdated sampling and assaying techniques. Submarginal demonstrated resources increased 14.5% to 1.6 Gt with Western Ridge and some of Yarrie ore now assessed as submarginal. Inferred resources decreased 13.6% to 12.3 Gt mainly due to Hamersley Iron downgrading the status of some undeveloped deposits, where initial estimates were made some time ago and modern standards of quality assurance were not applied.





IRON ORE MINING AT YANDI EASTERN PIT 2 MINE IN THE HAMERSLEY BASIN, WESTERN AUSTRALIA.

(BHP Billiton).

Exploration expenditure

ABS data indicates that exploration expenditure for iron ore in 2001 totalled \$20.1 million down from \$26.1 million in 2000. All of the expenditure was recorded by ABS as being in Western Australia.

Production

ABARE reported that Australia's iron ore production in 2001 was 181.6 Mt (167.9 Mt in 2000). Western Australia was the dominant State producing 176.4 Mt which was 97% of total Australia production. Smaller tonnages are produced in South Australia and Tasmania.

ABARE reported Australian exports were 156.7 Mt (157.3 Mt in 2000) in 2001, which were valued at \$5,200 million. The Bureau forecast Australia's iron ore exports will increase to around 190.6 Mt in 2006-07, with total Australian production increasing to around 209.5 Mt.

World ranking

Australia has some 9% of world EDR of iron ore and is ranked fourth after China (19%), Russia (19%) and Ukraine (16%). In terms of contained iron, Australia has about 11% of the world's EDR and is ranked fourth behind Russia (21%), Ukraine (18%) and China (11%).

Australia produces around 18% of the world's iron ore production and is ranked third behind China (22%) and Brazil (20%).

Industry Developments

Rio Tinto and its Japanese partners reached an agreement that allowed the development of West Angelas project (WA) to commence. The partners agreed to initially use Rio Tinto's rail network, however, a new rail line can be built once production reaches 20 Mtpa. It is planned to lay 60 km of track to link the project with Rio Tinto's existing line. Production is likely to start in late 2002 at an initial rate of 6 Mtpa moving up to 20 Mtpa by 2008.

Rio Tinto announced that Kwinana, Western Australia, has been selected as the preferred location for the development of the Hismelt project. The project has been referred to the Western Australian Environmental Protection Authority for the formal environmental impact assessment process.

At BHP Billiton's Area C project, contractors extracted a 740 000 t bulk sample of Marra Mamba ore from Deposit C. The ore was transported to Orebody 25 near Newman for rail to Port Hedland. Steel mills plan to trial the Marra Mamba lump and fine ore during 2002. The company is undertaking a bankable feasibility study for the development of a 15 Mtpa mine in 2003.

BHP Billiton is currently undertaking feasibility studies to expand the Yandi mine's capacity from its current level to 32 Mtpa.

Mt Gibson Iron Ltd are proposing to mine a 20 Mt haematite "cap" on top of the Mt Gibson magnetite deposit (WA), at a rate of around 1.5 Mtpa. The direct shipping ore would be trucked about 80 km to a rail siding and from there it would be railed to shipping facilities at Geraldton.

Portman Ltd are studying the possibility of establishing a Direct Reduction Iron (DRI) plant at Esperance, Western Australia, to treat high phosphorous iron ore from their Koolyanobbing mine. Laboratory scale testing will determine the feasibility of using lignite from the O'Sullivan's deposit as a reductant to process the high phosphorous iron ore. At Portman's Cockatoo Island operation an earth bund wall will be constructed to enable the extraction of iron ore below sealevel and extend the mine life by about 3 years.

Mineralogy Pty Ltd's Iron Ore Processing Agreement was signed in late 2001 by the Western Australian Government for the mining and processing of iron ore deposits near Cape Preston, 85km south west of Karratha.

Iscon Ltd has a two year option over a possible berth development at Harriet Point near Port Hedland for shipping Hope Downs ore.

Australian Bulk Minerals began mining the South Deposit in mid-2001 at Savage River in Tasmania. The company announced that the five oil furnaces at the Port Latta pelletising plant are to be converted to gas.

In the first half of 2001, the AuIron Energy Ltd demonstration plant at Whyalla, South Australia, operated at up to 75% higher than designed capacity. A decision to move to commercial production could be made in 2002 and the first commercial pig iron produced as soon as 2 years later.

LITHIUM

Lithium is a silvery grey metal with a density about half that of water. Lithium resources occur in two distinct categories — lithium minerals and lithium-rich brines. 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.

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. There was a slight decrease in EDR in 2001 to just over 153,000 t, mainly through depletion of resource by production.

Resources have remained unchanged for paramarginal demonstrated resources (78 kt Li), submarginal demonstrated resources (26 kt) and inferred resources (7 kt).

Greenbushes is the world's largest and highest-grade spodumene deposit.

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 in Chile and Argentina, it is 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 in 2001. Although production for the year was 63,443 t, a decrease of 22% over 2000, sales of lithium minerals increased by 16%. This improvement in sales reflected a recovery by the company 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 impact on the price and supply of lithium minerals on the world markets.

World ranking

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 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 2001 was estimated by Geoscience Australia from Australian and USGS data to be 15,000 t of contained lithium, a slight increase since 2000. However, information on USA production is withheld by the USGS for commercial reasons. Chile with 44% remained the world's largest producer, followed by China (17%), Australia (13%) and Russia (14%).

Industry developments

There were no significant developments in the Australia's lithium industry in 2001.

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 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 increased by nearly 27% to 366 Mt in 2001. About half of the increase occurred in South Australia, which has the largest holding of EDR. In South Australia, SAMAG (a wholly owned subsidiary of Pima Mining NL) has identified a global resource of 579 Mt of magnesite in the Willouran Ranges, northwest of Leigh Creek. About 235 Mt of this resource is classified as EDR, in the Mount Hutton and Witchelina deposits.

Queensland has the second largest inventory of magnesite EDR. The bulk of this is at Kunwarara (70 km northwest of Rockhampton), where Australian Magnesium Corporation Limited has an inferred global resource of 1200 Mt of magnesite-bearing material. Within this, the company has an inferred resource of 500 Mt magnesite containing several high-grade zones totalling 85.6 Mt, which are classified as EDR. 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 2000. 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 near Ravensthorpe (WA).

Subeconomic demonstrated resources, which account for around 4% of the total identified resources, fell by nearly 22% during the year. The decrease, all of which occurred in Queensland, was due to upgrading of the paramarginal demonstrated resources to EDR.

Inferred resources fell by nearly 10% to 986 Mt with Queensland accounting for 53% followed by South Australia (30%) and Tasmania (15%).

Exploration

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

Production

In 2001, Australian Magnesium Corporation Limited mined 2.7 Mt of crude magnesite ore at Kunwarara, which was beneficiated to produce 594,674 t of magnesite. This in turn produced 117,872 t of deadburned magnesia, 54,346 t of calcined magnesia and 21,781 t of electrofused magnesia. The only other recorded production of magnesite in 2001 was about 10,000 t in South Australia.

World ranking

According to Geoscience Australia and USGS data, Australia has about 6% of the world's EDR of magnesite. Russia and North Korea, together, account for nearly 61% of the world's EDR. 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 2001. USGS data show that China (24%) and Turkey (19%) were the world's largest producers, followed by North Korea (10%), Russia and Slovakia (both 8%).

Industry developments

During 2001, several potential magnesium metal plant projects continued to make progress towards development. Following the successful raising of \$525 million and confirmation of Ford Motor Company's 10-year take or pay magnesium supply agreement, Australian Magnesium Corporation Limited (AMC) announced approval to commence development of the \$1.3 billion, 97,000 tonnes per year magnesium metal Stanwell project. Site works at Stanwell, 23 km southwest of Rockhampton in central Queensland, were scheduled to commence in February 2002 with full construction expected to start in the third quarter of 2002. Production of the first metal is scheduled for December quarter of 2004.

SAMAG Limited signed a Heads of Agreement with Australian National Power (ANP) to provide power and gas to its proposed magnesium metal plant near Port Pirie, South Australia. ANP plans to construct a \$200 million, 230 MW gas-fired power station next to the proposed smelter site, using gas from BHP Billiton's Minerva Field. SAMAG finalised an offset agreement with ThyssenKrupp Metallurgie for 100% of its output.

Pima Mining NL increased their magnesite resources through the purchase of the deposits at Myrtle Springs, South Australia and at Huandot near Batchelor, North Territory, from Unimin Australia. Pima is expected to finalise, by the middle of 2002, their bankable feasibility study on the proposed 65,000 tpa magnesium metal plant based on the magnesite resource in the Willouran Ranges, northwest of Leigh Creek, South Australia.



In a preliminary study completed in July, Mt Grace Resources NL concluded that the optimum size for the initial stage of their Batchelor magnesium project would be a 14 MW furnace with a projected annual production capacity of 12,500 t of magnesium metal. The company estimate that the direct capital cost of the mine, mining infrastructure, calciner, furnace, condenser and all ancillaries will be A\$76 million. Kvaerner, an international engineering and construction group, has been retained to carry out a complete feasibility study for the project based on the Winchester magnesite deposit, 85 km south of Darwin.

Mt Grace Resources has licensed silico-thermic DC-arc furnace magnesium reduction technology, pioneered by the South African metallurgical group, MINTEK who are currently operating a 1.5 MW demonstration furnace for the project in Johannesburg, South Africa. During the year, the company concluded a memorandum of understanding with Franke & Schulte, a German raw materials supplier and processor, for a long-term off-take agreement to purchase 10,000 tpa of magnesium metal. The company also acquired the Princhester deposit, 95 km north of Rockhampton (Qld), from Gympie Gold Ltd.

In Tasmania, Indcor Limited (previously known as Crest Magnesium NL) deferred its proposed \$1 billion Tasmag project involving a magnesite mine and magnesium smelter following the lack of financial backing and a suitable joint venture partner.

In November, Rambora Technologies raised about \$300,000 to conduct a pre-feasibility study on a 100,000 tpa magnesium metal plant, based on brown coal fly ash tailings produced by power generators in the Latrobe Valley in Victoria. The project is sponsored by Magnesium Investment, a private company, and by Hazelton Power, owned by International Power of the UK. The Hazelton tailings ponds contain an estimated 5 Mt of ash with a magnesium content ranging from 8 to 12%. In addition, the power station produces some 100,000 t of ash annually. This project involves the acid leaching of fly ash followed by purification of the magnesium chloride solution, which is then treated by standard electrolysis using proven Alcan cell technology.

In Western Australia, WestMag Limited has placed on hold its definitive feasibility study into a proposed \$35 million magnesia plant to be built at Port Hedland. The processing plant would involve the mixing of seawater brine with dolomite sourced from the Governor deposit, 350 km southeast of Port Hedland to produce magnesia powder. This end product was to be used as a neutralising agent in the acid pressure leach process, which converts lateritic ore to nickel metal.

Pacific Magnesium Corporation Ltd (formerly Golden Triangle Resources NL) continued work on its magnesium project based on asbestos tailings at Woodsreef, near Armidale in northern New South Wales. The company was investigating the possibility of transferring the current magnesium R&D programs from Israel to Australia.

MANGANESE ORE

Manganese is essential to iron and steel production by virtue of its sulphur-fixing, deoxidising, and alloying properties. It is also an additive in plant fertilisers and animal feed, and a colorant for bricks. In Australia the production of manganese ore occurs at Groote Eylandt in the Northern Territory and at Woodie Woodie in Western Australia. The value of manganese ore exports in 2001 was \$294 million.

Resources

Australia's EDR of manganese ore decreased by 2.3% to 124.9 Mt in 2001 mainly as a result of updated resource data for both Groote Eylandt and Woodie Woodie.

Paramarginal demonstrated resources and submarginal demonstrated resources remained unchanged.

Inferred resources decreased marginally to 197.5 Mt again due to updated resource data.

Exploration expenditure

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

Production

In 2001, Australia produced 2.1 Mt of manganese ore with a manganese content of 0.9 Mt. Exports during 2001 were 1.6 Mt valued at \$300 million.

World ranking

Australia has 7% of the world EDR of manganese ore and is ranked fourth behind South Africa (46%), Ukraine (25%) and China (11%). In terms of contained manganese, Australia has 9% of the world EDR and is ranked third behind South Africa (53%) and Ukraine (20%).

Australia produces 10% of the world's manganese ore and is ranked fifth behind China (20%), South Africa (16%), Ukraine (15%) and Brazil (11%).

Industry developments

The Groote Eylandt Manganese Company (GEMCO) mines a large world class manganese deposit in the Gulf of Carpentaria. GEMCO is owned 60:40 by BHP Billiton and AngloAmerican. In recent years a major study was undertaken to construct a reconcilable resource/reserve model for use as a foundation for the continued operation of the mine. The study concluded that the resource could be mined at the current rate for at least 20 to 30 years.

