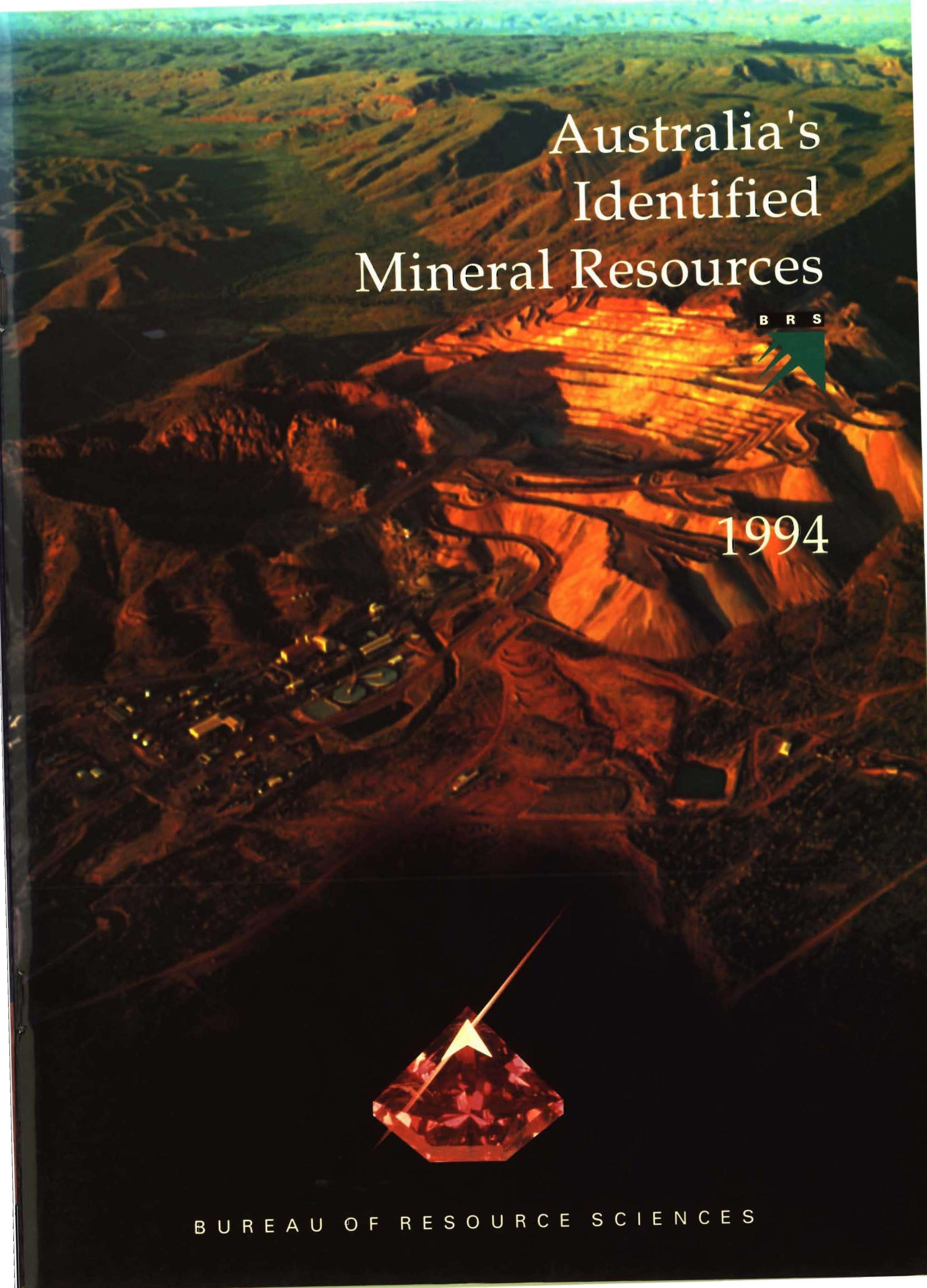
Australia's Identified Mineral Resources

BRS

1994



BUREAU OF RESOURCE SCIENCES

ADEN McKAY

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Bureau of Resource Sciences
PO Box E11
Queen Victoria Terrace
Parkes ACT 2600

The Bureau of Resource Sciences is a professionally independent Bureau established in October 1992 in the Department of Primary Industries and Energy. Its role is to enhance the sustainable development of Australia's agricultural, mineral, petroleum, forestry and fisheries resources and their industries by providing high quality scientific and technical advice to government, industry and the community.

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The **Mineral Resources Branch** of **BRS** is responsible for providing independent advice and analysis on Australia's inventory of identified mineral resources, their rate of development and exploration activity. To ensure that policy makers, the mining industry, the investment sector and the general community are well informed on these matters, the **Mineral Resources Branch** produces ***Australia's Identified Mineral Resources*** annually, drawing on current and historical data from mining and exploration companies.

To facilitate this function, the **Mineral Resources Branch** maintains two large databases on Australia's mineral resources: MINRES, which contains information on the quantity, quality, type, location and ownership of about 2000 mineral deposits; and MINLOC which contains detailed locations for over 40 000 Australian mineral occurrences. These are being linked to OZMIN, an Australian Geological Survey Organisation database listing the geological features of mineral deposits.

The **Mineral Resources Branch** 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 the context of resource assessment and providing advice on offshore exploration and mining technologies.

To achieve partial cost recovery, the **Mineral Resources Branch**:

- has released MINLOC and is soon to release MINRES commercially; and
- undertakes independent work for external clients, including:
  appraisals of mineral resource potential in Australia and overseas;
  integrated analyses of physical, chemical and biological data in the context of environment protection and sustainability of mining; and audits of mineral resource estimates and mining operations for government agencies.

B R S

Contents

List of Plates

List of Figures

List of Tables

List of Abbreviations and Acronyms

ABARE	Australian Bureau of Agricultural and Resource Economics
ABS	Australian Bureau of Statistics
AGSO	Australian Geological Survey Organisation
A$	Australian dollar
BMR	Bureau of Mineral Resources, Geology and Geophysics
BRS	Bureau of Resource Sciences
c	carat
EAR–I	estimated additional resources – category I
EDR	economic demonstrated resources
GIS	geographic information system
GL	gigalitre
Gt	gigatonne
IAEA	International Atomic Energy Agency
kc	kilocarat
kg	kilogram
km	kilometre
kt	kilotonne
L	litre
lb	pound
LCS	Legal Continental Shelf
m	metre
m^3	cubic metre
MEL	mineral exploration licence
MPJV	Mitchell Plateau Joint Venture
Mt	million tonnes
Mtpa	million tonnes per annum
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
U	uranium
U_3O_8	uranium oxide
USA	United States of America
USBM	United States Bureau of Mines
US$	United States dollar
USSR	Union of Soviet Socialist Republics
VIC	Victoria
WA	Western Australia

Terminology and Definitions

Resource: a concentration of naturally occurring solid, liquid, or gaseous materials in or on the earth's crust and in such form that its economic extraction is currently or potentially (within 20–25 years) feasible.

Categories of resources 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 resources: a collective term for the sum of measured and indicated resources.

Measured resources: 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: 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: 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 of resources based on economic considerations

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

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

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

Commodity Review

Summary

The mineral industry is an integral part of the Australian economy, generating $29 785 million in export revenue in the 1993–94 financial year. This was over 60% of all commodity exports for the year. Such an important contribution was possible because of the large and diverse resources that sustain the industry.

Economic demonstrated resources (EDR) of several commodities, including gold, ilmenite, manganese, magnesite, zinc, tin and silver, rose substantially in 1994. EDR for cadmium, diamond and vanadium fell significantly, and for other commodities remained steady or showed minor variation over the year.

Exploration expenditure continued to be dominated by the search for gold. Figures published by the Australian Bureau of Statistics (ABS) show that in 1993–94, $793 million was spent on mineral exploration of which 57% was on gold. Expenditure on diamond exploration rose by 54% to $58 million.

Successful exploration programs have maintained Australia's position as one of the world's premier resource nations despite continued high rates of production. Australia is one of the world's top six countries for resources of commodities as diverse as bauxite, bismuth, gold, mineral sands, lithium, iron ore, lead, silver, manganese, zinc, tantalum and uranium.

Introduction

This report presents the third annual assessment of Australia's identified mineral resources by the Bureau of Resource Sciences (BRS). It continues and is consistent with the resource assessment series published annually by the former Bureau of Mineral Resources, Geology and Geophysics (BMR).

The assessment is undertaken as an input into government policy decisions relating to resource and environment management for sustainable development. The report also examines trends in Economic Demonstrated Resources (EDR) of all major and some minor mineral commodities, and comments on Australia's position in the world. It reports on changes in exploration expenditure (expressed in current dollars) over the past four years. Further, it provides a perspective on mineral exploration expenditure, expressed in real terms, over the last 24 years.

Estimates of Australia's identified resources of all major and some minor mineral commodities are reported for 1994. The estimates were prepared by the Mineral Resources Branch of BRS, and are based on published and unpublished data available to the Branch up to mid-October 1994. Mine production data for Australia reported in Table 2 were provided by the Australian Bureau of Agricultural and Resource Economics (ABARE). Data on petroleum were provided by the Petroleum Resources Branch of BRS. World data have been obtained or calculated from various sources, mainly publications of the United States Bureau of Mines (USBM). Data on 1993–94 production, exports and value of exports are from ABARE (1994) unless indicated otherwise.

The mineral resource classification used in this report was adopted by the former BMR in 1975 (BMR 1976) and refined in 1983 (BMR 1983). It reflects both the geological certainty of occurrence of the mineral resources and the economic feasibility of their extraction (see Terminology and Definitions). EDR is used instead of 'reserves' for national totals of economic resources in Australia because the term 'reserve' has various meanings which are not always consistent. EDR also provides a basis for meaningful international comparisons of the economic resources of nations. With few exceptions, ore is mined from resources in the economic demonstrated category. The size of EDR of a commodity in relation to its rate of production is an indicator of the sustainability of that commodity. EDR are reduced by mining and increased by new discoveries and by technical and economic changes which turn hitherto uneconomic deposits into economic ones. 'Paramarginal' and 'submarginal' are two categories of subeconomic resources which refer to economic feasibility of extraction at current prices using existing technology (see Terminology and Definitions).

During 1994, the Mineral Resources Branch began a review of the BRS Mineral Resource Classification system. This review aims to ensure that the BRS system remains compatible with the revised Australasian Institute of Mining and Metallurgy/Australian Mining Industry Council/Australian Institute of Geoscientists industry code ('Australasian Code for Reporting of Identified Mineral Resources and Ore Reserves'. The review is scheduled to be completed in 1995 and a revised system, compatible with the industry codes, published afterwards.

