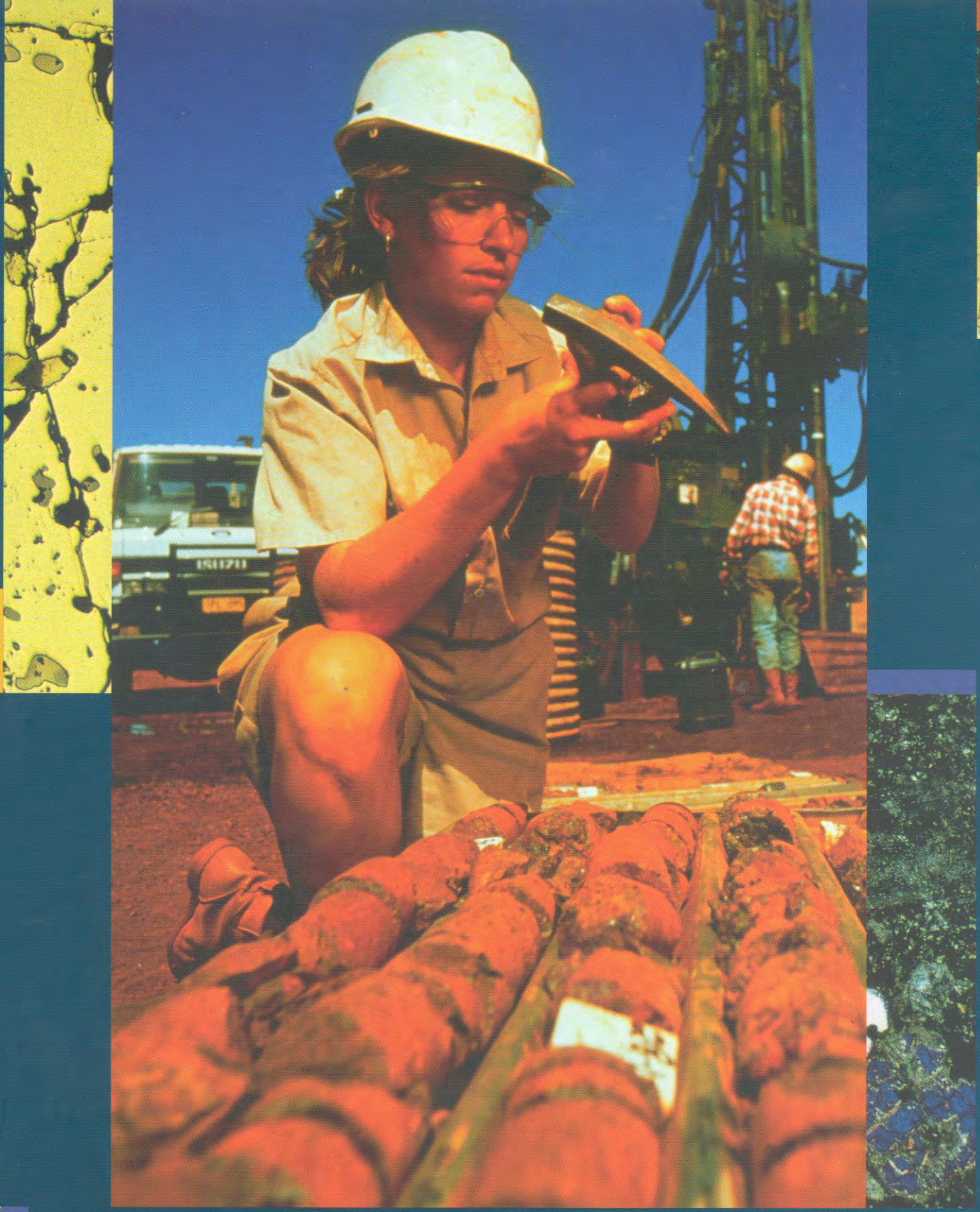

Australia's Identified Mineral Resources 1997

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The Bureau of Resource Sciences is a professionally independent scientific bureau within the Department of Primary Industries and Energy (DPIE). Its mission is to provide first-class scientific research and advice to enable DPIE to achieve its vision —rising national prosperity and quality of life through competitive and sustainable mining, agricultural, fisheries, forest, energy and processing industries.

It should be noted that no volume entitled *Australia's identified mineral resources 1996* has been published due to the adoption of a new naming convention.

Cover photograph: Geologist Kimberley Hutson examining drill core at BHP Iron Ore's Yandi iron ore project in the Pilbara region of Western Australia. Photo courtesy of BHP Iron Ore Pty Ltd and published with that company's permission.

Photos not credited in text:
pp. iv–v: Coal stockpiles and stacker/reclaimers at Hay Point, Queensland—photograph courtesy of BHP Coal Pty Ltd.

p. 1: Coal mining operations in Central Queensland—photographs courtesy of BHP Coal Pty Ltd.

p. 25: The drilling barge *Gulf Explorer* moored in the Joseph Bonaparte Gulf region—photograph courtesy of Cambridge Gulf Exploration N.L.

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Foreword

The Bureau of Resource Sciences (BRS) is a professionally independent scientific bureau within the Department of Primary Industries and Energy (DPIE). Its mission is to provide first-class scientific research and advice to enable DPIE to achieve its vision—rising national prosperity and quality of life through competitive and sustainable mining, agricultural, fisheries, forest, energy and processing industries.

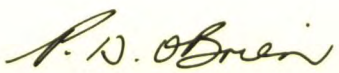
BRS provides independent advice and analysis on Australia's inventory of identified mineral resources, their rate of development and the level of exploration activity. To ensure that policy makers, the mining industry, the investment sector and the general community are well informed on these matters, BRS produces an inventory of Australia's mineral resources annually, drawing on current and historical data from mining and exploration companies.

BRS has developed the MINRES database to underpin its resource assessment work. MINRES contains information on the quantity, quality, type and location of over 2500 mineral deposits, and a commercially available version contains non-confidential entries for over 1500 of these deposits. BRS has another commercially available national mineral database, MINLOC, which contains detailed locations for over 50 000 mineral occurrences across Australia.

BRS also underpins government policy and management decisions by appraising the mineral resource potential of areas being considered for restricted land use, advising on environmental issues in relation to exploration, mining, rehabilitation and mineral processing, and providing advice on offshore exploration and mining technologies.

BRS undertakes work for external clients that is consistent with its role as a professionally independent government agency, including:

- developing innovative geographic information systems to assist resource and environment management and land use decisions;
- appraising mineral resources potential;
- undertaking independent audits of mineral resources;
- advising on mineral resource developments in emerging nations; and
- providing technical advice on energy efficiency and greenhouse gas emissions.



Peter O'Brien
Executive Director
Bureau of Resource Sciences

Contents

Plates

Figures

Tables

Commodity Review

Summary

In 1996, Australia's Economic Demonstrated Resources (EDR) of cobalt, gold, nickel, phosphate rock and tantalum increased substantially, while EDR of bauxite, lead, lithium, platinum group metals (PGM), silver and zinc rose slightly. There was a significant reduction in EDR of gem and near gem diamond and industrial diamond due to ongoing high levels of production. Magnesite and tin EDR were also significantly reduced as a result of depletion due to production and reassessment of deposits. EDR of all other commodities remained unchanged or had minor reductions.

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

Mineral exploration expenditure rose by 7.5% in 1995–96 to $960.2 million from $893.3 million in the previous year. Increases were recorded in all states and the Northern Territory. Gold was again the main target, accounting for 57% of the total expenditure. This continued high level of exploration expenditure will help Australia maintain its mineral resource stock, and in doing so it will ensure the sector can make a sustainable contribution to the economy.

Australia's mineral resources sector continued to underpin the standard of living of all Australians in 1996. As the nation's largest export earner, the minerals industry is vital to the wellbeing of the economy. In addition to its nationally important export performance, mining contributes significantly to the regional economies and the social wellbeing of communities in many parts of Australia.

In 1995–96 mineral resources exports increased to a new record of $34.7 billion (thousand million), a rise of 12.7% over the previous fiscal year. These export earnings comprised 60% of Australia's commodity exports, 45% of merchandise exports and 35% of the country's total exports of goods and services. The Australian Bureau of Agricultural and Resource Economics (ABARE) forecast export earnings to set a further record in 1996–97, rising by nearly 4% to over $36 billion.

Following election of the Liberal/National Coalition Government in March 1996, the mining industry responded to changes in policy concerning uranium mining, environmental processes and land access decision making. Expansion of existing operations and new mining proposals will increase production as we approach the year 2000. Because the potential increase in uranium production is significant, resources and new project proposals in this sector are featured in this report.

Introduction

This report presents the fifth annual assessment of Australia's identified mineral resources by BRS. It is used by policy makers, the minerals industry and the Australian Bureau of Statistics (ABS). The data are used in annual surveys of world mineral commodities.

The assessment is undertaken as an input into government policy decisions relating to the sustainable development of mineral resources and environmental management. 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 current dollars) in 1995–96 and the previous three fiscal years. The current level of expenditure is put into perspective by comparing it in real terms to expenditure over the preceding 26 years.

Estimates of Australia's identified resources of all major and several minor mineral commodities are reported for 1996 (Table 1). The estimates, prepared by the Mineral Resources and Energy Branch (MREB) of BRS, are based on published and unpublished data available to BRS up to the end of December 1996. Data on petroleum resources were provided by the Petroleum Resources Branch of BRS. 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 used in this report reflects both the geological certainty of existence of the mineral resource and the economic feasibility of its extraction (see Terminology and definitions). The term 'EDR' is used instead of 'reserves' for national totals of economic resources because the term 'reserve' has specific meanings under the terms of the Joint Ore Reserves Committee code used by industry for reporting reserves and resources. 'EDR' also provides a basis for meaningful international comparisons of the economic resources of other nations. With few exceptions, ore is mined from resources in the EDR category. EDR are reduced by mining and increased by new discoveries and by technical and economic changes, which can allow formerly subeconomic deposits to be reclassified as economic.

BRS has 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 1996). In this publication these estimates are reported under the corresponding resource categories of the BRS classification scheme. A correlation of the BRS 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 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.

Table 1 Australia's resources of major minerals and fuels and world figures for 1996

COMMODITY	UNITS	AUSTRALIA 1996								WORLD 1996	
		Demonstrated			Inferred			Mine (f) Production		Economic demonstrated resources (l)	Mine (a) production
		Econ-omic	Subeconomic		Econ-omic	Subeco-nomic	Undifferent-iated	1995	1996		
			Param arginal	Subm-arginal							
Antimony	kb Sb	89.9	37.0	35.8	7.7	3.9	15.1	0.9	1.3	-	100
Asbestos											
Chrysotile ore	Mt	-	46.24	-	-	-	75.18	-	-	large	} 2.4 (k)
Crocidolite fibre	Mt	-	0.37	-	-	-	2.12	-	-	large	
Bauxite	Mt	3024	-	5329	-	-	1598	42.7	43.1	23000	111 (b)
Black coal											
In situ	Gt	68	2	6	-	-	very large				
Recoverable	Gt	49	2	4	-	-	-	0.24 (c)	0.25 (c)	705	3.7 (d)
Brown coal											
In situ	Gt	46	1	2	-	-	184				
Recoverable	Gt	41	1	2	-	-	166	0.0507	0.0536	312	0.84
Cadmium	kt Cd	132.11	10.6	16.4	21.1	0.1	0.8	1.9	1.9	540	19
Chromium	kt Cr	-	55.5	207.8	-	1623.8	-	-	-	3700000	12000
Cobalt	kt Co	414.1	78.3	233.8	34.6	175.3	282.0	0.8	0.9	4000	24.1
Copper	Mt Cu	23.6	14.5	2.5	1.9	8.3	4.0	0.4	0.5	310	10.7
Diamonds											
Gem & near gem	10^6 c	85	220	3.5	28.2	-	6.2	} 40.7	42.0	-	54.0
Industrial	10^6 c	90	229	11.2	30.4	-	20.8			980	58.0
Fluorine	Mt F	-	24.34	9.59	-	-	2.06	-	-	102 (i)	1.92
Gold	t Au	4454	1206	57	-	-	1887	253	289	46000	2300
Iron ore	Gt	17.8	13.8	0.4	-	-	17.4	0.143	0.147	151	1
Lead	Mt Pb	18.7	4.8	9.4	4.8	16.1	1	0.46	0.52	69	2.8
Lithium	kt Li	166	79	3	-	-	7	4.1 (n)	6.6 (n)	2800	6.4 (b)
Magnesite	Mt-$MgCO_3$	179.9	1.2	326.5	-	-	109.8	0.23	0.31	8600	9.2 (b)
Manganese ore	Mt	118.0	27.1	167.0	70.5	96.1	-	2.2	2.1	1885	21.5
Mineral sands											
Ilmenite	Mt	135.0	68.1	0.7	-	-	89.2	2.0	2.0	586	6.6 (b)
Rutile	Mt	14.9	33.9	0.6	-	-	25.2	0.2	0.18	41.99	0.3 (b)
Zircon	Mt	21.4	24.6	0.5	-	-	20.8	0.5	0.46	60.95	0.89 (b)
Molybdenum	kt Mo	-	4.7	3.2	-	-	859.5	-	-	5500	126
Nickel	Mt Ni	6.4	2.2	3.4	-	-	6.6	0.1	0.11	51	1.04
Niobium	kt Nb	4.0	67.6	-	-	-	1995	-	-	3500	17.5
Petrol. recov. (e)											
Crude oil	GL	277	-	24	-	-	-	24.1	25.3	160176	3565
Natural (sales) gas	10^9m^3	1264	-	1099	-	-	-	30.0	29.8		
Condensate	GL	183	-	67	-	-	-	6.2	6.3	} 139703	
LPG naturally occ.	GL	144	-	92	-	-	-	3.6	3.7		2219
Phosphate rock	Mt	103	2758	-	-	-	1947	0.005	0.001	11000	131
PGM (Pt, Pd, Os, Ir, Ru, Rh)	t metal	19.1	17.5	27.7	3.5	82.3	2.1	0.6	0.7	56000	260.0 (j)
Rare earths											
REO and Y_2O_3	Mt	1	3.5	10.7	-	-	4.2	-	-	100	0.08
Shale oil	GL	-	-	4822	-	-	40360	-	-	na	na
Silver	kt Ag	43.3	11.5	12.9	9.5	12.7	1.0	0.9	1.0	280	14.8
Tantalum	kt Ta	8.1	5.4	0.3	-	-	64.8	0.2	0.3	19	366
Tin	kt Sn	119.5	28	186	-	303	5.3	8.7	8.8	7000	190
Tungsten	kt W	0.9	34.1	28	2.5	177.6	-	-	-	2100	30
Uranium (g)	kt U	622	-	93	136	44	-	4.4	4.9	2208 (h)	35.772(m)
Vanadium	kt V	15	1619	8425	-	2263	-	-	-	10000	36.0 (b)
Zinc	Mt Zn	39.9	12.4	11.9	9.7	9.9	1.2	0.9	1.07	140	7.2