Consolidated Minerals Ltd is hoping to be able to increase the resources at Woodie Woodie to underpin 10 years of production and to have reserves for 5 years of production. To this end, the company has committed to an annual exploration budget with a minimum of \$1.4 million per annum.

HiTec Energy NL is developing a \$209 million electrolytic manganese dioxide (EMD) project at Port Hedland. HiTec placed its EMD demonstration plant at Murdoch University on care and maintenance in late 2001. To achieve bankability, HiTec will require a minimum revenue stream to cover both operation and financing costs by way of offtake agreements. In addition, a key or strategic equity investor may be required.

MINERAL SANDS

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

Resources

The EDR of ilmenite increased again during 2001, up from 196.0 Mt in 2000 to 201.6 Mt, an increase of 2.8%. The largest increase occurred in Victoria, where ilmenite resources almost tripled as a result of successful exploration on the Douglas Project by Basin Minerals and on the Ouyen Project by Iluka Resources. Victoria has almost 4% of the total ilmenite EDR.

Western Australia has Australia's largest holding of ilmenite EDR (66%) but they decreased slightly as result of production. In Queensland, the second largest holding (26%), ilmenite resources declined by 4.7% as result of reassessment of the State's resources.





STOCKPILED HEAVY MINERAL SAND CONCENTRATES, WEMEN MINE, VICTORIA
(Sons of Gwalia Ltd)

New South Wales (4% of the total EDR) increased its EDR by 50% through successful drilling by BeMax Resources Limited and Iluka Resources Limited in the Murray Basin. Successful drilling in the South Australian portion of the Murray Basin resulted in a doubling of that State's ilmenite resources.

The EDR of rutile (which includes leucoxene in Western Australia) increased by nearly 3% from 21.9 Mt in 2000 to 22.5 Mt in 2001. All of the increase occurred in the Murray Basin in Victoria (up by 34%), New South Wales (up by 8%), and South Australia (a thirty-fold increase). Queensland and Western Australia, which together hold 77% of Australia's EDR of rutile, had slight decreases in 2001, due to production.

Zircon EDR increased by nearly 6% from 27.9 Mt in 2000 to 29.6 Mt in 2001. All of the increase occurred in the Murray Basin particularly in South Australia (ninety-fold increase), Victoria (85% increase) and New South Wales (19% increase). In Western Australia, EDR remained unchanged in 2001, but fell in Queensland, as a result of production in that State. Western Australia and Queensland together have 84% of Australia's EDR of zircon, down from 90% in 2000, a consequence of successful exploration in other areas.

Some 18%, 25% and 27% (compared with 19%, 26% and 30% in 2000) of Australia's EDR of ilmenite, rutile and zircon respectively, are unavailable for mining. Areas quarantined from mining and now largely incorporated into national parks include: Moreton, Bribie and Fraser Islands; Cooloolo 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.

Australia's subeconomic demonstrated resources of ilmenite, rutile and zircon remained unchanged in 2001 at 51 Mt, 12.12 Mt, and 18.95 Mt, respectively. Over 97% of these resources are 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 1.3% to 98.4 Mt in 2001. A four-fold increase in New South Wales' resources and a 19% increase in South Australian resources followed successful exploration in the Murray Basin. These increases offset the decreases in Western Australia (down by 46%), a result of reassessment of company data, and in Victoria (down by 9%) brought about by the upgrading of that State's ilmenite resources to EDR. Victoria is the main holder of inferred ilmenite resources with 41% of Australia's total. New South Wales with 23% has the second largest holdings of inferred resources followed by Western Australia with 17%. Inferred ilmenite resources in Queensland, with 12% of Australia's total, remained unchanged in 2001.

Inferred resources of rutile and zircon increased by 13% and 29%, respectively. The bulk of the increases occurred in New South Wales and South Australia, which offset small decreases in Victoria and Western Australia. Victoria is the main holder of rutile and zircon inferred resources with 53% and 57%, respectively of the Australian total. Victoria has some 8.7 Mt of inferred leucoxene resources, which were previously incorporated with that State's rutile resources. New South Wales with 32% and 22% of Australian inferred rutile and inferred zircon respectively, is the second largest holder of these resources. Queensland's inferred resources of rutile and zircon remained unchanged from the previous year.

Exploration

According to quarterly ABS figures, expenditure on exploration for mineral sands in 2001 was \$29.1 million, an increase of 25.4% over the previous year. Comprehensive State-by-State data are not published by ABS, but it is likely that most of the expenditure was in the Murray Basin, which has an extensive coverage of exploration leases.

Production

In 2001, Australia produced 2.02 Mt of ilmenite, 206 000 t of rutile, 30 000 t of leucoxene and 394 000 t of zircon. The bulk of Australia's rutile and zircon production is exported compared to about 45% for ilmenite. The remaining ilmenite is upgraded to synthetic rutile, which contains about 92-93% TiO_2 .

World ranking

According to Geoscience Australia and USGS data, Australia has the world's largest EDR of ilmenite, rutile and zircon with 32%, 45%, and 42%, of world EDR respectively. Other major rankings are South Africa (19%) and Norway (12%) for ilmenite; South Africa (17%) and India (13%) for rutile; and South Africa (28%) and Ukraine (8%) for zircon.

In 2001, world production of ilmenite decreased by 2% to 7.29 Mt, rutile decreased by about 1% to 379 kt, and zircon increased by 5.6% to 1.07 Mt. Australia produced about 28%, 55% and 37% each of world production of ilmenite, rutile and zircon, respectively, and 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, and upgrade it to titanium slag before export.



CLOSE UP OF THE CUTTER-WHEEL, WOMEN MINE, VICTORIA (Sons of Gwalia Ltd)



Industry developments

Exploration activity continued to centre on the coarse-grained strandlines in the Murray Basin in New South Wales, Victoria and South Australia. Global resources of the area have increased to about 80 Mt of heavy minerals as additional strandlines continue to be discovered.

In Victoria, Basin Minerals Ltd increased the resource base for the Douglas project near Horsham to 25 Mt at 4.1% heavy minerals using a cut-off of 1% heavy minerals. About 6 Mt of this resource in the Bondi and Bondi East strandlines has been upgraded to measured category, and is sufficient for a 10 year, Stage One operation. A bankable feasibility study is due for completion in first quarter 2002 and is premised on a project that would produce 300,000 t of product annually comprising 180 000 t of ilmenite, 75,000 t of zircon, 30,000 t of rutile and 15,000 t of leucoxene.

Production from the Wemen project, near Robinvale, Victoria, commenced in the April 2001. Wemen, owned by RZM Pty Ltd and Sons of Gwalia Ltd, is the first mineral sands mine in the Murray Basin. It has an annual production capacity of 30,000 t of rutile and 10,000 t of zircon.

In New South Wales, BeMax Resources NL announced that its Ginkgo deposit 120 km north of Mildura, contains a measured resource of 162 Mt at 3.56% heavy minerals plus an indicated resource of 43 Mt grading 1.99% heavy minerals. The average composition of the Ginkgo deposit is rutile (12%), zircon (10%), leucoxene (11%), and ilmenite (56%). An Environmental Impact Statement (EIS) for the proposed Ginkgo mine has been submitted for public comment and an EIS for the potential Mineral Separation Plant site in Broken Hill was in preparation at years end. The company upgraded resources at its Snapper deposit, 10 km southwest of Ginkgo to 109 Mt grading 4.8% heavy minerals with low slimes content. The project has a mine life of up to 14 years with an annualised production rate of 400,000 t of heavy mineral concentrate.

Murray Basin Titanium Pty Ltd announced that the global resource in the Willandra West and Willandra East projects, NSW, 100 km northeast of Mildura, has increased to 457.3 Mt grading 3.2% heavy minerals, following infill drilling on a number of known strandlines and the discovery of new ones.

Mineral Deposits Ltd received Government approval to proceed with mining, already commenced, of the Fullerton Extension deposit, near Newcastle (NSW), which will extend mine life by an additional 10 years.

In South Australia, Southern Titanium NL, as part of its bankable feasibility studies, has reported that resources at its Mindarie project, 120 km northeast of Adelaide, have increased to 290 Mt grading 2.41% heavy minerals. Production is scheduled for late 2003 at a possible rate of 17,600 t of rutile, 43,700 t of zircon, 14,800 t of leucoxene and 76,600 t of ilmenite.

In Western Australia, drilling of several strandlines, mapped using a magnetic mapping technique, resulted in Magnetic Minerals Ltd announcing that resources at its Dongara project, 35 km north of the Eneabba mine (WA), were 133 Mt at 4.8% heavy minerals. High-grade intersections include 18 m at 19.1% heavy minerals and 16 m at 15.8% heavy minerals on the Dionysus strandline, and 8 m at 12.6% heavy minerals on the Heracles strandline. A pre-feasibility study was being undertaken.

Iluka Resources Ltd announced plans to build a \$20 million zircon finishing plant at Geraldton (WA), to improve the quality of the zircon and thereby open up potential markets with high-grade zircon consumers.

Doral Mineral Sands Pty has been granted environmental approval to develop a 100,000 tpa ilmenite and zircon mine at Dardanup, 15 km east of Bunbury (WA). Development of the mine, formerly owned by ISK Minerals Ltd, is expected to commence in 2002.

In Queensland, Monto Minerals NL has commenced a feasibility study into the Goondicum Ilmenite Project, 90 km west of Bundaberg. As part of this process, proven and probable reserves totalling 69 Mt of ore have been outlined with the potential to produce 3.4 Mt of ilmenite at a recoverable grade of 4.9% ilmenite. The project has a potential mine life of 17 years producing 210,000 t of sulphateable ilmenite with a TiO_2 range of 49-50% and 80,000 t of titano-magnetite. Project commencement is subject to the final outcome of the feasibility study due for completion in 2002.

NICKEL

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

Resources

Total identified resources of nickel rose by 60,000 t (1.6%) in 2001 to 45.2 Mt. The bulk of the increase occurred in New South Wales and Western Australia.

EDR increased by nearly 9.4% in 2001 from 19.9 Mt to a record 21.9 Mt, representing 48% of total identified resources. Most of the increase in EDR occurred in New South Wales and Western Australia and primarily reflected industry reassessments of resources at existing deposits.

Western Australia remains the largest holder of nickel resources with 88% of total Australian EDR, down from 94%, following successful exploration in other States particularly New South Wales. At the operating sulphide mines of WMC's Kambalda and Mount Keith, Titan Resources' Radio Hill, Tectonic Resources' RAV 8 and Outokumpu Oy's Silver Swan, EDR decreased reflecting depletion of resources through production. However, successful drilling at WMC's Leinster mine and at Sally Malay Mining Limited's Sally Malay deposit resulted in an increase in EDR. A large increase in EDR of laterite was reported at Anaconda Nickel Limited's Siberia project, and a slight increase occurred at Heron Resources NL's Goongarrie project.

New South Wales, the second largest holder of EDR with 9%, more than doubled its EDR as a result of further industry drilling, which upgraded laterite resources at Thuddungra and Syerston.

In Queensland, there was no change in the EDR associated with the Marlborough laterite deposits west of Rockhampton.

In 2001, Allegiance Mining NL increased the indicated resource to 1.15 Mt grading 1.6% nickel at its North Avebury deposit, 7 km west of Zeehan, Tasmania.

Subeconomic demonstrated resources, which account for about 10% of total identified resources, decreased by 50,000 t during the year. The reduction was due to an 18% decrease in the submarginal demonstrated resources, which more than offset the 8% increase in the paramarginal demonstrated category. All of the changes in these categories occurred in Western Australia following further drilling and upgrading of some resources, notably lateritic resources to EDR.

Inferred resources, which account for 42% of the total identified resources, fell by nearly 6% to 18.8 Mt in 2001 (following an increase in 2000 of 24%). The bulk of the decrease occurred in New South Wales, where drilling resulted in resources being upgraded to EDR. Inferred resources decreased in Tasmania and Western Australia. However, despite the decrease in Western Australia, that State held 86% of the Australia's inferred resources followed by Queensland with 11%.



Exploration

Spending on nickel (including cobalt) exploration for 2001 totalled \$63.2 million, \$18 million less than in 2000. This decrease in expenditure is reflected in rate of growth in nickel resource inventory, which has slowed considerably compared with rapid growth over the previous two years. About 89% of this exploration expenditure occurred in Western Australia. The sharp decline in expenditure is on par with the decline in worldwide exploration expenditure.

The ratio of EDR to inferred resources has declined over the last three years from 1: 1.52 in 1999 to 1: 0.86 in 2001.

Over the last twelve months, the focus in nickel exploration has centred on the mafic-ultramafic Giles Complex in Western Australia and South Australia, where the West Musgrave and Wingellina projects has attracted considerable attention. Exploration for komatiite-hosted nickel sulphide deposits in the Yilgarn and for lateritic nickel deposits in a number of provinces has also continued. Some of the more interesting exploration results in 2001 include the following.