Uranium resources (Table 3) are classified by BRS in categories used by the Organisation for Economic Cooperation and Development/Nuclear Energy Agency (OECD/NEA) and the International Atomic Energy Agency (IAEA). 'Reasonably Assured Resources' of the OECD/NEA and IAEA classification can be equated with 'demonstrated resources' of the BRS classification, and 'Estimated Additional Resources – Category I' with 'inferred resources'. In previous years, uranium resources recoverable at a cost of less than US$80 per kilogram of uranium (U) were equated with EDR and those recoverable at a cost of US$80–130/kg U with 'paramarginal resources'. In 1994, most uranium was sold at prices below US$80/kg. Consequently, the less than US$80/kg category includes all economic resources and some that are currently uneconomic.

Mineral Industry Performance

Preliminary statistics published by ABARE (1994) show that mineral exports for 1993–94 were valued at $29 785 million, an increase of $27 million over the revised 1992–93 figure. Details of production and exports of selected minerals are reported in Table 1.

TABLE 1 Australian production and exports of selected mineral products, 1993-94

Commodity	Production	Export	Export value ($ million)
Aluminium			
Bauxite (Mt)	42.9	na	87
Alumina (Mt)	12.76	10.2	2292
Aluminium (Mt)	1.38	1.05	1814
Copper			
Ores and concentrates (kt) [a]	410	430	295
Refined (kt)	325	178	475
Diamond (kc)	39 909	31 715	542
Gold			
Mine production (t) [a]	256		
Refined (t)	295.5[b]	306.2[b]	5418[b]
Iron and Steel			
Ore and pellets (Mt)	123.9	114.4	2776
Iron and steel (Mt)	15.4[c]	2.92	1311
Lead			
Ores and concentrates (kt) [a]	530	165	60
Refined (kt)	220	165	120
Bullion (kt)	213	196	175
Nickel			
Mine production (kt) [a]	71		
Refined (kt)	97	na	585
Mineral sands			
Ilmenite concentrates (kt)	1740	1054	88
Rutile concentrates (kt)	205	208	111
Synthetic rutile (kt)	420	259	111
Titanium dioxide pigment (kt)	147	114	255
Zircon concentrates (kt)	460	454	94
Zinc			
Ores and concentrates (kt) [a]	1080	1516	429
Refined (kt)	289	240	366
Black coal			
Raw (Mt)	222.0		
Saleable (Mt)	178.3	129.1	7166

na = not available; t = tonne; kt = 10^3 t; Mt = 10^6 t; kc = 10^3 carats;
Source: *Australian Commodites Forecasts and Issues* ABARE September Quarter 1994.

[a] Total metal content.
[b] Includes gold of Australian and overseas origin.
[c] Includes 7.2 Mt pig iron and 8.2 Mt raw steel.

Long-term trends in EDR for bauxite, black coal, iron ore, gold, copper, lead, zinc, nickel and mineral sands are shown in Figure 1. The 1994 assessment of Australia's resources of minerals and fuels is reported in Table 2.

Bauxite

In 1993, Australia maintained its pre-eminent position as the world's largest producer of bauxite (just over 40%) most of which was refined to alumina (about 34% of world production). In early 1994, Australia and other countries that accounted for about two-thirds of world production of aluminium in 1993 acknowledged (via a memorandum of understanding) an excess of 1.5–2 million tonnes per annum (Mtpa) in world primary aluminium production. A succession of significant cuts in production has since been instituted by several of the world's major producers of primary aluminium. In response to lower international demand for alumina stemming from these cuts in production of aluminium, Australian production of alumina and bauxite is forecast to fall by 7% and 3% to 11.9 Mt and 41.5 Mt respectively in 1994–95 (ABARE 1994). Based on its wealth of bauxite resources and competitive mining costs, however, Australia is expected to maintain its dominant position as a producer and exporter of bauxite and alumina.

Australia's bauxite EDR and the ratio of EDR to identified resources (demonstrated and inferred) remained virtually the same as for the 1993 assessment. Major bauxite resources continue to be mined in the north on both sides of the Gulf of Carpentaria (Gove, Northern Territory and Weipa, Queensland) and in the southwest along the Darling Range in Western Australia.

Bauxite resources in the Admiralty Gulf region of northern Western Australia are extensive and cover an area of over 440 square kilometres. A reappraisal of part of this region, the Mitchell Plateau, was scheduled to be completed by the Mitchell Plateau Joint Venture (MPJV) at the end of 1994. Although currently considered as uneconomic, the Mitchell Plateau deposit is a significant bauxite resource with potential for successful future development using current mining and beneficiation techniques. An extension to the lease period was granted by the Western Australian Government in 1993 to MPJV (Mitchell Plateau Bauxite Co Pty Ltd, 58.3%; Alcoa of Australia Ltd, 19.4%; Billiton Aluminium Australia, 11.1%; and Sumitomo and Marubeni Corporations, 5.6% each).

Black Coal

In 1993, Australia had about 8% of the world's recoverable EDR of black coal, and was ranked fifth behind the USA, former USSR, China and South Africa. In 1994, New South Wales and Queensland accounted for 97% of Australia's in-situ black coal EDR, with 44% of total EDR in the Sydney Basin and 35% in the Bowen Basin. Black coal amenable to open-cut mining represents 41% of Ausralia's in-situ black coal EDR. Relatively small but locally important EDR of black coal occur in South Australia, Western Australia and Tasmania. The overall reduction of just under 6% in recoverable EDR in 1994 compared to 1993 resulted principally from a reassessment of the amount of in-situ coal that is considered recoverable.

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

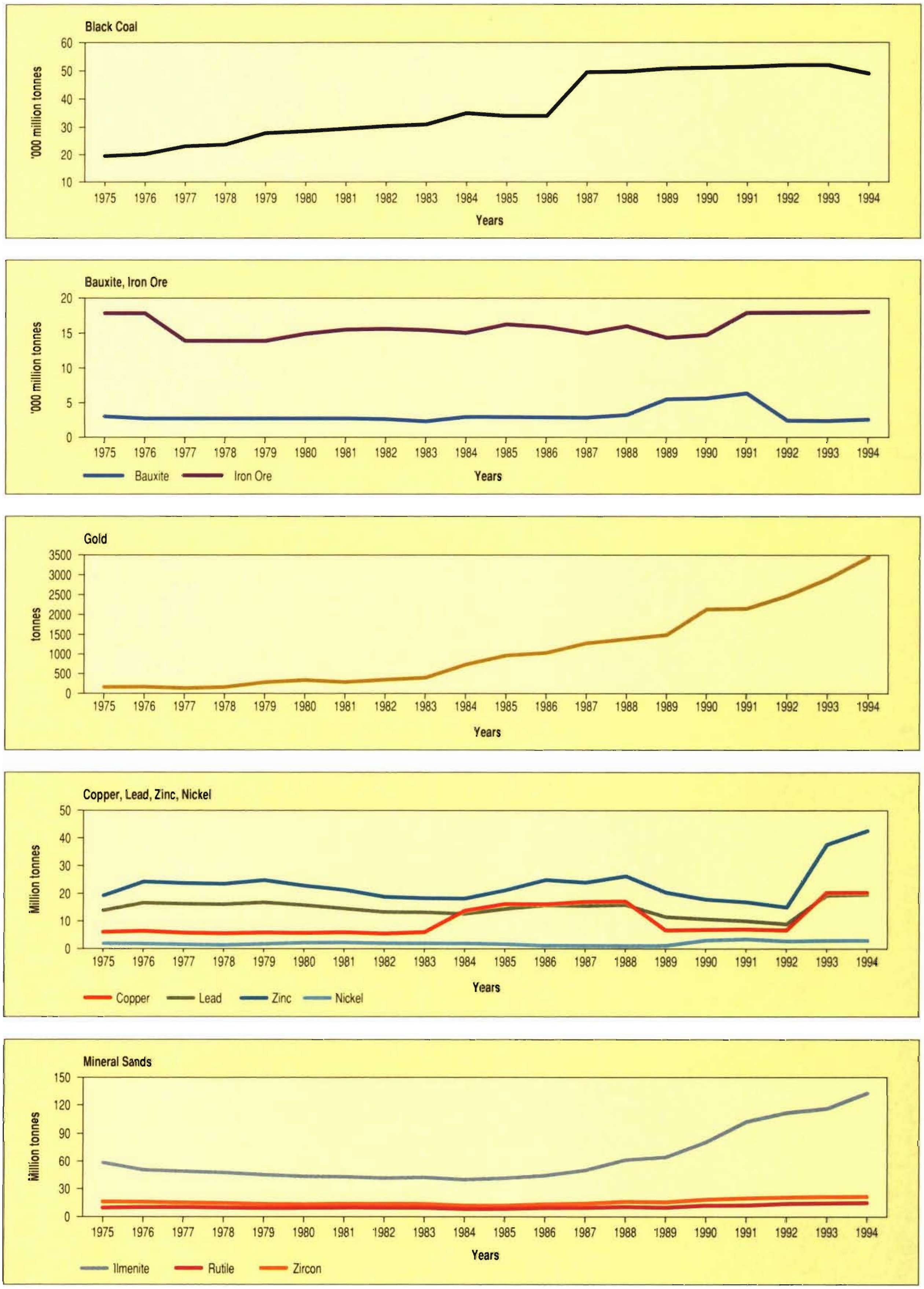

Table 2 Australia's identified resources of major minerals and fuels, 1994, and world figures for 1993