Abbreviations: t = tonne; c = carat; m^3 = cubic metre; L = litre; kt = 10^3t; Mt = 10^6t; Gt = 10^9t; GL = 10^9L; na = not available

(a) World mine production figures for 1996 mostly USGS estimates.
(b) Excludes USA.
(c) Raw coal.
(d) Saleable coal.
(e) Source: Petroleum Resources Branch, BRS (as at 31 Dec 1995).
(f) Source: ABARE.
(g) Refer to text for comparison of resource categories in the BRS scheme with those of the international scheme for classifying uranium resources.
(h) Source: OECD/NEA and IAEA (most recent data).
(i) Excludes USA and Brazil.
(j) Platinum and palladium only.
(k) Includes crocidolite production.
(l) Based on BRS, USGS and other sources.
(m) Source: *Ux Weekly*, 10 February 1997
(n) Tonnes Li_2O

Table 1 Australia's resources of major minerals and fuels and world figures for 1996

COMMODITY	UNITS	AUSTRALIA 1996								WORLD 1996	
		Demonstrated			Inferred			Mine Production[f]			
		Economic	Subeconomic		Economic	Sub-economic	Undifferentiated	1995	1996	Economic Demonstrated Resources[l]	Mine[a] production
			Para-marginal	Sub-marginal							
Antimony	(kt Sb)	89.9	37.0	35.8	7.7	3.9	15.1	0.9	1.3	—	100
Asbestos											
Chrysotile ore	(Mt)	—	46.24	—	—	—	75.18	—	—	large	2.4[k]
Crocidolite fibre	(Mt)	—	0.37	—	—	—	2.12	—	—	large	
Bauxite	(Mt)	3024	—	5329	—	—	1598	42.7	43.1	23000	111[b]
Black coal	(Gt)										
in situ		68	2	6	—	—	very large				
recoverable		49	2	4	—	—	—	0.24[c]	0.25[c]	705	3.7[d]
Brown coal	(Gt)										
in situ		46	1	2	—	—	184				
recoverable		41	1	2	—	—	166	0.0507	0.0536	312	0.84
Cadmium	(kt Cd)	132.11	10.6	16.4	21.1	0.1	0.8	1.9	1.9	540	19
Chromium	(kt Cr)	—	55.5	207.8	—	1623.8	—	—	—	3700000	12000
Cobalt	(kt Co)	414.1	78.3	223.8	34.6	175.3	282.0	0.8	0.9	4000	24.1
Copper	(Mt Cu)	23.6	14.5	2.5	1.9	8.3	4.0	0.4	0.5	310	10.7
Diamonds	(10^6 c)										
gem and cheap gem		85	220	3.5	28.2	—	6.2	40.7	42.0	—	54.0
industrial		90	229	11.2	30.4	—	20.8			980	58.0
Fluorine	(Mt F)	—	24.34	9.59	—	—	2.06	—	—	102[i]	1.92
Gold	(t Au)	4454	1206	57	—	—	1887	253	289	46000	2300
Iron ore	(Gt)	17.8	13.8	0.4	—	—	17.4	0.143	0.147	151	1
Lead	(Mt Pb)	18.7	4.8	9.4	4.8	16.1	1	0.46	0.52	69	2.8
Lithium	(kt Li)	166	79	3	—	—	7	4.1[n]	6.6[n]	2800	6.4[b]
Magnesite	(Mt $MgCO_3$)	179.9	1.2	326.5	—	—	109.8	0.23	0.31	8600	9.2[b]
Manganese ore	(Mt)	118.0	27.1	167.0	70.5	96.1	—	2.2	2.1	1885	21.5
Mineral sands											
Ilmenite	(Mt)	135.0	68.1	0.7	—	—	89.2	2.0	2.0	586	6.6[b]
Rutile	(Mt)	14.9	33.9	0.6	—	—	25.2	0.2	0.18	41.99	0.3[b]
Zircon	(Mt)	21.4	24.6	0.5	—	—	20.8	0.5	0.46	60.95	0.89[b]
Molybdenum	(kt Mo)	—	4.7	3.2	—	—	859.5	—	—	5500	126
Nickel	(Mt Ni)	6.4	2.2	3.4	—	—	6.6	0.1	0.11	51	1.04
Niobium	(kt Nb)	4.0	67.6	—	—	—	1995	—	—	3500	17.5
Petroleum (recoverable)[e]											
Crude oil	(GL)	277	—	24	—	—	—	24.1	25.3	160176	3565
Natural (sales) gas	(10^9m^3)	1264	—	1099	—	—	—	30.0	29.8		
Condensate	(GL)	183	—	67	—	—	—	6.2	6.3	139703	2219
LPG naturally occur.	(GL)	144	—	92	—	—	—	3.6	3.7		
Phosphate rock	(Mt)	103	2758	—	—	—	1947	0.005	0.001	11000	131
PGM (Pt,Pd,Os,Ir,Ru,Rh)	(t metal)	19.1	17.5	27.7	3.5	82.3	2.1	0.6	0.7	56000	260.0[j]
Rare earths											
REO and Y_2O_3	(Mt)	1	3.5	10.7	—	—	4.2	—	—	100	0.08
Shale oil	(GL)	—	—	4822	—	—	40360	—	—	na	na
Silver	(kt Ag)	43.3	11.5	12.9	9.5	12.7	1.0	0.9	1.0	280	14.8
Tantalum	(kt Ta)	8.1	5.4	0.3	—	—	64.8	0.2	0.3	19	366
Tin	(kt Sn)	119.5	28	186	—	303	5.3	8.7	8.8	7000	190
Tungsten	(kt W)	0.9	34.1	28	2.5	177.6	—	—	—	2100	30
Uranium[g]	(kt U)	622	—	93	136	44	—	4.4	4.9	2208[h]	35.772[m]
Vanadium	(kt V)	15	1619	8425	—	2263	—	—	—	10000	36.0[b]
Zinc	(Mt Zn)	39.9	12.4	11.9	9.7	9.9	1.2	0.9	1.07	140	7.2

Abbreviations: t = tonne; c = carat; m^3 = cubic metre; L = litre; kt = 10^3t; Mt = 10^6t; Gt = 10^9t; GL = 10^9L; na = not available

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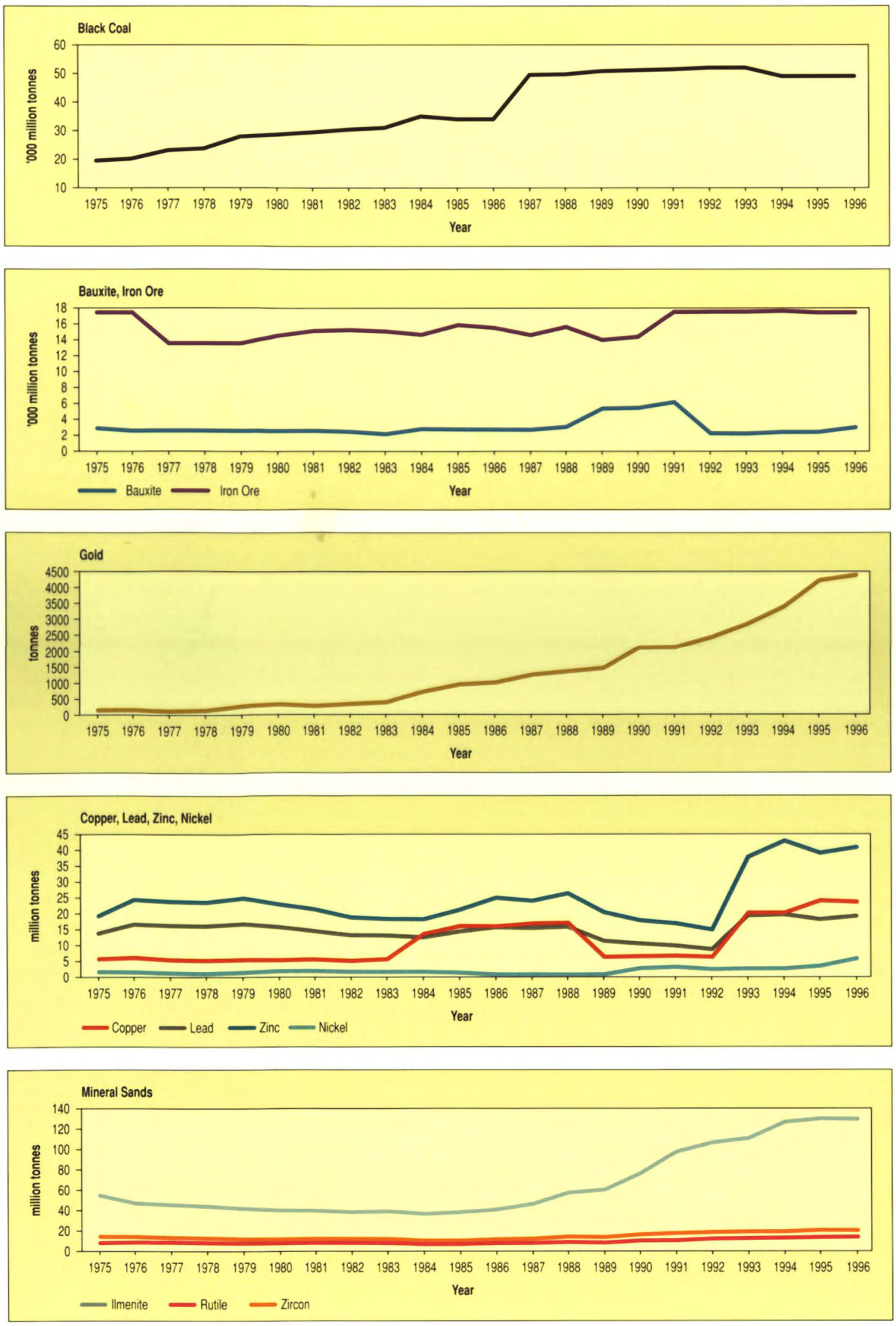
(i) Excludes USA and Brazil
(j) Platinum and palladium only
(k) Includes crocidolite production
(l) Based on BRS, USGS and other sources
(m) Source: *Ux Weekly*, 10 February 1997
(n) Tonnes Li_2O content

Figure 1 Trends in Economic Demonstrated Resources (EDR) for major commodities since 1975



Commodity Review

Bauxite

Australia's identified resources of bauxite remained relatively unchanged in 1996 compared with those of the previous year. EDR, however, increased by 19% to represent just over 30% of identified resources. The increase in EDR resulted from successful exploration programs and the upgrading of some resources previously classified as inferred. The bauxite deposits in the Weipa region (Plate 1) on the western coast of Cape York Peninsula in Queensland and the Darling Range in southwest Western Australia continue to rank among the world's largest in terms of extractable alumina content.