- Preliminary interpretations by WMC Resources Ltd at the Nebo and Babel prospects in its West Musgrave project in the Giles Complex, Western Australia, 100 km west of the Western Australia / South Australia / Northern Territory border intersection, suggest that both prospects are part of the same mineralising system which has strike length exceeding 4.5 km. Significant variations in the thickness and grade of mineralisation have been reported and the company believes that a feeder conduit has been intersected. Further work is required to establish whether a significant tonnage of massive sulphide mineralisation occurs. Subsequent drilling at Babel encountered a disseminated sulphide unit with a true thickness of up to 21 m and grades of up to 0.8% Ni, 1.4% Cu and 0.34 g/t Pt+Pd. Regional exploration in the project area has identified a number of gravity and geochemical anomalies for further work.
- Following an agreement with the Ngaanyatjarra Land Council, Acclaim Exploration NL began drilling at its Wingellina project south west of the intersection of the Western Australia / South Australia / Northern Territory borders. Intersections of 64 m at 2.1% Ni, 2 m at 3.1% Ni and 32 m at 1.32% Ni were reported. Drilling results reported after the end of the year were very encouraging with an intersection of 144 m of nickel oxide at a grade of 1.4% Ni. The company also reported the discovery of a new thick basal ultramafic unit that will be explored for nickel in 2002.
- Sally Malay Mining Limited has recorded a significant width of sulphide mineralisation in its infill drilling program at Sally Malay, 240 km south of Kununurra, Western Australia. Reported intersections included 9 m averaging 2.09% Ni, and 34 m averaging 1.87% Ni. A revised resource estimate increased uncut resources by 10% to 3.74 Mt grading 1.72% Ni, 0.72% Cu and 0.09% Co.
- At the Discus prospect (RAV 5) in its Ravensthorpe Jerdacuttup nickel sulphide project, north west of Ravensthorpe, Western Australia, QNI Exploration & Development Pty Ltd has intersected 0.9 m of massive pyrrhotitic sulphides grading 1.61% Ni, 0.2% Cu and 0.08% Co.
- Heron Resources Ltd reported encouraging drill results from its Goongarrie nickel laterite project 65 km north of Kalgoorlie, Western Australia. Drill intersections, at a 0.75% Ni cut-off grade, include 81 m grading 1.24% Ni and 0.02% Co, 104 m grading 1.33% Ni and 0.09% Co, and 83 m at 1.41% Ni and 0.15% Co from its Pamela Jean Zone.
- On its Melba project, north east of Zeehan, Tasmania, Allegiance Mining NL reported an intersection of 5.8 m (2.5 m estimated true width) of 4.6% Ni, 1.8% Cu, 1.5 g/t Pt+Pd, and 0.17g/t Au. This intersection was 30 m vertically beneath a massive sulphide outcrop assaying 10.7% Ni, 8.1% Cu, and 1.9 g/t Pt+Pd.

- Deep drilling by Tectonic Resources NL at its RAV 8 mine, east of Ravensthorpe, Western Australia, intersected several high-grade zones including 5 m at 2.3% Ni, 4 m at 7.7% Ni, and 7 m at 1.7% Ni.
- Jubilee Mines NL reported intersections of massive and disseminated nickel sulphides at its Taurus prospect, 11 km south east of its Cosmos nickel mine, 50 km north of Leinster, Western Australia. Intersections of 9 m at 0.57% Ni and 0.2 m at 8.1% Ni were recorded
- Golden State Resources Ltd has discovered a new zone of shallow, high-grade lateritic nickel mineralisation to the west of the Highway nickel deposit, 10 km south of Menzies, Western Australia. Intersections of up to 5 m at 3.2% Ni were recorded.

Production

Preliminary data from ABARE indicates that Australia's nickel production increased in 2001 by 19% to 197 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 3.2% to 59.9 Mt in 2001 (58 Mt in 2000). Australia's share of world EDR increased to 36.5% up from 34.3% in 2000, making it the largest holder of EDR followed by Russia and Canada (11% each) and Cuba (9%).

Australia produced about 15.5% of estimated world nickel output of 1.27 Mt. Russia was again the largest producer with 265 kt (21%), followed by Australia with 197 kt (15.5%) and Canada with 183 kt (14%). The fourth largest producer was New Caledonia with an output of 126 kt (10%).

Industry developments

Australia has ten nickel sulphide mines currently in operation: - WMC's Kambalda, Leinster and Mount Keith; Mincor's Miitel and Wannaway; Outokumpu Oy's Silver Swan; Titan Resources' Radio Hill; Tectonic Resources' RAV8; Jubilee Mines' Cosmos and LionOre's Emily Ann (commenced in late 2001). Three laterite nickel mines are operation: - Preston Resources' Bulong;, Centaur Mining & Exploration's Cawse; and Anaconda Nickel's Murrin Murrin. All these 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.

Production from all WMC Ltd's operations increased slightly during 2001, with concentrates produced totalling 711 kt (compared with 703 kt in 2000). The company is examining the feasibility of a \$300 million expansion of its Mount Keith nickel operations, near Leinster, possibly boosting nickel metal output to 70,000 tpa from its current capacity of 45,000 tpa. WMC is currently considering tenders for the sale of the Long-Victor nickel mine.



MIITEL NICKEL MINE PORTAL, WESTERN AUSTRALIA

(Mincor Resources NL)



WMC Resources acquired the Yakabindie nickel project adjoining to its Six Mile project, near Leinster, Western Australia, from Rio Tinto. Yakabindie contains an estimated 292 Mt of ore grading 0.52% Ni, which WMC Resources are considering using the Titan Resources' BioHeap technology to treat.

Mincor Resources NL constructed and brought into production two underground mines near Kambalda, which were established on deposits purchased from WMC during 2000. Mincor owns 76% of Miitel and Wannaway, both commissioned in October 2001. Production from the two mines totals about 13,000 tpa of contained nickel, with cash costs of production less than US\$1 per pound. Ore is trucked to WMC's Kambalda nickel operations mill, toll-treated, and sold to WMC Resources Ltd under a long-term off-take agreement.

At Titan Resources' Radio Hill in the west Pilbara, some 45,300 t of concentrates at an average grade of about 11% Ni was converted to nickel-in-matte at WMC's smelter. Mining of the known reserves at the mine site is expected to cease by mid-2002. The company has made significant progress in the development of its BioHeap(tm) bacterial leaching technology with several strains of bacteria that can function in water with chloride concentrations of up to 100 g/litre developed. Titan has constructed a second heap of ore from the Mt Scholl deposit at its Radio Hill mine, and after three months treatment, over 60% of the nickel contained in the 5000 t heap had been leached into solution.

Titan Resources purchased from WMC Resources the North Widgiemooltha Block, near Kambalda, Western Australia. The area has an inferred resource of 2.18 Mt grading 2.1% Ni totalling some 44,000 t of contained nickel. The company is to conduct a full feasibility study on the underground mining of massive nickel sulphides at the 132N prospect.

MacMahon Holdings, who purchased the Blair nickel mine from WMC, closed the mine in October 2001 in response to low nickel prices.

Tectonic Resources NL has commenced underground production from its RAV8 mine, east of Ravensthorpe, Western Australia, following the cessation of open-cut mining in August 2001. Underground mine production is forecast to last six months with all concentrate sold under an off-take agreement with WMC Ltd.

A feasibility study by Jubilee Mines NL has confirmed the viability of developing the Cosmos Deeps deposit via a decline on the western side of the Cosmos open pit. Cosmos Deeps reserves total 520,000 t grading 7.2% Ni. Underground mine production is expected to commence in September 2003. Over a mine life of three and half years annual mine throughput is expected to be 150,000 t of ore, which should yield 50,000 t of concentrate containing 10,000 t of nickel.

LionOre Australia (Nickel) Ltd produced its first nickel-in-concentrate in November from its Emily Ann underground mine nickel sulphide, 130 km west of Norseman, Western Australia. At full production the mine will have a throughput of 250,000 tpa of ore to produce 6,700 tpa of nickel-in-concentrates, that will be exported through Esperance to Canada for processing by Inco Ltd.

Australia's three laterite facilities (Bulong, Murrin Murrin and Cawse) planned to experience mixed success throughout 2001 and all were operating well below their production capacity. During 2001, Preston Resources' Bulong had reached an operating rate of about 77% of its capacity (9 ktpa of nickel) in June quarter before falling back to 60% in the December quarter as a result of maintenance shutdown and subsequent technical difficulties.

The Murrin Murrin project reached about 70% of its capacity (45 ktpa of nickel) in the September quarter before falling to 50% in the December quarter 2001, largely as a result of a scheduled maintenance shutdown in October. Murrin Murrin's capacity utilisation was expected to be in the order of 80% over the next twelve months.

The Cawse project (capacity 9 ktpa of nickel) was placed in receivership in March 2001, and acquired by the United States company OM Group based in Cleveland. The new owners have closed the refinery component of the Cawse operation and intend to ship 8000 tpa of intermediate nickel hydroxide product to their refining facilities in Europe.

BHP Billiton is seeking to develop its \$720 million Ravensthorpe lateritic nickel deposit in Western Australia. The project involves producing a nickel concentrate at the Ravensthorpe mine for shipment to the company's existing Yabulu refinery in Queensland. The refinery is to be expanded from its current capacity of 28 ktpa of nickel to 63 ktpa to produce an extra 35,000 t of refined product from the Ravensthorpe mine. Construction of the mine at Ravensthorpe is expected to commence in 2003 with the first production in late 2005.

Black Range Minerals has been granted development consent by the New South Wales Government for its Syerston lateritic nickel-cobalt-platinum project, 400 km north west of Sydney, New South Wales. Over a 36-year life the project is expected to produce 20,000 t of nickel and 5,000 t of cobalt annually subject to raising adequate capital to establish the operation.

Anaconda Nickel has placed any future developments of its Mount Margaret project and Murrin Murrin expansions on hold until the current Murrin Murrin operation is proven economically viable.

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) fertilizer 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) fertilizer.

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 2-4 millimetres. 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 increased in 2001 by approximately 14 Mt as a result of an increase in ore reserves, reported by WMC, for Phosphate Hill. All EDR is sedimentary phosphate rock (phosphorites), with an average grade of about 23-24% P_2O_5 at Phosphate Hill.

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 Western Australia, 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 and the Northern Territory. There is no publicly available information on Christmas Island's current phosphate resources.

Exploration

ABS does not publish data relating to exploration for phosphate specifically either nationally or at a State level.



Production

Australia's total production of rock phosphate in 2001 was 2.3 Mt (ABARE, March Quarter 2002). In 2001, WMC produced just over 709,445 t of DAP and MAP from 1.9 Mt of Phosphate Hill ore treated at its Queensland fertiliser operations.

World ranking

Australia's EDR of phosphate rock comprises less than 1% of the world's total EDR of 12 Gt, which occurs principally as sedimentary marine phosphorites.

Industry developments

WMC's Phosphate Hill ammonium phosphate plant is the first of its kind in Australia. At the end of 2001, the company announced that the plant had achieved design capacity (975 ktpa), which included 57,947 t of high-quality MAP. Operating at this level, ore reserves at Phosphate Hill will support production for at least 35 years.

During 2002, WMC plan to explore market opportunities and assess financial options for producing sulphur-fortified ammonium phosphate fertilizers.

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 may contain over 200 litres of oil. The organic material in oil shale is kerogen, which has escaped conversion to conventional oil because the strata have not been buried in the Earth's crust. Australian oil shale deposits of commercial interest are predominantly in a series of narrow and deep extensional-basins near Gladstone and Mackay (Qld). These are thick Tertiary lacustrine (lake-formed) deposits, which are relatively easy to mine and process in contrast with generally harder carbonate bearing oil shales (marls) found elsewhere in the world.

Resources

In 2000, Southern Pacific Petroleum and Central Pacific Minerals (SPP/CPM) systematically reviewed in-situ mineralisation to accord with the JORC Code in all ten of its oil shale deposits held solely or with joint venture partners in the Gladstone-Mackay region. The reserve and resource estimates reported by the companies remain unchanged for 2001 and are incorporated in this assessment. Australia has 4.6 GL (29 million barrels) of shale oil EDR. However, this could increase significantly if the research and development demonstration-scale processing of shale oil advances to a proposed commercial plant at SPP/CPM's Stuart deposit. Paramarginal and submarginal demonstrated resources are 202.1 GL (1.3 billion barrels) and 3,719 GL (23.4 billion barrels) respectively.

Production

Oil production at the Stuart demonstration plant for the 2001 calendar year was 37 million litres (233,000 barrels), increasing total production since the start of operations to 42.6 million litres (268,000 barrels). The oil products are Ultra Low Sulphur Naphtha (ULSN) 55-60% and Light Fuel Oil (LFO) 40-45%. The 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 about 500 ppm sulphur. Regulatory guidelines are in place to reduce this to 150 ppm for petrol by 2005 and to 50 ppm for diesel by 2006.

World ranking

According to the World Energy Council's 2001 survey of energy resources, Jordan, Australia and Morocco have the largest estimates of 'proved oil shale in place'.