COMMODITY	UNITS	AUSTRALIA							WORLD 1993	
		Demonstrated			Inferred			Mine production 1993	Economic demonstrated resources	Mine (a) production
		Eco-nomic	Subeconomic: Para-marginal	Subeconomic: Sub-marginal	Economic	Sub-economic	Undifferent-iated			
Antimony	kb Sb	88.1	33.8	33.1	17.1	0.1	11.5	1.5	4200	70
Asbestos										
Chrysotile ore	Mt	-	46.2	-	-	-	78.18	-	} large	
Crocidolite fibre	Mt	-	0.37	-	-	-	2.12	-		3.11
Bauxite	Mt	2538	-	5303	-	-	2134	40.9	23000	101 (b)
Black coal										
In situ	Gt	69	1	6	-	-	very large			
Recoverable	Gt	49	1	4	-	-	-	0.22 (c)	647	3.2 (d)
Brown coal										
In situ	Gt	46	1	2	-	-	184			
Recoverable	Gt	41	1	2	-	-	166	0.048	269	1.2
Cadmium	kt Cd	73.4	10.8	17.2	10.1	0.1	-	2.2	535	17
Chromite	Mt	-	2.37	0.52	-	21.35	-	-	1400	10
Cobalt	kt Co	52	129	241	-	136	-	0.49	4000	17.4
Copper (e)	Mt Cu	20.2	17.2	0.8	5.5	2.6	-	0.4	310	9.3
Diamonds										
Gem & near gem	10^6 c	130	148	-	-	-	9	} 41.9	300	51.7
Industrial	10^6 c	168	183	0.3	-	-	27		980	55.7
Fluorine	Mt F	-	24.1	5.8	-	-	0.7	-	102	1.8
Gold	t Au	3434	1234	54	-	-	1317	248	42000	2290
Iron ore	Gt	18	13.8	0.4	6.5	10.7	-	0.120	150	0.94
Lead	Mt Pb	19.7	4.6	9	1	11.7	2.2	0.5	63	3.2
Lithium	kt Li	159	-	3	-	-	7	2.3	2200	5.5 (b)
Magnesite	Mt-$MgCO_3$	246.9	-	288.5	-	-	230	0.26	2500	3.15
Manganese ore	Mt	124	28	167	71	94	-	2.09	800	20.4
Mineral sands										
Ilmenite	Mt	132.5	67.2	0.1	-	-	99.4	1.7	380	6.1 (b)
Rutile	Mt	14.4	33.4	0.2	-	-	26.3	0.19	89	0.5 (b)
Zircon	Mt	21.0	24.2	0.2	-	-	20.9	0.43	75	0.7 (b)
Molybdenum	kt Mo	-	5	3	-	238	-	-	5500	108
Nickel	Mt Ni	2.9	2.1	3.8	-	2.9	-	0.071	47	0.826
Niobium	kt Nb	3.4	67.6	-	-	-	1994	-	3500	15
Petroleum (recoverable) (f)										
Crude oil	GL	244	-	38	-	-	-	25.2	158517	3484
Natural (sales) gas	10^9m^3	1006	-	1130	-	-	-	24.7 (g)		
Condensate	GL	133	-	54	-	-	-	3.6	} 138353	2146
LPG naturally occur.	GL	135	-	89	-	-	-	3.7		
Phosphate rock	Mt	-	2095	-	-	-	1947	0.002	12000	131
Platinum-group Metals (Pt, Pd, Os, Ir, Ru, Rh)	t metal	17.7	20.7	16.7	3.5	115.5	-	0.5	56000	273
Rare earths oxides	Mt	1	3.5	10.6	-	-	4.0	-	100	0.06
Shale oil	GL	-	-	4564	-	-	40468	na	na	na
Silver	kt Ag	44.7	9.4	11	1.7	7.7	9.1	1.15	280	14.9
Tantalum	kt Ta	6.2	6.0	0.1	-	-	65.1	0.3	22	na
Tin	kt Sn	159.0	64.5	150.3	-	340.4	5.3	8.1	7000	175
Tungsten	kt W	1	96	107.1	-	81.8	-	0.02	2300	25.5
Uranium (see Table 3)	t U							2256		32700
Vanadium	kt V	15	1739	8425	-	2282	-	-	10000	28
Zinc	Mt Zn	42.6	13.1	12.3	2.7	8.4	1.6	1.0	140	7

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 1993 are estimates.
(b) Excludes USA.
(c) Raw coal.
(d) Saleable coal.
(e) Copper resources not assessed in 1994.
(f) Source: Petroleum Resources Branch, BRS (as at 1 Jan 1993); (Production as at 31 Dec 1993).
(g) Includes ethane.

TABLE 2 Australia's identified resources of major minerals and fuels, 1994, and world figures for 1993

		AUSTRALIA							WORLD 1993	
		Demonstrated			Inferred					
		Economic	Subeconomic Para-marginal	Subeconomic Sub-marginal	Economic	Subeconomic	Undifferent-iated	Mine production 1993	Economic demonstrated resources	Mine[a] production
Antimony	(kt Sb)	88.1	33.8	33.1	17.1	0.1	11.5	1.5	4200	70
Asbestos										
Chrysotile ore	(Mt)	-	46.2	-	-	-	78.18	-	large	3.11
Crocidolite fibre	(Mt)	-	0.37	-	-	-	2.12	-		
Bauxite	(Mt)	2538	-	5303	-	-	2134	40.9	23000	101 [b]
Black coal	(Gt)									
In situ		69	1	6	-	-	very large			
Recoverable		49	1	4	-	-	-	0.22 [c]	647	3.2 [d]
Brown coal	(Gt)									
In situ		46	1	2	-	-	184			
Recoverable		41	1	2	-	-	166	0.048	269	1.2
Cadmium	(kt Cd)	73.4	10.8	17.2	10.1	0.1	-	2.2	535	17
Chromite	(Mt)	-	2.37	0.52	-	21.35	-	-	1400	10
Cobalt	(kt Co)	52	129	241	-	136	-	0.49	4000	17.4
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Diamonds	(10^6 c)									
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Zircon	(Mt)	21.0	24.2	0.2	-	-	20.9	0.43	75	0.7 [b]
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[e] Copper resources not assessed in 1994.
[f] Source: Petroleum Resources Branch, BRS (as at 1 January 1993); (Production as at 31 December 1993).
[g] Includes ethane.

Australian black coal resources are mined for both domestic and export markets. In 1993, Australia produced 6% of the world's saleable coal output and as a producer was ranked sixth after China, USA, former USSR, India and South Africa. In 1993–94, 221.8 Mt of raw coal was produced, a decrease of 0.8 Mt over the previous financial year. In 1993–94, 72% of Australia's raw coal production came from open-cut operations. Saleable coal production in 1993–94 was 178.3 Mt, of which 129.9 Mt (73%) was exported. Coking coal contributed 53% of export tonnages.

Exploration expenditure for coal in 1993–94 totalled $27.7 million. In Queensland, exploration received a major boost in 1993 and 1994 when the State Government lifted restrictions on prospective coal areas in the Bowen Basin. This resulted in the new permit holders committing about $20 million over five years for exploration and evaluation. A report entitled 'Effects of Land Use on Coal Resources' was released by the New South Wales Government in early 1994. It shows that 48% of the total coal resources in the Sydney and Gunnedah Basins are affected by various land uses including National Parks, urban development, prime agricultural land, infrastructure, natural features, stored bodies of water and Commonwealth land.

With over 70% of Australia's annual saleable coal production exported, the loading capacity of Australia's eight major coal ports is an important logistical factor. Existing capacity is 152 Mtpa which will rise to 190 Mtpa as infrastructure projects are completed. This will ensure that Australian port capacity is adequate to meet the projected rise in Australian exports, which ABARE forecasts will reach 174.4 Mt in 2000.

Brown Coal

Australia's substantial resources of brown coal are mainly in Victoria which has 94% of EDR. About 86% of EDR is in the Latrobe Valley. The slight increase in recoverable inferred resources is due mainly to minor reassessment of recoverable resources in some deposits. Brown coal is only mined in Victoria and is used mainly for electricity generation. In 1993, Australia produced 4% of the world's brown coal output and was the ninth largest producer in the world.

Undeveloped brown coal resources occur in South Australia, Tasmania, Western Australia and Victoria. In Western Australia, Trans Global Resources N.L. has identified an inferred resource of lignite near Norseman and is continuing its evaluation.

Chromium

Chromite is the principal commercial source of chromium. Almost all of the chromite used in Australia, principally in refractory and foundry applications, is imported. Most of the country's chromium alloy and chemical product needs are also sourced from overseas. Chromite was last produced in Australia in the Marlborough district of Queensland in 1988.

Australia's identified chromite resources constitute less than 0.2% of world resources which exceed 11 000 Mt. More than 90% of Australia's identified resources occur in stratiform deposits in Western Australia — at Lamboo in the Kimberley district and Coobina in the Pilbara. These deposits have a high iron content but have potential for use in the production of low-grade ferrochromium and in chromium chemicals.

Chromiferous laterite resources at Range Well, 67 km north-northwest of Cue, Western Australia, have potential for development as a source of chromium for iron chromium alloys used in grinding mills. The resources are being further assessed by Dragon Mining N.L., and additional investigations into the recoverability of the chromium and marketing of the products are proceeding.

Cobalt

Australia produces more than 7% of world mine output of cobalt, and in 1993 was the sixth largest producer after Zambia, Canada, Russia, Zaire and Cuba. Australia's ranking as a cobalt producer declined in 1993 after depletion of resources at the Greenvale mine in Queensland. Cobalt is principally a by-product of nickel mining and processing in Australia. Most output is exported.

Cobalt products from the Yabulu nickel refinery in Queensland are derived mainly from the processing of lateritic nickel ores imported from New Caledonia and Indonesia. Queensland lateritic nickel ore is supplied to the refinery from Marlborough. Cobalt (in nickel cobalt sulphide) is produced at the Kwinana nickel refinery in Western Australia from the treatment of nickel matte derived from sulphide concentrates produced at Kambalda and Leinster, also in Western Australia. A small quantity of cobalt oxide is produced during zinc refining at Risdon, Tasmania.

Australia's EDR of cobalt rank sixth after Zaire, Cuba, Zambia, New Caledonia and Russia, but represent only 1% of the world total. In 1990, reclassification of resources associated with nickel sulphide mineralisation reversed the decreasing trend in EDR that resulted from mining the Greenvale deposit in Queensland. EDR again decreased after 1990 but to a lesser extent with the transfer of some sulphide resources into subeconomic categories and the exhaustion of resources at Greenvale. EDR were unchanged in 1994. Paramarginal demonstrated resources more than doubled after substantial laterite resources were delineated at Fifield, New South Wales.

Copper

Resource developments at mines around Australia indicate an optimistic outlook for copper. Australia's mine production of copper is the sixth largest in the world. The main producers are mines at Mt Isa, Queensland, and Olympic Dam, South Australia.