Australia's bauxite-alumina-aluminium industries maintained their rankings as major producers in the year under review. In 1995–96 Australia produced 43.3 Mt of bauxite, 13.3 Mt of alumina and 1.3 Mt of primary aluminium.

Australia currently has six bauxite mines, six alumina refineries and six aluminium smelters. Collectively, the aluminium industry employs over 90 000 people at its mines, refineries, smelters and semi-fabrication plants and is particularly important in regions such as north Queensland, the Hunter Valley, southwest Victoria, southwest Western Australia, the Northern Territory and north Tasmania.

In September 1996, Alcan South Pacific Pty Ltd signed a comprehensive Heads of Agreement with Aboriginal communities concerning the Ely Bauxite Project, a proposed new mine and beneficiation plant, located 25 km north of Weipa, and port facility 7 km south of the Pennefather River. The agreement covers strategies to minimise the impacts of development of the mine and port and to maximise the positive benefits to those communities affected if the project goes ahead. Economic and environmental studies of the project were nearing completion at the end of 1996.

Engineering optimisation work continued on the Comalco Alumina Project, a new alumina refinery based on Weipa bauxite. Comalco's ore reserves of 210 Mt and inferred resource of 3600 Mt make it one of the few known bauxite deposits that has the capacity to support a greenfield alumina refinery. This project will enter into a full feasibility study in 1997, which will include environmental clearances. The company has indicated that the refinery is likely to be located in either Queensland or Malaysia, and if approved could be in production at the turn of the century.

Photograph courtesy of Comalco Minerals and Alumina

Plate 1 *Scrapers removing overburden at the Weipa Mine on Queensland's Cape York Peninsula*

With demonstrated bauxite resources of 8.4 billion tonnes, Australia is now ranked first in the world ahead of Guinea, Brazil, Jamaica and India. Australia is the world's largest miner and refiner of bauxite and fourth largest producer of aluminium. It is responsible for approximately 34% and 27% of world bauxite mining and refining respectively, and 7% of aluminium smelting (9% of Western world aluminium smelting).

Black coal

Estimates of Australia's in situ and recoverable EDR of black coal remained unchanged in 1996 at 68 Gt and 49 Gt respectively. New South Wales accounted for 50% of the in situ EDR and Queensland 47%. The remaining 3%, although relatively small, is locally important to the economies of Western Australia, South Australia and Tasmania. About 40% of the in situ EDR is amenable to open-cut mining.

There were a number of new developments in both Queensland and New South Wales during 1996. In Queensland the Kenmare and Crinum longwalls commenced operations; the Burton open cut (Plate 2) made its first shipments of coal; underground mining commenced at New Hill; development of underground mines at Oaky Creek North and Moranbah North commenced, and a trial mining operation started at South Walker. In New South Wales construction work commenced at the Bengalla open cut; draglines were being erected at the Bulga and Bayswater No. 3 operations; longwall mining commenced at Dartbrook; Mount Owen reached full production, and feasibility studies were in progress for a number of projects including Mount Pleasant, Glendell and expansion of the Howick open cut.

In October, the Queensland Government called for expressions of interest for the development of infrastructure in the Surat Basin and Dawson Valley region in southern Queensland. The region has total thermal coal resources of 4.14 billion tonnes and has one operating mine, the Wilkie Creek open cut. The Government is seeking proposals from the private sector for the provision and/or development of water storage, mines, power generation, roads and railway. The New South Wales Government advertised two coal development areas for tender, Saddlers Creek and Mount Arthur North, both near Muswellbrook in the Hunter Valley.

In 1996, Australia produced 252 Mt of raw coal which yielded 200 Mt of saleable coal for domestic markets and export. These are increases of 4.6% and 3.3% respectively over 1995. Total exports of black

Photograph courtesy of Burton Coal Pty Ltd

Plate 2 *The Burton open-cut coal mine, Queensland*

coal during 1996 were 78 Mt of metallurgical and 63 Mt of steaming coal. The Australian Bureau of Agricultural and Resource Economics (ABARE 1997) projects that total Australian exports of coal will increase at an annual rate of 4.3% from 146 Mt in 1996–97 to 180 Mt in 2001–02. Most of this growth is anticipated to come from thermal coal exports, which are expected to exceed metallurgical coal exports by the end of the period. Australia has extensive recoverable resources of high quality metallurgical and thermal coals, which underpin the development of new mines and expansion of existing mines. These mines will support the expected growth in exports particularly of thermal coal, for new coal-fired power stations throughout Asia.

In 1996, Australia accounted for about 7% of the world's recoverable EDR of black coal and ranked sixth behind USA (29%), former USSR (20%), China (13%), India (10%) and South Africa (8%). Australia produced about 5% of the world's saleable black coal output in 1996 and ranked sixth after China (34%), USA (22%), former USSR (9%), India (7%) and South Africa (6%).

Brown coal

Estimates of Australia's resources of brown coal remained unchanged in 1996. Victoria accounts for 94% of Australia's in situ brown coal EDR and 86% of the total EDR is in the Latrobe Valley. Brown coal is mined only in Victoria and is used mainly for electricity generation. In 1996 Australian brown coal production was 53.6 Mt.

During 1996, the Victorian Government sold Yallourn Energy and Hazelwood Power and expressions of interest were sought for Loy Yang Power. Each of these organisations operates an open-cut brown coal mine that supplies fuel to its power stations for the generation of electricity.

The Herman Research Laboratory Ltd (HRL) commissioned a $100 million Integrated Drying Gasification Combined Cycle 10 MW brown coal demonstration facility at Morwell in 1996. HRL claim that the cost of electricity is up to 30% lower than conventional brown coal–fired power plants and CO_2 emissions are also about 30% lower.

In 1996, Australia had about 14% of the world's recoverable EDR of brown coal and ranked second behind the former USSR (32%). Australia produced about 5% of the world's brown coal output in 1996 and, as a producer, ranked seventh after Germany (23%), USA (13%), former USSR (12%), Poland (8%), Greece (7%) and Czech Republic (7%).

Copper

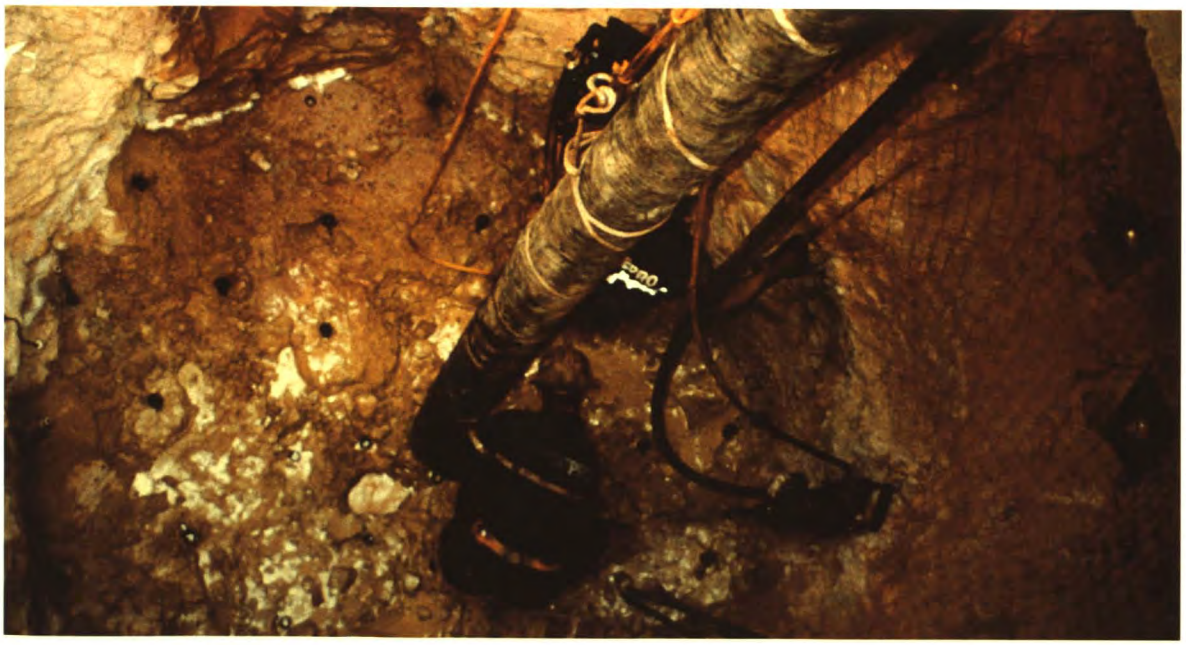
EDR for copper decreased by 2% to 23.6 Mt compared to 1995. However, total identified resources of copper increased by 5% to 54.8 Mt.

Improvement of electrowinning technologies in recent years, together with the introduction of heap leaching and solvent extraction, has enabled the development of resources which otherwise might not be economic. The processes are being widely used to treat secondary copper ores from open-cut mines and tailings and waste dumps adjacent to previous operations.

At the end of the period under review, development of the Ernest Henry open cut copper-gold mine in Queensland was on schedule to commence production in the first quarter of 1997. With planned full-scale ore production of 9 Mtpa, the operation will become Australia's third largest copper mine with annual concentrate production containing 95 000 t of copper and 120 000 oz of gold. The concentrate is to be smelted at Mount Isa.

At Mount Isa, MIM Holdings is to develop its new Enterprise Mine (incorporating the existing Deep Copper Mine) to extract ore from the 3000 and 3500 copper orebodies, which extend from 1200 m to 1950 m below surface. The new development will become the deepest underground mine in Australia and is scheduled to commence operations in late 1999.

WMC Limited is increasing the capacity of its Olympic Dam operations in South Australia, from 85 000 to 200 000 tonnes of refined copper by 1999. Although there are currently no plans to expand beyond 200 000 tpa of copper and associated products, WMC announced it would seek necessary approvals for the project to ultimately expand to 350 000 tpa.



Photograph courtesy of Ashton Mining Ltd

Plate 3 *Shaft sinking at the Merlin diamond project, Northern Territory*

In October, construction of an open cut copper-gold mine commenced at Cadia in New South Wales. The first concentrate is scheduled to be produced in September 1998. Several small to medium sized mines opened during the year, including Eloise and Mount Cuthbert in Queensland. Mining operations ceased at the Wilga copper-zinc deposit, near Benambra in Victoria; however, an 8 Mt zinc-copper-lead resource remains at the nearby Currawong deposit.

Australia has the world's third largest EDR of copper (8%), after Chile (28%) and USA (15%). As a copper producer, Australia ranks sixth in the world after Chile, the USA, Canada, Russia and Indonesia. Production is mainly from the Olympic Dam, Mount Isa, Northparkes, Osborne and Mt Lyell mines.

Diamond

During 1996 EDR decreased by just over 16 Mc (16%) to 84.5 Mc for gem/near gem diamond and 38 Mc (30%) to 90.2 Mc for industrial diamond. Total identified resources of gem/near gem increased by 42 Mc (14%), but decreased by 12 Mc (3%) for industrial diamond.

Production at the Argyle mine in Western Australia accounted for most of the EDR reduction in gem/near gem diamond and part of the decrease in industrial diamond. Most of the reduction in industrial diamond EDR, however, is attributable to an increase in the bottom screen size (1 mm to 1.5 mm) at Argyle's processing plant.

Final feasibility study and engineering design for the Merlin diamond project (Plate 3) in the Northern Territory is proceeding on an estimated initial throughput of 0.5 Mt of ore per year. A cluster of twelve diamondiferous pipes has been identified and reported average grades in the four pipes bulk sampled range up to 0.68 carats per tonne with average values up to US$100/carat. Initial sources of ore are to be open pits on these four pipes. A decision on development is expected in the first half of 1997.

Trial open pit mining will be conducted at Copeton (NSW) in 1997. Plant feed will come from two old open pits at Mount Ross. Significant diamond production was recorded from Copeton in the 1890s and the early 1900s.

Exploration for diamonds continued over much of the continent during 1996. Although emphasis remained on northern Australia, particularly the Kimberley region, increasing interest was shown in the Yilgarn Craton, Western Australia, and the Gawler Craton, South Australia. Exploration is

increasingly being directed to alluvial targets, such as ancient stream channels draining areas in which diamondiferous pipes are known to occur, and coastlines adjacent to the mouths of modern streams draining such areas.