In the same survey, the Council reported that production of oil from shale in 1999 was recorded in Brazil (239 ML), Estonia (185 ML) and Australia (6 ML).

Industry Developments

Trials at the \$300 million Stuart demonstration plant (Stage 1) commenced in August 1999 and continued throughout 2000 and 2001 with increasing production. In November 2001, the Stage 1 plant achieved an operating cash flow break-even. Breakeven requires monthly oil production of around 50,000 barrels (35% of plant capacity), which entails monthly operating costs of around \$3 million. Work is underway on a \$15 - 35 million improvement program at the Stage 1 plant, which should increase annual oil production from around 750,000 barrels in 2002 to over 1 million barrels in 2003.

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). An investment of up to \$25 million will be required to advance Stage 2 to project decision readiness by early 2003. If Stage 2 proceeds, it is expected to cost \$500 million and SPP/CPM are actively seeking joint venture partners.

SPP/CPM has committed to restricting net greenhouse gas emissions to lower than that produced by conventional oil extraction methods over the full cycle of production and end use. SPP/CPM's long-term goal is to achieve, through progressive plant expansion, production of 200,000 barrels per day. This would be similar to Bass Strait's current oil production, now in decline. Federal Industry Minister, Ian Macfarlane, noted in a press release on 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 while Australia's total known liquid petroleum reserves are less than 4 billion barrels."

TANTALUM

After strong growth in demand for tantalum capacitors over recent years for use in portable electronic devices such as mobile phones, computers, and video cameras, the global electronics sector began to slowdown in 2001. 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 controls the world's largest stock of tantalum resources, principally in its holdings at Greenbushes and Wodgina in Western Australia.

Resources

Despite increased production of tantalum pentoxide (Ta_2O_5), EDR increased by 39% in 2001 to 40,835 t. This was largely due to reassessment and discovery of resources in the Wodgina, Mount Deans and Bald Hill deposits in Western Australia. In their Annual Report for 2001, Sons of Gwalia Ltd reported that the resource base at Wodgina doubled from 30 to 60 Mlbs (13,607 - 27,216 t) of Ta_2O_5 .

Small resources in the EDR category occur elsewhere in Western Australia and the Northern Territory.

Subeconomic resources remained virtually unchanged from last year with only a slight adjustment resulting from the reassessment of Greenbushes and Wodgina deposits.

Inferred resources also remained stable on last year's estimates.



Exploration

ABS does not publish data relating to exploration for tantalum specifically either nationally or at a State level.

Production

In 2001 Sons of Gwalia produced 1,057,888 lbs (480 t) of Ta₂O₅ (containing 393 t Ta) from the Greenbushes operation and a further 718,844 lbs (326 t) (containing 268 t Ta) from its Wodgina mine.

Haddington International Resources commenced production with 49,758 lbs (23 t) of Ta₂O₅ (containing 23 t Ta) at its Bald Hill deposit, Western Australia.

World ranking

The increase in resources at Wodgina consolidated Australia's position as the world's largest holder of tantalum resources. 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 2001, based on USGS estimates modified to account for later Australian data amounted to 1,144 t tantalum. Production was dominated by Australia, with 684 t won in 2001 (just under 60% of world output). According to the USGS, other producers of tantalum metal were Brazil (which increased its production to 300 t), Canada (50 t), Congo (60 t) and Ethiopia (30 t).

Industry developments

During 2001, the Wodgina mine achieved record production due to a plant expansion, re-scheduling of higher grade ore identified in the March quarter, processing of softer ore and improvements in the treatment plant. Sons of Gwalia anticipate the production of just under 1 Mlbs (454 t) of Ta₂O₅ in 2002.

At Greenbushes, Sons of Gwalia commenced production from its underground extension below the existing Cornwall open pit and expects production to increase in 2002 to around 1.1 Mlbs (499 t) of Ta₂O₅. With Sons of Gwalia Ltd supplying approximately 25% of the world's tantalum metal, the planned expansions will ensure that the company continues to be the primary supplier of ore to the tantalum industry.

Australia's tantalum industry saw the introduction of Haddington International into the market with production at Bald Hill starting in the September quarter.

Australasian Gold Mines is also expected to start production at its Mt Deans deposit in 2002.

URANIUM

Resources

Geoscience Australia prepares estimates of Australia's uranium resources using both the national classification scheme and the classification schemes used 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 the corresponding resource categories of the national classification scheme. The resource categories of these schemes are correlated in [Table 2](#).

Table 2. 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 648,000 t U, a decrease of 6,000 t compared to the previous year. This fall was due to reassessments of the ore reserves and mineral resources for the Olympic Dam and Ranger deposits as well as production. Australia’s RAR recoverable at <US\$80/ kg U were estimated to be 661,000 t U.

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

- Olympic Dam (South Australia), which is the world’s largest uranium deposit,
- Ranger, Jabiluka, Koongarra in the Alligator Rivers region (Northern Territory),
- Kintyre and Yeelirrie (Western Australia).

Exploration

Uranium exploration expenditure in Australia reached an historic low of \$4.8 million in 2001 (\$7.59 million in 2000). Exploration was undertaken only in the Northern Territory (NT) and South Australia (SA). The main areas and deposit types targeted were:

- 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 breccia complex type copper-uranium-gold deposits in hematite-rich granitic breccias.

Annual expenditure on uranium exploration in Australia has declined progressively since 1997. Companies have reported that this decline was due to low market prices for uranium in recent years, uranium policies of State Labor Governments in Western Australia, Queensland, NSW, Victoria and Tasmania and difficulties in accessing prospective areas because of Native Title issues.



In November, Minatour Resources Ltd, operator of the Mt Woods Joint Venture, announced the results from diamond drillhole URN 1 at the Prominent Hill prospect, South Australia. The prospect is some 150 km north-west of Olympic Dam. The hole was drilled to test a gravity anomaly that is partly coincident with a well-defined magnetic anomaly. Coincident gravity and magnetic anomalies occur over the Olympic Dam deposit and these are used as geophysical targets for this type of mineralisation. The vertical hole passed through 108 m of barren sediments before entering hematite breccia. Copper-gold-uranium-rare-earth mineralisation occurs within the hematite breccias. The geological setting and mineralisation are similar to the Olympic Dam deposit.

Summary of results from diamond drill hole URN1:

From (m)	To (m)	Interval (m)	Copper (%)	Gold (g/t)	Silver (g/t)	REE* (%)	Uranium (ppm)
107.8	128	20.2	—	3.03	—	0.24	17
200	307	107	1.94	0.65	1.6	0.22	39
<i>Including</i> 272	307	35	3.86	0.82	4.5	0.22	33
429	581	152	1.10	0.61	2.6	0.48	267
<i>Including</i> 450	467	17	2.35	1.07	3.3	0.66	1398
<i>And</i> 525	543	18	1.34	1.03	1.9	0.62	123
<i>And</i> 558	579	21	1.62	0.69	3.5	0.41	171

* Rare Earth Elements: Lanthanum plus Cerium
(Source: Minotaur Resources Ltd web site www.minotaurresources.com.au)

A second hole DP 003 was drilled 170 m to the south of the discovery hole URN 1 and angled at 60° north. The hole passed through 124 metres of sedimentary cover before entering a complex mix of highly brecciated tuffs, sediments, volcanics and haematite breccias. In summary, the hole returned:

- 28 m (188-216 m) at 1.0 g/t Au,
- 235 m (400-635 m) at 1.05% Cu, 0.57 g/t Au, 2.9 g/t Ag, 130 ppm U,
- 54 m (635-689 m) at 0.5% Cu, 0.46 g/t Au, 1.4 g/t Ag, 142 ppm U.

The overall results of the drilling completed to the end of the year suggest that the mineralised breccia strikes WNW, sub-parallel to the trend of the magnetic anomaly. Further drilling is in progress.

Production

Australia's total production for 2001 was a record high of 9104 t U₃O₈ (7720 t U;

U = 0.848 x U₃O₈), comprised of Olympic Dam 4,355 t U₃O₈, Ranger 4,203 t U₃O₈, and Beverley 546 t U₃O₈.

World ranking

Australia's resources in RAR recoverable at <US\$40/kg U (equates to EDR) are the largest of all those countries, which have reported resources in this category. To date, not all countries have reported their resource estimates for this category. Because all countries have reported their resources in the <US\$80 category, the world ranking of the various countries is based on the <US\$80 figures. Australia has the world's largest resources of uranium in RAR recoverable at <US\$80/kg U, with 30% of world resources in this category (OECD/NEA & IAEA, 2002).

Industry Developments

Olympic Dam. During 2001, the Olympic Dam operations treated a record 9.3 Mt ore to produce 200,523 t copper and 4,355 t U₃O₈ which represents 11% of world production of U₃O₈. In October, uranium and copper production was curtailed by a fire in the solvent extraction plant. Despite the fire, the operation achieved record production for all commodities except U₃O₈. The uranium solvent extraction circuit is being rebuilt and the company anticipates that production for 2002 will be approximately 3,000 t U₃O₈.

A scoping study was carried out to examine the feasibility of increasing copper production to a level between 350,000 t and 600,000 t per annum. Estimated uranium production was not reported. The environmental impact statement approved in 1997 allows annual copper production to 350,000 t using the existing underground mining methods and mineral processing technologies. It is likely that a new environmental impact statement will be required for the proposed expansion.

Diamond drilling during the year 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. Mineralisation was intersected over a strike length of more than 1 km in a mineralised zone, which is from 50 to 100 m outside the active mining zones. The 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. Mining of the Ranger No.3 Orebody open pit continued during the year.

In 2001, Energy Resources of Australia (ERA) Ltd completed a drilling program aimed at testing the south-eastern extensions of the No. 3 Orebody. The mineral resources were reduced from 80,251 t U₃O₈ (as at Dec. 2000) to 65,054 t U₃O₈ (Dec. 2001) (Table 3). Approximately half of this was due to reductions in the inferred resources resulting from re-interpretations of the orebody outlines, the remainder was due to mine production during the year.

ERA Ltd reported that mining of the No. 3 Orebody is expected to continue until at least 2009, after which the open cut will be used as a repository for mill tailings. Processing of stockpiled ore will continue after 2009.

The company's environmental performance at both Ranger and Jabiluka continues to be closely scrutinised by the Supervising Scientist and the Northern Territory Government. The Supervising Scientist reported in the 2000-2001 Annual Report: 'The summary reports for the audits noted that there is a high standard of environmental management and protection being employed and achieved at Ranger.'



Table 3. Mineral Resources for the Ranger No. 3 Orebody as at December 2001 calculated using a cut off grade of 0.12% U₃O₈ (ERA Ltd Annual report, 2001).

Ore Mt	Grade	% U ₃ O ₈	Contained U ₃ O ₈ (t)
Measured	2.7	0.24	6,350
Indicated	18.9	0.25	46,721
Subtotal Measured and Indicated*	21.6	0.25	53,071
Inferred	6.4	0.19	11,983
Total Resources	28.0	0.23	65,054

* Includes those resources modified to produce the Ore Reserves

Jabiluka. During 2001, the Jabiluka project remained on environmental care-and-maintenance. ERA Ltd confirmed that Jabiluka and Ranger would not be in full production simultaneously.

Beverley. Commercial in situ leach operations commenced at Beverley in November 2000. The mine produced 546 t in 2001, the first full year of operations. Beverley is Australia's first in situ leach operation to mine uranium.

During the year three wellfields were completed and brought into production. Wellfield 4 is being drilled and developed and will be brought into production in 2002. Each wellfield comprises approximately 14 extraction wells and 20 injection wells. The three wellfields in operation by the end of 2001 comprised a total of approximately 43 extraction wells and 51 injection wells.

Honeymoon. The Environmental Impact Statement for the Honeymoon in situ leach project was assessed jointly by Federal and South Australian Government during 2000. In February 2001, the Federal Environment Minister announced that before could be made a final decision on the proposal, further detailed information would be required on the hydrology of the Honeymoon aquifers. With reference to the disposal of waste liquids by re-injection into the Basal Sands aquifer, the Minister stated that he must be confident about the characteristics of any migration of re-injected waste, and also that detrimental environmental consequences would not occur.



THE WELLFIELD AT THE BEVERLEY IN SITU LEACH URANIUM OPERATION, SOUTH AUSTRALIA (Heathgate Resources Pty Ltd)

Geoscience Australia and the Bureau of Rural Sciences provided technical advice to Environment Australia and assisted in preparing the terms of reference (released in March 2001) for additional work to be completed by the company. It was recommended that stratigraphic drilling and pump tests be carried out to better define the shape (and hydraulic boundaries) of the Yarramba palaeochannel and the limits of the Eyre Formation sediments, particularly along the northern and southeastern boundaries of the palaeochannel within the area of the mineral claims. Further investigations of the ground water chemistry, and the effectiveness of monitoring wells were also recommended.