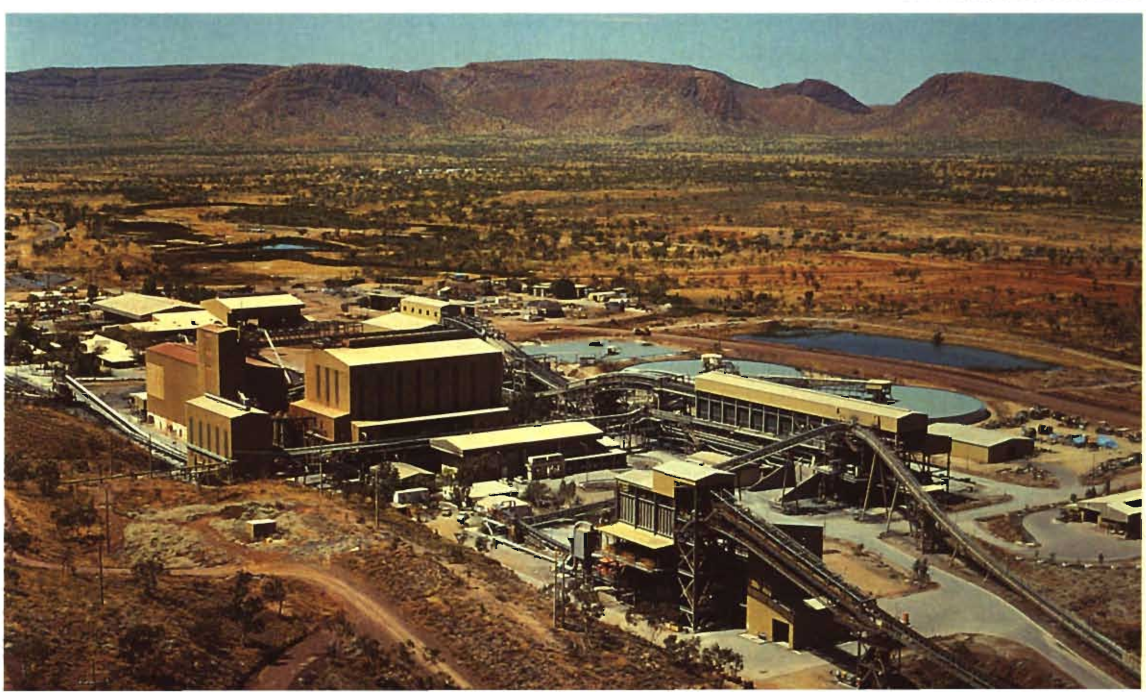
At Olympic Dam, the WS Robinson Shaft is scheduled to be completed for commissioning in February 1995. Drilling has located zones of higher grade ore and better defined existing zones, resulting in increased reserves.

The Mt Isa Deep Copper Mine (3000 orebody) achieved its first full year of production during 1994. To the north, additional copper resources were discovered at the Mammoth mine, where bacterial copper-leach extraction technology is used. To the east, near Cloncurry, a feasibility study of open-cut mining is underway at the Ernest Henry copper–gold deposit. To the south-east, at Selwyn, mine development and resource delineation continues at the Mt Elliott copper–gold deposit, which should become the main source of ore for the Selwyn operations in the future. To the south, mine development commenced during 1994 at the Osborne copper–gold deposit where an 11-year mine life is anticipated from open-pit and underground mining.

Copper concentrate production at the large copper–gold Northparkes project, in central New South Wales, is to start in 1995. Additional resources at the CSA Mine near Cobar were discovered below existing workings and the feasibility of deepening the mine and increasing output is being assessed. Significant additional resources have been discovered recently near the Girilambone mine (Nyngan region, NSW) and their potential as feed to the existing bacterial, heap-leach copper extraction plant is being evaluated.

Remaining copper–gold resources at the Mt Lyell mine, in Tasmania, are being assessed with a view to re-starting mining operations. Based on data from previous operations, the resource has been reported as 17.5 Mt of ore with a grade of 1.5% copper and 0.5 grams of gold per tonne. New drilling at the Prince Lyell deposit has confirmed extension of mineralisation to about 250 m below existing workings.

PLATE 1 Processing plant at the Argyle diamond mine, Western Australia. Photo: Lloyd David, BRS.



Diamond

Australia has over 40% of the world's EDR of gem and near-gem diamond, and more than three times the EDR of any other country's resources of industrial quality diamond. Australia produced over 40 million carats of diamond in 1993, more than twice that of any other country, but the low proportion of gem quality stones (5%) resulted in the total value of production being less than that of many other diamond producing countries.

Over 90% of Australia's resources are in the Argyle deposit in the Kimberley region, Western Australia. Argyle's mine output accounts for about 90% of Australia's diamond production. Open-pit mining has been in the southern, richer part of the orebody and is scheduled to progress to the northern part in the near future. Relatively small resources of alluvial diamond, derived from the Argyle deposit, are worked nearby at the Argyle Alluvials operation and about 30 km downstream at Bow River. Comprehensive environmental rehabilitation is an integral part of the alluvial operations. The feasibility of underground mining after open-pit resources are exhausted at Argyle, in about eight to ten years, is being examined.

Australia's EDR of gem and industrial quality diamond fell by 11%, mainly as the result of mine production at Argyle. Small subeconomic hard rock resources occur in Ellendale Pipes 4 and 9 east of Broome, Western Australia, and limited subeconomic alluvial resources are known at Copeton in northeastern New South Wales.

Two more small kimberlite pipes have been discovered by Australian Diamond Exploration Joint Venture (Ashton Mining Limited, 67.5%; Aberfoyle Limited, 22.5%; and others 10%) at the diamondiferous Merlin prospect, about midway between Tennant Creek and the Northern Territory–Queensland border. Bulk sampling of the 11 pipes discovered to date has commenced. Three 50-tonne samples of diamondiferous rock from the Coanjula prospect 140 km to the north are also being evaluated.

Two wide-diameter (1.2-metre) drillholes were used to take bulk samples from the northern lobe of the Aries kimberlite pipe in the central Kimberleys. The diamond content of these samples was relatively low and bulk sampling has ceased. Work on the delineation of the central and southern lobes is continuing.

At Copeton, several prospects are to be tested by a 2000-metre drilling program.

Technological advances in rolls crusher design at Argyle has resulted in the world's largest rolls crushers being installed at this mine. This and other measures have boosted mill processing capacity from 6 Mtpa to over 8 Mtpa of ore per year. Successful research and development resulted in development of a high-capacity radial X-ray diamond sorter to handle the exceptionally high diamond content of Argyle ore.

Gold

Australia's gold EDR grew by just over 14% in 1994 to a record 3434 t. This growth was the result of successful exploration programs funded by high levels of exploration expenditure in recent years, and reassessments based on the continuing higher gold prices. It is reasonable to expect that the high level of exploration expenditure will start to translate into additional resources in 1995. If the price of gold is sustained at or above present levels, exploration expenditure is expected to be maintained at high levels.

Australia's mine production of gold was reported by ABARE to be a record 256 t in 1993–94. ABARE have forecast a further increase to 270 t in 1994–95. The expected continued high level of exploration expenditure is essential for ensuring that such growth is sustainable. Only a small quantity of gold output is a by-product of the production of other metals.

Identified resources rose by just under 15% to 6039 t. This was achieved in a year in which production also reached record levels. EDR's share of identified resources remained unchanged at 57%. Demonstrated resources rose by 10.5% to 4722 t and inferred resources rose by 33% to 1317 t.

While EDR rose by 431 t, subeconomic resources rose by only 17 t. Given the higher gold prices over the last few years, the relatively small growth in subeconomic resources was not unexpected.

Gold resources are mined in all States and the Northern Territory. Western Australia had just over 62% of Australia's EDR, a small reduction from its 66% share in 1993. Western Australia also dominates production. Preliminary statistics published by ABARE show that Western Australia's mine production of gold was 193.8 t, 76% of the Australian total.

In 1993–94, exploration expenditure for gold rose by 42% to $453.8 million. This was 57% of total expenditure on mineral exploration. Of the total, 68% was spent in Western Australia.

Australia is the world's third largest gold producer after South Africa and the USA, accounting for about 11% of 1993 world output, the same share as in 1992.

Australia's share of world EDR fell slightly to 7% in 1993. It had the world's fourth largest EDR in that year. Successful exploration in 1993–94 may see Australia overtake Russia to become the world's third largest holder of EDR after South Africa and the USA.

Iron Ore

Australia's iron ore resources provide the foundation for one of its major export industries. Australia currently produces about 13% of world iron ore output and its exports are exceeded only by those of Brazil. As a producer, Australia ranks fourth in the world after the former USSR, China and Brazil. Australia's EDR of iron ore rank second after the former USSR.

Australia's identified iron ore resources are very large with about 90% in the Pilbara region of Western Australia, mostly in the Hamersley Basin, one of the world's major iron ore provinces.

World identified iron ore resources are estimated at 800 000 Mt. These are spread throughout many countries but most (possibly as much as 85%) occur in the former USSR, Australia, Canada, USA, Brazil, India, South Africa, China, Sweden and Venezuela.

Australia's EDR is slightly more than 35% of total domestic identified resources. A reduction in EDR between 1975 and 1976 resulted from the reclassification of some phosphorus-bearing resources. Since then, EDR has gradually risen. A jump in EDR between 1990 and 1991 followed additional exploration that resulted in upgrading inferred resources to EDR. A marginal increase in EDR from 1992 to 1994 reflects minor reclassification and revisions.

In response to a substantial rise in export demand for Australian iron ores since the mid 1980s (particularly from China, South Korea and Taiwan), more than a dozen new iron ore projects have been proposed or commissioned, mainly in the Pilbara. Expansions at Deepdale and Channar, and new mines established at Yandi (Marillana Creek) and Marandoo, will play a major role in meeting increased export demand in the next decade.

Despite three decades of falling prices in real terms, Pilbara iron ore remains competitive on export markets, and the industry is a leader in adopting advanced technology and mining methods. Recent large-scale investment in new mining capacity and ore handling equipment, optimisation of deposit development, and the adoption of other cost-efficient mining strategies are expected to lead to further increases in productivity and efficiency.

Given its raw material base and the needs of expanding steel industries in Asia, Australia is well placed to maintain its role as a leading supplier of relatively unprocessed iron ore. However, value adding is being vigorously pursued, and the industry is in the forefront of investigations into new iron and steel making technology that is anticipated to become important during the early decades of the 21st century.