Australia has the world's third largest EDR of industrial diamond after the Republic of Congo and Botswana and one of the largest for gem/near gem diamond. Australia's diamond production is the largest in the world for both gem/near gem and industrial categories. Production is mostly from the Argyle Pipe open cut with minor contribution from the nearby Argyle Alluvials operation.

Gold

The gold industry was successful during 1996 in increasing total Australian resources in all categories. For EDR, increases in some states were only partly offset by reductions in others. These successes were achieved despite increased production. Internationally, Australia maintained its position as the world's third largest holder of EDR and the third largest producer.

In 1996, Australia's stock of identified gold resources rose by 815 t largely as the result of the 509 t increase in inferred resources. EDR for gold showed a significant increase in 1996 but the rate of growth achieved in recent years was reduced (Figure 1). EDR increased by 191 t or 4.5% to 4454 t. This increase was substantially lower than the 24% increase recorded in 1995. Resources in the subeconomic category recovered much of the tonnage lost in the previous year as they rose by 115 t to 1263 t but this was still 25 t below the record 1994 level. Inferred resources rose by about 37% to 1887 t which surpasses the previous record level 1469 t recorded in 1992.

The increased level of inferred resources resulted in EDR's share of identified resources falling to 58.6%, from 63% in 1995. Inferred resources accounted for 24.8% of identified resources, substantially higher than the 20% in 1995. Subeconomic resources maintained a share of 16.6%, essentially the same as in 1995.

Western Australia, New South Wales and the Northern Territory increased EDR in 1996 while reductions occurred in all other states. Western Australia strengthened its position as the premier gold state, as its share of EDR rose from 58% to 60.7%. New South Wales, Queensland, South Australia and the Northern Territory combined accounted for 37.6% and the remainder was shared by Victoria and Tasmania. There are no known gold resources in the Australian Capital Territory.

ABS reported exploration expenditure on gold was $547.1 million in 1995–96, a fall of 1.3% over the 1994–95 level. With total expenditure on mineral exploration reaching $960.2 million in 1995–96, gold's share was 57% compared to 62% in the previous year. The reduced share is attributed to a combination of actual reduction in expenditure on gold and increased spending on most other minerals, particularly base metals and coal. Gold exploration expenditure was the third highest current dollar expenditure recorded in Australia, after 1994–95 and the record year of 1987–88 when expenditure was $581 million.

In Western Australia in 1995–96 $367.8 million was spent exploring for gold, maintaining its status as the principal state for gold exploration; its share of expenditure fell slightly from 68.4% to 67.2%. Queensland's share was 9.5% (10.8% in 1994–95), followed by the Northern Territory with 8.9% (7.8%), New South Wales with 6.3% (7.5%), Victoria with 5.4% (4%), Tasmania with 1.6% (0.5%) and South Australia with 1.1% (1%).

In the first half of 1996–97 ABS reported that exploration expenditure on gold was very strong at $352.3 million, which was 62% of total mineral exploration expenditure over that period. Expenditure in Western Australia and the Northern Territory in the first two quarters of 1996–97 was, on an annualised basis, running ahead of the totals for 1995–96. Other states' expenditures were at about the 1995–96 rate. Consequently, initial indications suggest that exploration expenditure for gold in 1996–97 is recovering from the small reduction recorded in 1995–96.

In the latter half of 1996 considerable attention was focused on the Gawler Craton. It was this activity

that caused the sharp rise in exploration expenditure in South Australia in the last half of 1996 to $7.4 million, an increase of $1.6 million over the whole 1994–95 expenditure. Several companies have identified areas of mineralisation or anomalous gold zones which require further work. By the end of the year the most advanced prospect was Challenger, owned by Resolute Limited and Dominion Mining Limited. Other significant prospects include Tunkilla (Helix Resources N.L.), Tarcoola (Grenfell Resources N.L.), Wildingi (Equinox Resources N.L.) and Golf Bore (Resolute and Dominion).

Subsequent to Newcrest Mining Limited announcing that it would proceed with the development of the Cadia Hill project in central New South Wales, the company announced that an area with significant high grade gold-copper mineralisation had been located at Ridgeway, some 3 km northwest of Cadia, where exploration is continuing.

Preliminary figures provided by ABARE show mine production of gold in 1996 was 289 t, an increase of 14% over 1995. All states recorded increased production in 1996, with Western Australia dominating output with 219.4 t (75.9% of Australia's total). The share of production for the other states was Queensland 28.9 t (10.0%), Northern Territory 22.1 t (7.6%), New South Wales 11.2 t (3.9%), Victoria 4.6 t (1.6%), Tasmania 1.7 t (0.6%) and South Australia 1.1 t (0.4%). ABARE forecast gold production to reach 336 t in 1999–2000 after which growth is expected to flatten out.

Australia has the world's third largest stock of gold after South Africa and the USA. Based on figures published by the USGS, Australia's share of EDR is 10% compared with 41% for South Africa and 12% for the USA. Australia ranked third in terms of world gold production, again after South Africa and the USA. South Africa with an output of 490 t accounted for 21% of world production, the USA (325 t) for 14% and Australia (289 t) for 12.6%. Compared to 1995, Australia increased its share slightly while the USA remained constant and South Africa had a slightly smaller share of world output.

Iron ore

Australia's EDR of iron ore fell by less than 1% in 1996 as production only marginally exceeded additions to resources in the EDR category. Resources in the subeconomic categories rose by less than 1% during the year while inferred resources rose by just over 1%.

Western Australia remains the premier iron ore state with over 99% of Australia's EDR. Within Western Australia approximately 97% of EDR occurs in the Hamersley Basin in the Pilbara region. Small but locally important EDR of iron ore occur in Tasmania and South Australia.

In August, the Department of Minerals and Energy, South Australia (MESA), completed an exploration program for iron ore in the Tarcoola–Coober Pedy region. MESA reported the identification of four significant deposits or prospects: Giffen Well with an inferred resource of 130 Mt at an indicated grade of 36.5% Fe; Sequoia with an inferred resource of 25 Mt at an average grade of 30.0% Fe; Peculiar Knob with an inferred resource of 14 Mt at an average grade of 63.2% Fe with low alumina and phosphorus; and Hawks Nest where several promising zones have been identified. MESA also reported that low-grade magnetite-BIF from Hawks Nest, Giffen Well and Sequoia can be successfully upgraded to a high-grade product.

The MESA exploration was undertaken in support of the South Australian Steel and Energy Project. BHP will design a demonstration Ausmelt plant to be constructed at Whyalla. This plant is expected to be in operation by the end of 1997.

Resources in the Tallering Peak and Koolanooka deposits, Western Australia, are the basis for the proposed Mid-West Iron and Steel Project at Geraldton. A feasibility study examining the potential for the production of iron ore pellets, direct reduced iron and steel slabs was underway at the end of the year. It is proposed that slabs produced would be exported to Taiwan. The project is a joint venture between Kingstream Resources N.L. and An Feng Steel Company, a Taiwanese company.

The Mid-West project is one of a number of proposals for further processing of iron ore in

Western Australia that are under consideration or construction. BHP Iron Ore is well advanced on construction of its HBI plant at Port Hedland. Other proposals include the Australian United Steel Industry (AUSI) project for a DRI plant at Cape Lambert; Mineralogy Pty Ltd's Fortescue project for an HBI plant based on a magnetite deposit near Dampier; Asia Iron Ltd's proposed pellet plant and DRI/HBI project based on the Mount Gibson magnetite deposit east-southeast of Geraldton.

ABARE reports that Australian iron ore production in 1996 totalled 147.1 Mt of which 142.9 Mt was from Western Australia (Plate 4), 2.5 Mt from South Australia and 1.7 Mt from Tasmania.

Photograph courtesy of BHP Iron Ore Pty Ltd

Plate 4 *A blast hole drill at BHP Iron Ore's Mount Whaleback iron ore mine, Western Australia*

In Tasmania, the Savage River project was in the early stages of revitalisation at the end of 1996. Australia Bulk Minerals (ABM) completed the purchase of the project from Pickands Mather International. ABM plans to mine ore from three pits and the concentrate produced will be transported to Port Latta via the existing pipeline. Pellets will be produced for export. ABM expects a 25 to 30 year mine life and there is a possibility that pig iron will be produced at the project in future.

Internationally, Australia has the second largest EDR of iron ore after Russia. On the basis of estimates published by the USGS, Australia has 12% of world iron ore EDR, a similar proportion as in 1995. In terms of contained iron, Australia has about 16% of the world total and is ranked second, again after Russia which has about 20% of the total.

Lithium

An increase of 8.5% in EDR, which stood at 166 000 t Li at year's end, followed the publication of new resource estimates for lithium in 1996. Further, subeconomic demonstrated resources increased markedly in 1996 with the addition of 79 000 t Li to the paramarginal category. Resources in the submarginal and inferred resource categories were unchanged.

Australia has the world's largest spodumene ($Li_2O.Al_2O_3.4SiO_2$) deposit at Gwalia Consolidated's Greenbushes mine in the southwest of Western Australia. In 1996 Gwalia produced 117 944 t of lithium minerals from the Greenbushes mine. Exploration to better define resources was undertaken during the year.

The lithium carbonate plant constructed at Greenbushes did not perform satisfactorily during commissioning. Consequently, the plant has been modified and a new calciner constructed. Recommissioning was scheduled to take place in February 1997. The plant will allow Gwalia to expand into the lithium chemicals industry.

On a world scale, Australia maintained its position as the fourth largest holder of EDR after Chile, USA and Canada, but increased its share to just over 8% from slightly less than 7% in 1995.

World production, excluding the USA, is estimated by the USGS to have been 6 600 t of lithium in 1996. Australia was the second largest producer after Chile and accounted for over 27%, based on USGS estimates.

Magnesite

Australia's EDR of magnesite decreased by 34% to about 180 Mt in 1996. Most of the reduction resulted from reclassification of resources in the Kunwarara mine (Australia's largest known deposit of magnesite) by the mine owner, Queensland Metals Corporation (QMC). The downgrading followed a change in end use demand for magnesite.

The magnesite at Kunwarara, some 55 km northeast of Rockhampton, extends over an area of 63 km^2. It occurs as nodules of irregular size and shape (1–500 mm) and is generally confined to mudstone and weakly indurated sandstone units. Beneficiation of the magnesite is carried out at the mine site. Clean magnesite is then trucked to Parkhurst on the northern outskirts of Rockhampton where it is processed into deadburned and electrofused magnesia.

Subsequent to the end of 1996, QMC and Normandy Mining Limited, through a 50–50 joint venture company, Australian Magnesium Investment Pty Ltd, announced plans to build a magnesium smelter with a 90 000 tpa capacity at Gladstone at a cost of $700 million. Ford Motor Company, the largest user of magnesium alloys in the world for automotive applications, has entered into an agreement to purchase up to 45 000 tpa of magnesium alloy for up to ten years.

The magnesium smelter will use a process developed by CSIRO which involves dissolving clean magnesite in hydrochloric acid to produce magnesium chloride. This is then purified, dehydrated to a dry feed and electrolysed in an Alcan cell to produce molten magnesium, which is tapped from the cell and cast into ingots. The chlorine gas generated in the process is recycled and combined with hydrogen, derived from natural gas, to produce hydrochloric acid for use in the process.

Australia's only other operating magnesite mine is located at Thuddungra in New South Wales. No further mining is expected at Thuddungra for a few years as the plant, located in Young, is operating on previously stockpiled material. The Thuddungra deposit is noted for its high purity magnesite, typically 98–99% $MgCO_3$. This material is calcined to produce magnesia for use in acid neutralisation.

A potentially significant resource of magnesite occurs at Yaamba in Queensland, where it is associated with oil shale. Other resources occur in the Myrtle Springs area of South Australia and in the Ravensthorpe district in Western Australia. However, no detailed resource figures are available for these areas.

Although Australia accounted for only 2% of the world's EDR of magnesite ore in 1996, the Kunwarara deposit is still the world's largest known resource of cryptocrystalline, nodular magnesite.

Manganese ore

Australia's EDR of manganese ore decreased by about 3% in 1996, compared with 1995, from 121.2 Mt to 118 Mt mainly reflecting a depletion of resources through mining at Groote Eylandt.

Australia's principal manganese resource and major operating manganese mine is on Groote Eylandt, Northern Territory. The deposit is a world-class resource, which is being mined for both export and domestic consumption.

Resources of manganese ore in the Woodie Woodie area of Western Australia's east Pilbara district increased following the discovery and definition of resource at the Big Mack deposit by Valiant Consolidated Limited during the year. However, the known resources in this province are small relative to those on Groote Eylandt. The overall decline in Australia's EDR since 1975 has resulted from a combination of production and the reclassification of resource estimates in light of more detailed information.