Southern Cross Resources completed this work during the year. The findings of the stratigraphic drilling program were in good agreement with the results of the pumping tests; both sets of results indicated that the aquifers are wholly contained within the Yarramba Palaeochannel. The mining solutions and injected liquid wastes can be contained within this hydrogeological environment. The aquifer system is overlaid by about 80 metres of Namba clays, which form an effective seal to the Eyre Formation in the Yarramba Palaeochannel and restricts any possible natural movement of water into surface areas.

From the results of modelling studies it was concluded that the disposal of liquid waste into selected parts of the Basal Sands Aquifer in the Honeymoon project area at a depth of more than 100 m is possible, because the aquifer sands of the Eyre Formation are confined.

Based on the results of the additional work, the Environment Minister cleared the way for the project to proceed in November 2001. The Government issued a 5-year export licence that incorporates conditions based on the Minister's recommendations.

It is estimated that the project will have a production rate of 1,000 t U_3O_8 per year, and generate annual export earnings of \$40 million.

VANADIUM

Vanadium is used in metal alloys with iron to produce high strength steel. Mine production accounts for only 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 increased by 42% to more than 267 kt V during 2001, due to the reassessment of the resources in the Windimurra deposit, 75 km southeast of Mount Magnet, WA. This deposit contains more than 97% of Australia's EDR.

Vanadium deposits with significant resources occur in the Yilgarn Craton WA (Windimurra, Gabanintha, Buddadoo, Youanmi, and Narndee deposits), in the Pilbara Craton WA (Balla Balla and Don Well deposits), and in the Julia Creek oil shale deposits, northwest Queensland.

Exploration

Exploration for vanadium declined to very low levels in 2001 because of low metal prices in recent years. Only very limited exploration continued for titanium-vanadium deposits in Archaean layered gabbroic intrusions in the Yilgarn and Pilbara Cratons. WMC Ltd continued exploration for titanium-vanadium deposits in Mesoproterozoic layered mafic-ultramafic intrusions in the Musgrave Complex. This exploration has identified ilmenite-magnetite horizons that extend up to 35 km. Reconnaissance drilling along these horizons, at 5 - 10 km intervals, intersected a number of large low-grade zones of mineralisation. These zones are 10 - 50 m thick, with grades of 5 - 9% TiO_2 and 0.1 - 0.5% V_2O_5 .





**LOOKING NORTH INTO
THE WINDIMURRA
VANADIUM MINE,
WESTERN AUSTRALIA**
(Xstrata AG)

Greater Pacific Gold Ltd completed a drilling program at the Gabanintha-Yarrabubba deposit, 45 km southeast of Meekatharra. The deposit comprises a high grade zone of titaniferous magnetite 10 - 25 m wide within a layered gabbroic intrusion. This zone has a strike length of 12 km. Inferred resources within a zone 9 km long were reported as:

Resource	Category	Million tonnes	Average grades
Oxidised	Indicated	20.638	0.49% V_2O_5 , 6.62% TiO_2
Partially oxidised	Indicated	17.021	1.05% V_2O_5 , 12.25% TiO_2
Total	Indicated	37.659	0.74% V_2O_5 , 9.16% TiO_2

Source: Greater Pacific Gold Ltd, March Quarterly Report 2001)

The company is investigating the possibility of developing a mine and processing plant with capacity to produce 5,200 t V_2O_5 per year.

Production

In 2001, Australia produced 4,450 t V_2O_5 flake (2,492 t V) all from the Windimurra mine in its second year of production. Windimurra is Australia's only vanadium mining operation. Mining commenced in July 1999 and production of V_2O_5 from the processing plant commenced in February 2000.

Vanadium mineralisation is in a magnetite-ilmenite horizon hosted by a layered mafic-ultramafic intrusive body (Windimurra Complex) and the vanadium occurs in the magnetite and ilmenite. The horizon extends for approximately 25 km.

The mine was developed and commissioned at a time of high prices, with the price of V_2O_5 peaking at around \$US6.80 per pound in May 1998. However, the price has steadily declined since then and finished 2001 at around \$US1.10 per pound.

The market for vanadium has been oversupplied for several years. Current world production capacity is much greater than world consumption.

**MINING AT NIGHT,
CENTURY ZINC MINE,
QUEENSLAND**

(Pasminco Ltd)



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 sometimes 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 gradual 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 all rose in 2001. Total identified resources of zinc rose by 1.4% to 80.8 Mt of contained zinc, lead rose by 1.3% to 50.7 Mt of contained lead and silver by 2.2% to 87.3 kt of contained silver. For all three commodities, strong growth in EDR (and a small increase in paramarginal resources for zinc), more than offset the reductions that occurred in all other categories.

Australian EDR for zinc rose by 7.1% to 35.1 Mt in 2001. Although Queensland remained pre-eminent and its EDR rose from 18.7 Mt to 19.1 Mt, its share of the total EDR fell from 57% in 2000 to 54% in 2001. The small rise in Queensland's EDR resulted from increases at Mt Isa, Cannington and Walsh River being substantially offset by production and the reclassification of George Fisher-Hilton, Ernest Henry and Century. The Northern Territory at 10.4 Mt (8.1 Mt in 2000) again had the second largest EDR and its share of national EDR was 29.5% compared to 24.7% in 2000. This increase in EDR was primarily due to the increased resources and reclassification at McArthur River. New South Wales had the third largest EDR with 3.4 Mt (3.1 Mt in 2000), with the slight increase due mainly to the reclassification of the Broken Hill deposits (CML7, North, Potosi and Southern). They were followed by Western Australia 1.7 Mt (2.4 Mt in 2000), with the fall due almost entirely due to production depleting Golden Grove resources. Victoria at 0.39 Mt (0 Mt in 2000), had a slight increase due to reclassification of Wilga and addition of Currawong resources, and Tasmania with 0.17 Mt (0.26 Mt), decreased primarily due to production depleting Rosebery resources.

Of Australia's EDR of zinc, almost 74% occurs in the JORC Code ore reserves categories. The national EDR/production ratio is 23, and the ore reserve /production ratio is 17.

Paramarginal demonstrated resources of zinc rose marginally from 8.35 Mt to 8.38 Mt and submarginal demonstrated resources fell marginally from 16.6 Mt to 16.0 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 3% to 21.3 Mt in 2001 following small variations in all States and the Northern Territory.

Total identified lead resources rose by 1.3% to 50.7 Mt in 2001. Australia's EDR of lead showed substantial growth in 2001 rising by 18% to 17.3 Mt of contained lead and constitute 34% of total identified resources. All States with EDR recorded increased holdings in 2001 except Tasmania and Western Australia. Queensland retained the premier ranking with 8.8 Mt with 51% of total EDR (50% in 2000), again due to increased resource definition at Cannington and Mt Isa. It was followed by the Northern Territory where EDR rose by 0.93 Mt to 5.75 Mt or 33% of the national total, due to increased resources at McArthur River. New South Wales also recorded a small growth in EDR, rising to 2.0 Mt from 1.8 Mt in 2000, due to the reclassification of the Broken Hill deposits (CML7, North, Potosi and Southern) offsetting production depletion of the Elura resources. EDR in Western Australia fell by 0.2 Mt (29%) to 0.6 Mt, due to production depleting Golden Grove resources, and in Tasmania by 0.02Mt (36%) to 0.06Mt, where production depleted the Rosebery resources.

Of Australia's EDR of lead, 57% occurs in the JORC Code ore reserves categories. The national EDR/production ratio is just under 25, and the ore reserve /production ratio is 14.

Australia's paramarginal demonstrated resources of lead are 3.4 Mt, which is 6.7% of total identified resources. Submarginal demonstrated resources totalled 9.1 Mt or 18% of total identified resources. The aggregate sub-economic resources were 3.7% less than in 2000. These global variations are attributed to relatively small changes in most states and the Northern Territory in both categories.

Total inferred lead resources fell by just under 7% to 20.8 Mt in 2001, following small variations in the States and the Northern Territory.

Australian EDR for silver rose by 29% to 41.4 kt in 2001. Queensland remained pre-eminent and its EDR rose from 20.7 kt to 28.7 kt and its share of the total EDR rose from 64% in 2000 to 69% in 2001, with increases at Cannington offsetting production losses at Century. The Northern Territory at 5.1 kt (4.1 kt in 2000), with the increase due to growth at McArthur River, again had the second largest EDR and its share of national EDR was down marginally to 12.2% compared to 12.8% in 2000. South Australia had the third largest EDR with 3.6 kt (3.56 Mt in 2000). It was followed by New South Wales 2.6 kt (2.3 kt in 2000), with the growth due to small increases at Broken Hill and Kempfield due to reclassification. Western Australian EDR was 0.9 kt (1.08 kt in 2000), and the reduction was due to small decreases at Golden Grove, Kapok, Kutarta and Pillara. Victoria's EDR was 0.28 kt (0 kt in 2000), with the rise due to addition of Currawong and reclassification of Wilga resources. In Tasmania EDR was 0.19 Mt (0.3 kt in 2000) and the depletion was due to production at Rosebery.

Of Australia's EDR of silver, 63% occurs in the JORC code ore reserves categories. The national EDR/production ratio is 21, and the ore reserve/production ratio is 13.

Paramarginal demonstrated resources of silver fell from 11.09 kt to 9.65 kt and submarginal demonstrated resources also fell slightly from 11.5 kt to 10.9 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 fell by 17% to 25.3 kt in 2001, following small variations in all States and the Northern Territory.

Exploration

In 2001, Australian base metal (copper, lead, zinc, silver, nickel and cobalt) exploration spending totalled \$150.9 million, \$14.4 million less than in 2000. Expenditure on the search for zinc, lead and silver in that period at \$49.3 million was just under 33% of total base metal expenditure. The 2001 spending on zinc, lead and silver was \$9.5 million less than in 2000.

Production

Australian mine production for zinc, lead and silver was 1.52 Mt, 0.7 Mt and 2.0 kt respectively. These figures were a slight increase for zinc (0.1 Mt) and a slight fall for silver (0.06 kt), while lead output was unchanged.

**SURVEYING THE PIT,
CENTURY ZINC MINE,
QUEENSLAND**
(Pasminco Ltd)



World ranking

Australia has the world's largest EDR of zinc (18% of the world), lead (28%) 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.

Industry developments

At Mt Isa, MIM through a reduction in operating costs, has identified the possibility of extending the life of operations for the Isa Pb-Zn-Ag mine. Current reserves are due to be exhausted by FY2003, however, studies are underway to mine the remaining Isa resources as well as the balance of the George Fisher orebodies not included in ore reserves.

Kagara Zinc Ltd is planning a \$43 million development of its Mt Garnet Zinc Project. Queensland. The Mt Garnet facility will source high grade zinc ore from a number of deposits including Surveyor, Dry River South and Mt Garnet as part of an integrated project treating some 500,000 tpa of high-grade ore. Kagara also announced resource figures for the King Vol deposit and commented that the deposit was open both along strike and down dip and offered significant potential for further resources.

At Lady Loretta, Queensland, Noranda Pacific Pty Ltd is considering capital expenditure of about \$200 million to construct a 1.0 Mtpa mine and concentrator.

The Macmin Ltd Texas Silver Project, Queensland, is a proposed 600,000 tpa heap leach mine with a capital cost of about \$6.6 million. Macmin plan to expand the current silver reserve base before commencing open-pit operations.

Consolidated Broken Hill Pty Ltd are planning to resume mining on CML7 at Broken Hill, New South Wales, by constructing a 966 m decline from the base of the Kintore Open Pit for the trial mining of 125,000 t of medium-grade ore. After trial mining and a feasibility study, full-scale mining at 500,000 tpa is proposed in the Western Mineralisation.

Perilya Ltd purchased Pasminco's Broken Hill operations in early 2002. The company plans to extend the mining operations until at least 2011 at a rate of 2.45 Mtpa. At Broken Hill a complete three-dimensional model of the Broken Hill Block has been constructed using all relevant geological information. The 3-D model has changed the understanding of the belt and identified several target areas.

At Elura, New South Wales, the production stopes are at 800 m below the surface and the present mine life (2006) is curtailed at 900 m, where the orebody is cut off by a major fault. A deep diamond drilling program has been undertaken in an effort to identify where continuation of the orebody has been displaced.

Newmont is proposing to spend \$25 million to develop the zinc-rich Amity deposit below the existing Gossan Hill workings in Western Australia. Stope production is due to commence in 2003-04 and continue until 2007-08. The Hougoumont Zone, 300 m north of Amity, has returned wide ore grade intersections including 15 m at 31.8% Zn.

The Western Metals Goongewa mine, Western Australia, has ceased production and the Cadjebut mill ceased production after the Pillara mill expansion to 2.4 Mtpa was successfully completed in late 2000. Exploration drilling by the company has continued to confirm extensions of resources at Pillara and Fossil Downs.

Ivernia West Inc, a Canadian based company, is conducting a feasibility study on the Magellan lead carbonate deposit discovered by Renison Ltd in 1987 in western Australia.