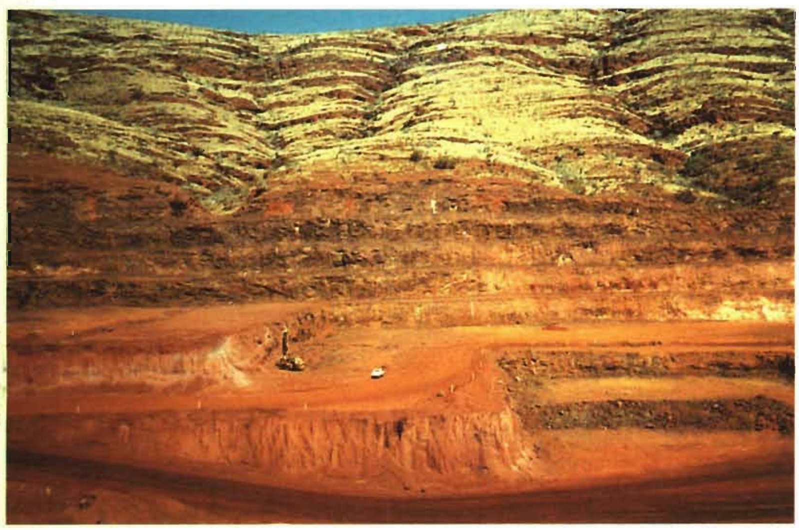


PLATE 2 Hamersley Iron's Brockman No.2 Detritals mine 65 km northwest of Tom Price, Western Australia.
Photo: Roger Pratt, BRS.

PLATE 3 Mount Newman Mining's iron ore crushing and stockpiling facilities at Mount Whaleback (foreground) and Orebody 29 mine (background) at Newman, Western Australia.
Photo: Roger Pratt, BRS.

Manganese Ore

Australia produced 9% of world manganese ore output in 1993 and was the second largest exporter after Gabon, displacing South Africa for the first time. The principal mines and resources are on Groote Eylandt, Northern Territory, and at Woodie Woodie in the Pilbara, Western Australia. Most manganese mining at Woodie Woodie became uneconomic in 1994, and was suspended after prices fell and mining costs rose as a consequence of pit dewatering requirements. However, the new Mike mine at Woodie Woodie, operated by Valiant Consolidated Limited, began production during 1994 on the basis of the ore's high manganese grade, low impurities and relatively low development cost.

Based on contained manganese, Australia has about 6% of world EDR and ranks third after South Africa (44%) and the former USSR (36%). Australia's EDR increased by more than 15% in 1994 compared with 1993. This reflected an increase in resources at Groote Eylandt which more than offset the reclassification of some relatively small Woodie Woodie resources. The decline in Australia's EDR since 1975 mainly reflects the reclassification of resources in the early 1980s when more detailed information became available; a re-evaluation of resources after more intensive exploration in the mid-1980s; and depletion as a result of mining.

Australia's resources of manganese ore support a significant export industry and significant domestic ferromanganese, silicomanganese and manganese dioxide processing.

Mineral Sands

Australia has 35 % of the world's EDR of alluvial ilmenite, 16 % of rutile and 35 % of zircon. It ranks first in 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 a hard rock deposit and the former from dune sands. Both countries upgrade their ilmenite to titanium slag before export. Most of Australia's currently mined resources are located along the east and west coasts in both modern and ancient coastal sand systems.

EDR of ilmenite, rutile and zircon increased by 12%, 3% and 1% respectively in 1994. Western Australia has about 50% of rutile and zircon and over 70% of ilmenite EDR. Significant increases in demonstrated resources, particularly ilmenite, occurred in the southwest of Western Australia, where exploration at several deposits extended existing resources and defined resources in new areas.

About 75 % of rutile and zircon EDR are unavailable for mining. These resources are mainly in Queensland and New South Wales. Areas quarantined from mining are largely included in national parks. They include Moreton and Fraser Islands, the Cooloola sand mass north of Noosa and the Shoalwater Bay area in Queensland, and the Yuraygir, Bundjalung and Myall Lakes areas in New South Wales.

Australia's mineral sands industry is currently expanding in expectation of forecast growth in demand for titanium dioxide pigment, the principal end use for ilmenite and rutile. Cable Sand (WA) Pty Ltd's Jangardup mine in the southwest of Western Australia commenced production in early 1994. In anticipation of forecast market growth and increased prices, other mines have returned to full capacity. Several additional mineral sand projects such as Beenup near Augusta in Western Australia and Byfield near Rockhampton in Queensland are under investigation. Value adding is expected to increase, especially for synthetic rutile and titanium dioxide pigment. Australia is the world's largest producer of synthetic rutile. Up to half of the ilmenite mined in Western Australia is upgraded to synthetic rutile (containing in excess of 92% titanium dioxide) in four synthetic rutile plants located in Western Australia.

Molybdenum

Molybdenum (as molybdenum trisulphide) was last produced in Australia at King Island, Tasmania, in 1990 in conjunction with scheelite (a tungsten mineral) mining. Production of molybdenum concentrates commenced at King Island in small quantity in 1980. Chemical treatment of scheelite fines at that time was required to reduce their molybdenum content. This was necessary because the contained molybdenum attracted a penalty which reduced the price received. Treatment of the scheelite resulted in the production of high-grade calcium tungstate (artificial scheelite) as well as molybdenum trisulphide.

Australia's identified resources of molybdenum constitute about 2% of the world total of 12 Mt. All of Australia's resources are subeconomic. The largest resources are in the inferred category, and occur with tungsten (scheelite) mineralisation at Mount Mulgine, 95 km east of Morawa in Western Australia. In Queensland, resources occur at Wombah (65 km southwest of Bundaberg), Ben Lomond (60 km southwest of Townsville) and Maureen (40 km northwest of Georgetown) the latter two being in association with uranium. Molybdenum resources in the Molyhill deposit, in the Jervois Ranges, Northern Territory, are associated with tungsten (scheelite) mineralisation. Resources also occur at Yetholme (20 km east of Bathurst) in New South Wales.

World oversupply and low prices have deterred interest in exploration for molybdenum in Australia since the early 1980s. The potential for future production in Australia is therefore expected to depend largely on the economics of recovering the metal as a by-product from polymetallic deposits.

Nickel

Most nickel mined in Australia is processed to smelted and refined forms, making it a substantial domestic value adding industry. The industry also produces significant copper, cobalt and platinum group metals as by-products.

Australia produces about 8% of the world's annual mine output of nickel and in 1993 was ranked fourth (fifth in 1992) behind Russia, Canada and New Caledonia. The main Australian mines are at Kambalda, Leinster and Forrestania in Western Australia, and Marlborough in Queensland. Smelting operations are located at Kalgoorlie, Western Australia, and refineries at Kwinana, Western Australia, and Yabulu, Queensland.

Australia's EDR rank sixth in the world after Cuba, Russia, Canada, New Caledonia and Indonesia. Almost all EDR (97%) are in sulphide deposits in Western Australia. Changes in EDR after 1975 partly reflect the impact of nickel price fluctuations on the economics of mining. Several mines closed in the late 1970s and again in the mid 1980s as a result of depressed prices; EDR decreased on both occasions. An increase in EDR to record levels in 1990 and 1991 resulted from the reclassification of resources at a reopened mine and at projects where open-cut mining was assessed to be economically viable. EDR were unchanged in 1994.

The Australian nickel industry is undergoing major expansion and revitalisation in expectation of market growth. The programs are expected to result in an expansion of Australia's world market share and further improvement in Australia's competitive position, which is based mainly on the mining of relatively shallow sulphide deposits. Smelting and refining capacity have increased, mine production capacity at Leinster has doubled and a major $450 million open-cut mining project (based on disseminated nickel sulphides) at Mount Keith, Western Australia, was scheduled to begin commissioning operations in late 1994. Additional nickel mining projects are also under investigation in Western Australia.

Platinum–Group Metals

Minor production of platinum–group metals (PGM: platinum, palladium, osmium, iridium, rhodium and ruthenium) occurs in Western Australia as a by-product of nickel mining at Kambalda. Nickel concentrates containing PGM are smelted at Kalgoorlie and PGM are retained in the matte, which is either refined at Kwinana or exported. PGM (mainly platinum and palladium) are recovered at Port Kembla from the processing of by-product copper sulphide residue produced at the Kwinana nickel refinery.

Australian mine production of PGM is about 2% of world output. Variations in EDR, which are mostly contained in nickel sulphide deposits of the Kambalda field, largely reflect changes in nickel resources at this location. EDR decreased from 1990 to 1992 but increased slightly in 1993 and were unchanged in 1994. EDR comprise platinum (26%), palladium (47%) and other PGM (27%).

Exploration in recent years has resulted in the discovery of substantial resources of PGM in Australia, mostly in Western Australia, but these resources are not commercially viable. Substantial inferred resources occur at Munni Munni in the Pilbara. Resources in a similar setting to those at Munni Munni occur at nearby Mount Sholl and at Panton near Halls Creek in the Kimberley region. Relatively large resources were discovered in

1993 at Range Well and Weld Range in the Murchison region, 370 km northeast of Geraldton. The extraction of PGM from these resources is being evaluated by Dragon Mining N.L. and Austmin Gold N.L.

Shale Oil

Australia's in situ shale oil resources were unchanged in 1994. Virtually all demonstrated and inferred resources are in Queensland but small resources occur in New South Wales and Tasmania. Shale oil is not currently produced in Australia.

Research is currently directed predominantly toward characterisation studies, processing technologies and shale oil upgrading. The most advanced project is that based on the Stuart deposit near Gladstone. A three stage development is proposed in which stage one will be a commercial demonstration plant that may be used as a module in subsequent stages. Stage two would be a full commercial plant module and stage three a full commercial plant. To assist this project, the Commonwealth Government has exempted from excise duty any petrol produced by the project for sale in Australia for up to 600 000 barrels per year until 2005.

Spent shale from processing of oil shale would normally be used as mine fill or stockpiled. Investigations into possible other uses for residues from spent torbanite from the Alpha deposit in Queensland, indicate that it has potential for use in production of activated carbon. Research into this possibility is continuing.

Tantalum

Australia has the world's largest EDR of tantalum, with about 20% of the world total. The world's largest tantalum resource occurs in the Greenbushes deposit in the southwest of Western Australia. Important resources also occur in deposits that form the basis of the Wodgina project in the Pilbara district of Western Australia.

Gwalia Consolidated Ltd's Greenbushes operation produced 337 442 pounds of tantalum products in 1993-94. The Wodgina project of Pancontinental Mining Ltd and Goldrim Mining Australia Ltd produced 132 573 pounds in 1993-94. Small quantities are also produced in the Pilbara from the Pilgangoora project.

Tin

Australia is the world's fourth largest tin producer after China, Brazil and Indonesia. However, in terms of EDR, Australia is ranked seventh after China, Brazil, Malaysia, Thailand, Indonesia and Zaire.