Mining of high grade manganese ore for export continued at the Woodie Woodie operation. Ownership of Woodie Woodie changed during the

year when Portman Mining Limited sold the project to Valiant Consolidated Limited.

Valiant's acquisition of Woodie Woodie allows it to continue to produce manganese ore following the closure of its Mike Mine, located south of Woodie Woodie, in December 1996. The closure of the Mike Mine resulted from the depletion of resources.

In 1996, the east Pilbara district produced over half a million tonnes of manganese ore despite the effects of cyclones early in the year.

Australia's resources of manganese ore are the basis of a major mineral export sector as well as a significant domestic ferromanganese, silicomanganese and manganese dioxide processing industry.

Based on a combination of BRS and USGS data, it is estimated that, in terms of contained manganese, Australia's EDR is ranked third after South Africa and the Ukraine. Based on contained manganese, Australia is the world's third largest producer of manganese ore after South Africa and the Ukraine.

Mineral sands

The estimate of Australia's EDR of ilmenite increased slightly in 1996 to 135 Mt. The increase resulted from reclassification of resources in Queensland and Western Australia, which more than offset depletion of resources through mining. The increase in the subeconomic demonstrated categories resulted from the discovery of new deposits of mineral sands in New South Wales and Victoria.

A reduction of less than 1% in EDR of rutile resulted from depletion of resources through production in all states. The depletion was partially offset, however, by reclassification of some inferred resources in Western Australia in response to more detailed information and stronger market conditions. Successful exploration in the Murray Basin of western New South Wales and northwest Victoria resulted in a substantial increase in the subeconomic demonstrated resource categories.

EDR of zircon was 21.4 Mt in 1996, 1 Mt less than that reported in 1995. An increase in zircon EDR in Queensland was not sufficient to offset depletion due to production at current mining operations.

Resources of zircon discovered in the Murray Basin in New South Wales and Victoria during the year are classified as demonstrated subeconomic.

Some 20%, 30% and 34% 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; Cooloola sand mass north of Noosa; Byfield sand mass and the Shoalwater Bay area in Queensland; and Yuraygir, Bundjalung, Hat Head and Myall Lakes National Parks in New South Wales.

During the year, Renison Goldfields Consolidated discovered two high grade mineral sands deposits east of Ouyen in northwest Victoria. Sand in these deposits is coarse grained and amenable to conventional mineral sands separation techniques. Rutile Zircon Mines Pty Ltd continued evaluation of mineral sand deposits in southwestern New South Wales. In Queensland, Monto Minerals N.L. progressed feasibility studies on their Goondicum ilmenite deposit west of Bundaberg.

The titanium dioxide pigment industry, the main user of rutile and ilmenite, experienced some recovery in the latter part of 1996. Increased demand resulted in reduced stocks of pigment and firmer prices. The recovery is expected to continue and lead to increased demand for titanium mineral feedstock.

Tioxide's sulphate process pigment plant at Burnie, Tasmania, closed in July 1996. The closure resulted from the trend towards larger, more cost effective and environmentally acceptable plants. However, Australia's other pigment producers (both using the environmentally preferred chloride process) have foreshadowed expansions: the Tiwest Joint Venture from 80 kt/year to about 145 kt/year, and SCM Chemicals from 79 kt/year to 190 kt/year.

From USGS and BRS data, BRS estimates that at the end of 1996 Australia had 23%, 36%, and 35% of the world's EDR of ilmenite, rutile and zircon, respectively. Australia has the largest EDR for all three minerals, and is the world's largest producer and exporter of alluvial ilmenite, rutile and zircon. South Africa and Canada mine more ilmenite than Australia, the latter from hard rock deposits and the

former from dune sands. Both these countries upgrade their ilmenite to titanium slag before export.

Molybdenum

Australia's identified resources of molybdenum comprise about 7% of the world's total identified resources of 12 Mt. All of Australia's molybdenum resources are subeconomic.

The largest resources are in the inferred category and occur at Yetholme (20 km east of Bathurst) in New South Wales and with tungsten (scheelite) mineralisation at Mount Mulgine (230 km east-southeast of Geraldton in Western Australia). Substantial inferred molybdenum resources occur with copper at Coppins Gap (40 km northeast of Marble Bar in Western Australia). In Queensland, resources occur at Wolfram Camp (75 km southwest of Cairns), Ben Lomond (60 km southwest of Townsville) and Maureen (40 km northwest of Georgetown), the last two being in association with uranium. Molybdenum resources in the Molyhill deposit, in the Jervois Ranges, Northern Territory, are associated with tungsten (scheelite) mineralisation.

During 1996, exploration by Newcrest Mining Limited at Cadia East (adjacent to Cadia Hill near Orange) in New South Wales identified an inferred resource of 150 Mt containing 179 ppm molybdenum associated with gold and copper mineralisation.

Nickel

Australia's EDR of nickel increased by 70% in 1996 to a record 6.37 Mt. Demonstrated subeconomic resources fell by about 820 000 tonnes to 5.58 Mt, a decrease of 12.8%. Inferred resources of nickel increased by over 51% to 6.63 Mt.

All of the increase in EDR occurred in Western Australia. Infill drilling at deposits in, or nearing production, resulted in either the upgrading of resources to EDR or addition of new resources into this category. These resources included laterite deposits at Bulong, Cawse, and Murrin Murrin, and the massive and disseminated sulphide deposits at Silver Swan, Yakabindie, Maggie Hays and Mount Keith.

Exploration drilling in the region of the Bulong laterite deposit and the Yakabindie deposit, as well as discoveries at Eucalyptus Bore, southeast of Leonora, and at Bandalup Hill near Ravensthorpe, resulted in an increase in inferred resources. An additional benefit flowing from the substantial increases in resources in Western Australian laterite nickel deposits was the significant increase in Australia's cobalt resources.

Reticulation of North-West Shelf gas to Kalgoorlie (with attendant reduction in energy cost), introduction of new processing technologies, and anticipated increased demand for stainless steel has stimulated development of new nickel mines in the Yilgarn region. Projects based on resources of lateritic ore such as Bulong, Cawse and Murrin Murrin are scheduled to come on stream in 1998 and production from the primary sulphide Silver Swan deposit is expected to commence in mid-1997.

Australia's current operating nickel mines are at Kambalda, Leinster and Forrestania in Western Australia. Smelting operations are located at Kalgoorlie, Western Australia, and refineries at Kwinana, Western Australia, and Yabulu, Queensland.

Internationally, Australia's share of world EDR increased to 10% in 1996, up from 9% in the previous year. As a result of successful exploration, Australia overtook New Caledonia to become the world's fourth largest holder of EDR after Cuba, Russia, and Canada. Based on USGS data, Australia produced about 19% of world nickel output in 1996 and was the fourth largest producer after Russia, Canada and New Caledonia.

Shale oil

Australia's demonstrated shale oil resources increased slightly in 1996 following publication of some new resource data for Queensland deposits. Inferred resources fell slightly on the basis of the newly published data.

On completion and approval of an Environmental Impact Assessment Study, the Queensland Government issued a Mining Lease over that part of the Stuart oil shale deposit relating to the project's

Stage 1 development. The mining lease is for a period of 30 years from 1 August 1996.

Foreign investment approval was received from the Australian Government for the Canadian company Suncor Inc. to participate in the Stuart Energy Joint Venture. Suncor will hold 50% and Southern Pacific Petroleum N.L. and Central Pacific Minerals N.L. will each hold 25%. The first step in the development of the project is the proposed construction of a 4500 barrels/day R&D plant. It is proposed to follow this with production increases to 85 000 barrels/day. By the end of 1996 the companies were working to finalise both an Engineering Procurement and Construction Contract and financing for Stage 1.

The Exploration Permit covering the Alpha deposit was replaced by a Mineral Development Licence during the year. Preparation of an environmental audit was a requirement of the conversion, and this was submitted in July.

Tantalum

Australia's EDR of tantalum rose by 30% to 8057 t in 1996. The increase resulted from the assessment of newly available data for important deposits in Western Australia. Subeconomic resources rose by 1.8% to 5703 t but inferred resources fell by 0.5% to 64 815 t. All the resource variations were in Western Australian deposits.

A major rationalisation occurred in the Australian tantalum industry in 1996. Gwalia Consolidated Ltd, operators of the world's largest hard rock tantalum mine at Greenbushes, in the southwest of Western Australia, completed the purchase of the Wodgina mine in Western Australia's Pilbara region. Gwalia notes in its 1996 annual report that Wodgina is the world's second largest hard rock tantalum mine. Completion of this transaction entrenches Gwalia's position as the world's leading producer of tantalum products, allowing it to supply some 25% of world tantalum demand. Exploration was being undertaken in 1996 to define further resources at both Greenbushes and Wodgina. In addition to its activities at these two projects, Gwalia reported that it was reviewing its tantalum resources at Bynoe in the Northern Territory and at Bald Hill in Western Australia. Development options are being considered for these deposits.

At Cattlin Creek, near Ravensthorpe in Western Australia, Greenstone Resources N.L. undertook a drilling program aimed at upgrading an inferred resource of 277 000 t at a grade of 827 ppm Ta_2O_5 to the measured and/or indicated categories. They were also attempting to extend the limits of the known mineralisation. Results from this program were not available at the end of the year.

In the Pilbara region, the Pilgangoora tantalite mine ceased operation in the December quarter 1996. The mine closed following the depletion of high grade resources and the failure to delineate additional reserves. The mining tenement, which abuts the northwest boundary of Lynas Gold N.L.'s Lynas Find gold project, has been transferred to Lynas. Lynas intends to undertake further work on previously identified gold soil anomalies.

Mining of the small Mount Farmer deposit, which commenced in late 1995, was completed early in 1996 as resources were depleted.

Gwalia Consolidated reported production of 578 995 lbs Ta_2O_5 from Greenbushes and 112 614 lbs Ta_2O_5 from Wodgina. Prior to the closure of the Pilgangoora mine, Prima Resources N.L. reported that 37 961 lbs Ta_2O_5 was produced.

In world terms, Australia has the largest stock of EDR. Based on estimates published by the USGS for other world resources and BRS estimates of Australia's EDR, Australia has about 43% of world EDR. Nigeria has the second largest stock with 17%, followed by Canada and Zaire, each with just under 10%. Australia is the world's largest producer, accounting for just over 75% of total world output in 1996 according to the USGS.

Tin

Australia's demonstrated resources of tin were 334 010 t in 1996, an increase of just under 9 000 t from the previous year. The increase resulted from recently published data on some older, well known uneconomic deposits, namely Queen Hill (Tasmania), Gillian (Queensland) and Collingwood

(Queensland). EDR, of which over 90% are located at the Renison mine in Tasmania, fell to 119 490 t in 1996. This was largely the result of depletion of reserves and adjustments in ore reserve calculations at Renison.

In June 1996, a new 590 m ore haulage shaft was commissioned at Renison, and development of the major decline continued. These activities should improve access to the deeper, higher grade, more metallurgically favourable ore and lower haulage costs.

The Greenbushes mine in Western Australia continues to be one of the few remaining producers and the only smelter of tin in Australia. Tin from Greenbushes is recovered from the massive pegmatite deposits as a byproduct of tantalum and lithium mining.

In October 1995, mining commenced at Leichhardt Creek, one of many alluvial deposits owned by Norminco Ltd in north Queensland. The operation encountered technical difficulties during 1996 and ceased production. The viability of mining Norminco's other tin deposits is in doubt if the same technical difficulties are encountered. This has resulted in a reclassification of a small amount of resources in the demonstrated category from economic to paramarginal.

Australia's EDR are estimated to represent about 1.7% of the world total, while production is about 4% of the world total. The largest producers of tin are China, Indonesia, Peru, Brazil and Bolivia.

Uranium

Changes to Commonwealth Government policies relating to uranium mining and milling

Following its election in March 1996, the Liberal/National Coalition Government removed the former Government's policy which restricted the development of new uranium mines in Australia (i.e. the 'three mines' policy). The current Government's policy is to approve new uranium mines and exports provided they comply with strict environmental, heritage and nuclear safeguards requirements. Where Aboriginal interests are involved, the Government is committed to ensuring full consultation with the affected Aboriginal communities.

Uranium export contracts remain subject to Government approval but are no longer scrutinised for pricing purposes. The previous Government had required exporters to demonstrate that their prices were comparable to those received by other suppliers in the various markets.