Tectonic Resources announced that the Trilogy polymetallic deposit located 170 km west of Esperance, Western Australia, is largely recoverable by open-cut mining. Following satisfactory results from a pre-feasibility study, Tectonic plan to proceed with a full bankable feasibility study.

At Rosebery, Tasmania, Pasminco is developing a decline to link up an existing decline and remove the reliance on a shaft to move men, materials, machinery and ore to the surface. Rosebery is currently at a depth of 950 m and has a minimum remaining mine life of 8 years, however, the orebody has not been closed off either at depth or along strike.

Western Metals Ltd at the Hellyer tailings project are undertaking a \$5 million feasibility study including pilot plant trials.

Compass Resources is examining development options at its Browns polymetallic project, 80 km south of Darwin, Northern Territory. Around 30 - 40% of the mine's revenue would come from lead sales, with the remaining from cobalt, nickel and copper.

Austminex NL at Benambra in Victoria conducted a mine re-opening study, which increased resources by some 45% and improved the metallurgical performance. However, plans to recommence open-cut mining at 600 ktpa will only be implemented when economic conditions improve.

MINERAL INDUSTRY PERFORMANCE AND OUTLOOK

According to quarterly preliminary figures released by ABARE (March 2002), the minerals industry contributed \$55.8 billion to Australia's export earnings in 2001, making it the nations largest export earner.

ABARE report that after rising 23% in the five years to 2001-02, the total volume of Australian mine production is projected to rise by some 8% in the five years to 2006-07. Growth in mine output over this period is expected for nickel (55%), zinc (10%), bauxite and alumina (21% and 13% respectively), iron ore (14%), black coal (10%), uranium (23%) and ilmenite, rutile, leucoxene and zircon (30 - 60%). These increases in production reflect increasing output from new operations and expansion in capacity at others, referred to in the preceding commodity assessments. In summary they include:

- incremental expansions at existing nickel sulphide ore mines and expansions in output from the new laterite operations in Western Australia;
- Century mine moving toward full production for zinc;
- expansions at alumina refineries in the Darling Range (WA), which began in the past year or so;
- iron ore contributions expected from Mining Area C, West Angelas and the Koolyanobbing expansion;
- new ilmenite, rutile, leucoxene and zircon output from the Murray Basin (Gingko, Douglas and Mindarie) and Dardanup (WA); and
- additional black coal production from new operations such as Hail Creek, Mount Arthur North, Moorvale and Millmerran.

Production and exports of selected mineral commodities for 2000-01 are presented in [Table 4](#). Australia's total minerals and energy export earnings in 2001-02 are forecast by ABARE to remain flat at \$56.4 billion. Metals and related mineral export earnings are projected to increase by 13.5% to \$35.4 billion in real terms (2001-02 dollars) in 2003-04 and then decline to \$32.7 billion in 2006-07.



ABARE and ABS reported that new capital expenditure on mining was \$5.2 billion in 2000-01, marginally less than in 1999-2000. In real terms, new capital expenditure in 2000-01 was the lowest since 1991-92. According to the Minerals Council of Australia, this decrease in investment spending reflects the completion of a number of large projects recently. Most of these projects are now fully commissioned and will, in coming years, add further to Australian minerals production. For 2001-02, ABS data indicate that capital expenditure on mining may be around \$8.4 billion, which is about 60% up on estimated 2000-01 expenditure. This increase is due mainly to an increased number of projects scheduled to be completed in 2001-02 and higher project values than in the previous year.

In 2001, ten major minerals and energy projects valued at \$0.5 billion were completed. This compares with 18 projects completed in 2000 valued at around \$3.6 billion. Currently there are 18 projects scheduled to be completed in 2002, which are valued at some \$3.3 billion. Over the next 5 years, 35 projects are scheduled to be completed, which compares favourably with numbers recorded in previous years.

Nation-wide benefits that have accrued from mining are documented in a feature paper prepared by Geoscience Australia for the ABS, entitled *The Australian mining industry: from settlement to 2000*. [Australia's Mining History](#).

For mining to continue as a sustainable wealth-generating industry for Australia in the 21st Century, it must continue to replenish its stock of mineral and energy resources through new discoveries. This presents new technical challenges, which were identified by an independent working group drawn from industry, government and universities, and presented to the Prime Minister's Science, Engineering and Innovation Council in mid 2001. [Australian Mineral Exploration](#).

TABLE 4

Australian production and exports of selected mineral products 2001-02

Commodity	Production	Exports	Export value \$ million
Aluminium			
Bauxite (Mt)	54.600		196
Alumina (Mt)	16.098	12.721	4,507
Aluminium (Mt)	1.788	1.471	4,229
Coal			
Black raw (Mt)	321.30		
Black saleable (Mt)	256.80	193.50	10,801
Brown	65.00		
Copper			
Ores and concentrates (kt)	2,577	1,150	1,037
Refined primary (kt)	518	366	1,249
Diamond (kc)	22,475	25,513	634
Gold			
Mine production (t)	295.40		
Refined (t) (a)	360.60	301.80	4,887
Iron & Steel			
Ore & Pellets (Mt)	175.80	157.300	4,903
Iron and steel (Mt)	8.100	2.513	1,277
Lead			
Ores and concentrates (kt)	1,000	433	318
Refined (kt)	215	199	167
Bullion (kt)	153	119	151
Manganese			
Ores and concentrates (kt)	1,948	1,516	260
Mineral sands			
Ilmenite concentrates (kt)	2,092	1,012	154
Rutile concentrates (kt)	209	190	161
Synthetic rutile (kt)	650	443	317
Titanium dioxide pigment (kt)	181	140	494
Zircon concentrates (kt)	378	375	228
Nickel			
Concentrate (kt Ni)	197		
Refined (kt)	221(b)	187	2039(c)
Uranium (t U₃O₈)	9,575	9,722	497
Zinc			
Ores and concentrates (kt)	2,697	1,903	977
Refined (kt)	534	391	782

t = tonnes; kt = 10³t; Mt = 10⁶t; kc = 10³ carats**Source:** Australian Mineral Statistics, ABARE, March quarter 2002

Australian Commodities ABARE, March 2002

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

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

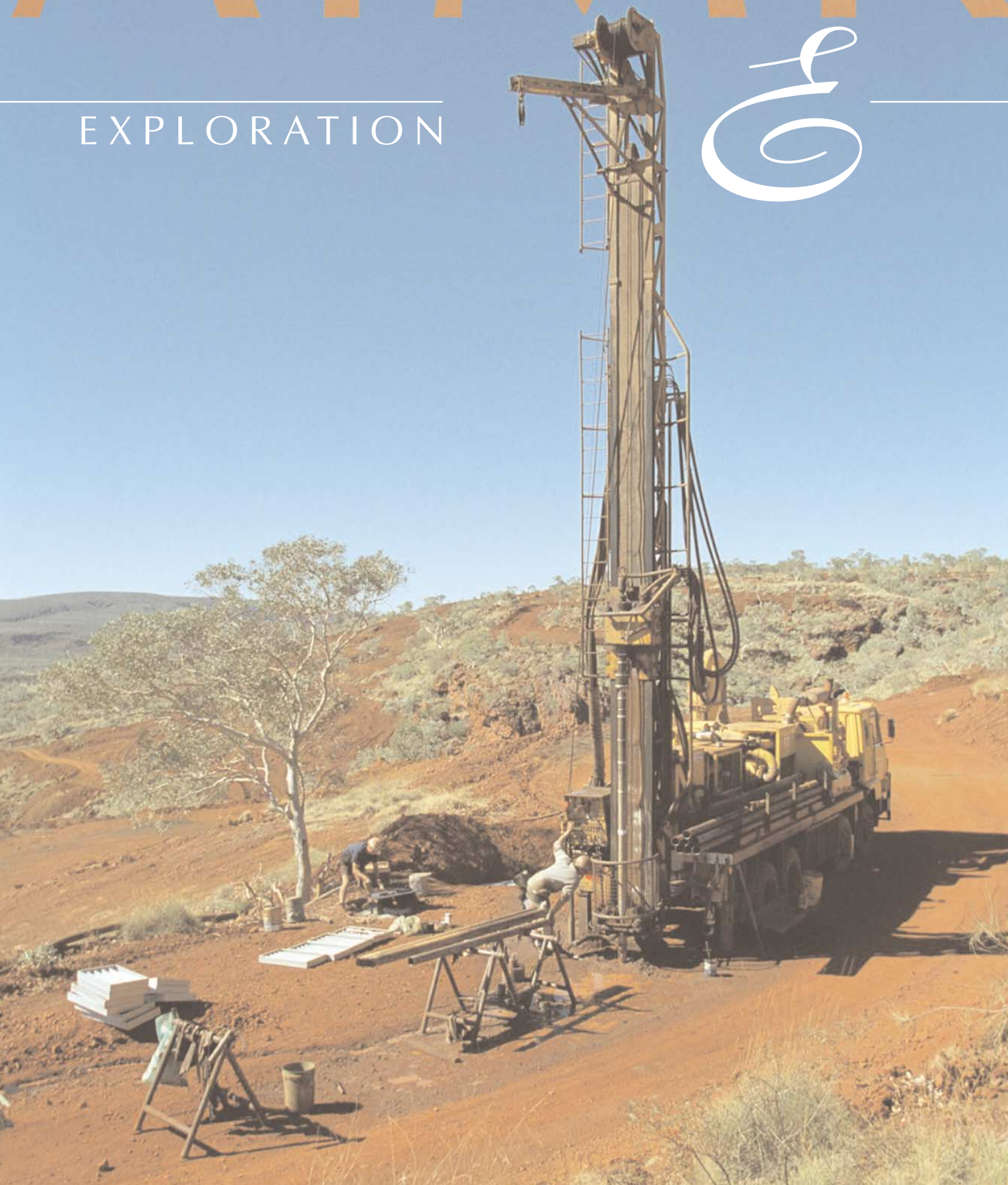
(c) Sum of all nickel product export values



AIMR

EXPLORATION

&



Cover: Iron ore exploration at BHP Billiton Ltd's Area C project in the Hamersley Basin, Western Australia (Photo by R.Sait, published with permission from BHP Billiton)

Exploration expenditure

Mineral exploration expenditure for a range of commodities is collected quarterly by ABS. The following discussion is based on the survey data for 2000-2001 (year ended 30 June 2001) and the first two quarters for 2001-02. 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 rose by 1% to \$683.3 million in 2000-01 according to the ABS, the first increase in annual exploration spending since 1996-97.

Spending for calendar year 2001, based on the sum of ABS four quarter figures, was down by \$11.9 million to \$664.4 million.

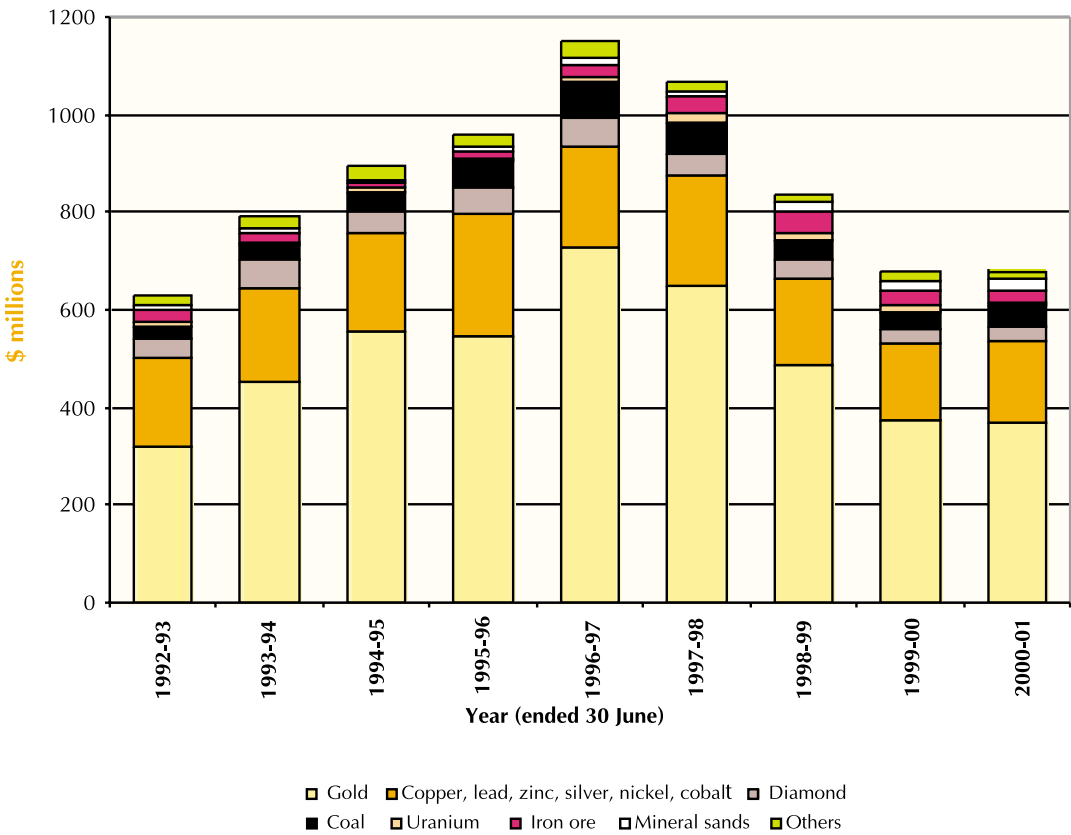


Figure 4: Australian mineral exploration expenditure by commodity since 1992-93 (Source ABS)



Gold was again the principal commodity sought and accounted for 54.2% of all exploration spending in 2000-01. Despite retaining the dominant position, exploration expenditure on gold fell by \$4.6 million to \$370.2 million (Figure 4). While the fall was far lower than in the previous year it still took gold spending to its lowest level since 1992-93. Several commodity groups had increased spending in 2000-01 (Table 5) including mineral sands, which rose by \$2.1 million to \$23.6 million, a record.