Australia's demonstrated resources of tin totalled 373 380 tonnes in 1994. This was an increase of 10% over 1993, which resulted largely from further definition of the Rendeep reserves and resources at the Renison Mine in Tasmania. Revised estimates for resources at Ringarooma Bay, also in Tasmania, contributed significantly to the increase.

EDR increased by 30% in 1994. The increase in Australia's EDR reflects the announcement by Renison Goldfields Consolidated Ltd of plans to develop the Rendeep resources. Initial development commenced in July 1994 and production of ore is scheduled to commence in late 1996.

A significant tin resource occurs in the Greenbushes deposit in Western Australia where it is recovered as a by-product of tantalite and spodumene mining. Mount Carrington Mines Ltd has acquired a series of tenements in the Mount Garnet area of north Queensland, where it hopes to commence production before the end of 1995.

Tungsten

Small quantities of tungsten, in scheelite concentrates, continue to be produced at the Kara mine at Hampshire, south of Burnie, Tasmania. Production in 1993 was less than 0.1% of world production. Australia was once an important world tungsten producer but since the early 1980s more than six mines have closed because of depressed prices and world oversupply.

Australia's demonstrated resources of tungsten constitute about 6% of the world's total. Most identified resources occur at Mount Mulgine and Mount Alexander, Western Australia; King Island, Cleveland, Oakleigh Creek and Kara, Tasmania; Torrington, New South Wales; Wolfram Camp, and Mount Carbine, Queensland; and Molyhill, Northern Territory. Apart from the EDR at Kara, all resources are classified as subeconomic.

Prospects for future tungsten mining in Australia depend upon an increase in price and a closer balance between world tungsten supply and demand.

Vanadium

Numerous occurrences of vanadium minerals have been recorded in Australia. A deposit at Coates, Western Australia, was mined in 1980 and 1981 before mining was suspended because of falling prices and plant processing difficulties. Several other Australian deposits have been explored as possible vanadium sources.

Australia's demonstrated resources are very large on a world scale. However, virtually all resources are subeconomic. The only resources classified as economic occur in the Savage River iron ore deposit in Tasmania, and the Yeelirrie uranium deposit in Western Australia.

Of Australia's demonstrated resources of vanadium, 83% are contained in the Julia Creek oil shale deposit in Queensland, 12% in the Mitchell Plateau and Cape Bougainville bauxite deposits in Western Australia and the remaining 5% in the Yeelirrie uranium deposit, Windimurra, Coates, Barrambie, and Gabanintha titaniferous magnetite deposits in Western Australia, and the Savage River iron ore deposit in Tasmania.

Vanadium resources contained in or associated with titaniferous magnetite deposits are considered to have the best potential for economic development in Australia. The feasibility of developing vanadium bearing deposits at Windimurra and Coates is being investigated by Precious Metals Australia Limited and Clough Resources respectively. Recovery of vanadium contained in oil shale at Julia Creek depends mainly on the economics and technology of oil shale extraction, and is unlikely to become commercially viable in the medium term.

Zinc, Lead and Silver

Australia has the world's largest EDR of both zinc (30%) and lead (31%) and lies third behind Canada and Mexico for silver (16%). Australia is the world's largest producer of lead, second largest of zinc and fourth largest of silver. Production is mainly from mines at Mount Isa in Queensland , Broken Hill in New South Wales and Hellyer and Rosebery in Tasmania.

In 1994, EDR rose significantly for zinc (up 13%) and silver (up 33%), and lead increased slightly. Reassessment of resources at major deposits resulted in large increases in zinc, lead and silver EDR at some which were partially offset by production and reclassification of resources at others.

Exploration and evaluation of deposits continues in the Carpentaria-Mt Isa Minerals Province (northwest Queensland and northeast Northern Territory) where mine production is due to commence at the McArthur River deposit in 1995. Bulk sampling for metallurgical testing is underway at the Century deposit and preliminary metallurgical tests on the Cannington mineralisation were completed successfully at Mt Isa. Development decisions are scheduled to be made for both these deposits in the first half of 1995. Studies continue into possible development of the Dugald River zinc-rich deposit northeast of Mt Isa.

Deep exploration drilling from the surface at Rosebery has intersected significant new high-grade resources beneath the existing mine. A detailed evaluation and development program, to be implemented from the existing deeper underground workings, is to take place over the next few years.

Exploration continues for base metals in the Pilbara region of Western Australia. Two new small to medium deposits at Salt Creek and Sulphur Springs have been delineated.

Together with the known deposits such as Mons Cupri and Whim Creek, these deposits enhance the prospectivity of the region.

Zinc-rich resources at Blendevale, in the Kimberley region of Western Australia, have been reassessed and upgraded by new owners. These, together with similar resources at the Kapok and Goongewa (formerly called Twelve Mile Bore) deposits, may augment economic resources at the nearby Cadjebut mine. Exploration potential exists for further resources in the region.

At Broken Hill, open-pit economic resources were delineated at the Potosi Prospect to the near north of the Broken Hill deposit. Encouraging drillhole intersections were made at the Consols Prospect (formerly Pinnacles) southwest of Broken Hill.

Research and development on the MM130 continuous hard rock mining machine continued at Broken Hill. This technology may contribute to making low-grade resources at Broken Hill and in other deposits economic in the future.

Uranium

Table 3 presents estimates of Australia's recoverable uranium resources, together with the latest available figures for other countries. The resources are shown in categories as defined by the OECD/NEA and IAEA. The Australian estimates were calculated by the Mineral Resources Branch of BRS using basic exploration data provided by companies. The revision of estimates for 1994 takes into account production and reassessments in the light of additional exploration, cost increases, and changes in the exchange rate of the Australian dollar.

In addition to the resources with low production costs (less than US$80 per kilogram of uranium) listed in Table 3, the following countries have reported 'known' resources with production costs of less than US$80 per kilogram of uranium: Kazakhstan 417 500 t of uranium (U); the Russian Federation 219 600 t U; Ukraine 62 200 t U; and Mongolia 19 000 t U. These resource estimates are not strictly consistent with the standard terminology and definitions used by OECD/NEA and IAEA because:

- they are estimates of in-situ resources with no indication of recoverability;
- they may include resources that have already been produced;
- they have not been subdivided into reasonably assured resources (RAR) and estimated additional resources – category I (EAR–I); and
- there are uncertainties in determining the costs of production for these resources.

However, if these resource estimates are added to the total RAR with low production costs in Table 3, it gives an approximation of total world resources in the low-cost RAR category of just over 2 313 000 t U.

Australia's resources in the low-cost RAR category (Table 3) are the largest in the world and represent about 27% of world resources in this category. During the past year,

TABLE 3 Estimated recoverable resources of uranium, 1994[a] (tonnes U)

	Resources with recovery costs of: Less than US$80/kg U[b]		US$80-130/kg U[b]	
COUNTRY	**Reasonably assured resources[c]**	**Estimated additional resources, Category I[d]**	**Reasonably assured resources[c]**	**Estimated additional resources, Category I[d]**
Algeria	26 000	0	0	0
Argentina	4 600	2 300	2 700	300
Australia [e]	633 000	154 000	77 000	40 000
Brazil	162 000	94 000	0	0
Canada	277 000	31 000	120 000	43 000
France	19 850	3 550	13 800	3 180
Gabon	9 780	1 300	4 650	8 300
Namibia	80 620	30 000	16 000	23 000
Niger	159 170	295 770	6 650	10 000
South Africa	144 400	34 720	96 440	19 700
Spain	17 850	4 200	21 150	0
USA [f]	114 000	na	255 000	na
Other countries [g]	53 390	20 240	83 740	72 530
Total (adjusted) [h]	1 595 000	552 000	681 000	214 000

na=not available

[a] Data for countries other than Australia are from the most recent OECD/NEA and IAEA publications available at 31 December 1994.

[b] The OECD/NEA and IAEA quote uranium production costs in US$ per kilogram U. These cost categories must not be confused with market prices; previous development costs or profits are not included. US$80 per kilogram U approximately equals US$30 per pound U_3O_8.

[c] Reasonably assured resources refer to uranium that occurs in known mineral deposits of such size, grade and configuration that it could be recovered within the given production cost ranges, with currently proven mining and processing technology. Estimates of tonnage and grade are based on specific sample data and measurements of the deposits, and on knowledge of deposit characteristics. Reasonably Assured Resources have a high assurance of existence.

[d] Estimated additional resources, Category I, refer to uranium in addition to reasonably assured resources (RAR) that is expected to occur, mostly on the basis of direct geological evidence, in extensions of well explored deposits and in deposits in which geological continuity has been established but where specific data and measurements of the deposits and knowledge of the deposits' characteristics are considered to be inadequate to classify the resources as RAR. Such deposits can be delineated and the uranium subsequently recovered, all within the given cost ranges. Estimates of tonnage and grade are based on such sampling as is available and on knowledge of the deposit characteristics as determined in the best known parts of the deposit or in similar deposits. Less reliance can be placed on the estimates in this category than on those for RAR.

[e] Data for Australia compiled by BRS as at December 1994.

[f] The United States' estimated additional resources are not reported separately for EAR–I and EAR–II.

[g] Austria, Central African Republic, Czech Republic, Denmark, Finland, Germany, Greece, Hungary, Indonesia, Italy, Japan, Republic of Korea, Mexico, Peru, Portugal, Slovenia, Somalia, Sweden, Thailand, Turkey, Vietnam, Zaire, Zimbabwe.

[h] Totals have been adjusted by OECD/NEA and IAEA to account for milling and/or mining losses not incorporated in the estimates for Algeria, Brazil, Niger and certain countries grouped under 'Other countries'. Because of these adjustments, these totals do not represent the sum of the country assessments detailed above.

Australia's RAR in the low-cost category increased by 2000 t U, and EAR–I in this cost category increased by 5000 t U.

Australia's RAR in the cost category of US\$80–US\$130 per kilogram U increased by 1000 t U during the year, whereas EAR-I in this cost category remained unchanged from the previous year's estimates.

In addition to the RAR and EAR–I categories of resources shown in Table 3, BRS estimates there is a 75% probability that Australia has undiscovered potential resources (Undiscovered Resources) amounting to more than 2 600 000 t U and a 50% probability that the Undiscovered Resources may exceed 3 900 000 t U.

The uranium policy of the Australian Government has permitted the mining and export of Australia's uranium from three mines — Nabarlek and Ranger in the Northern Territory and Olympic Dam in South Australia. With the closure of Nabarlek in mid 1988, only Ranger and Olympic Dam now mine and export uranium.