In November 1996, the Treasurer announced changes in the Foreign Investment Review Board guidelines relating to foreign investment in Australian uranium mining:

> The Government has decided that the foreign investment policy in relation to the uranium sector will be the policy that currently applies to the mining sector generally. This means that foreign investment above the notification thresholds in the uranium sector will be subjected to the well established *contrary to national interest test* and that no special investment restrictions will apply. The establishment of a new mine involving investment of $10 million or more, or the acquisition of a substantial interest in an existing uranium mining business valued at $5 million or more, requires prior approval and no objections will be raised unless the proposal is considered contrary to the national interest.

Resources

BRS estimates 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 1996). In Table 1, the estimates are reported under the corresponding resource categories of the BRS classification scheme. Comparisons of the resource categories within both schemes are shown below.

Australia has the world's largest resources of uranium in the low cost RAR category, with 28% of world resources in this category. Other countries which have large low cost resources include Kazakhstan (20%), Canada (17%), South Africa (9%), Namibia (7%), Brazil (7%), and the USA (5%).

Approximately 95% of Australia's total uranium resources in the low cost RAR category are within the following six deposits (Figure 2):

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

Mining operations

Uranium oxide is currently produced at two mining/milling operations—Ranger and Olympic Dam. Australia's total production for 1996 was a record high of 4975 t U (5867 t U_3O_8) [U = 0.848 x U_3O_8] of which Ranger produced 3509 t U and Olympic Dam produced 1466 t U.

BRS Scheme	OECD/NEA & IAEA Scheme
Economic Demonstrated Resources	Reasonably Assured Resources (RAR) recoverable at less than US$80/kg U (commonly referred to as low cost resources)
Subeconomic 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$80/kg U
Subeconomic Inferred Resources	EAR-1 recoverable at US$80–130/kg U

Figure 2 Uranium deposits and prospects in Australia

Total production for 1996 was 34% higher than 1995 as a result of the return to continuous milling and ore processing at Ranger during 1996, and production increases at the Olympic Dam operations following completion of the second optimisation project in mid-1995 and improved recovery rates.

Mining at the Ranger No. 1 open pit was completed in December 1994 and Energy Resources of Australia Ltd (ERA) reported that stockpiled ore is sufficient to maintain milling operations through to 1999.

In May 1996, the company received approval from the Northern Territory Department of Mines and Energy to mine the Ranger No. 3 Orebody. Development work for the open cut commenced in late 1996 (Plate 5) and production from this deposit is scheduled to commence in mid-1997. No. 3 Orebody has proven plus probable reserves of 19.9 Mt ore with average grade 0.28% U_3O_8, containing 55 700 t U_3O_8. The deposit is within the Ranger Project Area and was included in the original Environmental Impact Statement (EIS) for the Ranger Project which was completed in the late 1970s.

The company is currently expanding the capacity of the Ranger mill from its previous level of 3500 tonnes per annum (tpa) U_3O_8 to 5000 tpa U_3O_8. The mill expansion is scheduled to be completed by mid-1997 to coincide with the commencement of mining at No. 3 Orebody. In the event that ERA's current proposal for the development of Jabiluka is approved (permitting processing of Jabiluka ore at Ranger mill), capacity of the mill would be increased further to approximately 6000 tpa U_3O_8.

Olympic Dam operations comprise an underground mine and a metallurgical complex. The metallurgical complex includes a grinding/concentrating circuit, hydrometallurgical plant, copper smelter, copper refinery and a recovery circuit for precious metals. Ore reserves and resources for the Olympic Dam deposit are summarised in Table 2.

The Olympic Dam operation currently has an annual production rate of 85 000 t copper, 1700 t U_3O_8 and associated gold and silver. WMC Limited (WMC) recently announced that the operation is to be expanded and that annual production would be increased to 200 000 tpa of copper, 4600 tpa U_3O_8, 75 000 ounces gold and 950 000 ounces silver. Based on the current production levels of existing mines,

Photograph courtesy of ERA Ltd

Plate 5 *Development of the open cut at Ranger No. 3 Orebody, Northern Territory*

Table 2 Olympic Dam ore reserves and resources as at June 1996

Reserves/Resources	Ore (Mt)	% Cu	% U_3O_8	Contained U_3O_8 (t)
Reserves				
Proved	73	2.5	0.08	58400
Probable	496	2.0	0.06	297600
Resources				
Measured	0			
Indicated	1220	1.1	0.04	488000
Inferred	400	1.3	0.04	160000

Note: Resources are additional to reserves

Source: WMC *Annual Report*, 1996

Olympic Dam will rank as one of the world's five largest uranium production centres. The overall capital cost of this expansion is estimated to be $1.48 billion and is scheduled to be completed by the end of 1999.

WMC has also announced it will seek the necessary approvals for the project to ultimately expand to 350 000 tpa of copper and associated products, although there are currently no plans to expand beyond 200 000 tpa.

Under the original Indenture Agreement between WMC and the South Australian state government, the operation had approval to produce up to 150 000 tpa of copper and associated products. The Indenture was amended in 1996 to allow the project, subject to environmental clearances, to produce up to 350 000 tpa of copper. The draft EIS for the project to expand to 350 000 tpa copper was released for public comment in May 1997. The final EIS will be assessed jointly by both Commonwealth and South Australian Government authorities.

Recent exploration drilling has discovered large tonnages of moderate to high grade copper mineralisation along the southeastern margin of the deposit (Scott 1995). Drill intersections of up to 84 metres averaging 2.1% copper have been reported. Uranium grades for these intersections have yet to be announced.

Proposed new mining operations

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

- Jabiluka deposit, NT (ERA Ltd)
- Kintyre deposit, WA (Canning Resources Ltd, a subsidiary of Rio Tinto)
- Beverley deposit, SA (Heathgate Pty Ltd, a wholly owned subsidiary of General Atomics, a United States company)

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

ERA plans to develop Jabiluka by the year 2000. Initially 300 000 t of Jabiluka ore would be processed annually to produce approximately 1800 tpa of U_3O_8. Production would increase to approximately 4000 tpa of U_3O_8 in the fourteenth year from the processing of 900 000 t ore.

Jabiluka has total proved and probable ore reserves of 19.5 Mt ore averaging 0.46% U_3O_8, and containing 90 400 t U_3O_8. The total geological resource (which includes the ore reserves) was estimated to be 28.7 Mt ore averaging 0.52% U_3O_8.

The draft EIS for the project was released for public comment in October 1996, and the final EIS is due to be released in June 1997.

The Kintyre deposit is located on the western edge of the Great Sandy Desert in the eastern Pilbara region of WA. The project area is located immediately north of the Rudall River National Park. Canning Resources proposes to mine the four orebodies which make up the Kintyre deposit by a number of small open cuts commencing in 1999. Initially the operation would produce 1200 tpa U_3O_8 with the potential to increase up to 2000 tpa U_3O_8 at a later date.

The ore occurs as high grade veins within barren host rock, which makes it suitable for radiometric sorting. This reduces the tonnage of ore to be processed, and consequently only a relatively small acid leach treatment plant with capacity to process 45 000 t ore per annum will be constructed. Probable resources are estimated to be 24 500 t U_3O_8, with an additional 11 500 t U_3O_8 of inferred resources.

The company is currently preparing an EIS which will be assessed jointly by Commonwealth and Western Australian environmental authorities.

Beverley is a sandstone-hosted uranium deposit located near Lake Frome, approximately 530 km north-northeast of Adelaide. Heathgate Pty Ltd proposes to develop an in situ leach operation capable of producing 900 tpa U_3O_8 with production commencing in the year 2000. The company considers that the deposit is particularly suited to in situ leaching because of its shape, grade and leachability (Brunt 1997). Metallurgical and hydrological studies, including aquifer pump tests, are currently being carried out.

The deposit comprises several large flat-lying lenses which are between 100 m and 150 m below surface. From an overall resource of 16 200 t U_3O_8 with an average grade of 0.27% U_3O_8, approximately 11 600 t U_3O_8 could be recovered by in situ leaching. The current proposal is in the initial phase of a joint Commonwealth/South Australia EIS process.

Future production increases

The abolition of the 'three mines' policy means that several new uranium mines are likely to be developed to take advantage of market opportunities. Australia's annual production could increase from the 1996 level of 4975 t U (5867 t U_3O_8) to approximately 10 800 t U (12 700 t U_3O_8) by the year 2000 as a result of proposed increases in production at both Ranger and Olympic Dam, together with projected production from possible new mines (Jabiluka, Kintyre and Beverley). Such increases in production, however, will depend on market conditions.

Vanadium

Australia's demonstrated resources of vanadium are large on a world scale but most are subeconomic. The only resources classified as economic are in the Yeelirrie uranium deposit in Western Australia and the Savage River iron ore deposit in Tasmania.

Vanadium has not been mined in Australia since the early 1980s. The feasibility of developing vanadium-bearing deposits at Windimurra (24 km east of Mount Magnet, WA) and Coates (60 km east of Perth, WA) is being investigated by Precious Metals Australia Limited and Clough Resources respectively.

At the Windimurra deposit, vanadium is associated with titaniferous magnetite in Archaean gabbroic sills. Precious Metals Australia Limited reported that the resources of 44 Mt of oxidised ore average 0.56% V_2O_5. The deposit has been subjected to deep lateritic weathering, and as a result, the ore is friable and could be easily mined.

Vanadium mineralisation at the Coates deposit occurs in lenticular layers of magnetite and ilmenite within the core of an Archaean layered gabbroic complex. The primary deposit has demonstrated in situ resources of 39 Mt ore averaging 0.51% V_2O_5 and the lateritized deposit, which overlies the primary deposit, has indicated resources of 1.5 Mt ore averaging 0.6% V_2O_5.

Zinc, lead, silver

Estimates of EDR for zinc (39.9 Mt), lead (18.7 Mt) and silver (43.3 kt) increased in 1996 by between 2% and 4% compared to 1995. Total identified resources of zinc decreased by 1.1 Mt (1%), while those of lead and silver increased by 4.4 Mt (9%) and 2.3 kt (3%) respectively. The substantial increase in lead stocks occurred in the inferred category through the addition of lead from the Magellan deposit in the Pilbara region of Western Australia.

The decision to develop the Century zinc-lead deposit in northwest Queensland was announced in May 1997. Proposed annual production of 450 000 t of zinc, 40 000 t of lead and 200 t of silver in concentrates will make the mine the world's largest producer of zinc. Production is scheduled to begin in the first half of 1999. About half the zinc concentrate will be treated at Pasminco's Budel smelter in the Netherlands.

The underground mine at Cannington (Queensland) will be the world's largest silver mine and is scheduled to begin production in late 1997. With planned output of 745 t silver in lead and zinc concentrates (250 000 t and 100 000 t respectively), Cannington will account for about 6% of the Western world's mine production of silver.

At Broken Hill (NSW), ore reserves increased marginally (following re-interpretation of mineral resource data by Pasminco Ltd) and slightly exceeded depletion of resources through production. The upgrading of resources to the reserves category at the Elura lead-zinc deposit (NSW) resulted in a net gain against losses due to production and mine subsidence. At Rosebery (Tasmania) work is focusing on upgrading confidence in inferred resources of 5.5 Mt in the deeper parts of the mine.

Development work is proceeding at the George Fisher lead-zinc mine (Queensland), which is accessed underground from the Hilton mine. At Mount Isa, Mount Isa Mines Ltd reduced their ore reserves of zinc-lead-silver by 6.6 Mt as a consequence of production and downgrading of resources resulting from reappraisal of the mining plan.

Final feasibility and underground reconnaissance studies of the Blendevale deposit in northwest Western Australia began in April 1996. The $20 million study is addressing mining 1.5 Mt of ore per year to produce concentrates containing about 100 000 t of zinc and 29 000 t of lead.

Australia has the world's largest EDR of zinc (29%), lead (27%) and silver (15%). As a producer, Australia ranks first in the world for lead, second for zinc and fifth for silver. Production is mainly from mines at Mount Isa, Broken Hill, Elura, McArthur River, Hellyer and Rosebery. Australia's gold mines are significant contributors to silver production.

Mineral industry performance and outlook

Data published by the Minerals Council of Australia (MCA 1996) show that overall mine production, reported by respondents to its annual industry survey, increased by 5% in 1995–96. This followed 4% growth in the previous year.

Mine production for Australia reported in Table 1 was provided by ABARE, and this year includes 1995 and 1996 data to provide a continuous time series with previously published resource assessments. Mineral resource exports increased to a new record of $34.7 billion (thousand million) in 1995–96, a rise of 12.7% over the previous fiscal year (ABARE 1997) and a further 4% rise has been forecast for 1996–97. These export earnings comprise about 60% of Australia's commodity exports, 45% of merchandise exports and 35% of total exports of goods and services. Details of production and exports of selected minerals are reported in Table 3.