Increases were also recorded for base metals (5.5%), diamond (6%), and coal (16.7%). These movements resulted in base metals, diamond, coal and mineral sands increasing their share of national spending (Table 5). Gold and base metals combined accounted for over 78% of total exploration spending, a similar level to 1999-00. Significant reductions in spending compared to the previous year, were recorded for iron ore and uranium, which fell by 21.2% and 28.2% respectively from 1999-2000

State	Exploration spending (\$ million)		Change (\$ million)	Proportion of Australian total exploration spending (%)		Change % points
	1999-00	2000-01		1999-00	2000-01	
Gold	374.8	370.2	-4.6	55.4	54.2	-1.2
Base metals	156.8	165.4	8.6	23.2	24.2	1.0
Diamond	29.8	31.8	2.0	4.4	4.7	0.3
Coal	35.4	41.3	5.9	5.2	6.0	0.8
Iron ore	29.7	23.4	-6.3	4.4	3.4	-1.0
Mineral sands	21.5	23.6	2.1	3.2	3.5	0.3
Uranium	11.7	8.4	-3.3	1.7	1.2	-0.5
Others	16.7	19.3	2.6	2.5	2.8	0.3

Table 5: Australian mineral exploration expenditure by commodity, 1999-00 and 2000-01.



EXPLORATION DRILLING BY BEMAX RESOURCES NL AT ITS GINGKO MINERAL SANDS PROJECT IN THE MURRAY BASIN, NEW SOUTH WALES

(BeMax Resources N.L.)

ABS data for base metals exploration show copper spending rose by 15.5% to \$32.8 million, zinc-lead-silver increased by 7.9% to \$59.8 million but nickel-cobalt exploration fell by 0.3% to \$72.8 million.

Exploration spending rose in all States except Victoria and the Northern Territory in 2000-01 (Figure 5 and Table 6). Western Australia was again the principal destination for exploration with \$424.1 million spent (2.2% increase), 62.1% of total Australian spending, slightly higher than last year. Spending was also again just over five times higher than in Queensland, the State with the second highest expenditure. Queensland attracted \$83.1 million (12.2% of total Australian spending), which was \$0.5 million (0.6%) higher than in 2000-01. Although it recorded only a 2.2% increase to \$57.2 million, New South Wales regained the position as the third largest exploration destination following a 17.4% fall in spending in the Northern Territory. Actual spending in the Northern Territory was \$10 million less at \$47.5 million, a level not recorded since 1987-88. In Victoria, spending fell by almost \$1 million to \$32.7 million, 4.8% of the Australian total and was the State's lowest expenditure since 1994-95. South Australian spending recovered somewhat from the dramatic decline in 1999-00 to rise by \$7 million (31%) to \$29.6 million, and its share of national spending rose to 4.3%. Tasmania had \$9.2 million spent on exploration, an increase of \$0.4 million (4.5%) but its share of national spending was unchanged at 1.3%.

The depth of the current exploration recession is well illustrated in constant 2000-01 dollar terms (Figure 6), with the 2000-01 spending the lowest since 1978-79 and 4.8% lower than 1999-00.



**EXAMINING DRILL CORE
AT CENTURY ZINC MINE**
(Pasminco Ltd)



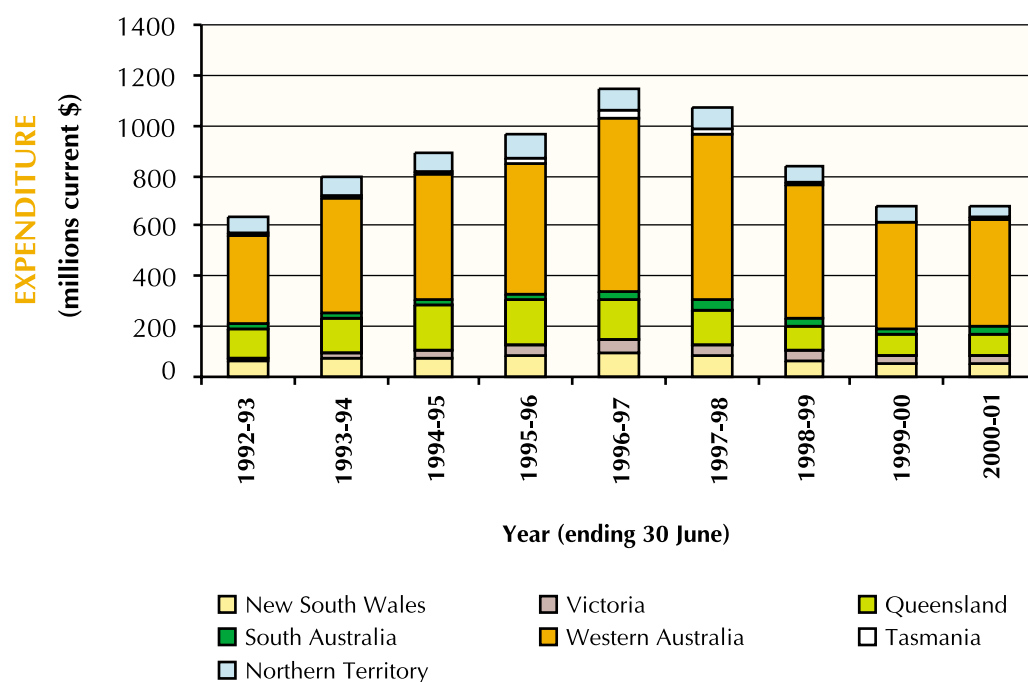


Figure 5: Australian mineral exploration expenditure by State since 1992-93 (Source ABS).

State	Exploration spending (\$million)		Change (\$ million)	Proportion of Australian total exploration spending		Change % points
	1999-00	2000-01		1999-00	2000-01	
Western Australia	415.0	424.1	9.1	61.4	62.1	0.7
Queensland	82.6	83.1	0.5	12.2	12.2	-0.0
Northern Territory	57.5	47.5	-10.0	8.5	7.0	-1.5
New South Wales	56.1	57.2	1.1	8.3	8.4	0.1
Victoria	33.8	32.7	-1.1	5.0	4.8	-0.2
South Australia	22.6	29.6	7.0	3.3	4.3	2.0
Tasmania	8.8	9.2	0.4	1.3	1.3	0.0

Table 6: Australian mineral exploration expenditure by State, 1999-00 and 2000-01.

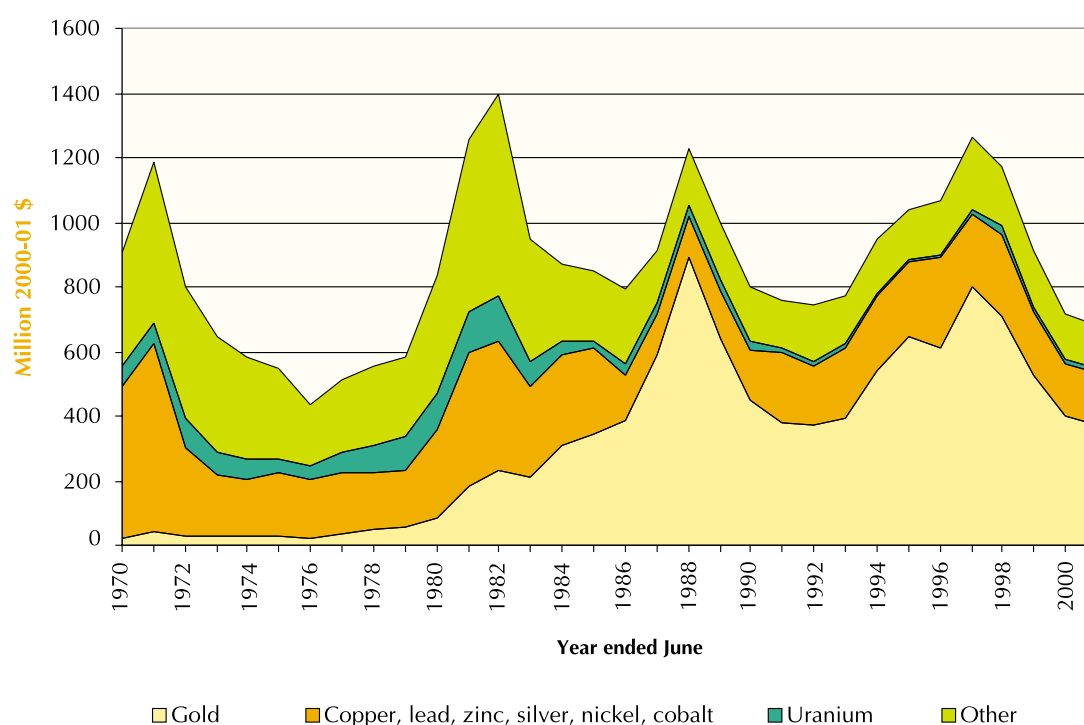


Figure 6: Australian mineral exploration expenditure since 1969-70 (2000-01 dollars).

ABS exploration expenditure figures show that spending for the September and December quarters 2001 was down by \$19 million to \$338 million, compared to the equivalent period in 2000. This expenditure was almost \$12 million higher than in the first half of 2001. In Western Australia, spending in the last six months of calendar 2001 was \$16 million lower than in the last half of 2000. Increases in last half calendar year spending were recorded only in Queensland (up by \$3.4 million) and South Australia (up \$1.6 million), when compared to the last half of calendar year 2000. All other regions recorded falls with Tasmania hardest hit as spending was more than halved to \$2.1 million by a fall of \$2.2 million. Actual expenditures for the six months for the other states are, with the figures for the corresponding half year of 2000 in brackets: - New South Wales \$25.1 million (\$29.4 million); Victoria \$14.3 million (\$15.9 million); and the Northern Territory \$28.3 million (\$29.5 million).

Since 1981-82 there has been a general trend for the proportion of total exploration spending to increase on Production Leases¹, with a consequent reduction in the proportion spent in all other areas (Figure 7). Although the proportion has been stable over the last several years, the long term trend shows a concerted move away from the higher risk “greenfields” exploration. In current dollar terms, the 2000-01 “Other areas” expenditure increased by \$8.3 million compared to 1999-00, which was the lowest since 1992-93.

1 ABS define a production lease as an area on which production or development is actually taking place. All other areas are areas outside a production lease and can include exploration leases, retention leases and areas not leased but under assessment for exploration.



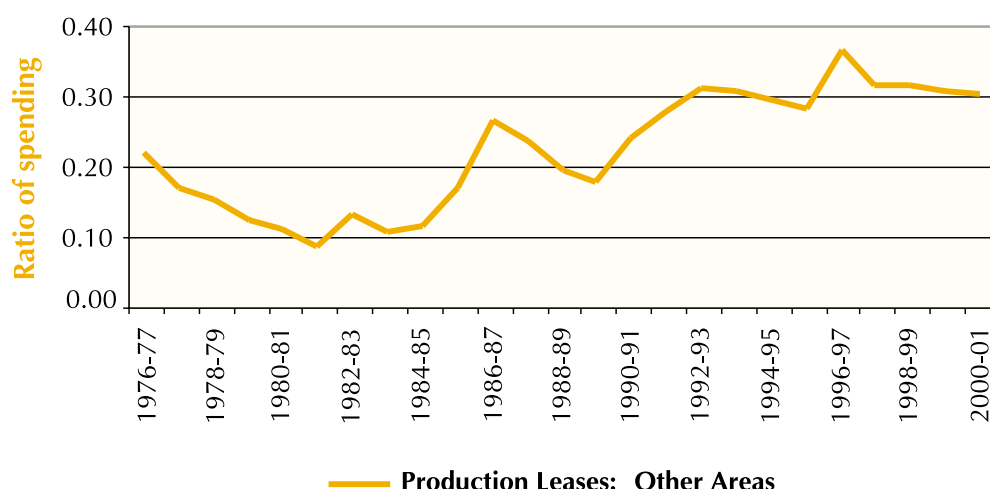


Figure 7: The ratio of exploration spending on production leases against all other areas.