Australia's total production for 1993 was 2256 t U (2660 t U_3O_8), 7% of world production. Mining at the Ranger open cut (No.1 Orebody) was completed in December 1994. On completion of open-cut operations, surface stockpiles of ore will be sufficient to maintain production at projected levels through to the year 2000. Energy Resources of Australia Limited has stated that it will need to develop a second orebody for initial production in 1998. The company has two undeveloped orebodies, Ranger No. 3 and North Ranger (Jabiluka) No. 2. Ranger No. 3 is adjacent to the existing Ranger mill, and North Ranger No. 2 is 20 km to the north of Ranger on an adjoining lease. Development of North Ranger No. 2 requires a change in the Australian Government's uranium policy.

The Olympic Dam deposit is mined for copper, uranium, gold and silver. It is one of the world's largest deposits of low-cost uranium. Western Mining Corporation reported that annual production capacity at the Olympic Dam operation will be increased to 84 000 t of copper and 1500 t of U_3O_8 in 1995.

In 1993–94, the 3384 t of U (3990 t U_3O_8) exported in concentrates was valued at A\$193 million. The average export price was A\$45.74 per kilogram of U_3O_8 (ABARE 1994). Exports were significantly higher in 1993-94 due to shipments from the Commonwealth uranium stockpile.

Australia applies stringent conditions to the export of uranium to ensure it is used only for peaceful purposes. These conditions, referred to as nuclear safeguards, require customer countries to allow inspectors from the International Atomic Energy Agency to verify that the uranium is not directed into weapons programs. In addition, the countries to which Australia exports uranium must comply with parallel safeguards agreements under treaties between Australia and each of these countries. Compliance with these bilateral safeguards agreements is monitored by the Australian Safeguards Office.

In August 1994, the Minister for Finance announced that contracts had been signed to sell the last remaining portions of the Commonwealth uranium stockpile. The total stockpile was 2052 t of U_3O_8. The stockpile material was stored at Lucas Heights, New South Wales, and at Ranger, Northern Territory. The Minister reported that the Lucas Heights material had already been shipped, and it was expected that the remainder of the material would have left Australia by the end of 1994.

References

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Exploration

Exploration Expenditure

The following discussion and statistics are based on mineral exploration expenditure for commodity groups monitored by ABS. The differentiation of commodity groups before 1980 is based largely on a breakdown of ABS totals by BRS.

Exploration expenditure in 1993–94 totalled $792.6 million (ABS 1994). This was an increase of 25% over the previous year. Figure 2 shows trends in actual expenditure over the last four years. The most striking feature is the sharp rise in 1993–94 expenditure on gold exploration which grew by 42% over the previous year to $453.8 million. Diamond expenditure also rose sharply, up 54%, to $58.7 million

Western Australia's dominance of exploration expenditure continued in 1993–94, with 57% of total expenditure being spent in that State compared to 55% in 1992–93. Queensland was ranked second, achieving 18% of total expenditure, followed by New South Wales and the Northern Territory with 9.3% and 8.8% respectively.

Gold accounted for 57% of all exploration expenditure in 1993–94 (Figure 2). This compares to a 4.6% share two decades earlier but is still well below the peak share of 72% achieved in 1987–88. At $191.6 million, expenditure on base metals exploration (copper, lead, zinc, silver, nickel and cobalt) was the highest in current dollar terms since 1981–82, and was 4.5% higher than in 1992–93. However, as a consequence of the large increases in gold and diamond expenditure, the share of expenditure on base metals rose only slightly from 24.0% in 1992–93 to 24.2% in the current year

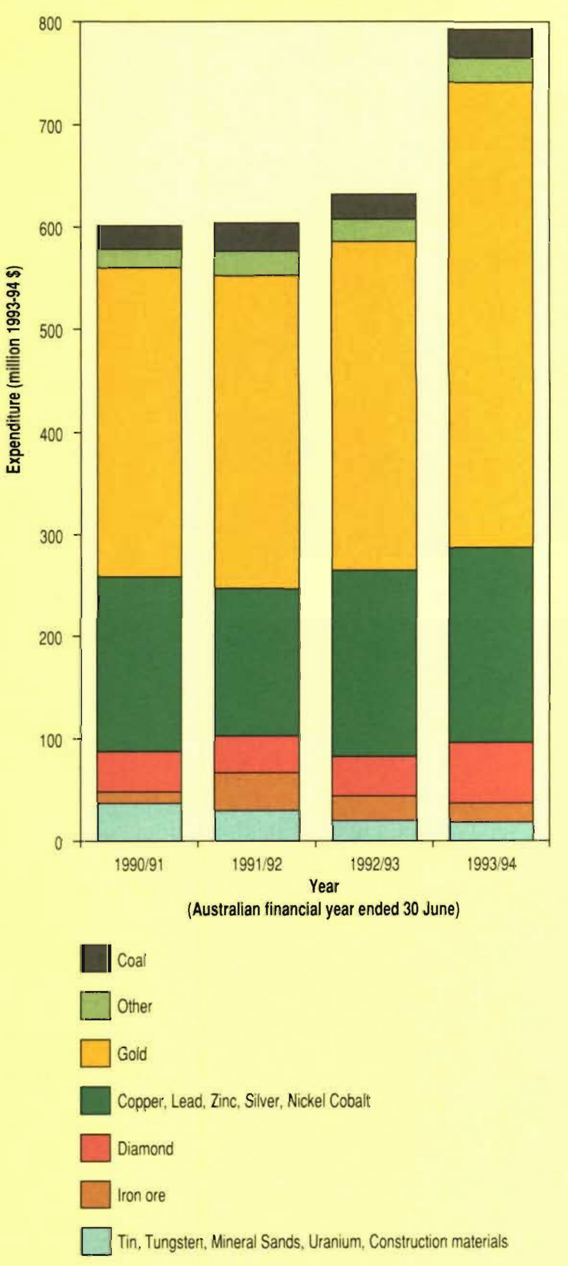
In constant dollar terms (1993–94 dollars), the recovery in mineral exploration commenced in 1992–93 and accelerated in 1993–94 (Figure 3). Despite this strong recovery, expenditure remained below the peak years of 1970–71, 1981–82 and 1987–88.

Exploration Drilling

In 1994, BRS commissioned ABS to undertake a survey of exploration and mining companies to ascertain the amount and type of exploration drilling carried out in 1993–94. Data were also collected on exploration drilling expenditure. The data were released by ABS in November 1994 and a preliminary analysis follows.

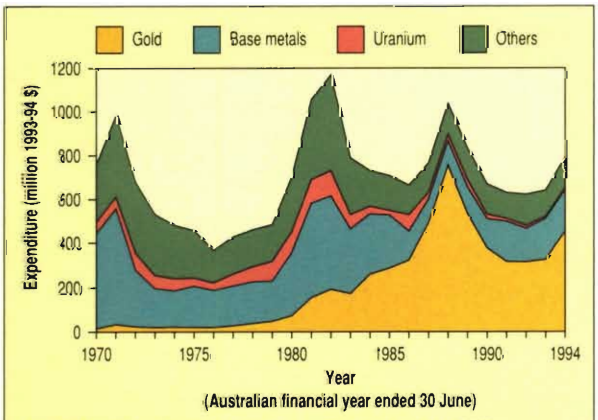
Of the $792.6 million expended on exploration in 1993–94, $283.6 million, or 36%, was spent on drilling. A State-by-State breakdown of drilling expenditure is incorporated into Table 4. Over 40% of exploration expenditure in Tasmania and Western Australia was directed to drilling in 1993–94 (Figure 4), compared to just under 15% for South Australia.

FIGURE 2 Annual exploration expenditure since 1990–91



Source: ABS

FIGURE 3 Australian exploration expenditure since 1969–70 expressed in 1993–94 dollars



Source: ABS (Current dollars deflated by Consumer Price Index 1993-94 = 100 provided by ABARE)

TABLE 4 Exploration expenditure and exploration drilling, 1993–94

State	Total exploration expenditure ($million)	Exploration drilling	
		'000 metres[a]	$ million[a]
New South Wales	73.7	406.6	21.3
Victoria	20.7	101.7	4.2
Queensland	139.9	1015.3	40.8
South Australia	24.7	124.0	3.6
Western Australia	453.7	7764.8	192.1
Tasmania	10.1	55.5	4.9
Northern Territory	69.8	614.2	16.6
Australia	**792.6**	**10082.2**	**283.6**

[a] Statistics collected by Australian Bureau of Statistics for Bureau of Resource Sciences.
Note: totals and sums of components may vary because of rounding.

TABLE 5 Methods of exploration drilling in Australia, by type of area, 1993–94

Drilling Method	Production areas			Other areas		
	'000 metres[a]	'000 $[a]	Average $/m	'000 metres[a]	'000 $[a]	Average $/m
Diamond	749.0	73041	97.52	561.7	58866	104.80
Reverse circulation	1617.9	42454	26.24	1817.8	48888	26.89
Percussion	141.4	4522	31.98	203.6	6823	33.51
Rotary air blast	1214.4	10251	8.44	3208.0	29704	9.26
Others	81.9	1130	13.80	486.5	7872	16.18

[a] Statistics collected by Australian Bureau of Statistics for Bureau of Resource Sciences.

Almost 10.1 million metres of exploration drilling was undertaken in 1993–94, of which 38% was in production areas (Table 5). Western Australia dominated with 77% of total drilling (Figure 5). In terms of drilling expenditure, Western Australia was dominant, with 60% of the total. This lower share of expenditure compared to actual drilling is attributed, at least in part, to the lower proportion of diamond drilling in the Western Australian total compared to other States.

Exploration drilling outside of production areas (62% of all exploration drilling) totalled 6.3 million metres at a cost of $152.2 million. Table 5 and Figure 6 summarise exploration drilling statistics for 1993–94. In all categories, the average cost per metre drilled was higher in non-production areas.