Many of the new projects commissioned in 1995–96 are referred to in the preceding review of commodities. There are also numerous projects under construction and scheduled for completion by 2000. These are estimated to have a total value of around $6 billion as at June 1996 (MCA 1996). While some of the production, particularly in the gold sector, will be required to replace production from depleting deposits, these projects are expected to result in a substantial increment to Australian minerals production and export earnings. In addition to projects currently under construction, there are various projects either committed or at an advanced feasibility study stage.

Table 3 Australian production and exports of selected mineral products, 1995–96

Commodity	Production	Exports	Export value $ million
Aluminium			
Bauxite (Mt)	43.308		88
Alumina (Mt)	13.292	10.984	2717
Aluminium (Mt)	1.331	1.043	2381
Coal			
Black raw (Mt)	243.02		
Black saleable (Mt)	194.51	138.52	7760
Brown (Mt)	51.30		
Copper			
Ores and concentrates (kt)	448	520	486
Refined primary (kt)	300	115	442
Diamond (kc)	40693	32339	519
Gold			
Mine production (t)	272.3		
Refined (t)[a]	310.1	341.0	5607
Iron and steel			
Ore and pellets (Mt)	148.498	126.364	2863.2
Iron and steel (Mt)[b]	16.154	3.126	1510.0
Lead			
Ores and concentrates (kt)	505	139	50.3
Refined (kt)	248	193	209.1
Bullion (kt)	181	169	196.6
Nickel			
Mine production (kt)	106		
Refined (kt)	73[c]	na	1157
Manganese ores and concentrates (Mt)	2224	1739	220
Mineral sands			
Ilmenite concentrates (kt)	2071	1192	110
Rutile concentrates (kt)	185	203	137
Synthetic rutile (kt)	517	304	324
Titanium dioxide pigment (kt)	185	127	324
Zircon concentrates (kt)	495	450	223
Uranium (t U_3O_8)	5105	5286	242
Zinc			
Mine production (kt)	1035	1437	433
Refined (kt)	345	243	381

na = not available; t = tonnes; kt = 10^3 t; Mt = 10^6 t; kc = 10^3 carats

Sources: *Australian Commodities*, ABARE September Quarter 1996
Australian Commodity Statistics, ABARE December 1996

(a) Includes gold of Australian and overseas origin

(b) Includes 7.554 Mt pig iron and 8.6 Mt raw steel

(c) Sum of products in the <99% Ni and >99% Ni categories

Photograph courtesy of Comalco Minerals and Alumina

Plate 6 *The* River Embley *being loaded with bauxite at Weipa for shipment to Queensland Alumina Limited's refinery at Gladstone, Queensland*

References

ABARE (1997) *Outlook 97* Minerals & Energy Volume 3, Proceedings of the National Agricultural and Resources Outlook Conference, Canberra, 4–6 February 1997.

Brunt, D.A. (1997) Proposed in situ leach mining at Beverley, South Australia. *Uranium 97 Conference*, Darwin, February 1997.

Minerals Council of Australia (1996) *Minerals Industry 96 Survey*. Minerals Council of Australia, Canberra.

OECD/NEA & IAEA (1996) *Uranium 1996 resources, production & demand*. OECD Nuclear Energy Agency & International Atomic Energy Agency, Paris.

Scott, I.R. (1995) The discovery of Olympic Dam and potential of Mixed Ore Mining. *ANA 95 Conference*. Australian Nuclear Assoc. Inc. Lucas Heights.

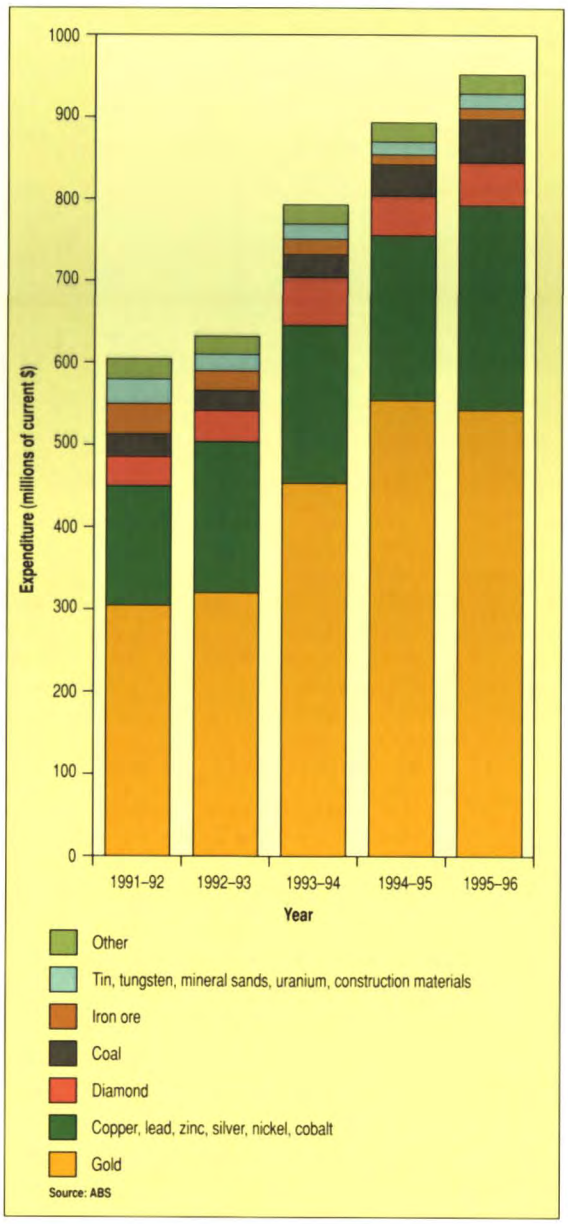
Mineral Exploration in Australia

Exploration expenditure

Mineral exploration expenditure for a range of commodity groups is monitored regularly by ABS and the following discussion and statistics are based on the 1995–96 survey data. The differentiation of commodity groups before 1980 is based largely on a breakdown of ABS totals by BRS.

Mineral exploration expenditure in Australia during 1995–96 rose by about $67 million or 7% from a total of $893.3 million in 1994–95 to a peak of $960.2 million (Figure 3). This was the smallest increase in expenditure since the 1992–93 year when it rose by only $28 million. Base metals ($51 million) and coal ($15 million) were responsible for the bulk of the increase. All states showed increases in total exploration expenditure. Western Australia was again responsible for much of the expenditure (54%), followed by Queensland with 19% and the Northern Territory with 10%.

Figure 3 Australian exploration expenditure since 1991–92



Gold accounted for 57% of total Australian exploration expenditure by commodity group, down from 62% in the previous year, followed by a group made up of the base metals (copper-lead-zinc) plus silver, nickel and cobalt, with 26%, diamonds with 6%, and coal accounting for 5% of the total exploration expenditure.

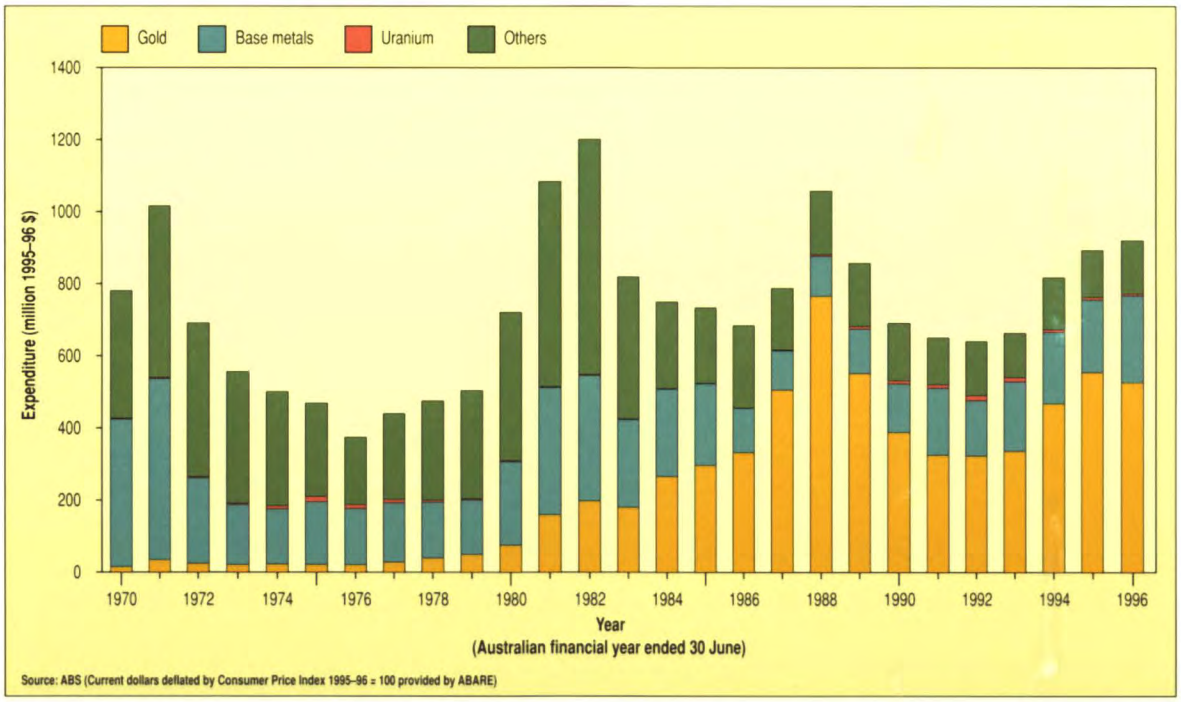
Expenditure on base metals increased by 25%, coal by 38%, iron ore by 17% and diamond exploration by 9%. As mentioned, gold exploration expenditure declined slightly by $7 million or about 1% in 1995–96.

Expenditure on 'greenfields' exploration again rose slightly whereas exploration expenditure on 'production leases' declined marginally. Overall, about 22% or $209 million was spent on 'production leases' in 1995–96 while 78% or $752 million was spent on 'greenfields' leases.

In constant 1995–96 dollar terms, the rise in exploration expenditure which began in 1992–93 continued through 1994, 1995, and 1996 (Figure 4) but the level of expenditure still has not yet reached the peak attained in 1987–88 nor the all time high reached in 1981–82.

Exploration expenditure figures published by ABS for the first half of 1996–97 show an increase of 24% to $565.8 million over the corresponding period for 1995–96. All states, other than Queensland, recorded substantial percentage increases in this period; Queensland recorded an increase of less than 1%. Western Australia continued to dominate expenditure, accounting for almost 60% of the total compared to 56% in the corresponding period of the previous fiscal year. Expenditure on exploration for all commodities increased, except for tin-tungsten which fell by 33% and construction materials which was unchanged. Gold accounted for 63% of expenditure in this period, slightly more than its share for the same period in 1995–96. Spending on mineral sands exploration in this period almost doubled to reach $7 million.

Figure 4 Australian exploration expenditure since 1969–70 expressed in 1995–96 dollars



Exploration drilling

In 1996, BRS again commissioned ABS to undertake a survey of exploration and mining companies to ascertain the amount and type of exploration drilling carried out in Australia in 1995–96. The survey was undertaken on behalf of the Chief Government Geologists to enable a state-by-state comparison to be made of expenditure and metres drilled by type of drilling. A summary of the reported data was released by ABS on 20 January 1997 (ABS Catalogue No. 8412.0).

Table 4 Australian exploration expenditure and exploration drilling, 1995–96

State	Total exploration expenditure ($ million)	Exploration drilling	
		$ million[a]	'000 metres[a]
New South Wales	80.4	24.636	523.6
Victoria	42.6	6.939	153.7
Queensland	181.0	47.758	1119.5
South Australia	24.1	2.933	130.2
Western Australia	519.5	215.774	7474.8
Tasmania	18.8	5.858	69.8
Northern Territory	93.9	25.531	916.6
Australia	960.3	329.429	10388.1

Note: Totals and sums of components may vary because of rounding

(a) Statistics collected by Australian Bureau of Statistics for Bureau of Resource Sciences on behalf of the Conference of Chief Government Geologists

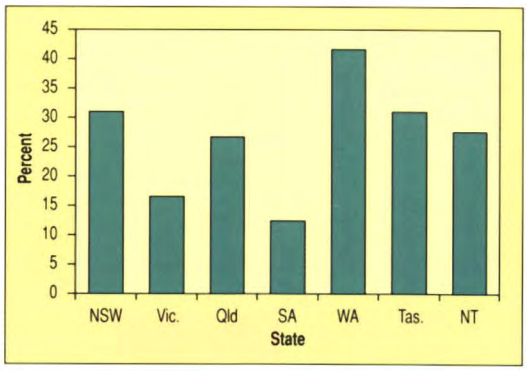
Of the $960.3 million expended on exploration in 1995–96, about $329.4 million, or 34%, was spent on drilling. A state-by-state breakdown of drilling expenditure is presented in Table 4. The highest and lowest proportion of exploration expenditure directed to drilling in 1995–96 was 42% in Western Australia and 12% in South Australia (Figure 5).