Exploration Drilling

In past years, Geoscience Australia commissioned ABS to undertake a survey of exploration and mining companies to ascertain the amount and type of mineral exploration drilling done in Australia. These surveys were commissioned on behalf of some of the members of the Chief Government Geologists Conference to enable a comparison of expenditure and amount of drilling done throughout Australia. This survey was discontinued in 2000-01 due to its cost and the declining amount of data ABS was able to release as a result of its confidentiality guidelines. A summary of the results of the last survey commissioned was released by ABS on 20 December 2000 in the ABS publication 8412.0. More details of previous surveys can be obtained in past editions of Australia's Identified Mineral Resources.

In 2000-01, 5.82 million metres of exploration drilling were completed in Australia, a reduction of 3% over the previous year. Of the total metres drilled, 28% were in Production Areas, the same as in 2000-01.

World Exploration

On an international basis, Australia maintained its position as the leading country for mineral exploration. The Metals Economics Group annual survey of world exploration budgets showed that Australia increased its share marginally to 17.5% (Figure 8) and that world exploration budgets in 2001 totalled US\$2.2 billion, down 15% on 2000.

Government Programs Assisting Exploration

Geoscience Australia and its State/Territory counterparts launched the Australian governments' geoscience web portal in November 2001. It provides a single entry point for users of Australia governments' geoscience data, information and services. Industry and other users may access information at a national level or satisfy their requirements for regional or local information via pathways provided to the relevant State/Territory datasets. Entry to the Australian geoscience web portal is via www.geoscience.gov.au.

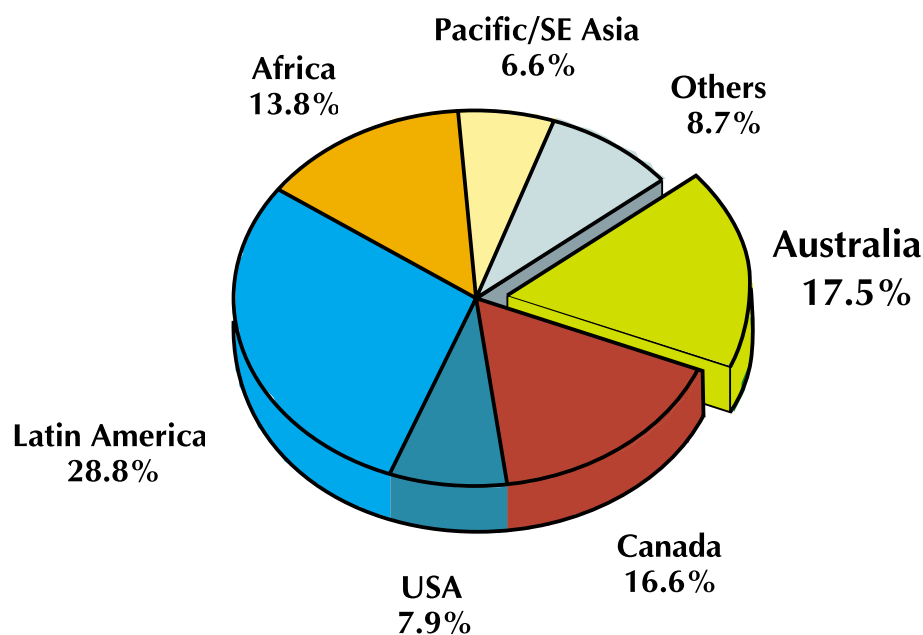


Figure 8: Distribution of world exploration budgets 2001 (Source Metals Economics Group, Canada)

In September, the then Minister for Industry, Science and Resources announced initiatives to promote the development of Australia's spatial information industry. Under the new policy, free online access will be progressively provided to a range of national spatial datasets including topography, geology and geophysics. For products not deliverable via the Internet, supply will be at a price based on the marginal cost of transfer.

Geoscience Australia and State and Northern Territory geological surveys have mapping programs to provide industry with new geoscientific data and information in proven and greenfields mineral provinces. Most States and the Northern Territory also have initiatives to boost mapping and provision of geoscientific information in their jurisdictions, including open file company reports of past exploration results, to help promote exploration investment. Details of these programs may be obtained by visiting the appropriate web sites accessible via the Australian geoscience web portal.

Outlook for Exploration

Mixed signals concerning the outlook for exploration indicate that its future direction is far from clear. ABARE believe a sustained period of higher mineral prices is necessary for a significant improvement in the outlook for exploration (Australia Commodities, December Quarter 2001 p. 593). ABARE expect price recovery to occur in late 2002. The small increase in Australian exploration spending for 2000-01 in current dollar terms was the first significant positive annual spending result since the last peak in 1996-97. However, ongoing industry rationalisation in Australia and globally is causing a reduction in the combined exploration budgets compared to the pre-amalgamation budgets of the individual companies.



A more positive prognosis is suggested by the listing of some 14 mineral resource companies on the Australia Stock Exchange (ASX) in 2001 and others listing on the London Alternative Investment Market (AIM). A number of companies are awaiting listing. Also, in November, the Australian Gold Council/Hartley Poynton Explorers Index hit a record high after rising 25% in the month. This compares with the S&P/ASX All Resources Index growth of only 5%. One of the key drivers of the increase in the Explorers Index was Minotaur Resources' exploration success in South Australia. These factors, combined with an anticipated economic recovery in the US, and the expected lift in metal prices later in 2002, suggests a more positive outlook relative to recent years.

Australia's record of exploration successes continued with new resources being added to the national resource inventory. Exploration will continue to focus on the established mineral provinces such as the Yilgarn Craton, Mount Isa Inlier, Lachlan Fold Belt, Curnamona Craton and the Murray Basin but there is likely to be increased interest in newer provinces such as the Tanami-Arunta, Gawler Craton, Kimberley, and Musgrave Ranges in the light of recent exploration successes. The traditionally targeted commodities (gold, nickel, copper, zinc, mineral sands and diamond) will be the focus of attention and the current high levels of interest in mineral sands is expected to continue for the short to medium term. Interest in tantalum and PGMs is buoyant and is likely to stay so in the short term at least.

Offshore mineral exploration in Commonwealth waters

Under the Offshore Constitutional Settlement of 1979, the Commonwealth and States agreed that there would be a common mining code to apply from the territorial sea baseline (generally the low water mark) out to the edge of Australia's continental shelf. It was also agreed that this common mining code would be governed by complementary Commonwealth and State/Northern Territory offshore minerals legislation.

The Commonwealth Offshore Minerals Act 1994 regulates the exploration for minerals and the mining of minerals, other than petroleum, over the continental shelf three nautical miles beyond the territorial baseline of the state 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 (or Northern Territory) minister and is responsible for major decisions relating to titles, such as grants, refusals, etc. The State minister is called the Designated Authority and is responsible for the normal day-to-day administration of the Commonwealth legislation.

The initial term of an exploration licence 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 Mineral Exploration Licence (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.

A total of 65 offshore MEL applications have been received since February 1990, but there was only one active licence at the end of 2001. This is T-2-MEL, in Ringarooma Bay in north east Tasmania, where previous exploration has identified an inferred tin resource of 23 million cubic metres at a grade of 149 g tin metal per cubic metre. During the 1990's there was exploration for alluvial diamonds in offshore palaeochannels and tidal shoals in the Joseph Bonaparte Gulf region of north west Australia. While no diamonds were discovered in Commonwealth waters, a limited number of gem quality diamonds were discovered in State waters.

Most offshore mineral exploration to date has been based on known distributions of diamonds, gold, heavy mineral sands and tin in adjacent onshore areas. Other mineral commodities with offshore extensions from known onshore deposits include tungsten, coal, manganese and iron ore. Phosphates and polymetallic manganese nodules (containing nickel, cobalt and copper) occur in deeper water.

APPENDIX 1

Abbreviations and acronyms

ABARE	Australian Bureau of Agricultural and Resource Economics	mm	millimetre
ABS	Australian Bureau of Statistics	Mozs	million ounces
AIMR	Australia's Identified Mineral Resources	MREB	Mineral Resources & Energy Branch
BRS	Bureau of Resource Sciences	Mt	million tonnes
c	carat	Mtpa	million tonnes per annum
CSIRO	Commonwealth Scientific & Industrial Research Organisation	MW	megawatt
EAR-1	estimated additional resources - category 1	na	not available
EDR	economic demonstrated resources	NSW	New South Wales
GIS	geographical information system	NT	Northern Territory
g	grams	OECD/NEA	Organisation for Economic Cooperation and Development/Nuclear Energy Agency
g/t	grams per tonne	PGM	platinum-group metals
GL	gigalitre	ppm	parts per million
Gt	gigatonne	Qld.	Queensland
IAEA	International Atomic Energy Agency	RAB	rotary air blast
JCB	Joint Coal Board	RAR	reasonably assured resources
JORC	Joint Ore Reserve Committee	RC	reverse circulation
kg	kilogram	\$	dollar
km	kilometre	SA	South Australia
kt	kilotonne (thousand tonnes)	SDR	Subeconomic demonstrated resources
ktpa	kilotonne per annum	t	tonne
L	litre	Tas.	Tasmania
lbs	pounds	tpa	tonnes per annum
m	metre	U	uranium
m³	cubic metre	U₃O₈	uranium oxide
Mc	million carats	USA	United States of America
MEL	mineral exploration licence	USGS	United States Geological Survey
ML	million litres	US\$	United States of America dollar
MIbs	million pounds	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 subsequently merged with the Australian Surveying and Land Information Group (AUSLIG) to form 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 (e.g., 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	
		ECONOMIC				
		SUB-ECONOMIC	PARAMARGINAL			
			SUB MARGINAL			
Decreasing degree of economic feasibility	↓					

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 (e.g., 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 (i.e., 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.

References

- BMR, 1976. BMR adopts new system of resource classification. Australian Mineral Industry Quarterly, 28(1), 11-13.
- BMR, 1984. BMR refines its mineral resource classification system. Australian Mineral Industry Quarterly, 36(3) 73-82.
- JORC, 1999. Australasian Code for Reporting of Mineral Resources and Ore Reserves (the JORC code). Report of the joint committee of the Australasian Institute of Mining & Metallurgy, Australian Institute of Geoscientists and Minerals Council of Australia. 16p.
- King, H.F., McMahon, D.W. and Bujtor, G.J., 1982. A guide to the understanding of ore reserve estimation. Australasian Institute of Mining and Metallurgy, Melbourne, 21 p.
- OECD/NEA and IAEA, 2001. Uranium 2001: Resources, Production and Demand. A Joint Report by the OECD Nuclear Energy Agency and the International Atomic Energy Agency, 348p.
- USBM/USGS, 1980. Principles of a resource/reserve classification for minerals. US Geological Survey Circular 831, 5 p.



APPENDIX 3

National Resources and Land Use

Group Leader: IAN LAMBERT 6249 9556 ian.lambert@ga.gov.au

AIMR 2002: staff, commodity responsibilities and related projects

Mineral Resources & Advice		
BILL MCKAY (Unit Leader) Phosphate, decision support	6249 9003	bill.mckay@ga.gov.au
YANIS MIETIZIS Mineral potential, decision support	6249 9523	yanis.miezitis@ga.gov.au
SUBHASH JAIRETH Mineral potential, decision support	6249 9419	subhash.jaireth@ga.gov.au
KEITH PORRITT Copper, shale oil, decision support	6249 9479	keith.porritt@ga.gov.au
ADEN MCKAY Uranium, vanadium, mineral potential	6249 9230	aden.mckay@ga.gov.au
ROY TOWNER Nickel, mineral sands, magnesium, cobalt, minerals promotion	6249 9480	roy.towner@ga.gov.au
RON SAIT Coal, iron ore, manganese, construction materials, offshore mineral exploration	6249 9550	ron.sait@ga.gov.au
ANDREW McMAHON Bauxite-alumina-aluminium, tin, tungsten, mineral databases, decision support	6249 9698	andrew.mcmahon@ga.gov.au
ANDREW LUCAS Diamonds, gemstones, platinum group metals, decision support, mineral potential	6249 9635	andrew.lucas@ga.gov.au
Minerals Promotion		
MIKE HULEATT (Unit Leader) Gold, exploration expenditure	6249 9087	mike.huleatt@ga.gov.au
MITCH RATAJKOSKI Minerals promotion, web site development, zinc, lead, tantalum, niobium and lithium	6249 9323	mitch.ratajkoski@ga.gov.au

Postal Address:

Geoscience Australia

GPO Box 378
Canberra ACT 2601
AUSTRALIA

Location:

Cnr Jerrabomberra Ave and
Hindmarsh Drive
Symonston ACT 2600
AUSTRALIA

Internet: **<http://www.ga.gov.au>**

ABN: 80 091 79 039



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Photo 3	Tailings restacking at Viney Creek mineral sands operation near Hawks Nest, New South Wales	Mineral Deposits Ltd
Photo 4	Pouring gold at mine-site operations	AurionGold Ltd
Photo 5	Underground workshops at the Henty gold mine, Tasmania	AurionGold Ltd
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