FIGURE 4 Proportion of exploration expenditure spent on drilling, by state, 1993–94

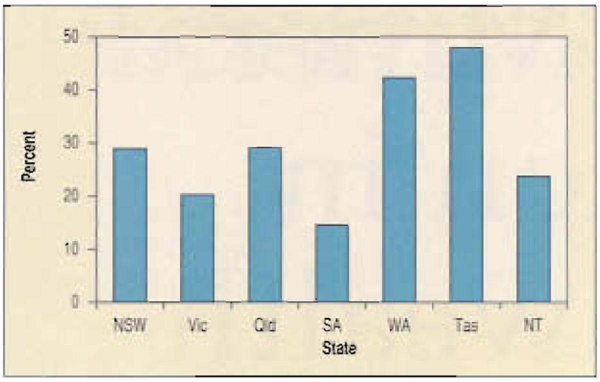


FIGURE 5 Exploration drilling, by State, 1993–94

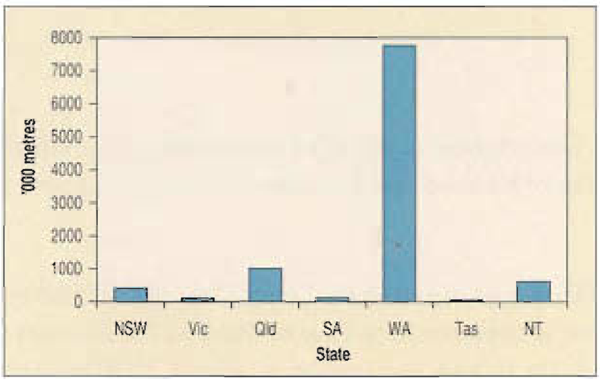
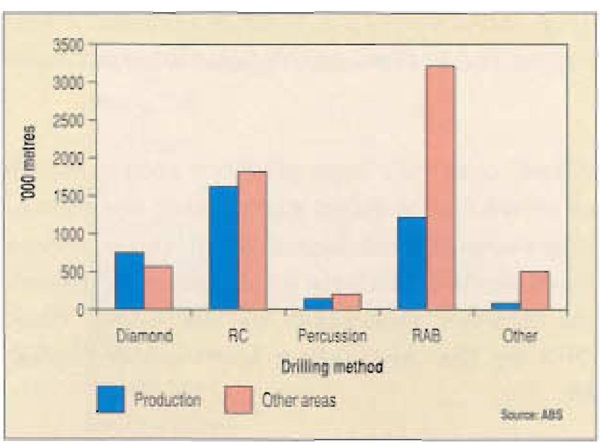


FIGURE 6 Exploration drilling, by drilling method and by area, 1993–94 (RC, reverse circulation; RAB, rotary air blast)



Reference

ABS (1994) Actual and expected private mineral exploration, Australia, June Quarter 1994. Catalogue No. 8412.0. Australian Bureau of Statistics, Canberra.

Offshore Mineral Exploration in Commonwealth Waters

The area of Australia's geomorphological continental shelf is of the order of 2 million square kilometres, about one-quarter the size of its land mass of about 7.8 million square kilometres.

The geomorphological continental shelf is part of Australia's Legal Continental Shelf (LCS) which is defined under Article 76 of the United Nations Law of the Sea Convention. The area of the LCS around Australia and its island territories is about 11.9 million square kilometres or about 14.8 million square kilometres if the Australian Antarctic Territory is included (Symonds and Willcox 1989).

The Law of the Sea Convention took effect internationally on 16 November 1994, and Australia has 10 years to define the outer boundaries of its LCS. Australia has sovereign rights over its LCS for the purposes of exploring and exploiting the natural resources of the seabed and subsoil.

The potential for minerals other than petroleum over this large offshore area is mostly unknown. Widespread and detailed studies as well as ongoing exploration are needed to build up a geoscientific database to develop knowledge of Australia's offshore mineral resources. Available information comes from limited offshore exploration by private companies and from some reconnaissance surveys undertaken by the former BMR, State Geological Surveys and since 1992 by the Australian Geological Survey Organisation(AGSO), the successor to BMR.

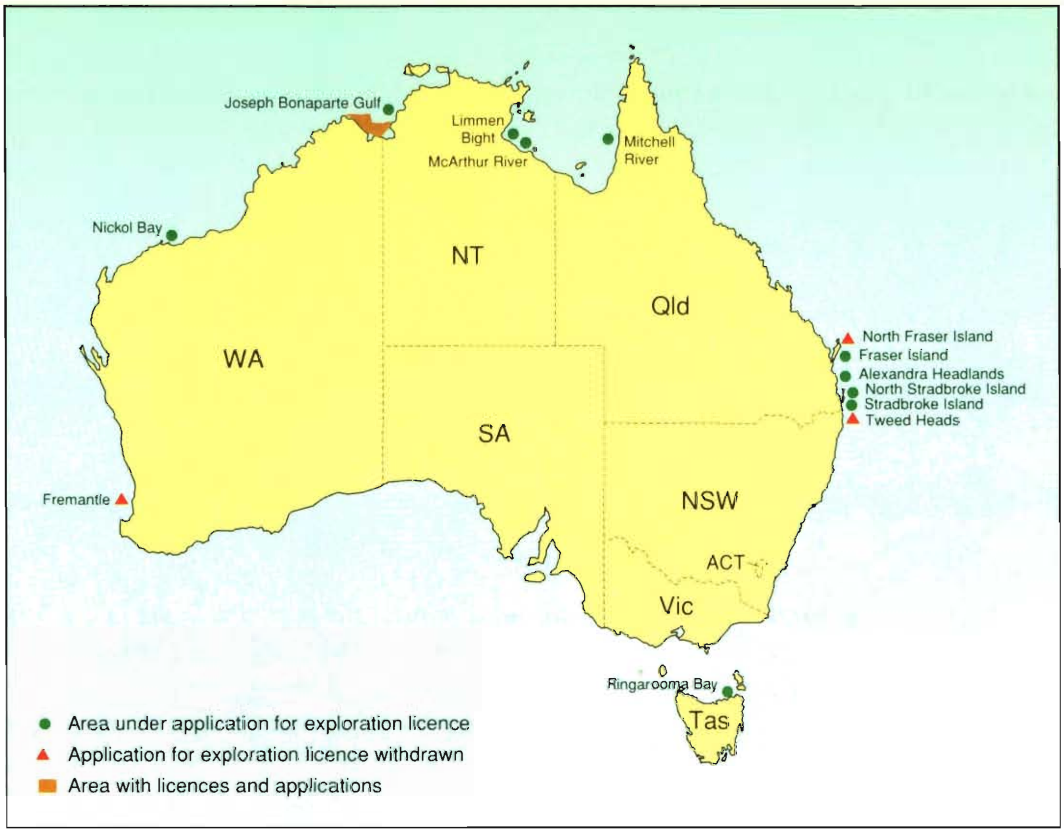
Deposits potentially economic in the short to medium term are likely to be in relatively shallow waters of the continental shelf close to the coast. Commodities forming such deposits include diamonds, gold, heavy mineral sands, tin and other placer deposits and construction materials (sand and gravel). Offshore extensions of known onshore mineralisation such as tungsten, coal, manganese and iron ore are known to occur in some areas. Most of the offshore mineral exploration for diamonds and heavy mineral sands is based on known distribution of these minerals on adjacent onshore areas. Other mineral commodities such as phosphates and polymetallic manganese nodules (containing nickel, cobalt and copper) which occur in deep water are likely to be of long-term interest only.

Australia's 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. The Act came into force in February 1994. Before then, the granting of licences was regulated by the Offshore (Submerged Lands) Act 1981.

Applications for a mineral exploration licence (MEL) are made to the Designated Authority (usually the relevant State or Territory Minister responsible for mining) with an application fee of $3000. The application must be made in the approved manner and must specify such details as:

- block numbers (each block being approximately 2 km by 2 km; and no more than 500 blocks can be applied for with each application);
- proposed exploration program;
- amount of money allocated to each part of the program;
- technical qualifications of applicant and employees; and
- financial resources.

FIGURE 7 Offshore mineral exploration in Commonwealth waters



Each MEL usually has conditions attached to it related to specified expenditure, reporting, and the steps to be taken to protect the environment. The initial term of the licence is four years, and each renewal period is for a term of two years. There is a mandatory reduction of licence areas on renewal of an MEL. However, it is possible for an exploration licence holder to apply for a retention licence to retain rights over an area if there is a reasonable prospect of developing a deposit.

Since February 1990, 39 offshore MELs have been applied for in Commonwealth waters (see Figure 7). As at 31 October 1994, seven had been granted, one had been refused, four had been withdrawn, one had expired and 26 were pending.

Of the 39 applications, 24 (20 off Western Australia and 4 off the Northern Territory) were in the Joseph Bonaparte Gulf in northwest Australia. This exploration is directed at the search for alluvial diamonds in offshore palaeochannels. In other areas, MEL applications have been made to explore for gold, diamonds, mineral sands, tin, and sand and gravel.

Reference

Symonds, P.A. and Willcox, J.B. (1989) Australia's petroleum potential in areas beyond an Exclusive Economic Zone. BMR Journal of Australian Geology and Geophysics 11: 11–36.

Mineral Resources Branch

Director

Ian Lambert	272 3042
Personal Assistant – Suzy Obsivac	272 4391

Identified Resources and Mineral Databases

Bill McKay (Manager) Bauxite	272 4020
Mike Huleatt Gold, iron ore, tantalum, niobium, lithium, oil shale	272 3245
Lloyd David Copper, lead, zinc, silver, antimony, arsenic, bismuth, cadmium, selenium, tellurium, gem and semi-precious stones, cobalt	272 4127
Roy Towner Titanium, zirconium, rare earths, clays, magnesite, talc, dolomite, peat, limestone, gypsum, silica, chemical industry minerals and specialty minerals, molybdenum	272 4369
Brian Elliott Mineral databases	272 4433
Keith Porritt Mineral databases, GIS support	272 3044
Stuart Girvan Tin, platinum-group metals, tungsten, chromium, mineral databases	272 3243

Appraisal of Mineral Resource Potential

Yanis Miezitis (Manager) Potential mineral resources	272 5939
Don Perkin Exploration analysis, manganese	272 5815
Aden McKay Uranium, nickel, vanadium, potential mineral resources	272 3045
Ron Sait Coal, off-shore mineral exploration	272 5875

Facsimile No: (06) 272 4161
Postal Address:
PO Box E11 Queen Victoria Terrace
PARKES ACT 2600

Australia's
Identified
Mineral Resources

1994

Australia is one of the world's most important suppliers of minerals, and the mineral industry is an important sector of the Australian economy. This publication includes information on the state of Australia's mineral resources including:

Bauxite, black coal, chromium, cobalt, copper, diamond, gold, iron ore, manganese, mineral sands, molybdenum, nickel, platinum-group metals, shale oil, tantalum, tin, tungsten, vanadium, zinc, lead, silver, and uranium.

It also contains information on mineral exploration onshore and offshore in Commonwealth waters.

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