About 10.4 million metres of exploration drilling was undertaken in 1995–96 (Table 5), of which 34% was in production areas. Drilling in Western Australia accounted for just under 7.5 million metres or 72% of total metres drilled (Figure 6). In terms of drilling expenditure, Western Australia was responsible for 66% of the total.

Exploration drilling outside of production areas (66% of all exploration metres drilled) involved 6.901 million metres at a cost of $187.7 million. Drilling statistics by method are summarised in Table 5 and Figure 7.

Overall expenditure on drilling increased by 2% to $329 million in 1995–96, while actual metres drilled

Figure 5 Proportion of Australian exploration expenditure spent on drilling in each state in 1995–96



increased by 7% to 10.388 million metres compared with 9.711 million metres in the previous year.

Average RAB drilling costs rose by 12% to $11.7/m for all areas compared with the previous year, while the average cost of diamond drilling ($102.2/m) decreased by 6%. Average percussion drilling costs increased by 33% to $42.6/m, while average drilling costs for reverse circulation and other drilling costs increased slightly over the period.

The 7% increase in total metres drilled in 1995–96 compared with the previous year was mainly the result of a greater proportion of RAB drilling in greenfields areas, although drilling on production leases also increased.

Table 5 Methods of exploration drilling in Australia by type of area drilled, 1995–96

	Production areas			Other areas			Total		
	'000 metres[(a)]	'000 $[(a)]	Average $/m	'000 metres[(a)]	'000 $[(a)]	Average $/m	'000 metres[(a)]	'000 $[(a)]	Average $/m
Diamond	763.3	75298	98.65	594.8	63486	106.74	1358.1	138784	102.19
Reverse circulation	1727.7	51254	29.67	2191.3	66665	30.42	3919.0	117919	30.09
Percussion	77.7	2773	35.69	285.9	12721	44.49	363.6	15494	42.61
Rotary air blast	804.8	9545	11.86	3222.8	37388	11.60	4027.6	46933	11.65
Others	113.3	2812	24.82	606.5	7487	12.34	719.8	10299	14.31
Total	3486.8	141682	40.63	6901.3	187747	27.20	10388.1	329429	31.71

(a) Statistics collected by Australian Bureau of Statistics for Bureau of Resource Sciences, on behalf of the Conference of Chief Government Geologists

Figure 6 Australian exploration metres drilled in each state from 1993–94 to 1995–96

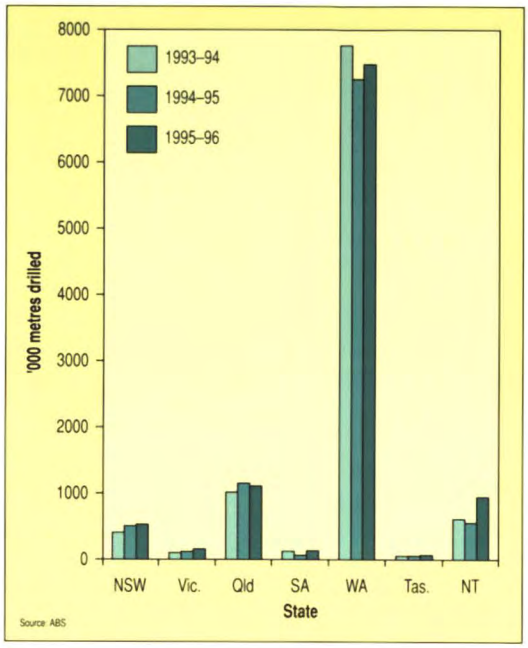
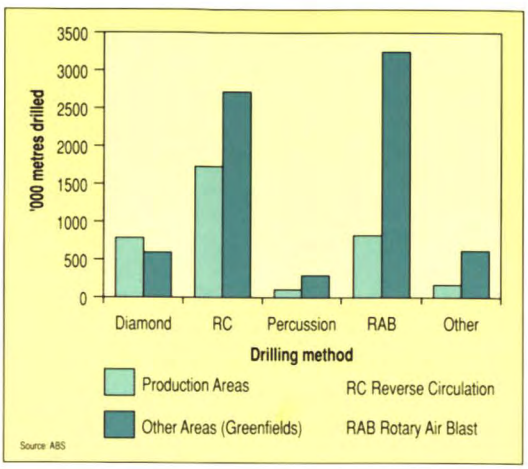


Figure 7 Australian exploration drilling by drilling method and area during 1995–96



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 states and territories. Initially the *Commonwealth Minerals (Submerged Lands) Act 1981*, which came into force on 1 February 1990, regulated the exploration for and the production of minerals. The administration is shared between the Commonwealth and the states and Northern Territory. This joint administration operates through two institutions, the Joint Authority and the Designated Authority.

The Joint Authority, consisting of the relevant Commonwealth minister and state (or Northern Territory) minister, 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.

Under the *Offshore Minerals Act 1994* there are five kinds of authorisations:

- exploration licences
- retention licences
- mining licences
- works licences
- special purposes consents

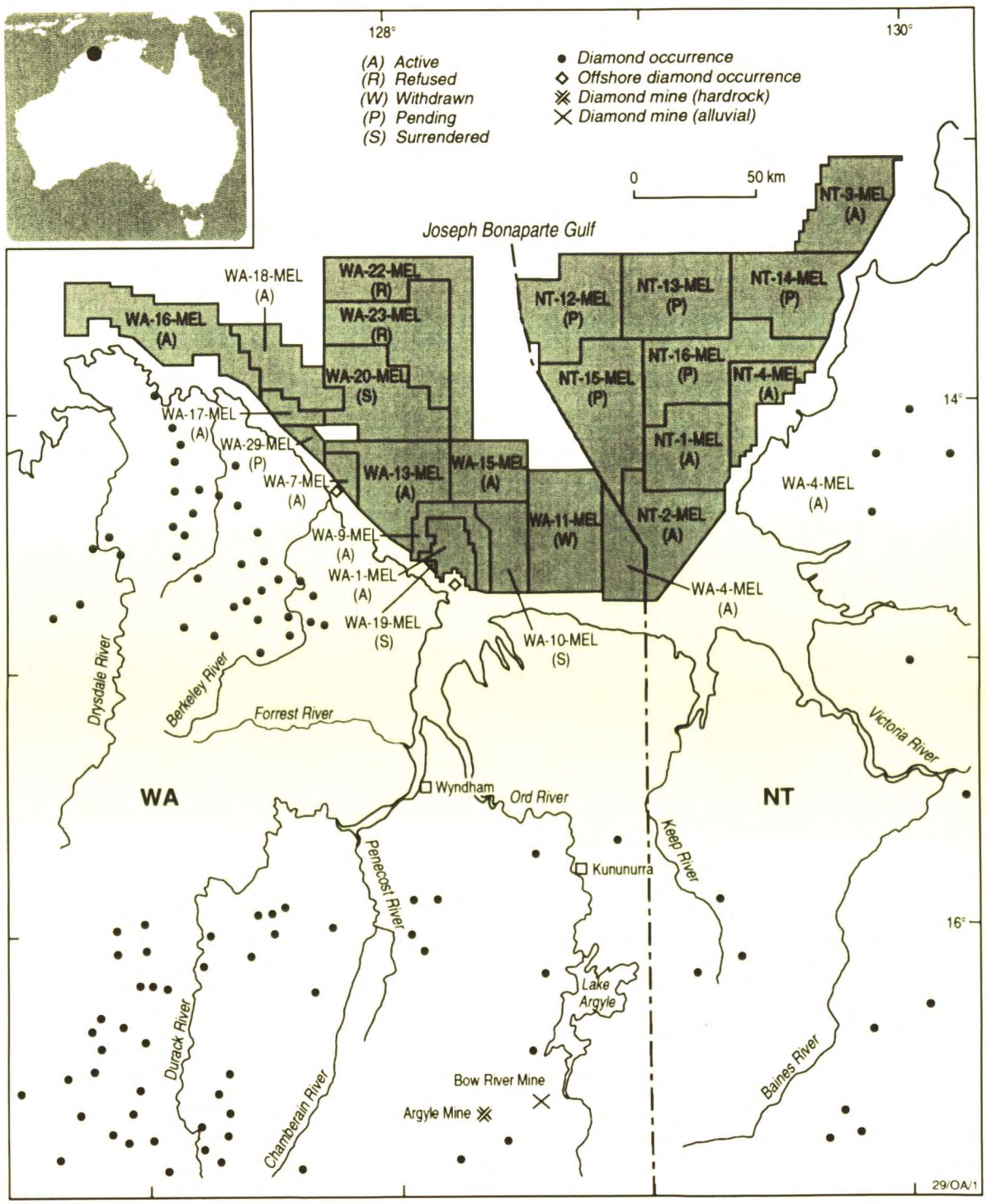
Offshore mineral exploration licences (MELs) are granted to allow exploration and if minerals are discovered mining licences may be granted to allow production to be undertaken. The grant of an exploration licence does not give or imply an automatic right to a mining licence.

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

As at 1 April 1997, a total of 61 offshore MEL applications have been received since February 1990. Twenty-one licences have been granted and 17 are active (13 offshore Western Australia and 4 offshore Northern Territory). Sixteen of the active MELs are in the Joseph Bonaparte Gulf (Figure 8) in the northwest of Australia. In this area companies are exploring for alluvial diamonds that may be derived from erosion of onshore diamond deposits such as the Argyle pipe. Cambridge Gulf Exploration N.L. (CGE) has discovered diamonds in palaeo-drainage channels in Western Australian state waters at the mouths of the Berkeley and Ord Rivers. The *Gulf Explorer*, a drilling barge, is undertaking a reconnaissance drilling program in CGE's MELs at the mouths of the Berkeley, Ord and Victoria Rivers.

Applications to explore for diamonds have also been received covering offshore areas in the Gulf of Carpentaria. The first application area is off the mouth of the McArthur River where potential may exist for alluvial diamonds eroded from the Merlin diamond deposits onshore. Another area is in the Limmen Bight, where potentially diamondiferous alluvials from the Roper and Limmen Bight Rivers could have been deposited in palaeo-channels. Applications for offshore diamond exploration have also been received for areas south of Kangaroo Island in Commonwealth waters.

Figure 8 Commonwealth offshore mineral exploration licences in the Joseph Bonaparte Gulf as at 1 April 1997



Abbreviations and acronyms

ABARE	Australian Bureau of Agricultural and Resource Economics
ABS	Australian Bureau of Statistics
BRS	Bureau of Resource Sciences
c	carat
CSIRO	Commonwealth Scientific & Industrial Research Organisation
EAR-1	estimated additional resources—category 1
EDR	economic demonstrated resources
GL	gigalitre
Gt	gigatonne
IAEA	International Atomic Energy Agency
kg	kilogram
km	kilometre
kt	kilotonne
L	litre
m	metre
m^3	cubic metre
Mc	million carats
MEL	mineral exploration licence
mm	millimetre
MREB	Mineral Resources and Energy Branch
Mt	million tonnes
Mtpa	million tonnes per annum
MW	megawatt
na	not available
NSW	New South Wales
NT	Northern Territory
OECD/NEA	Organisation for Economic Cooperation and Development/ Nuclear Energy Agency
PGM	platinum group metals
Qld	Queensland
RAB	rotary air blast
RAR	reasonably assured resources
RC	reverse circulation
$	dollar
SA	South Australia
t	tonne
Tas	Tasmania
tpa	tonnes per annum
U	uranium
U_3O_8	uranium oxide
USA	United States of America
USGS	United States Geological Survey
US$	United States of America dollar
Vic	Victoria
WA	Western Australia

Terminology and definitions

Resources: 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 currently or potentially (within a 20–25 year time frame) feasible.

Categories based on degree of assurance of occurrence

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

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

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.

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, of 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.

Categories based on economic consideration

Economic: Resources for which, at the time of determination, profitable extraction or production under defined investment assumptions has been established, analytically demonstrated or assumed with reasonable certainty.

Subeconomic: Resources that do not meet the criteria of economic. Subeconomic resources include paramarginal and submarginal categories:

Paramarginal: Subeconomic resources that, at the time of determination, almost satisfy the criteria for economic. The main characteristics of this category are economic uncertainty and/or failure (albeit just) to meet the criteria that define economic. Included are resources that would be producible given postulated changes in economic or technological factors.

Submarginal: Subeconomic resources that would require a substantially higher commodity price or some major cost-reducing advance in technology to render them economic.

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